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► **To cite this version:**

Romain Espinosa, Nicolas Treich. Eliciting Non-hypothetical Willingness-to-pay for Novel Products: An Application to Cultured Meat. *Environmental and Resource Economics*, 2023, 85, pp.673-706. 10.1007/s10640-023-00780-8 . hal-04167450

**HAL Id: hal-04167450**

**<https://hal.science/hal-04167450>**

Submitted on 9 Jan 2024

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# Eliciting Non-hypothetical Willingness-to-pay for Novel Products: An Application to Cultured Meat

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February 27, 2023

## Abstract

Estimating the demand for greener products may be challenging when these products are not yet on the market. We design an experiment to elicit the willingness-to-pay (WTP) for a novel product in a non-hypothetical way, despite the fact that the product is not marketed and thus cannot be delivered to participants. We consider a cultured meat product which is presented to participants using the producer's advertising. The basic experimental device consists in eliciting i) how much a participant is willing to pay for the product under uncertainty about product delivery, and ii) her beliefs about the probability that the product will be actually delivered. In our sample of 158 French students, under 20% of participants never want to buy the product, and below 10% assign a probability of zero that the product will be delivered if purchased. The average WTP is fairly low, at about 3 Euros per 100g. A number of factors increase (e.g., education and low meat consumption) or decrease (e.g., neophobia and disgust) this WTP. The simple exposure to the new meat substitute during this experiment reduces subjects' pro-meat justifications. We investigate the external validity of our results using a hypothetical survey on a representative sample (N=1,200). We also discuss methodological issues such as deception and incentive compatibility.

**JEL codes:** Q18, C91, D91.

**Keywords:** greener products, cultured meat, experiment, willingness-to-pay, belief elicitation.

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\*The authors thank seminar participants at ALISS (Paris), CREM (Rennes), BSB (Dijon), CERNA (Paris), ASFEE (Dijon), and East Anglia University for useful comments. They would also like to thank Andrew Clark and Christian Vossler for their feedback. Romain Espinosa acknowledges financial support from the ANR under grant ANR-19-CE21-0005-01 and the Burgundy School of Business (BSB). Nicolas Treich acknowledges support from the ANR under grant ANR-17-EURE-0010 (Investissements d'Avenir program), and the FDIR and SCOR chairs at the Toulouse School of Economics (TSE-Partnership). Corresponding author: Romain Espinosa; E-mail: romain.espinosa@cnrs.fr.

# 1 Introduction

Knowing the demand for novel products at a pre-market stage is central to the development of greener technologies. Indeed, since the success of novel products ultimately depends on their adoption by consumers, public and private investors seek to invest in green technologies that have the potential to be widely demanded. Unfortunately, it is probably during this pre-market stage that the demand for novel products is the hardest to estimate as economists cannot rely on real purchase decision data to quantify the consumers' willingness-to-pay (WTP). This paper proposes a new experimental method to estimate the demand for such novel products. It uses real incentives (i.e., a non-hypothetical setting), despite the fact that the product cannot be delivered to participants and thus cannot be actually purchased during the experiment. As a proof of concept, we apply this method to a novel product that could significantly reduce the environmental footprint of the food sector, i.e., cultured meat.

Cultured meat can significantly reduce the negative externalities of meat production on the environment, health and animals. Cultured meat is produced *in vitro* from animal cells and does not require animal slaughtering. Although there is still a lot of uncertainty about its environmental impacts, preliminary life-cycle analyses suggest that it has a significantly lower environmental impact than conventional meat (Tuomisto and Teixeira de Mattos, 2011; Mattick et al., 2015; Smetana et al., 2015; Delft, 2021). Cultured meat should indeed reduce greenhouse gases emissions compared to conventional meat (especially methane emissions<sup>1</sup>) and it should also reduce air and water pollution as well as water use. Cultured meat is also expected to significantly reduce land use, which should create natural regeneration opportunities with associated carbon-capture and biodiversity benefits (Treich, 2021). The production of cultured meat can also virtually eliminate the risks of infectious disease associated with traditional meat production (Espinosa et al., 2020), and reduce the use of contaminants and antibiotic (Post et al., 2020). Dozens of companies are currently working to develop their products and put them on the market in the coming years (Specht, 2020). A number of food experts consider that cultured meat may well revolutionize the future market of animal products (Gerhardt et al., 2020; Gasteratos, 2019; ATKearney, 2019).

However, a necessary condition for the successful development of greener products such as cultured meat is consumer acceptance, which remains an open question as some previous work has underlined consumer reluctance to accept innovative technology (Post et al., 2020; Stephens et al., 2018). The controversies around and varying worldwide acceptance of Genetically Modified Organisms illustrate the relevance of these issues (Mohorčich and Reese, 2019). Many contributions have already explored consumer acceptance of cultured meat. In their literature surveys based on about forty studies, Bryant and Barnett (2018, 2020) emphasize that the results vary widely depending on the sample and the framing of the question. Bryant and Dillard (2019) show that highlighting the technological and scientific aspects of cultured meat can reduce positive attitudes toward the

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<sup>1</sup>We note however that cultured meat should increase carbon dioxide emissions leading to uncertain climate impact in the very long run (Lynch and Pierrehumbert, 2019). Nevertheless, it should overall decrease greenhouse gases emissions compared to all types of conventional meats with the use of renewable energy (Delft, 2021).

product unlike focusing on its social benefits or its resemblance with conventional meat. These analyses moreover identified a number of barriers to acceptance, such as neophobia (Wilks et al., 2019), unnaturalness (Macdonald and Vivaldi, 2017), safety concerns (Shaw and Iomaire, 2019) and disgust (Siegrist et al., 2018).

As emphasized by Post et al. (2020), the hypothetical nature of research on the consumer acceptance of future products is a major limitation here. As cultured meat products were not available on food markets, consumer acceptance in this research typically relies on a hypothetical questionnaire about the willingness to try or buy the new product. The fact that this product is not yet widely authorized for sale by food safety authorities<sup>2</sup> prevents the use of revealed preference analysis based on consumers' actual purchase data. Rolland et al. (2020) circumvent this problem and elicit subjects' willingness to taste and buy two pieces of hamburger by deceiving consumers and labelling the same conventional meat product as either conventional or cultured. Another limitation is that consumer-acceptance analyses do not usually elicit the (hypothetical) WTP for cultured meat, although there are three recent exceptions (Asioli et al., 2018; Van Loo et al., 2020; Carlsson et al., 2021). As a result of the hypothetical bias, as well as the unfamiliarity with the new product, existing consumer-acceptance research may not be very reliable. Perhaps unsurprisingly, the results vary widely across existing analyses and are very sensitive to framing (Bryant and Dillard, 2019).

In this paper, we make two contributions, one on the WTP elicitation methodology, and the other on the applied literature on cultured meat. Regarding the first methodological contribution, we introduce an experimental procedure that allows us to elicit a subject's non-hypothetical WTP for a novel product, despite the fact that this product cannot be delivered to the subjects. The design is incentive-compatible under standard expected utility, and does not convey false information to subjects. The central idea is to use the subjects' imperfect knowledge about the possibility that the new product will be delivered, and to make them decide under a veil of ignorance. More precisely, in the experimental instructions we present two scenarios to the subjects: either the product is available (scenario 1) and can be delivered, or it is not and cannot be delivered (scenario 2). We inform the subjects that the scenario to be implemented was determined before the experiment (in a non-random way), but the result of this decision is not transmitted to the participants, and participants are aware of it. This approach is similar to the strategy method (Selten, 1965), as only one decision is implemented at the end of the experiment, and participants make their decisions under a veil of ignorance. It is also similar to the Conditional Information Lottery developed by Bardsley (2000), in which participants are told that one game is real and that the remaining games of the experiment are fictional. It is also close to Chavez et al. (2020) who show that researchers can successfully conduct incentivized choice experiments without having all the product alternatives being available.<sup>3</sup> Unlike previous work on non-marketed products (Rolland et al., 2020), we do not

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<sup>2</sup>To date (February 2023), only one safety body has authorized cultured meat: the Singapore Food Agency regarding Eat Just's cultured chicken in December 2020.

<sup>3</sup>Muller et al. (2019) is an example where only one fourth of the food participants can buy in the experiment is actually available.

make false statements and explicitly tell participants that only one scenario is real and the other is not.<sup>4</sup> Then, the subjects' WTP for the new product is elicited using a standard Multiple-Price-List (MPL) mechanism given the availability contingency. Moreover, the subjects' probabilistic beliefs about the scenario that has been selected are also elicited using a scoring rule. This WTP elicitation procedure is incentive compatible if and only if the subject's elicited probability that the product is available (i.e. the scenario with delivery) is strictly positive. A number of further details regarding our experimental method such as the impact of risk aversion and stakes are explored theoretically and empirically.

Regarding the second contribution, we apply this new experimental procedure to elicit the WTP for cultured meat. Importantly, we selected a real cultured foie-gras product. This product is obtained from the culture of liver cells extracted from a duck egg and is developed by *Gourmey*, one of two startups currently working in cultured meat in France, where the experiment was run. Given previous results that emphasize the importance of framing, the product was introduced to the participants using *Gourmey's* own marketing material that is available on their website. This permits to mimic real market conditions and avoid relying on a specific framing conceived by researchers as in all previous studies. However, it is important to keep in mind that the presentation of the product and the associated technology is thus positively framed, as would be expected from standard marketing practices.

