Protocol and statistical analysis plan - impact of environmental labelling on food choices: a randomized controlled trial in a virtual reality supermarket

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PROTOCOL AND STATISTICAL ANALYSIS PLAN

Study title: Impact of Environmental Labelling on Food Choices : a Randomized Controlled Trial in a Virtual Reality Supermarket

Short title: Environmental labelling in a virtual supermarket

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Date: May 24th, 2021
NCT number: not yet assigned

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BACKGROUND AND RATIONALE

Food systems have been recognised to play a major role in climate change and it was estimated that they contributed to 34% of total anthropogenic greenhouse gas emissions (GHGe) in 2015 (Crippa, 2021). A French study evaluated that food accounted for 24% of the carbon footprint of households (Barbier et al., 2019). The largest contributor of these emissions is agriculture since it represents more than two-thirds of the food system's GHGe (Barbier et al., 2019). The remaining third of the GHGe is due to transportation, consumption, industrial processes and packaging. A recent study showed that even if we were to stop fossil fuel emissions, the GHGe from food systems would not allow to stay under the targeted 1.5°C increase in global temperatures (Clark et al., 2020) highlighting the importance of cutting down agricultural GHGe. It has also been shown that the structure of our diets can be modified to reduce their carbon footprint and remain within a "*safe operating space for humanity*" as modelled by planetary boundaries (Willett et al., 2019). In particular, the reduction of meat and dairy consumption and the increase of plant-based food consumption are major levers to reduce the environmental impact of our diets (Hedenus et al., 2014; Scarborough et al., 2014).

In developed countries particularly, where meat and dairy consumption is high, a shift towards more plant-based diets has been advocated by scientists for its beneficial impacts on health and the environment (Willett et al., 2019). However, this shift may not be easily achieved by consumers (Hartmann & Siegrist, 2017). This can be explained by the fact that eating meat is associated with pleasure and has strong cultural, social and personal values in our societies (Macdiarmid et al., 2016). The reluctance to reduce meat consumption may also be associated with the lack of knowledge of the environmental footprint of meat (Hartmann & Siegrist, 2017; Macdiarmid et al., 2016). The underestimation of the GHGe of different types of foods, especially animal products, has been previously highlighted and was considered as a potential area for interventions (Camilleri, 2019). In line with this idea, studies have shown that consumers with a higher knowledge regarding the impact of human behaviours on climate change declared higher intentions to adopt environmentally-friendly behaviours (Truelove & Parks, 2012).

Environmental labels on food products have been described as potential drivers of the choice of environmentally-friendly products, as they may increase consumers' knowledge about the environmental impact of the food products allowing consumers to make more informed decisions when choosing food products (Camilleri, 2019). In addition, consumers wish to be informed about the environmental footprint of the products that they consume (Gadema & Oglethorpe, 2011). However, when presented with those labels, many consumers found them hard to understand and to use (Gadema & Oglethorpe, 2011). Yet, the use of an environmental label is directly linked to its understanding (Grunert et al., 2014). Thus, there is a need of a clear environmental label that conveys key information regarding the environmental impact of foods and that is easily understood by consumers.

Interventional studies using gold-standard design (i.e., randomised controlled trials) in realistic food purchasing environments are needed to demonstrate the effect of environmental labels on food choices (Vyth et al., 2012). Supermarkets are key environments to test the effect of food labelling interventions since they represented roughly 70% of the total food sales in 2019 in France (Insee, 2019). Studies testing the effect of environmental labels on food choices carried out in realistic food purchasing settings, such as online supermarkets (Muller & Lacroix, 2019), real supermarkets (Pelletier et al., 2016; Vanclay et al., 2011; Vlaeminck et al., 2014) or restaurants (Brunner et al., 2018) are scarce. To our knowledge, only one randomised controlled trial, consisting in an online food shopping task for soups, tested the effect of an environmental label on food choices (Camilleri, 2019).

We will conduct a 2-arm randomised controlled trial (with and without labels) to test the effects of an environmental label on food choices in a virtual supermarket. Participants will take part in two shopping tasks: 1/ selection of 3 products to prepare a home-made dish, and 2/ selection of a ready-to-eat dish. These two tasks will be repeated for two scenarios: 1/ participants will be asked to select the foods as they would do for a usual day (everyday scenario), and 2/ participants will be asked to select the foods for an environmentally friendly meal (environmentally-friendly scenario). This experimental design will allow to compare food choices in the presence vs. the absence of an environmental label and to investigate whether the label is informative and likely to help individuals to choose more environmental-friendly food options when explicitly asked to do so. In line with previous results showing that participants were more likely to choose pulses for a meal at a restaurant compared to a home-cooking scenario (Melendrez-Ruiz et al., 2019), we also hypothesise that it might be easier for a consumer to choose more environmentally friendly ready-to-eat dish than more environmentally friendly ingredients to cook it from scratch.

On top of the lack of knowledge regarding the link between food systems and climate change, it has been emphasized that food choice motivations are key barriers for a shift towards more plant-based diets (Grunert et al., 2014). Many criteria are considered when purchasing foods and differ among consumers. In the French population taste, price and geographical origin of products are the key declared criteria influencing food choice (European Commission. Directorate General for Health and Food Safety, 2020). Environmental considerations such as the carbon footprint were poorly rated among food choice motives by UK supermarket shoppers (Gadema & Oglethorpe, 2011). Similarly, the environment was declared by only 15% of European respondents as an important driver influencing food choice (European Commission. Directorate General for Health and Food Safety. et al., 2020). An additional aim of the present study is to investigate the relationships between food choice motives and the effect of an environmental label on food choices.