The experiment was carried out in October 2020 in France, with an initial (respectively final) sample of 182 (158) students. Our main results are the following. About 18% of subjects do not want to buy/try the product, even when it is free. The average WTP is about 3 Euros per 100g, and only one out of seven participants is willing to buy 100g for about 5-6 Euros (the average price for 100g of duck-farm foie gras). Flexitarians, as well as subjects with more positive perceptions of conventional foie gras, have a higher WTP, suggesting the emergence of a new market segmentation once the product is on the market. We also find a high price elasticity, emphasizing the importance of the market price on top of acceptance issues. As in previous hypothetical work, neophobia, disgust and lower academic performance reduce the WTP. More positive perceptions of the positive attributes of both products (such as healthiness, naturalness and tastiness) increase the WTP for cultured meat. Fewer than 10% of subjects estimate a zero probability that the product will be delivered, so that the WTP elicitation procedure is in theory incentive-compatible for a large majority of participants. Also, we find that simple participation in the experiment, in which subjects are exposed to this new product, reduces subjects' pro-meat justifications.

We also explore whether our results can be generalized outside the lab using an additional survey study on a sample of French students (N=300) and on a representative sample of the French population (N=1,200). Overall, we find similar WTP profiles (i.e., the proportion of participants who always or never buy), and the average (hypothetical) WTP in both samples is also in the vicinity of 3-4 Euros as in our lab experiment. The average student WTP in the hypothetical survey is about 3.76 Euros, i.e., 0.93 Euro larger than the WTP in our experiment with students. This

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<sup>4</sup>We discuss more precisely the issue of deception in Section 5.4.

difference shrinks to 0.54 Euro when we control for differences in observables (demographics, attitudes toward foie gras and cultured meat, consumption habits, pro-meat attitudes, food neophobia). The remaining difference suggests that our method could possibly reduce the bias in hypothetical surveys.

The remainder of the paper is organized as follows. Section 2 briefly discusses the main challenge in eliciting the WTP for non-marketed products. Section 3 presents our experimental design and Section 4 the experimental results. Section 5 then proposes a methodological discussion while Section 6 discusses external validity. Last, Section 7 concludes.

## 2 Eliciting the WTP for Novel Products

Our main objective is to design an experimental protocol that allows us to elicit the WTP for a product that is not yet on the market. That is, the basic version of the product exists but we cannot deliver it to the participants in the experiment, for instance because the product has not yet received official market approval. We want our design to respect two conditions. First, participants should face real incentives, as revealed preferences might better predict actual consumption behavior than stated preferences. Second, following standard practice in experimental economics, we do not want to make explicitly false statements to participants, as deception can in particular generate negative externalities for experimental analyses (see Ortmann and Hertwig (2002) for a discussion).

Our approach is similar to the strategy method (participants take decisions under a veil of ignorance), and its core idea is similar to the *Conditional Information Lottery* (CIL) proposed by Bardsley (2000). In standard experiments, economists usually select only one game to be paid to the participants at the end of the session to avoid cross-task contamination. In this setting, participants face several games but the selected game remains unknown until the very end, such that they are incentivized for each game of the session. The CIL acts in a similar way and includes several games. However, in the CIL, participants are told that only one game is real while the others are fictional. Participants know that only the real game will be paid at the end of the experiment. The uncertainty is therefore not about which of the real games will be selected at the end of the experiment, but which game is real. The CIL permits to test for fictional scenarios in an incentivized manner without inducing deception as it is made clear upfront to the subjects that only one game is for real.

Our protocol is similar to the CIL, but we propose additional mechanisms. We proceed as follows. We first give participants a lump-sum payment. Second, we introduce them to two scenarios, and explain that only one of the two will be implemented and that they will make their decisions without knowing which one will be effectively chosen.<sup>5</sup> In one scenario (the *delivery* scenario), the product is available and participants can effectively buy the product, which will then be delivered if purchased; in the alternative scenario (the *non-delivery* scenario), the product is not available and cannot be delivered, whether they wish to purchase it or not. We next tell participants that

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<sup>5</sup>Our approach can be extended to more than two scenarios.

the scenario to be implemented was chosen before the experiment given the availability of the product. Similarly to Bardsley (2000), we do not assign or communicate probabilities regarding the scenario selection as this is not a random process (the *non-delivery* scenario was chosen upfront) and participants are aware of this. Third, we elicit participants' WTP for the product of interest via a Multiple-Price-List<sup>6</sup> (MPL) mechanism (i.e. a list of increasing prices with binary purchase decisions) under delivery contingency. Fourth, we elicit participants' (subjective) beliefs about the likelihood of the delivery scenario being implemented using a scoring rule. To reduce uncertainty, we tell participants which price in the MPL game was retained before eliciting their beliefs about scenario implementation (see Section 5).

Economic theory predicts that participants who believe that the delivery scenario is possible (i.e. they assign a strictly positive probability to this event) will report honest WTPs in the MPL game (see Appendix D for a formal proof). The intuition is the same as in strategy-method experiments: when a decision has a strictly positive probability of affecting her payoff, an agent takes the incentives as real and preference-revealing incentive schemes work. In contrast, participants who believe that the delivery scenario has no chance of occurring face no material incentives in the MPL game, and are thus expected to answer in the experiment in a similar way as for a hypothetical questionnaire. Moreover, these participants should then report a zero-probability of delivery, and we thus know who they are and we can perform further statistical analyses (see Section 5.3).

### 3 Design

Our experimental protocol has two parts. The first is an online survey that took place two weeks before the second, the main experiment, which happened in the lab. The online survey does not contain any reference to cultured meat. This split into two parts aimed to limit cross-contamination and single-source bias. The two parts of the experiment were computerized using *LimeSurvey*. The protocol, summarized in Figure 1, was pre-registered online on the American Economic Association's dedicated platform (AEARCTR-0006476) and received the approval of the Institutional Review Board of the University of Rennes 1 (September 23<sup>rd</sup> 2020). The full experiment is reproduced in the Online Appendix.

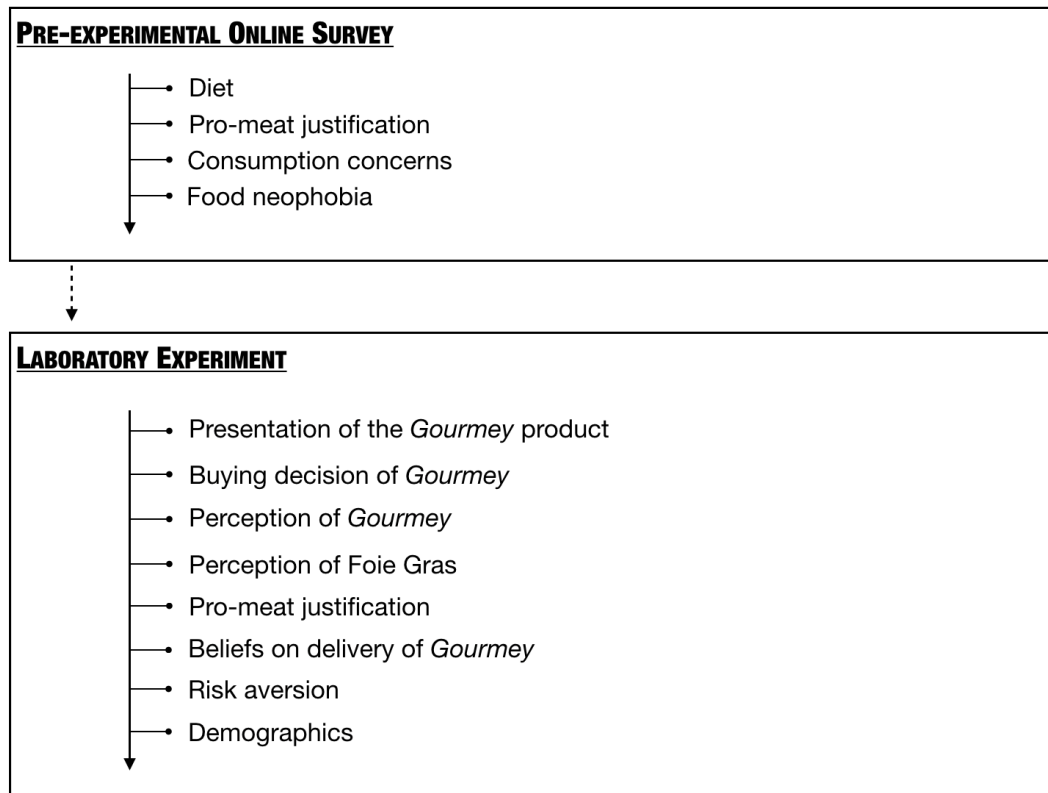
#### 3.1 First Part: Pre-Experimental Survey

The pre-experimental questionnaire is made up of four series of questions. The first refers to diet, as this has been shown to be closely related to the WTP for cultured meat (e.g. Bryant and Dillard 2019). Participants are asked with which frequency they eat the following products: red meat, white meat, fish, eggs, dairy products, vegetables, pulses, fruit, and starchy foods.

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<sup>6</sup>The MPL elicitation scheme is a popular and relatively transparent method to elicit people's WTP in experimental economics. However, this method raises some concerns, such as framing effects or the complexity involved, see Andersen et al. (2006); Asioli et al. (2021). Recent research suggests nevertheless that that factors leading to elicitation effects in WTP studies (e.g., anchoring and complexity) may be of second-order importance (Vossler and Zawojnska, 2020).

Figure 1: Summary of the experiment



The second series of questions explores justifications for meat consumption (Graça et al., 2015a,b, 2016), which have been shown to be correlated with the WTP for cultured meat (Bryant and Dillard, 2019). In prior research, we evaluated participants' levels of agreement with a list of ten statements that promote meat intake to create a pro-meat justification (PMJ) scale (see Espinosa and Treich 2021). This list includes the elements of the 4N theory according to which people explain their consumption of (conventional) meat by claiming that it is normal, natural, necessary, and enjoyable (Joy, 2011; Piazza et al., 2015). We also consider hierarchical justification (consuming meat is acceptable insofar as animals are raised specifically for that end). Last, we propose several arguments that were discussed in the literature on cognitive dissonance regarding meat consumption (eating meat is acceptable as animals do not suffer, animals have lower cognitive capacities than humans, and eating meat damages the environment but so do plant-based diets).

Third, we ask seven questions about dietary concerns regarding the consumption of natural, home-made and healthy products, and avoiding processed foods and GMOs. These also assess the extent to which participants care about the negative externalities of their diet (GHG emissions and animal suffering).

Fourth, we include a series of questions proposed by Pliner and Hobden (1992) to measure food neophobia<sup>7</sup>, as this is correlated with attitudes towards cultured meat (Bryant and Dillard, 2019).

<sup>7</sup>We translated the items of Pliner and Hobden (1992) into French.



These cover the participant’s likelihood of sampling new food, even when they do not know what it contains. We further ask participants whether they trust new food, and whether they would eat almost anything.

### 3.2 Second Part: Main Experiment

The experiment starts with the instructions on the first screen that the subjects see. We tell participants that they will start the experiment with a lump sum of 8 Euros that they can use to purchase a product.<sup>8</sup> For a list of prices, they are asked to say whether they wish to buy the product (Yes/No answers).

We next say that there are two scenarios, one of which was chosen *before* the experiment started regarding product availability. In the first scenario, the product is available and participants will receive the product (if they decide to buy it) together with their remaining money (or the full lump sum if they do not want to buy it); in the second scenario, the product is not available and participants will not receive it but will keep the 8 Euros. In both scenarios, participants receive the product and/or the money three weeks after the experiment (in our case: from November 2<sup>nd</sup> to the 13<sup>th</sup> 2020).<sup>9</sup>

On the second screen, we introduce the product using the visuals from the company’s public website (see Figure 2). The product is displayed in a jar with a label. The description of the product is friendly, and the production process is set out in a positive way. We decided to take the firm’s own marketing material to increase the external validity of our experiment, as the product will likely be marketed by the company in this way once it comes to market. At the end of the screen, participants are asked to check whether they read the description of the product correctly.

Third, we show participants a list of prices for which they say whether they wish to purchase the product; these range from 0 Euros (i.e. free) to 8 Euros by increments of 50 cents per 100g. We say that only one price per participant will be randomly chosen and implemented. Under the first *delivery* scenario, their decision for this randomly-selected price will be effected.

Next, we assess participants’ perception of Gourmey (screen 4) and duck-farm foie gras (screen 5). Using a Likert-scale, participants report whether they perceive the product as healthy, natural, environmentally-friendly, tasty, animal-friendly, nourishing, or disgusting. In addition, we ask participants whether they would buy the products on a regular basis. On the next screen, we ask the

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<sup>8</sup>It is a common practice for the WTP for food products to provide such a lump sum before the experiment. We note however that this could generate an endowment effect, in line for instance with mental accounting theory. These behavioral aspects may thus have implications regarding how people spend the money, but are not further explored here.

<sup>9</sup>We told participants that the product would be delivered, if this scenario had been selected, three weeks after the laboratory experiment. This was made to have enough time to gather all responses (we did not want some participants to know that the product will not be delivered while others have not participated in the experiment yet), and to make the delivery scenario more credible (the company needs time to prepare the delivery). We further decided to give the money at the same moment for two reasons. First, if we gave the money just after the experiment, participants would have known which scenario had been selected. Second, giving the money at the same moment as the product limits the risks of temporal trade-offs (e.g., money now vs. product in three weeks). If we assume a similar temporal discount rate for money and products, choosing between future money and future products should be similar to choosing between money and products now.

Figure 2: Screenshot of the presentation of GourmeY

## THE FOIE GRAS THAT WE'VE BEEN WAITING FOR

GOURMEY is developing a delicious and 100% ethical foie gras without force-feeding or slaughter from duck cells. An uncompromising foie gras, better for you, for animals and for the planet.




### GOURMEY SAVOIR-FAIRE

A revolutionary culinary feat at the crossroads of innovation and gastronomy.



**It all starts with an egg.**  
We select a freshly laid duck egg and carefully extract a few cells.



**Our cultivator, a cell paradise.**  
We place these cells in our cultivator, where they benefit from its ideal conditions of perfect temperature, basic nutrients and space to grow. The cells multiply naturally and we harvest real duck foie gras.



**Culinary preparation**  
From here our chefs take over and cook up our foie gras without compromise. A pinch of salt, freshly ground pepper, a drop of Armagnac... ready for the table!

### THE GOURMEY MISSION

Beyond foie gras, a delicious, ethical and sustainable meat.



**Reinventing the meat we love**  
Our mission is to bring you delicious meat that is respectful of our health, the environment and the animals.



**The impact of meat**  
The industrial production of meat has a detrimental impact on the environment. It produces more greenhouse gas emissions than all the cars and planes in circulation on the planet.



**The same meat - better**  
We do not want to give up meat. However we urgently need a method of sustainable production. Producing meat by cultivating natural animal cells means offering the same experience with around 90% less water, land surface and CO2 emissions. No antibiotics and of course no animal suffering. In short, it is the meat of our dreams.

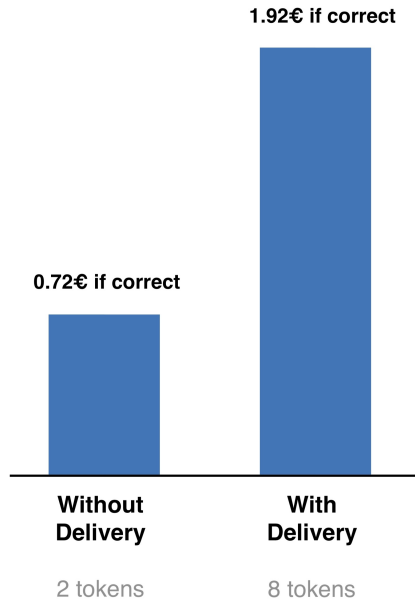
PMJ questions (see above) again.

On the seventh screen, we elicit participants' subjective beliefs about the likelihood of the delivery scenario. We first tell them that they have 10 tokens with which to bet on the two outcomes: the product is available for delivery (scenario 1) or the product is not available (scenario 2). We use

a quadratic scoring rule for the payment scheme.<sup>10</sup> Participants can visualize the outcomes with different splits of tokens between the two scenarios via a dynamic graph that depicts the payoffs for each event (see Figure 3). Before deciding on the split of the tokens, participants are told which price has been randomly-drawn in case scenario 1 is implemented. We further remind them whether they decided to buy the product at this price.

The last two screens contain a lottery game (Holt and Laury, 2002) (fixed vs. lottery payments) and socio-demographic questions. Participants report their gender and age, whether they grew up in the countryside, their political self-placement, their relative wealth, and whether they received honors with their High-School diploma.

**Figure 3:** Screenshot of the dynamic graph for token allocations



<sup>10</sup>We use the following quadratic scoring rule:  $\pi_i = 1 + (2r_i - \sum r_j^2)$ , where  $\pi_i$  is the payoff in the case event  $i$  is realized and  $r_i$  is the share of tokens assigned to event  $i$ .

## 4 Results

### 4.1 Sample

The experiment took place at the Burgundy School of Business (BSB) in France in October 2020. A total of 182 students completed the two parts of the experiment.<sup>11</sup> Of these students, 86.8% displayed economically-consistent behavior in the WTP game: 6.6% always buy the product, 15.4% never buy the product, and 64.8% buy the product at low prices and stop buying above a certain threshold (Online Appendix Figure OA4.1). We exclude from the subsequent analysis participants who had multiple switching points (12.1%) or who had a single switching point but in an economically-inconsistent order (i.e. they start buying after some price threshold: 1.1%). We thus do not detect any unusual pattern of irrationality, as our data are consistent with the usual proportions of irrational answers in the literature when using this type of mechanism.