OBJECTIVES, OUTCOMES MEASURES AND HYPOTHESES

OBJECTIVES	OUTCOME MEASURES	HYPOTHESES
Primary objectives		
1.1 To study the effect of an environmental label on the environmental impact of ingredients and ready-to-eat dish choice in a virtual supermarket.	Mean of PEF[1] score for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish in the “everyday scenario”.	▪ An environmental label will lower the environmental impact of the food choices made by the participants compared to no label. ▪ The effect of the environmental label will be greater when choosing a ready-to-eat dish compared to when choosing ingredients.
1.2 To investigate whether the environmental label is informative and likely to help individuals to choose environmentally friendly food options when they	Mean PEF score for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish in the “everyday scenario” and the “environmentally-friendly scenario”.	▪ The reduction of the environmental impact of the foods chosen in the “environmentally-friendly scenario” compared to the “everyday scenario” will be greater for participants in the

[1] PEF score is the “Product Environmental Footprint”. Details regarding its calculation is described in the paragraph “Creation of an environmental score” (page 9).

are encouraged to make environmentally friendly food choices.		environmental label condition than in the no label condition.
Secondary objectives		
2.1 To study the effect of an environmental label on the nutritional quality, liking, familiarity, level of process and price of ingredients and ready-to-eat dish choices in a virtual supermarket.	The following variables will be calculated for the 3 ingredients (average) and for the ready-to-eat dish chosen in the "everyday scenario": ▪ FSA scores ▪ Liking ▪ Familiarity ▪ NOVA score *(only for the average of the 3 ingredients)* ▪ Price per calorie (continuous variables)	▪ The environmental label will have an impact on the nutritional quality (FSA score), liking, familiarity, NOVA score and price of the foods chosen by the participants.
2.2 To investigate the relationships between food motives and the effect of an environmental label on ingredients and ready-to-eat dish selection in a virtual supermarket.	▪ Mean PEF score for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish in the "everyday scenario". ▪ Level of ethical concern (questionnaire score)	▪ The environmental label will be more effective in reducing the environmental impact of food choices in participants with higher levels of ethical concern when making food choices.

EXPERIMENTAL DESIGN

This study will be a randomised controlled trial with two experimental arms:
1/ No label (no label condition)
2/ Environmental label (label condition)

A 2-block randomisation sequence (male and female) of 1:1 will be generated to allocate each participant to one of the experimental arm before recruitment using the Random Allocation software (Saghaei, 2004).

Each participant will be asked to perform two hypothetical shopping tasks in a virtual shopping environment, first in an "*everyday scenario*": 1/ choice of 3 ingredients for an everyday home-cooked dish among 66 products, 2/ choice of a ready-to-eat dish for an everyday meal among 30 products. The order of presentation of the two tasks will be counterbalanced. Then, the participants will be asked to perform the same two tasks while choosing foods for a dish that is "good for the planet" ("*environmentally-friendly scenario").* For a given participant, the order of presentation of the two tasks will remain the same as in the everyday scenario.

The experimental design is described **Figure 1**.

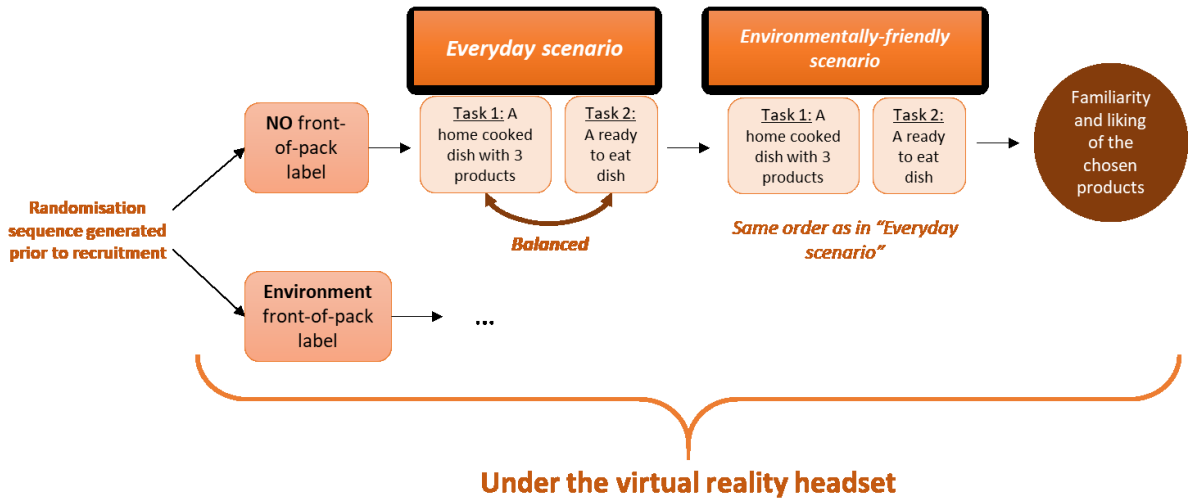

Figure 1. Experimental design for the virtual reality tasks performed by participants

PARTICIPANTS AND RECRUITMENT

Recruitment

Participants will be recruited thanks to the "PanelSens" database from the "Chemosens" platform. This database was declared to the relevant authority (*Commission Nationale Informatique et Libertés; CNIL; n°1,148,039*). Participants will be invited to take part in a lab study that aims to study food choices in a virtual supermarket. After completing the study, participants will receive a 10-euro voucher.

The recruitment will be stratified on sex:

- 50% male
- 50% female

and on age:

- ~33% between 18 and 35 years old
- ~33% between 36 and 50 years old
- ~33% over 50 years old

This recruitment structure also aims to include a diverse sample including single participants, participants with children and participants with children that have left the house (estimated around 18 years of age) as we hypothesise that age, gender and the structure of the household may have an impact on food choice behaviour.

Inclusion criteria

- Age ≥ 18 years old
- Responsible for a substantial proportion of household grocery shopping
- Fluent in French
- No dietary restrictions (vegetarian, vegan, allergies, intolerance, …)
- No uncorrected eye problems
- No known symptoms of nausea and dizziness when wearing a virtual reality headset

METHODS

Online shopping tasks

Shopping tasks

The experimental sessions will take place individually. After participants will have given their informed consent to take part in the experiment, they will be asked to sit down and will be equipped with a virtual reality headset. A qualified experimenter will be present to assist the participants.

The first step will consist in a test of the virtual environment so that participants can familiarise themselves with the virtual supermarket environment. Participants will be asked to navigate and test the functionalities of the virtual reality headset. This dummy supermarket will only include cosmetic products (shampoos, soaps, etc.).

Then, participants will start the shopping tasks under two scenarios. If participants are allocated to the "label condition", the label will be presented and explained to the participants prior to the shopping tasks with a pop-up message.