The final sample consists of the 158 economically-consistent participants. On average, participants are 20.3 years old and are majority female (64.5%); about half grew up in the countryside (44%). A slight majority reported growing up in a family that was wealthier (40.5%) or significantly wealthier (10.1%) than average. About 43% of the sample said they were as rich as the average French citizen, while under 6% considered themselves below average. Their political views were mostly moderate: over 84% categorized themselves as center, center-left or center-right.

As far as dietary habits are concerned, most participants said they ate red meat several times a week (44.3%) or at almost every meal (9.5%). Participants reported eating white meat even more frequently, with over 72% saying they ate it several times a week or more. Overall, our participants have relatively high consumption of animal-based products (see Online Appendix Table OA3.1). The majority of participants eat eggs a couple of times a week or more (57.6%), and dairy products are consumed at almost every meal (44.3%) or at least several times a week (42.4%). For the remainder of the analysis, we construct a score of *animal-based consumption* (ABC) that ranges from 0 to 1 to reflect the participants' propensity to eat animal-based products (see Online Appendix for the construction of the control variables).

The consumption of animal-based products is closely related to pro-meat justifications (see Online Appendix Figure OA4.2). Those with higher ABC scores are significantly more likely to justify meat consumption. These consumers are more likely to use the 4N arguments to justify meat consumption, saying that it is necessary, natural, normal, and nice. They are to a lesser extent also more likely to say that slaughtered animals do not suffer, or that the environmental impact of meat is no worse than that of plant-based alternatives.

Last, regarding their relation to food, participants have relatively low neophobia scores (see Online Appendix Figure OA4.3). Most students like to try new food and are not scared of trying them even when they do not know the ingredients. However, participants show a stronger preference for home-made meals over prepared meals, and prefer to avoid GMOs (see Online Appendix Figure

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<sup>11</sup>We had hoped for 300 participants in the experiment in the pre-registration, but the Covid-19 crisis significantly affected both the number of students enrolled at the Business School and the organization of classes. All French-speaking 1st-year students of the school were enrolled for the experiment.

OA4.4). Students do not seem very concerned about the externalities of their food choices (GHG emissions or animal suffering).

## 4.2 Average WTP

Most of our experimental participants are willing to try the Gourmey product: 82.3% choose to “buy” it when it is free (Figure 4). This figure falls with the price, and only 7.6% wish to buy it at 8 Euros. These results suggest a high price elasticity for cultured foie gras in our sample.

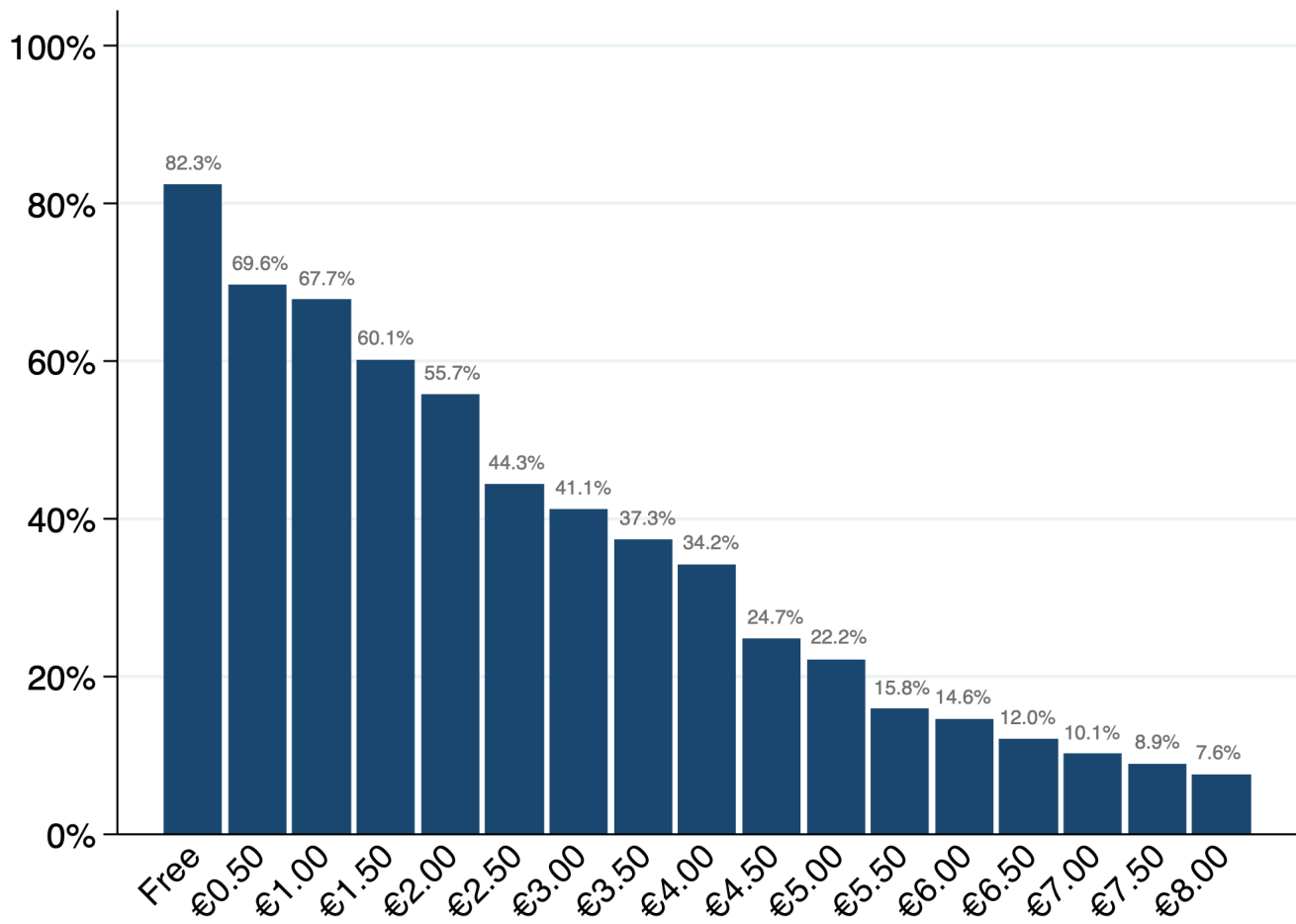
The average WTP in our sample is estimated to be about 2.90 Euros for 100g of Gourmey (from a constant-only interval regression: 95% CI = €2.47 - €3.33). The average WTP is relatively low compared to the market price. Gourmey did not want to indicate its projected price, but said they plan to be competitive relative to duck-farm foie gras. Looking at the figures of the foie gras industry, the average price of 100g of duck-farm foie gras in 2020 was €5.43.<sup>12</sup> Assuming Gourmey to be price-competitive, we would expect 5.50 Euros for 100g of Gourmey in retail stores. At this price, only 15.8% of the participants in our sample would be ready to buy the product.<sup>13</sup>

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<sup>12</sup>Source: CIFOOG, 2020 (Interprofessional Committee of Foie Gras Palmipeds).

<sup>13</sup>Note however that our experiment elicits the WTP for a product delivered in three weeks and not immediately, which may underestimate the WTP.

Figure 4: The decision to buy 100g of the Gourmey product



### 4.3 Determinants of the WTP

We now regress the WTP on a set of control variables to determine the profile of the consumers who are willing to buy *Gourmey* (Table 1). We include the individual scores for animal-based consumption (*ABC*), pre-experimental pro-meat justifications (*PMJ*), and food neophobia. We further consider four variables (see Online Appendix for their construction) that reflect participants' general appreciation of *Gourmey* foie gras (*ProGourmey*), of duck-farm foie gras (*ProDuckFarm*), and whether they are concerned by the food they eat (*Generally concerned*) and the externalities their consumption choices generate (*Externality concerned*).

First, participants with higher levels of animal-based consumption are significantly less likely to pay for the product. This suggests that cultured foie gras is more likely to appeal to flexitarians rather than regular meat-eaters. This result might not be consistent with previous studies that tend to find that cultured meat is more appealing to heavy meat eaters than to vegetarians (Bryant and Barnett, 2020). This may be related to the specific meat considered in our experiment, namely foie gras. We note also that we have no strict vegetarians in our sample, such that the difference comes from a discontinuity between flexitarians and vegetarians. This issue regarding the demand of some segment of consumers and food substitution effects raises a central question about the future market impact of cultured meat (Treich, 2021), and is further discussed in the next section on market segmentation.

Second, students who are more likely to justify meat consumption are also less likely to buy *Gourmey*. Here again, the aversion towards cultured meat of consumers who are attached to farm meat indicates that cultured meat will appeal to consumers with weaker justifications for meat consumption. Third, those with a more positive perception of the product are more likely to pay for it. Fourth, participants who usually have a more positive perception of duck-farm foie gras are also more likely to pay for the cultured foie gras. This might be due to the fact that conventional foie-gras consumers like the taste the most and are thus ready to pay more to experience this taste again. This result holds controlling for the perception of cultured foie gras, which suggests that duck-farm foie-gras consumers may well substitute between the two products: for a given perception of *Gourmey*, individuals with a more positive view of duck-farm foie gras will be more likely to pay for the cultured alternative. Fifth, there is weak evidence that more-neophobic consumers are less likely to pay for *Gourmey* as in Baum et al. (2021) and in Siegrist and Hartmann (2020). We find no statistical relationship between the WTP and the two dimensions of consumption concerns. Among the control variables, there is also no significant relationship with age, gender, political views, the area in which the individual grew up (countryside), or wealth, which is inconsistent with previous studies that find in general that the young, male, left wing/liberal and urban people are more accepting of cultured meat (Bryant and Barnett, 2020). Also, participants who received High-School honors have significantly higher WTPs.

We now decompose the aggregate variables to identify the most important drivers of the WTP. In Table 2, we break down the Pro-*Gourmey* score into its seven original components. All of these are found to be positively associated with the WTP, except for disgust for which the correlation is

negative. The dimensions of the perception of Gourmey are strongly pairwise correlated (see Online Appendix Table OA3.2), which explains why most of the significant variables turn to be insignificant when they are put in together. Overall, the results suggest that tastiness and disgust are the two most-important predictors of the WTP for the product: the tastier and the less-disgusting Gourmey appears, the more participants are willing to pay for it. This is consistent with earlier survey results (Siegrist and Hartmann, 2020; Wilks et al., 2021).

Last, we investigate whether the single components of the dietary concerns are significantly correlated with the willingness-to-pay. We find no significant relationship at the 5% level (see Online Appendix Table OA3.3).

**Table 1: Interval regressions of the willingness-to-pay for Gourmey**

	Willingness-to-pay							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ABC	-2.156*							-2.395**
	(1.236)							(1.210)
PMJ (pre-exp)		-2.209*						-2.349*
		(1.244)						(1.212)
Neophobia			-3.054**					-1.535
			(1.310)					(1.237)
ProGourmey				0.618***				0.515***
				(0.115)				(0.124)
ProDuckFarm					0.396***			0.207*
					(0.118)			(0.121)
Generally concerned						0.166		0.150
						(0.121)		(0.107)
Externality concerned							0.160	0.064
							(0.202)	(0.176)
Observations	158	158	158	158	158	158	158	158
LL	-442.986	-442.933	-441.820	-431.288	-439.083	-443.566	-444.176	-423.290

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) All regressions include controls for age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.



**Table 2: Interval regressions of the willingness-to-pay for Gourmey on product perceptions**

	Willingness-to-pay							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gourmey Healthy	2.023** (0.794)							0.394 (0.975)
Gourmey Natural		1.366* (0.699)						-0.947 (0.841)
Gourmey Environment-friendly			2.671*** (0.756)					1.571 (1.213)
Gourmey Tasty				3.294*** (0.747)				2.122** (1.007)
Gourmey Animal-friendly					1.942*** (0.603)			0.612 (0.950)
Gourmey Nourishing						3.296*** (0.868)		0.368 (1.062)
Gourmey Disgusting							-3.138*** (0.663)	-1.781** (0.827)
Observations	158	158	158	158	158	158	158	158
LL	-441.316	-442.610	-438.476	-435.321	-439.457	-437.592	-434.003	-426.354

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) All regressions include controls for age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

#### 4.4 Market Segmentation

The arrival of cultured meat on the market is likely to significantly affect market shares.<sup>14</sup> We can distinguish between three types of consumers. First, some consumers of duck-farm foie gras might not see cultured meat as a satisfactory substitute: competition in this market segment will therefore be only limited. A second type of duck-farm foie-gras consumers might however think that Gourmey is a good substitute: these consumers may thus be sensitive to price, and competition could be substantial in this market segment. Last, the foie-gras market might attract new consumers, i.e. those who previously turned away from duck-farm foie-gras (e.g. for ethical reasons such as the practice of force-feeding): here again there is little competition between duck-farm and cultured foie gras, as duck-farm foie gras is not a satisfactory substitute.

Table 3 shows the distribution of consumers in our experiment according to their willingness to buy the two products on a regular basis<sup>15</sup>, and the average associated WTPs. Overall, 25% of participants would be ready to buy duck-farm foie gras regularly, as against 18% for Gourmey. We find that 68% of the participants would not buy any of the two products on a regular basis.

<sup>14</sup>About 40% of French households purchased foie gras in 2020, with an average consumption of about 500g and an average expenditure of 17 Euros over the year. (Source: Kantar Worldpanel tous circuits 2020)

<sup>15</sup>Note that we asked participants whether they would buy the product “regularly” without specifying a specific frequency. While this might not be a strong concern for within-individual analyses (i.e., we expect people to report their willingness-to-buy for the two products with the same understanding of what “regularly” is), this might hinder between-subject analyses (i.e., people might have different views of what “regularly” means). Future works that replicate our framework should state clear frequencies of consumption.

Consistent with this statement, these participants have the lowest average WTP for Gourmey (2.11 Euros).

About 14% of participants are ready to buy duck-farm foie gras regularly, but would not be interested in cultured foie gras. This is the market segment in which Gourmey cannot compete. They still however have a larger WTP (2.82 Euros) than consumers who would buy neither of the two products (confirming the previous regression results in Table 1). Next, 11% of the sample would be ready to buy the two products. These participants have a larger WTP (3.82 Euros), and represent the market segment that would be the most affected by the arrival of Gourmey on the market. Last, about 7% of consumers would be willing to buy only Gourmey regularly. These consumers exhibit the largest average WTP (4.16 Euros), and are only interested in cultured foie gras.

Based on these figures, we can make a first estimate of how the market would be affected by the arrival of Gourmey.<sup>16</sup> We find that 56% of the existing market share would not change (i.e. consumers who buy duck-farm foie gras exclusively), while the remaining 44% would be subject to competition (i.e. consumers could substitute). The number of consumers who buy foie gras would rise by 28% due to the new consumers who buy only cultured foie gras.

**Table 3: Average willingness-to-pay by market segment**

		Ready to buy <b>Gourmey</b> on a regular basis ?	
		<b>No</b>	<b>Yes</b>
Ready to buy <b>Foie Gras</b> from duck farms on a regular basis ?	<b>No</b>	<b>68%</b> [€2.11]	<b>7%</b> [€4.16]
	<b>Yes</b>	<b>14%</b> [€2.82]	<b>11%</b> [€3.82]

Note: The figures refer to the distribution of participants by purchase preferences, with their estimated average willingness-to-pay (from interval regressions) in brackets.

## 4.5 Belief Elicitation

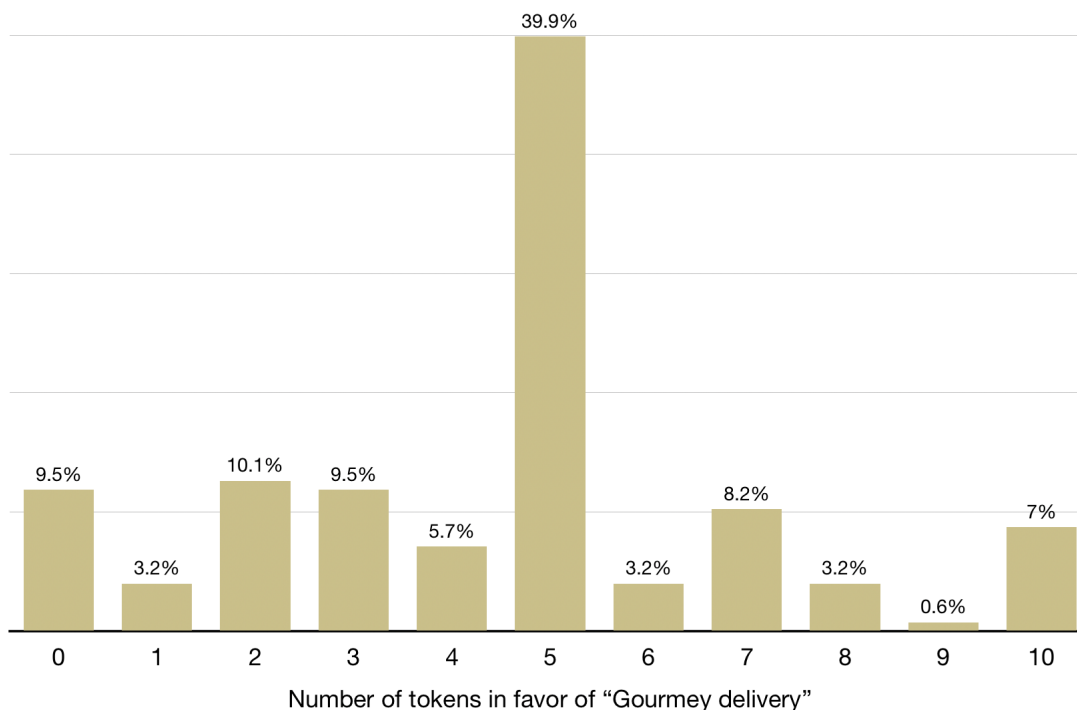
The above discussion assumed that participants report sincere WTPs for Gourmey. A sufficient condition for this, given by our experimental design, is that they assign a strictly-positive probability to the delivery scenario. Under standard expected utility theory, we show in Appendix that whenever participants believe that there is a chance, even though small, that the product will be available, they are incentivized to report their true WTP.