1) For the first scenario, in the first task, we will ask the participants to navigate in the aisles of a virtual environment of 66 foods and to select 3 food items in order to prepare a home-cooked dish for an everyday meal. In the second task, the shopping environment will be composed of 30 foods and participants will be asked to select 1 ready-to-eat dish for an everyday meal. The order of these tasks will be balanced.
2) The second scenario will be broken down in the same two tasks. We will keep the same order for the two tasks as in the first scenario. This time we will ask the participants to choose foods for a meal that is "good for the planet".

Experimental virtual supermarket

This study will be undertaken in a virtual reality environment that mimics the aisles, shelve and position of food products of a real supermarket. This virtual environment will be developed by our partner STRATEGIR under Oculus Quest 2 (https://www.strategir.com/fr/). The food products available in the virtual supermarket will be real products that can be found in three French supermarkets (*Intermarché*, *Carrefour and Picard*). Participants will see the front of the products on the shelves in the same size as if they were in a real supermarket. With a hand controller, participants will be able to navigate in the virtual supermarket, come closer, seize and examine closely the products they would like to choose. Once a product is selected, they will have the option to either put the product in their shopping cart or to put it back on the shelf.

Choice of the foods available in the supermarket

Based on a recent study carried out in a virtual supermarket (Melendrez et al. *working paper*), four food groups will be included in our virtual supermarket: "Meat, egg, fish and substitutes", "legumes", "vegetables" and "starchy foods". The number of foods composing each category, for each task of the shopping scenarios ("everyday scenario" and "environmentally-friendly scenario"), is described in **Table 2**. The foods included in each category are either canned, dry, fresh, or frozen.

As participants will be asked to select foods for a main dish only, the items included are all savoury foods. They are typical foods that can be part of a main dish. We will focus on the main dish as it is the meal item where we found the greater variability in terms of environmental impact, as compared with starters and desserts. Food sub-categories were chosen with distinct environmental impacts to maximise the likelihood of substitutions between food products of contrasted environmental impact.

Table 2. Foods included in the virtual supermarket

Tasks for each shopping scenario	Main Food Groups	Food Sub-groups	Number of products included
Task 1: Home-cooked dish	Starchy foods	-	12
	Vegetables	-	12
	Legumes	-	12
	Meat, eggs, fish and substitutes	Beef and lamb	6
		Other meat	6
		Fish	6
		Other animal products	6
		Plant-based meat substitutes	6
Task 2: Ready to eat dish	Beef and lamb	/	6
	Other meat	/	6
	Fish	/	6
	Vegetarian dishes (with animal products)	/	6
	Vegan dishes (without animal products)	/	6

Availability and placement of the products in the virtual supermarket

The first rule we adopted to create our virtual environment was to keep the same types of shelves as in a real supermarket. The shelves are defined by the storage method of the products.
4 types of shelves have been identified:

- With canned products
- With dry products
- With fresh products
- With frozen products

As in a real supermarket, within each shelf, we grouped products from the same food category (**Table 3**). To control for availability effect, we chose to allocate the same space to each product.

Table 3. Number of products composing each shelf of the virtual supermarket.

Task 1: Home-cooked dish					Task 2: Ready to eat dish		
Food categories		Canned products	Dry products	Fresh products	Ready-to-eat dish category	Frozen products	Fresh products
Meat, egg, fish and substitutes	Dairy products	0	2	4	Dairy products	4	2
	Poultry and pork	0	0	6	Poultry and pork	3	3
	Cow or sheep meat	0	0	6	Cow or sheep meat	3	3
	Sea food	2	0	4	Sea food	4	2
	Plant-based substitutes	0	2	4	Plant-based substitutes	4	2
	Vegetables	5	0	7	Total	18	12
	Legumes	4	6	2			
	Starchy foods	1	10	1			
	Total	12	20	34			

Intervention (environmental label)

As mentioned in the design of the experiment, an environmental label will be added to the front of the pack of the 96 food items included in the virtual supermarket.

Development of an environmental score:

In order to identify the environmental impact of the 96 foods included in the virtual supermarket, we matched each experimental food product with items in Agribalyse database[2]. To create our environmental score, we used the PEF, *Product Environmental Footprint,* score recommended by the European Commission (Pant et al., 2019). This score has the aim to evaluate the environmental impact of a food product based on 16 indicators such as climate change (kg CO_2 eq), ozone depletion (kg CFC-11 eq), marine eutrophication (kg N eq), land and water use or acidification (mol H^+ eq). These 16 indicators are calculated throughout the life cycle of the products. In order to obtain a unique PEF score, the indicators are weighed according to a method described by the European Commission (Pant et al., 2019). PEF scores for the foods present in the Agribalyse database are expressed in mPt for 1 kg of product. Pt means “eco-indicator point” and on a scale, 1 mPt represents the mean annual environmental load of an average European inhabitant.

In order to highlight PEF score variability across the different products presented in the virtual supermarket we created a segmentation of this score into five modalities. We defined the cut-offs

[2] Agribalyse is a database with the environmental impact, calculated thanks to a life cycle analysis, of 2480 different foods created by the French Environmental and Energy Management Agency (ADEME). https://agribalyse.ademe.fr/app/aliments

across modalities as the quintile values from a larger selection of similar foods from Agribalyse database. For the first shopping task (choice of 3 ingredients to compose a home-cooked dish), we created quintiles for the PEF score of 1655 foods that correspond to the food groups included in the virtual supermarket (**Table 4**). We replicated this method for the second task (choice of a ready-to-eat dish among 30 products). The quintiles were therefore calculated for the 281 foods from Agribalyse database with corresponding food groups (**Table 4**).

The process for the creation of the environmental score, explained for the first shopping task, is summarised **Figure 2**.