<sup>16</sup>The estimate should obviously be interpreted cautiously, as the external validity of the results is limited by the specific sample taking part in the experiment.

Figure 5 displays the distribution of tokens that participants assigned to the delivery scenario (i.e. that the product will effectively be available for delivery). Only 9.5% of participants believe that the delivery scenario is impossible (or close to impossible<sup>17</sup>), but these participants do not have statistically-different WTPs.<sup>18</sup> The manipulation thus seems to be globally successful as we expect more than nine out of ten participants to report sincere WTPs.

We further observe that the mode of the distribution is at 50%. The equal-probability case is by far the most likely in the sample. This fifty-fifty pattern may be an artifact of our elicitation method (such as the framing of our instructions), and further studies with different elicitation methods might be useful here. However, we note that this pattern has been regularly observed in surveys or experimental belief elicitation studies. The fact that 50% serves as a probability magnet may be due to psychological and/or rational factors (Fischhoff and Bruine De Bruin, 1999; Kothiyal et al., 2010; Armantier and Treich, 2013). The distribution of beliefs is in addition slightly right-skewed, showing that the delivery scenario is, on average, thought to be a little more unlikely than likely (the average number of tokens bet on the delivery scenario was 4.5).

**Figure 5: The distribution of tokens to the "Gourmey Delivery" scenario**



<sup>17</sup>Some participants whose beliefs are strictly positive but very close to zero might assign zero tokens to the delivery scenario, as our discrete 10-token scale is not fine enough for them to express their beliefs appropriately.

<sup>18</sup>We run two interval regressions for the WTP including a dummy variable for zero-token players (one model without control variables and the other with control variables). We do not find any statistically-significant effect ( $p > 0.10$ ).

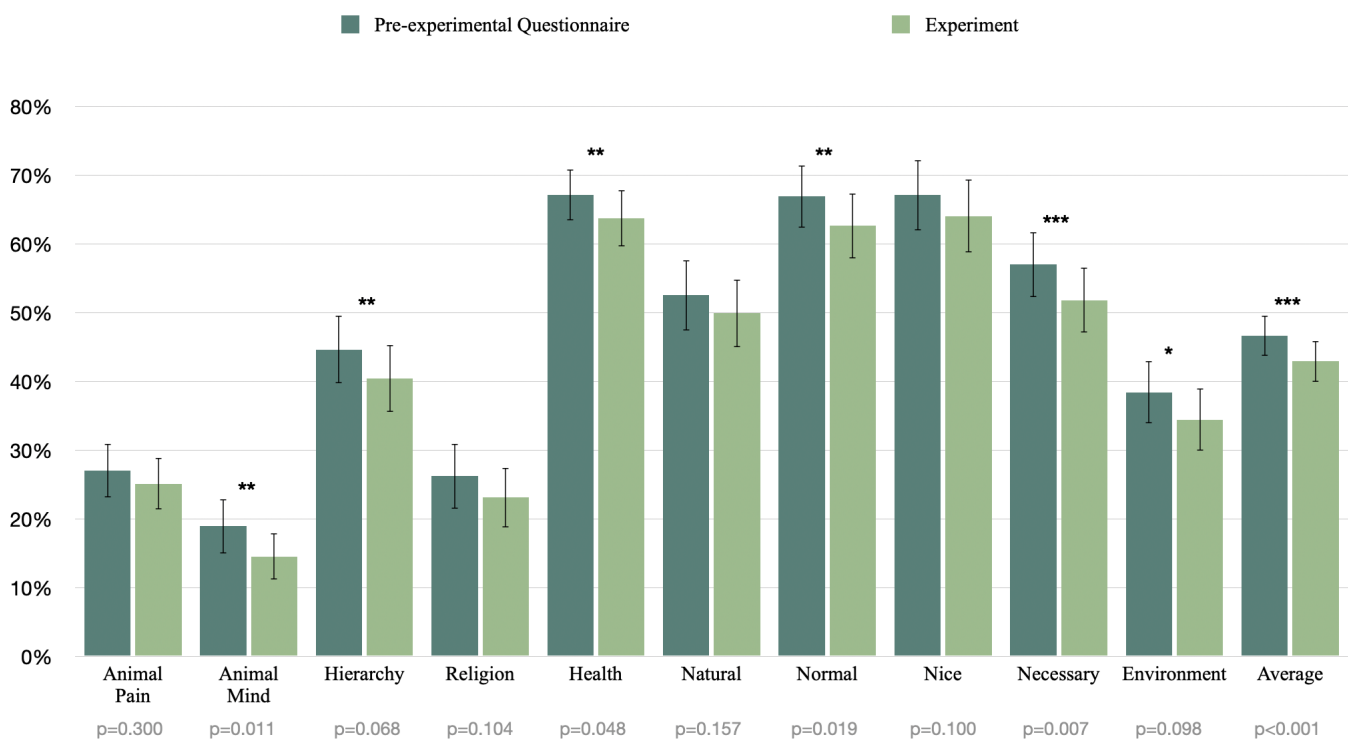
## 4.6 Changes in Pro-meat Justifications

We now ask whether exposure to the novel meat substitute during our experiment changes beliefs toward conventional meat. Any such change could reflect cognitive-dissonance theory applied to meat eating, also called the "meat paradox" (Hestermann et al., 2020). The reasoning is that meat eaters may experience disutility, as their meat consumption generates externalities on the environment and animals. To reduce this disutility, they may wish to change their actions and/or their beliefs. Following cognitive-dissonance theory, if actions are difficult to change, typically because reducing meat consumption is costly, it may be easier for people to adjust (perhaps unconsciously) their beliefs. They may for instance ignore some evidence in order to lower their perceived externalities of meat-eating, or look for excuses for their behavior (Joy, 2011; Piazza et al., 2015). Following the same logic, if a substitute such as cultured meat appears, it may become easier for people to change their actions, so that this need for self-deception is reduced. Cognitive-dissonance theory then predicts that the mere availability of the new meat substitute can reduce incentives to distort beliefs about conventional meat.

Vivalt and McDonald (2020) recently explored this hypothesis in a MTurk survey of U.S. participants. In a first baseline survey, participants' beliefs toward meat products were elicited. Moreover, one set of subjects was exposed to information about cultured meat and a persuasive message about the health, environmental and ethical advantages of reducing consumption of conventional animal products. A month later participants were again asked about their beliefs toward meat. Surprisingly, Vivalt and McDonald found that the exposure to the description of the new product had no effect on stated beliefs. A follow-up survey helped to explain this surprising result: due to concerns that cultured meat may be unnatural or unhealthy, many participants did not find it an acceptable substitute; however, those who perceived cultured meat positively did actually change their beliefs.

In our experiment, we propose a simple test in the spirit of Vivalt and McDonald (2020). As discussed above, we elicited PMJ scores both before and after the experiment (Espinosa and Treich 2021). We can thus explore how exposure to the new product in our experiment changed the PMJ score. In Figure 7, the pro-meat justification figure is lower after the experiment for each of the 10 statements used in the score, and statistically-significantly so in 6 cases. Overall, participating in the cultured-meat experiment significantly reduced the PMJ score. Obviously, a number of factors can explain this change; in particular we made the meat topic salient to participants, and some time elapsed between the two PMJ-elicitation tasks. Nevertheless, a similar experimental design was used in Espinosa and Treich (2020), which also covered meat-related issues, without there being a significant change in the PMJ score before and after the experiment in the control group. Our experimental result therefore appears to be consistent with cognitive-dissonance theory, in that simple exposure to the new product changed beliefs towards the conventional product.

Figure 6: The changes in PMJ



Notes: The spikes represent the 95% confidence intervals. Group comparison t-tests: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

## 5 Methodological Discussion

Our results suggest that the experiment was successful in capturing sincere WTP scores, as a large majority of participants (90.5%) considered the delivery scenario likely. However, the application of our method in other situations might produce a significant share of zero-token participants. We now discuss how belief elicitation may be distorted in this case, and how the estimates can be corrected. Finally, we discuss the question of deception.

### 5.1 Risk Aversion

Belief elicitation may first be distorted by risk aversion, as risk-averse participants facing a quadratic scoring rule are incentivized to distort their beliefs (see, for instance, Harrison et al. (2017)). The intuition here is that the risk-averse have a tendency to equalize payoffs across states of the world. It follows that, whenever a risk-averse participant believes that the two States of the World can occur with strictly positive probability, he/she will report probabilities that are closer to the uniform distribution than his/her true beliefs.

However, risk attitude is in theory not a concern in our method. First, participants who are sure that the delivery scenario is impossible should not be affected by any risk-aversion distortion and will continue to report 0 (Proposition 3 in Harrison et al. (2017)). In other words, the risk-averse subject should always invest 0 tokens in the delivery scenario whenever they believe it to be impossible. Second, negative risk-aversion, i.e. risk-loving, would distort beliefs in the opposite direction: risk-loving participants report more extreme beliefs than their true beliefs in order to "take more risk". Under a discrete scoring rule, participants who assign a small probability to the delivery scenario could thus be more likely to assign 0 tokens to this scenario due to their risk-loving preferences (see Appendix). Overall, risk preferences may only distort belief elicitation in a conservative way, i.e. by overestimating the proportion of zero-token participants.