Table 4. Food groups from the Agribalyse database that are common with the food items included in the virtual supermarket

Food groups from Agribalyse used to create a list of foods from which we created quintiles	
Task 1: Choice of 3 ingredients to compose a home-cooked dish among 66 products	**Task 2:** Choice of a ready-prepared dish among 30 products
• Fruits, vegetables, legumes, nuts and seeds • Cereal products • Milk and dairy products • Meat, egg and fish	• Starters and dishes
These food groups represent:	
N=1655 foods	N=281 foods

Table 5. Limits of the quintiles created for the PEF scores of the different foods selected.
The values in the following table are PEF scores expressed in (mPt/kg of product)

Ingredients	**Ready-to-eat dishes**
1655 foods	*281 foods*
0 < **Q1** ≤ 0,17	0 < **Q1** ≤ 0,20
0,17 < **Q2** ≤ 0,35	0,20 < **Q2** ≤ 0,36
0,35 < **Q3** ≤ 0,62	0,36 < **Q3** ≤ 0,46
0,62 < **Q4** ≤ 1,36	0,46 < **Q4** ≤ 0,84
1,36 < **Q5** ≤ 6,09	0,84 < **Q5** ≤ 3,23

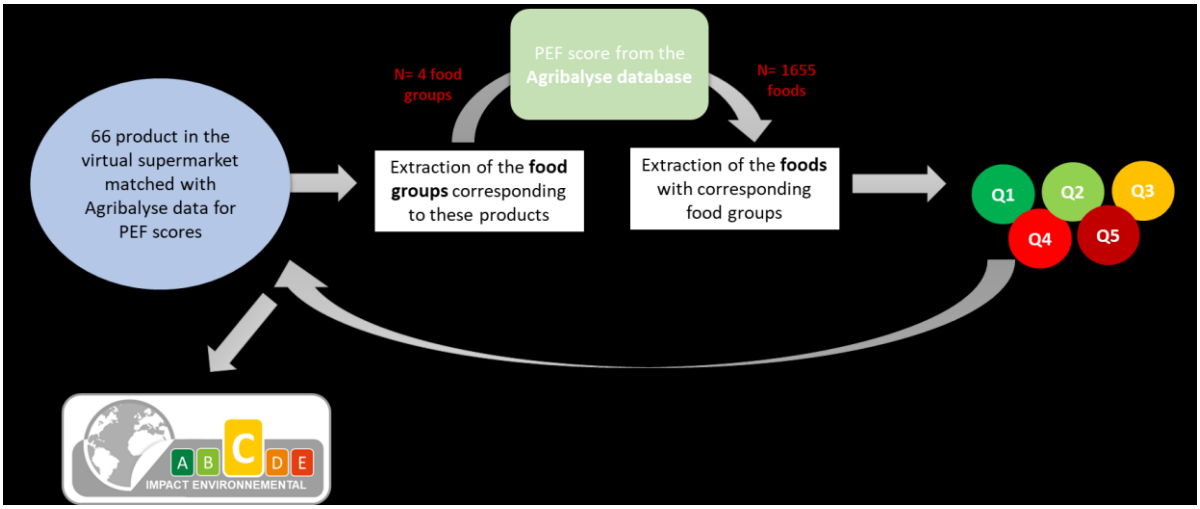

Figure 2. Creation of an environmental score for the label

Creation of an environmental label:

Since no environmental label design is currently being used in France for food products, we created a design considering previous findings regarding the most effective label designs.

The ideal label proposed by Carrero and collaborators is "traffic-light labels" (Carrero et al., 2021). It has been shown that green is often seen as a validation ("go") and a positive colour whereas red is associated with negative aspects and danger (Schuldt, 2013). This was put forward in research preceding the adoption of a nutritional front-of-pack label (Ducrot et al., 2015).

In September 2020, the French Agency for ecological transition (ADEME) published a design for a label assessing the environmental impact for the life cycle analysis of products or services (ADEME, 2020), see **Figure 3**. The colour was changed to obtain a "traffic light label" since it is considered as the best option to increase understanding and therefore behaviour change in consumers, see **Figure 3**. The label will be placed on the bottom part of the products.

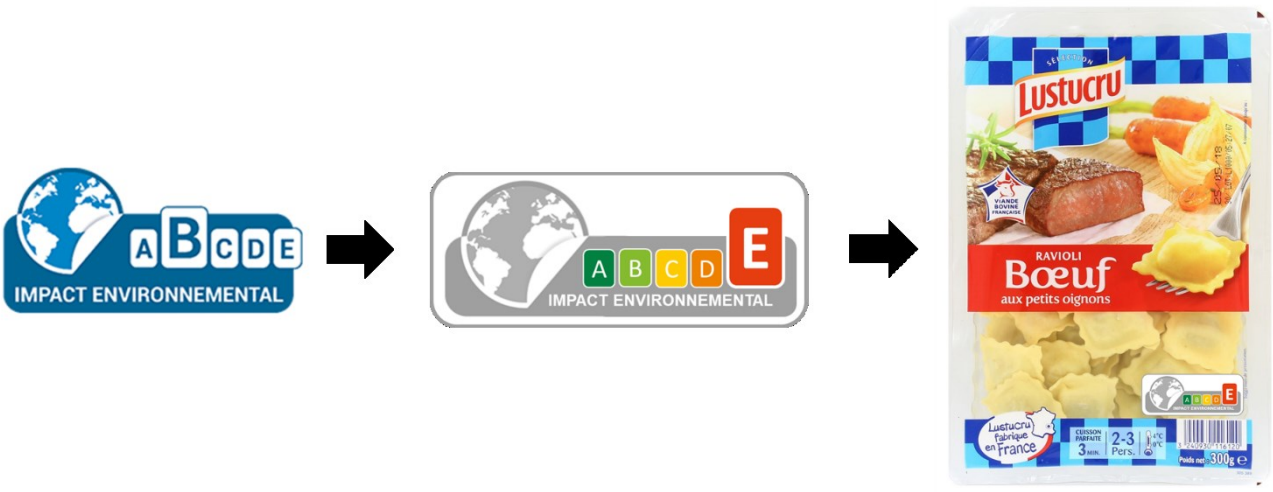

Figure 3. Design of the environmental label inspired by the French environmental label of ADEME

Questionnaires after the shopping experience

After the shopping experience, participants will be asked to complete one questionnaire with the virtual reality headset and four questionnaires on a separate computer (Qualtrics). These questionnaires will be presented in the following order:

1) After the four shopping tasks, participants will be asked to evaluate their familiarity and liking of the eight products selected under the virtual reality headset. The eight products will successively appear under the headset and participants will give a familiarity score (frequency of consumption of a similar product, ranging from "never" to "very often") and a liking score (score ranging from 1 to 10) for each product.

2) An investigation questionnaire will then be presented to participants on a computer to identify aim-guessers and record participants' feedback about their experience in the virtual supermarket. We will use questions adapted from the *presence questionnaire* used in previous studies (Schnack et al., 2019; Witmer et al., 2005). We will ask participants to evaluate, for each scenario, the importance of the presumed price, taste, packaging size, nutritional quality and environmental impact when making their choices ("not influenced" to "very influenced" by each criteria). For participants in the "label condition", we will also investigate if they paid attention, understood and used the environmental label while selecting products. Participants in the "no label condition" will also be asked if they noticed the presence of an environmental label in the virtual supermarket (*manipulation check*) and if they understand the meaning of the environmental label (displayed in the questionnaire). We will also ask questions to investigate what participants understood when asked to choose an environmentally-friendly dish.

3) From this will follow a food choice motivation questionnaire. We will use the adaptation of the *Food Choice Questionnaire* (Steptoe et al., 1995) for the French population (Cottet et al., 2017). This version includes 24 items that are grouped in 9 subscales (health, convenience, sensory appeal, natural content, ethical concerns, weight control, mood, familiarity and price). In order to have a better understanding of the sustainability motives consumers have for selecting their food, we will also ask independently the "Environmental welfare" subscale from the recently published Sustainable Food Choice Questionnaire (SUS-FCQ) (Verain et al., 2021). This subscale is composed of 5 items and its reliability was considered, by its authors, high enough to be used independently. The 5 items were translated in French and back-translated to English. For each item, participants will be asked to give a score ranging from 1 to 4 (1= not at all important, 2= a little important, 3= moderately important and 4 = very important). We will calculate the average scores for the "ethical" subscale of the FCQ and for the "environmental welfare" subscale of the SUS-FCQ. We will use the score with the highest Cronbach's coefficient in the analyses. The *Food Choice Questionnaire* will be complemented with questions regarding potential changes in food consumption habits that will inform future research work and will not be analysed as part of the present study. This latter was studied by (Gadema & Oglethorpe, 2011)[3]. Will follow, questions evaluating participants' declared capacity to make food choices based on the environmental impact or the nutritional quality of products.

[3] These questions have the purpose to inform an additional research project.

4) A socio-demographic questionnaire to collect data regarding the participants (age, gender, level of qualification, etc.) will be completed by the participants.

STUDY FLOW

<table>
<tr><td>RECRUITMENT
(Chemosens platform)</td><td colspan="2">▪ An email will be sent to individuals in the PanelSens database. Inclusion criteria will be mentioned in the email.
▪ If a person wishes to participate in the experiment, a questionnaire to assess eligibility will be sent.</td></tr>
<tr><td>INFORMED CONSENT
(On paper)</td><td colspan="2">▪ Participants will read the information sheet
▪ Participants will sign the consent form</td></tr>
<tr><td rowspan="2">RANDOMISATION
(Random Allocation Software)</td><td colspan="2">▪ Participants will be randomly allocated to one of the two experimental conditions (1:1)</td></tr>
<tr><td>No label
(X)</td><td>Environmental label
(E)</td></tr>
<tr><td>SHOPPING TASKS
(virtual reality headset)</td><td colspan="2">▪ Participants will navigate in a dummy virtual supermarket.
▪ <u>Everyday scenario (1)</u>: Participants will be asked to go shopping in the supermarket twice to select foods for an everyday meal:
- <u>Task 1:</u> Selection of 3 items to compose a home-cooked dish among 66 products
- <u>Task 2:</u> Selection of 1 ready-to-eat dish among 30 products
(The order of these two tasks will be counterbalanced)
▪ <u>Environmentally-friendly scenario (2)</u>: Participants will be asked to go shopping in the supermarket twice to select environmentally friendly ready-to-eat dishes:
- <u>Task 1:</u> Selection of 3 items to compose a home-cooked dish among 66 products
- <u>Task 2:</u> Selection of 1 ready-to-eat dish among 30 products
(The order of these two tasks will be the same as in the everyday scenario)</td></tr>
<tr><td>FAMILIARITY AND LIKING OF THE PRODUCTS SELECTED
(virtual reality headset)</td><td colspan="2">▪ Under the virtual reality headset, participants will be asked to evaluate their familiarity and liking of the 8 products they selected during the 4 shopping tasks.</td></tr>
<tr><td>INVESTIGATION QUESTIONNAIRE
Qualtrics</td><td colspan="2">▪ This questionnaire aims to gather information regarding the shopping tasks participants underwent under the virtual reality headset. We will identify potential aim-guessers and food motives during the online shopping experience. For participants in condition E, we will investigate if they paid attention, understood and used the environmental labelling.</td></tr>
<tr><td>FOOD CHOICE QUESTIONNAIRE
Qualtrics</td><td colspan="2">▪ Food choice motives will be assessed through an adaptation of the “Food Choice Questionnaire”.</td></tr>
<tr><td>SOCIO-DEMOGRAPHIC CHARACTERISTICS
Qualtrics</td><td colspan="2">▪ Participants will complete a questionnaire on socio-demographic data.</td></tr>
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The complete study flow is represented in **Figure 4**.