We illustrate the effect of risk preferences on the proportion of participants assigning zero tokens to the delivery scenario via a regression. Table 4 displays the results of a linear probability model (see Online Appendix Table OA3.4 for a probit model). Columns 1 and 11 show that participants who take more risky choices in the lottery game are significantly more likely to assign 0 tokens to the delivery scenario. This is in line with the insight above that risk loving may inflate the proportion of zero-token participants compared to the true share of participants who believe that the delivery scenario is impossible.

**Table 4: The probability of assigning zero tokens to the delivery scenario (OLS)**

	Zero tokens to Gourmeiy delivery scenario											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
Risky Choices	0.020** (0.009)											0.024** (0.009)
WTP		-0.008 (0.009)										-0.0001 (0.015)
ProGourmeiy			-0.001 (0.0136)									0.011 (0.016)
ProDuckFarm				-0.016 (0.013)								-0.024* (0.014)
ABC					0.152 (0.134)							0.010 (0.139)
Generally concerned						0.032** (0.013)						0.037*** (0.013)
Externality concerned							-0.004 (0.022)					-0.006 (0.021)
Neophobia								-0.077 (0.144)				-0.045 (0.149)
Selected Price									-0.017* (0.009)			-0.023* (0.013)
Stakes dummy											-0.011 (0.050)	-0.044 (0.081)
Observations	158	158	158	158	158	158	158	158	158	158	158	158
R-squared	0.194	0.173	0.168	0.176	0.176	0.203	0.168	0.170	0.188	0.168	0.168	0.282

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) All regressions include controls for age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

## 5.2 Stakes

A second methodological concern is that the distribution of tokens might be biased by the stakes that participants derive from their purchase decision (see Appendix). The reasoning is as follows. Before assigning tokens between the two scenarios, participants were told which price had been randomly selected to be applied in case the delivery scenario were implemented.<sup>19</sup> Participants were also reminded whether they had decided to buy the product at this price. Individuals who did not want to buy the product at the selected price would obtain utility of 8 Euros whatever the scenario. However, participants who intended to buy the product at the selected price would obtain a monetary-equivalent utility greater than 8 Euros in the delivery scenario, reflecting the utility premium from their true WTP being above the selected price. In other words, participants have a stake, and this may distort their reported beliefs (Armantier and Treich, 2013).

Our data however suggest that there was no stake distortion in our experiment. Table 5 shows the results of four linear regressions of the number of tokens assigned to the delivery scenario on the stakes. We first created a dummy variable for the participant deciding to buy the product at the randomly-selected price. Column 1 shows that this dummy variable has no statistically-significant impact on the number of tokens assigned. Second, we generated a continuous stakes variable as the difference between the maximum price a participant is willing to pay and the randomly-selected price if the participant has stakes, and zero otherwise. This variable helps capture whether larger stakes are associated with greater distortion. Column 2 shows that this variable has no significant effect.<sup>20</sup> Columns 3 and 4 run the same models on the sub-sample of participants who decided to buy the product when it was free, as the excluded participants could never have had stakes: we obtain similar results. Last, we can see from columns 10 and 11 in Table 4 that the stakes do not affect the probability to assign zero tokens either.

However, we can further note that having a stake is not random since consumers with higher WTP will have a greater probability of having a stake. This reflects that the selected price is uniformly distributed and that participants with higher WTPs are thus more likely to face a price at which they would buy the product. We account for the different propensities to have stakes via matching estimation methods. We use the fact that the probability of having stakes given the reported purchase decisions is known for sure. A participant who always wants to buy the product will have a 100% chance of having a stake. On the contrary, a consumer who refuses to buy the product, even when it is free, has no probability of having a stake. Whenever a participant accepts to buy Gourmey for the next price level, his/her probability of having a stake rises by  $\frac{1}{17}$ . Figure 7 shows the distribution of the probabilities of having a stake. A considerable part of the sample does not appear in the common support as either the probability of stakes is zero or it is too large (greater or equal to  $\frac{15}{17}$ ). Restricting the sample to the observations in the common support (N=114), Table 6

<sup>19</sup>Not revealing that information to participants would make the theoretical analysis more complex without removing the possibility of stakes. It in addition likely reduces the cognitive burden of participants by dropping uncertainty about prices.

<sup>20</sup>Note however that the (insignificant) estimated coefficients on the dummy or continuous stakes variables are also of the opposite sign to that predicted.



**Table 5: Regression of the number of tokens assigned to the delivery scenario on the stakes.**

	Number of tokens on the delivery scenario			
	(1)	(2)	(3)	(4)
<b>Without controls</b>				
Stakes: dummy	0.186 (0.438)	0.066 (0.629)	0.140 (0.469)	0.020 (0.657)
Stakes: continuous		0.056 (0.211)		0.056 (0.215)
<b>With controls</b>				
Stakes: dummy	0.280 (0.443)	0.039 (0.618)	0.147 (0.480)	-0.134 (0.652)
Stakes: continuous		0.118 (0.210)		0.139 (0.217)
Observations	158	158	130	130
R-squared	0.001	0.002	0.001	0.001

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) The controls are age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

shows the difference in tokens assigned to the delivery scenario between participants with and without stakes for various matching estimates. The results come from weighted linear regressions, where the weights are determined by the corresponding matching algorithms. None of the specifications yields a significant effect on the stakes variables.

**Table 6: Weighted and unweighted regressions of the number of tokens assigned to the delivery scenario on the stakes (matching weights).**

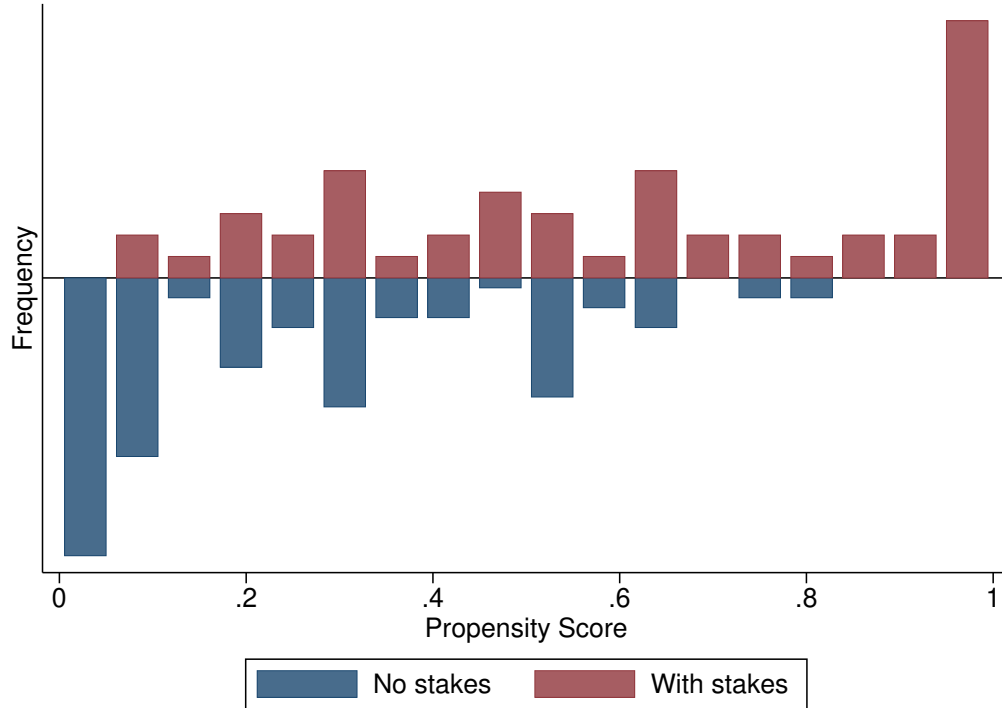
	Unmatched	Matched				
		Nearest Neighbor			Kernel	
		$k = 1$	$k = 2$	$k = 3$	Epanechnikov	Gaussian
(1)	(2)	(3)	(4)	(5)	(6)	
<b>Without controls</b>						
Stakes: dummy	-0.118 (0.535)	0.0588 (0.616)	0.118 (0.582)	-0.529 (0.635)	-0.0853 (0.634)	-0.402 (0.624)
<b>With controls</b>						
Stakes: dummy	-0.0848 (0.553)	-0.0547 (0.788)	0.388 (0.653)	-0.236 (0.715)	0.0684 (0.697)	-0.266 (0.701)
Weights	No	Yes	Yes	Yes	Yes	Yes
Observations	114	114	114	114	114	114

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) The controls are age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

Figure 7: The distribution of the probabilities of having a stake



### 5.3 Selection

The analysis of data from experiments with a large share of zero-token players may need to be restricted to participants who assign at least one token to the delivery scenario, as theory predicts that these players sincerely reveal their WTP. Zero-token players, on the contrary, are supposed to play the experiment in a hypothetical way, and may also have significantly lower or higher WTP so that excluding them from the analysis may bias the estimates.<sup>21</sup>

The selection effect resulting from the exclusion of the zero-token players can be addressed by modeling the selection stage. Let  $s$  be the selection stage, where  $s_i = 0$  if the participant is a zero-token player and  $s_i = 1$  otherwise (i.e. assigns a strictly positive number of tokens to the delivery scenario). We can analyze the buying decision  $y_i$  for participants with  $s_i = 1$  only. Let  $X_i$  be the vector of explanatory variables that are common to the two equations, and  $Z_i$  the exclusion variables that appear in the selection stage only. The latent model is:

$$\begin{aligned}
 s_i^* &= \alpha_0 + \alpha_X X + \alpha_Z Z + u \\
 y_i^* &= \beta_0 + \beta_X X + v && \text{if } s_i^* > 0
 \end{aligned}$$

<sup>21</sup>We recall here that we did not find any significant difference in our sample between the WTP of the zero-token participants and the other participants.