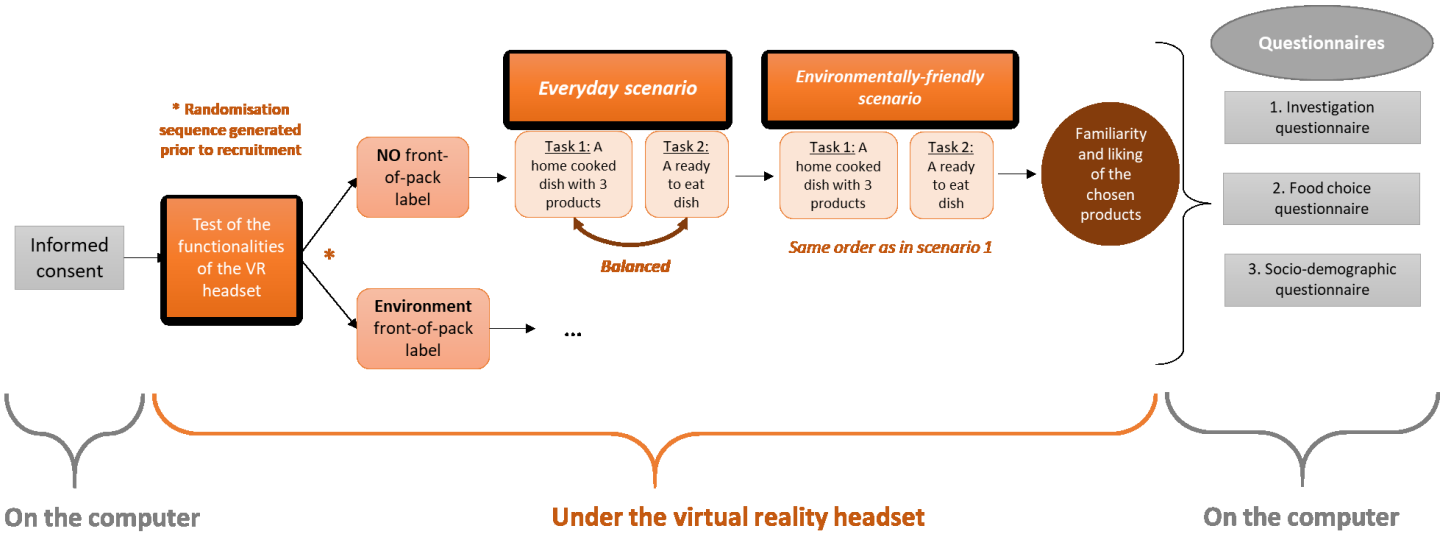

Figure 4. Complete study flow.

STATISTICAL ANALYSES

All statistical analyses will be performed using SAS version 9.4. The level of significance will be set at $p < 0.05$ for all pre-registered analyses.

Definition of the population for analysis

Participants who will be included in the statistical analyses are the ones having completed the shopping tasks and answered all of the questionnaires. Aim-guessers will be excluded in the sensitivity analysis.

Participant's characteristics

Participants' characteristics, overall and for each condition, will be displayed in a table. We will include gender, age, highest educational qualification, current employment, number of people living in the household, the perceived financial status of the household, dieting status and BMI. Continuous variables will be summarised using means and standard deviations. Categorical variables will be summarised using counts and percentages.

Overview of the statistical analysis

Objective	Dependent variables (Y)	Independent variables (x)	Data used	Statistical analysis
1.1. *To study the effect of an environmental label on the environmental*	Mean of PEF scores for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish.	- Environmental label (0= no / 1= yes)	Only data from scenario 1 ("everyday scenario")	Mixed model analysis with random effect of participants. *PEF = label (0/1) + type_of_food (I/RTEd) + label*type_of_food*

impact of ingredients and ready-to-eat dish choice in a virtual supermarket.		- Type of food (I[4] / RTEd[5])		If *label*type_of_food* interaction is not significant, it will be removed from the model.
1.2. *To investigate whether the environmental label is informative and likely to help individuals to choose environmental-friendly food options when they are encouraged to make environmental-friendly food choices.*	Mean of PEF score for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish.	- Environmental label (0= no / 1= yes) - Scenario ("everyday scenario"/ "environmental-friendly scenario") - Type of food (I / RTEd)	Data from the two labelling conditions and the two scenarios	Mixed model analysis with random effect of participants. Mixed model analysis with random effect of participants. *PEF = label (0/1) + type_of_food (I/RTEd) + scenario (everyday/environmental) + label*type_of_food + label*scenario + scenario*type_of_food* Non-significant interactions will be removed from the model. If the *labelling*type_of_food* or the *scenario*type_of_food* interaction is **statistically significant***:* • For the 3 ingredients chosen (Task 1) *PEF = labelling + scenario + labelling*scenario* • For the ready-ot-eat dish chosen (Task 2) *PEF = labelling + scenario + labelling*scenario*
2.1. *To study the effect of an environmental label on the nutritional quality, liking, familiarity, level of process and price of ingredients and ready-to-eat dish choice in a virtual supermarket.*	- Mean of the FSA scores for 100g of each ingredient selected and FSA score for 100g of the ready-to-eat dish. - Average liking of the 3 ingredients selected and liking for the RTEd (continuous variable) - Average familiarity of the 3 ingredients selected and familiarity for the RTEd (continuous variable) - Average NOVA score of the 3 ingredients	- Environmental label (0= no / 1= yes) - Type of food (I / RTEd)	Data from scenario 1 only (everyday scenario)	Mixed model analysis with random effect of participants. - ***FSA****= label (0/1) + type_of_food (I/RTEd) + (label*type_of_food)* - ***Liking****= label (0/1) + type_of_food (I/RTEd) + (label*type_of_food)* - ***Familiarity****= label (0/1) + type_of_food (I/RTEd) + (label*type_of_food)* - ***Price per calorie*** *= label (0/1) + type_of_food (I/RTEd) + (label*type_of_food)* If the *label*type_of_food* interaction in model 1.1 is not statistically significant, this

[4] Ingredient (3 ingredients are chosen by the participant)
[5] RTEd: ready-to-eat dish

	selected (continuous variable) - Average price per calorie of the 3 ingredients selected and price per calorie for the RTEd (continuous variable)			interaction will not be included in these models. ANOVA model for the 3 ingredients chosen (Task 1): ***NOVA score**= label (0/1)*
2.2. *To investigate the relationships between food motives and the effect of an environmental label on ingredients and ready-to-eat dish selection in a virtual supermarket.*	Mean of PEF scores for 100g of each ingredient selected and PEF score for 100g of the ready-to-eat dish.	- Environmental label (0= no / 1= yes) - The average ratings for items in the ethical subscale of the FCQ (*Ethic_score*[6]) - Type of food (I / RTEd)	Data from scenario 1 only (everyday scenario)	Mixed model analysis with random effect of participants. *- PEF = labelling + Ethic_score + type_of_food + labelling* type_of_food + labelling* Ethic_score* If *label*type_of_food interaction* is statistically significant: 2 ANCOVA models • For the 3 ingredients chosen (Task 1) *- PEF = labelling + Ethic_score + labelling* Ethic_score* • For the ready-ot-eat dish chosen (Task 2) *- PEF = labelling + Ethic_score + labelling* Ethic_score*

Description of variables

Dependent variables

Primary outcome

The primary outcome is the environmental impact of the food selected by the participants. The environmental impact of the food selection will be quantified using the PEF score in mPt for 100g of product throughout the life cycle of the products.

The environmental impact of the 3 ingredients (i) chosen during task 1 of each scenario is calculated by the mean of the PEF scores of each product (PEF_i) [7].

$$PEF_j = \frac{\sum_{i=1}^{i=3} PEF_i}{3}$$

[6] We will calculate the average for the ethical subscale of the FCQ (Cottet et al. translation) and for the "environmental welfare" subscale of the SUS-FCQ. We will use the score with the highest Cronbach's coefficient.

[7] eCO_2 stands for CO_2 equivalent

PEF_j is the environmental impact for 100g of the selection of the 3 ingredients (mPt/100g). PEF_i is the environmental footprint for 100 g of each ingredient i.

The environmental impact of the ready-prepared dish chosen (task 2 of each scenario) is assessed by the PEF score for 100g of this product.

Secondary outcomes

- The nutritional quality of the dishes chosen by participants is assessed by the FSA score (the British Food Standards Agency nutrient profiling system) (Rayner et al., 2009), as described for each product (Julia & Hercberg, 2017).

The nutritional quality of the home-cooked dish (j) chosen during task 1 of each scenario is calculated by the mean of the FSA scores of each of the 3 ingredients (i) composing the dish.

$$FSA\ score_j = \frac{\sum_{i=1}^{i=3} FSA_i}{3}$$

FSA_i scores are calculated for 100g of the ingredient i.

The nutritional quality of the ready-prepared dish chosen (task 2 of each scenario) is assessed by the FSA score for 100g of this product.

- The liking score of the home-cooked dish (j) is the average of the 3 ingredients (i).

$$Liking\ j = \frac{\sum_{i=1}^{3} liking\ i}{3}$$

For the ready-to-eat dish, we will directly use the liking score given by participants.
The liking score ranges from 1 to 10, 10 being the highest degree of liking.

- The familiarity score of the home-cooked dish is the average of the familiarity score of the 3 ingredients selected.

$$Familiarity\ j = \frac{\sum_{i=1}^{3} familiarity\ i}{3}$$

The familiarity score of the ready-to-eat dish is directly used.
Familiarity scores range from 1 to 5 (1=Never and 5=Very often).

- The NOVA score of the home-cooked dish is the average of the NOVA score of the 3 ingredients selected.

$$NOVA\ score\ j = \frac{\sum_{i=1}^{3} NOVA\ score\ i}{3}$$

The NOVA score of the ready-to-eat dish will not be analysed since, by definition, all of these foods will be categorised in category 4 (ultra-processed foods).

- The price per calorie of the home-cooked dish is the average of the price per calorie of the 3 ingredients selected. The price per calorie of the ready-to-eat dish is directly used.

$$Price\ (\frac{€}{kcal})\ j = \frac{\sum_{i=1}^{3} price\ per\ calorie\ i}{3}$$

The price per calorie for one product will be calculated with the following equation:

$$Price\ per\ calorie_i\ (\frac{€}{kcal}) = \frac{Price_i(€) \times 100}{Weight_i(g) \times\ Energy\ density_i(\frac{kcal}{100g})}$$

Independent variables

Variables for the primary outcomes

- Labelling (presence (yes) vs. absence (no) of an environmental label)
- Scenario ("everyday scenario" vs. "environmentally friendly scenario")
- Type of food present in the virtual environment (Ingredients vs. Ready-to-eat dish)

Variables for the secondary outcomes

- Labelling (presence (yes) vs. absence (no) of an environmental label)
- Scenario ("everyday scenario" vs. "environmentally friendly scenario")
- Type of food present in the virtual environment (Ingredients vs. Ready-to-eat dish)
- Ethical concern scores will be calculated for:
    - the items of the "Environmental Welfare" subscale from the Sustainable Food Choice Questionnaire (SUS-FCQ).
    - the items of the "Ethical" subscale from the French translation of the Food Choice Questionnaire (SUS-FCQ).

  Each rating for individual items, such as "is produced in an environmentally friendly way", ranges from 1 to 4: 1 = Not at all important; 2 = A little important; 3 = Moderately important; 4 = Very important. Out of the two ethical concern scores described above, we will use the one with the highest Cronbach's alpha in the analyses. This score will be noted "*Ethic_score"* and will be regarded as a continuous variable.

Other variables

Socio-demographic characteristics

- **Gender:** 0=male, 1=female
- **Age:** continuous variable
- **The level of education:** This variable will be coded as the highest educational qualification from 1 to 4: 1= "< High school + 2-years diploma", 2= "high school + 2-years diploma", 3= "High school + 3 or + 4-year diploma" and 4 = "≥ High school + 5-year diploma".
- **Employment status:** The employment status of the participant will be coded from 1 to 6: 1 = "full or part-time", 2="student", 3="retired", 4="looking for a job", 5="looking after home" and 6="other".
- ***The number of people living in the household:*** this will be regarded as a continuous variable.
- ***Dieting status:*** *0 = no, 1 = yes.*
- ***BMI:*** BMI will be calculated as weight (kg) / height (m^2). BMI data will be trimmed for implausible values excluding weight for less than 30 kg and more than 250 kg, height for less

than 145 cm and more than 3m, BMI < 14, or BMI > 48 (Hardy et al., 2016; Miller, 2003). We will use the BMI as a continuous variable or use the categories defined by the WHO.

Missing data

We do not anticipate missing data for our analysis. It will be impossible for the participant to finish the shopping scenarios without having selected the 8 products. We have calculated the FSA-NPS scores and the PEF score for all of the products presented in our virtual supermarket.

We do not anticipate missing data for the dependent variables because the questionnaires will not allow missing answers. Data from participants who start but do not finish the study will not be included. Any *a posteriori* withdrawal will be reported and reasons for withdrawal will be documented (e.g., incorrect answers, technical problems).

Primary analyses

MODEL 1.1: Mixed model analysis will be used to test the effect of *labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling* type_of_food interaction* on PEF scores in the "everyday scenario", with random effect of participants to account for correlation between repeated measures. If the *labelling*type_of_food interaction* is not significant, it will be removed from the model.

MODEL 1.2:

- Mixed model analysis will be used to test the effect of *labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish), *scenario* (categorical variable: "everyday scenario" or "environmentally friendly scenario"),*labelling*scenario*, *labelling*type_of_food* and *scenario*type_of_food* interactions on PEF scores, with random effect of participants to account for correlation between repeated measures. Non-significant interactions will be removed from the model.
- If the *labelling*type_of_food* or the *scenario*type_of_food* interaction is **statistically significant**, two mixed model analysis will be carried out for the home-cooked dish (average of the 3 ingredients) and for the ready-to-eat dish separately. These models will test the effect of *labelling* (categorical variable: yes or no), *scenario* (categorical variable: "everyday scenario" or "environmentally friendly scenario") and *labelling*scenario* interaction on PEF scores, with random effect of participants to account for correlation between repeated measures.

Secondary analyses

- For the first secondary analysis (**MODEL 2.1**), mixed model analysis will be used to test the effect of *labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling*type_of_food* interaction on 4 dependent variables, with random effect of participants to account for correlation between repeated measures. We will only look at the data from the first scenario ("everyday scenario"). The 5 mixed model analysis that will be carried out are:

- ***FSA*** *= labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling* type_of_food* interaction
- ***Liking*** *= labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling* type_of_food* interaction
- ***Familiarity*** *= labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling* type_of_food* interaction
- ***Price per calories (€/kcal)*** *= labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish) and *labelling* type_of_food* interaction

If the *labelling*type_of_food interaction* is not significant, it will be removed from the models.

ANOVA model will be used to test the effect of *labelling* (categorical variable: yes or no) on NOVA score for task 1 (for the 3 ingredients chosen). We will only look at the data from the first scenario ("everyday scenario").

- For the second secondary analysis (**MODEL 2.2**), we will only use "everyday scenario" data.
  - Mixed model analysis will be used to test the effect of *labelling* (categorical variable: yes or no), *type_of_food* (categorical variable: ingredients or ready-to-eat dish), *labelling*type_of_food* interaction, *Ethic_score* (continuous variable) and *labelling* Ethic_score* interaction on PEF scores, with random effect of participants to account for correlation between repeated measures. If the *labelling*type_of_food* interaction is not significant, it will be removed from the model.
  - If the interaction between the labelling condition and the type of food is **statistically significant**., two ANCOVA models will be carried out for the home-cooked dish (average of the 3 ingredients) and for the ready-to-eat dish separately. ANCOVA models will be used to test the effect of *labelling* (categorical variable: yes or no), *Ethic_score* (continuous variable) and *labelling*Ethic_score* interaction on the mean PEF score.

Sensitivity analyses

- Sensitivity analysis will be carried out to analyse if the results found for **MODEL 1.1.** remain the same when aim guessers are excluded.
- **MODEL 1.1.** will be adjusted for age, sex, level of education and BMI.
- **MODEL 1.1.** (raw and adjusted) will be replicated for the GHGe from the Agribalyse database instead of the PEF score.

Exploratory analyses

Descriptive analyses of the answers to the investigation questionnaire will be performed.

1/ We will calculate the scores of participants responding to the following questions depending on the label condition and the scenarios ("everyday" / "environmentally friendly"):

- How much did taste / nutritional quality / environmental impact / packaging size / presumed price influence participant's food choice in the virtual supermarket? (5 possible answers ranging from "strongly disagree" to "strongly agree")

2/ We will calculate the scores of participants responding to the following questions depending on the label condition:

- What participants understood when asked to make food choices that are "good for the planet" (8 possible answers).
- Participant's perception of their capacity to distinguish 2 foods depending on their environmental impact (5 possible answers ranging from "strongly disagree" to "strongly agree").

3/ We will calculate the scores of participants, in the labelling condition, responding to the following questions:

- If they noticed the label (0=they did not notice the presence of the label on the products chosen or thought that the label was present on less than half of the products chosen /1=the participant thought the label was present on all of the products chosen or on more than half of them).
- If they understood the environmental label presented on the foods in the virtual supermarket (0=the participant did not answer correctly / 1=the participant answered correctly).
- If they used the environmental label when making food choices (we will categorize the scale ranging from 0 to 100 into 4 parts).

Further exploratory analyses will be conducted to have a broader understanding of the effects of the environmental label on food choices and are summarised in **Table 6**.

Table 6. Summary of exploratory analysis.

Data used of the analysis	Dependent variable	Independent variables	Statistical analysis
Both labelling conditions and the 2 scenarios will be considered	Importance of food choice motives for each scenario ***(taste, nutritional quality, environmental impact,* presumed price** *and* ***packaging size)*** Continuous variables	- Environmental label (0= no / 1= yes) - Scenario ("everyday scenario"/ "environmental-friendly scenario")	Mixed model analysis
Data for participants in the "label condition" only	Mean PEF scores	- Attention paid by the participant to the label (0=they did not notice the presence of the label on the products chosen or thought that the label was present on less than half of the products chosen /1=the participant thought the label was present on all of the products chosen or on more than half of them) - Type of food (I / RTEd) - Scenario ("everyday scenario"/ "environmental-friendly scenario")	
		- Use of the label by the participant (continuous variable ranging from 0 to 100) - Type of food (I / RTEd) - Scenario ("everyday scenario"/ "environmental-friendly scenario")	

		- Time spent to carry out each shopping task[8] (continuous variable) - Environmental label (0= no / 1= yes) - Type of food (I / RTEd)	
		- Score obtained for the question regarding the knowledge about the environmental impact of food systems (continuous variable). - Environmental label (0= no / 1= yes) - Type of food (I / RTEd) *(knowledge_score*labelling interaction will be interesting to analyse in order to test the moderating effect of knowledge on the environmental impact of food choices)*	
	Mean FSA scores	- The average ratings for items in the health subscale of the FCQ - Environmental label (0= no / 1= yes) - Type of food (I / RTEd)	

Sample size

We powered primary analyses in order to detect a d=0.50 effect size of labelling on PEF scores based the results of a previous randomised control trial that tested the effect of an environmental label on food choices (Camilleri, 2019). A sample size of 122 participants will be required for 80% power at $\alpha = 0.05$ (SAS 9.4). We will recruit a sample of 130 participants to account for potential data loss due to technical problems.

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[8] The time spent in the supermarket is calculated under the virtual reality headset. We can also identify the time spent between for each task performed by participants.

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