The above latent model can be used to control for potential selection effects with a large share of zero-token participants, given the presence of good instruments  $Z$ . The corrected buying decisions in the MPL game can be retrieved using a biprobit Heckman selection model containing only the intercept for the outcome equation. The estimate  $F(\beta_0)$ , where  $F(\cdot)$  is the normal CDF, in an intercept-only model (i.e.  $X$  is empty) represents the corrected proportion of participants who would buy the product at the given price.

One good strategy to produce a valid instrument  $Z$  is to add a treatment variation in which the delivery scenario is intentionally made less likely. For instance, telling participants that if the delivery scenario is selected only 10% of the experiment participants will receive the product should significantly reduce the probability that an individual is selected under the delivery scenario, but does not affect individual WTP. A positive estimated correlation between  $u$  and  $v$  would imply that participants who have larger WTPs are more likely to believe in the delivery scenario. In this case, the uncorrected estimates overestimate the true WTP.

Another, broader, problem concerns the case where participants hold a (very) low subjective probability of delivery. The problem here concerns the strength of material incentives in the presence of other, non-material, incentives. Suppose for instance that there is a social desirability bias, in the sense that participants receive a non-material benefit when they reveal a socially desirable value for the product. In this case, it is easy to understand that the incentives to tell the truth may vanish when the probability of delivery becomes small, as the material benefit to reveal the true value may loom small compared to the nonmaterial social benefit of revealing a different value.<sup>22</sup>. Although addressing comprehensively this problem is complex and beyond the scope of the current paper, a starting point is to exclude low-token participants in a similar way as we just described for zero-token participants.

## 5.4 Deception

Our experimental protocol makes a trade-off between the need to incentivize decisions (revealed preferences) and the will to avoid deception in experiments. As explained in Section 2, the core idea of our method is close to what Bardsley (2000) proposed. Bardsley (2000) argues that having one real scenario and other fictional scenarios is not deceptive under the condition that subjects are aware of the fact that only one game is real. In the above experiment, we proceed in a similar way by telling participants that only one scenario will be implemented and that it was selected upfront depending on the availability of the product. As a result, the participants decide under a veil of ignorance where only one scenario is real.

Several works in economics have discussed deception, which remains relatively vague as it has no commonly accepted definition. Krawczyk (2019) discriminates between protocols with regard to their deception potential. First, experimenters could make explicitly false statements or could omit some information. Second, participants could be aware of the omission or unaware. Third, as compared to the benchmark of complete information, the message can change or not some of

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<sup>22</sup>We thank a reviewer for suggesting this point

the subjects' behavior, and their willingness to participate in the experiment. For each dimension, one option is less deceiving than another (e.g., omitting information has a lower deception potential than making explicitly false statements). Our protocol can be seen as a case of partial information omission (students are not told which of the scenarios will be implemented). The retained information might affect their answers to the multiple-price-list but do not affect their payoff compared to the case of complete information.

In a recent survey, Colson et al. (2016) analyze whether some practices that could be considered as potentially deceptive, such as information omission, are likely to affect the participants' willingness to participate in the experiment and whether economists believe these practices should be banned. Among the 10 procedures under investigation, Colson et al. (2016) find that 91% of the students would be willing to participate in a study that provides incomplete information. As far as researchers are concerned, 80% of the experimenters believe that information omission should not be banned. These results reflect a broadly-accepted norm in experimental economics according to which not telling subjects things is not deception while telling them false things is deceptive (Hey, 1998).

To evaluate the risks of deception of our protocol, we ran an additional online survey in December 2021 using *Prolific* (French sample, 85 observations<sup>23</sup>). We introduced participants with the instructions of the lab experiment and asked them similar questions as in Colson et al. (2016). First, about 88% percent of the participants declared that they would be willing to participate in such a study, which is similar to the incomplete information case in Colson et al. (2016). Second, 78% of the participants considered that this type of procedure should not be banned, which is also similar to incomplete information case in Colson et al. (2016). Altogether, it seems that our protocol is largely accepted by participants and that it is perceived in a similar way as providing incomplete information which is an accepted practice in experimental economics.

## 6 External Validity

We now investigate to which extent the above estimates can be generalized outside of the lab. To do so, we ran a survey on two samples of the French population: (i) a sample of French students between 18 and 25 (N=300), and (ii) a representative sample of the population (N=1,200). The survey was implemented by a French polling institute (*Opinionway*) in February 2022.

The survey consists of several elements of the above experiment and pre-experimental questionnaire. First, we elicited the participants' food consumption habits, pro-meat justifications, dietary concerns, and food neophobia. Second, we showed participants the same description of the Gourmeys cultured foie gras as in the experiment and elicited their (hypothetical) WTP using the same list of prices. Third, we asked the participants their perception of Gourmeys and farmed foie gras using

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<sup>23</sup>We invited 100 Prolific users living in France and speaking French as first language to complete the survey, among which 85 passed the two attention checks. The sample is 36% female, 25% student, and on average 31 years old. The estimated the survey to take 120 seconds to complete, and participants took on average 130 seconds. Participants received a fixed payment of £0.30.

the same scales as in the experiment. Last, we asked them whether they would buy each type of product regularly.

First, we observe similar shares of consistent answers in the WTP task (86.8% in the experimental sample, 89.3% in the student sample, and 83.3% in the representative sample). Table 7 shows that about one out of twenty participants always buys GourmeY in all samples, and between one and two out of ten participants never buys it. Between 7.4% and 14.7% of the participants show multiple switching points, and only 1.1% to 3.4% have a single but economically inconsistent switching point.

**Table 7:** Share of WTP profiles across samples (in %)

	Experimental Sample	Student Sample	Representative Sample
Always buy	6.6	6.4	7.0
Never buy	15.4	10.9	20.7
One switching point - consistent	64.8	71.9	55.6
One switching point - inconsistent	1.1	3.4	2.0
Multiple switching points	12.1	7.4	14.7
Total consistent	86.8	89.3	83.3

Notes: The Student and Representative samples are weighted by the importance weights reported by the polling institute.

Second, we see that the participants in our experiment show different demographics but have similar habits and attitudes as the general population (Table 8). First, the experimental sample is slightly more female, and wealthier than the student and representative samples. The experiment and student samples are, by definition, much younger than the representative sample. However, the participants show stable dietary habits across samples. About half of each sample eats red meat several times a week or more (i.e., "often"). Similarly, about 7 (respectively 6 and 8) out of 10 participants often eat white meat (respectively eggs and dairy) in each sample. Participants in the experiment are less likely to justify meat consumption than the participants in the survey. In general, we observe that students are less likely to justify meat consumption (student vs. representative samples). Participants in the experiment are more neophobic than the participants in the surveys. Last, we see that participants in the experiment have similar concerns when they choose what to eat.<sup>24</sup> Among those variables, only three dimensions show important deviations between our sample and the representative population, i.e., have a Cohen's score larger than 0.5: the age, the perceived wealth, and neophobia.

<sup>24</sup>We used the eigenvectors of the PCAs run on the experimental data to project the scores of the participants in the two surveys on the two retained dimensions (*Generally concerned* and *Externally concerned*).

**Table 8:** Demographics, attitudes and habits of participants across samples (means)

	Experimental Sample (ES)	Student Sample (SS)	Representative Sample (RS)	Cohen's d or h	
				ES vs. SS	ES vs. RS
Female <sup>‡</sup>	64.5	52.6	52.2	0.242	0.250
Below 25 <sup>‡</sup>	100	100	10.2	0.000	2.491
Countryside <sup>‡</sup>	44.0	46.1	48.5	0.042	0.090
Wealthier <sup>‡</sup>	50.6	30.3	19.3	0.417	0.673
Center <sup>‡</sup>	84.0	82.2	74.7	0.048	0.231
Often Red Meat <sup>‡</sup>	53.8	52.4	52.1	0.030	0.036
Often White Meat <sup>‡</sup>	72.3	65.0	71.2	0.151	0.018
Often Eggs <sup>‡</sup>	57.6	59.6	56.9	0.041	0.014
Often Dairy <sup>‡</sup>	86.7	83.9	86.3	0.079	0.012
PMJ	4.66	5.51	6.03	-0.442	-0.433
Neophobia	0.32	-0.21	0.07	0.800	0.662
Generally concerned	0	0.35	0.51	-0.306	-0.460
Externally concerned	0	0.14	0.13	-0.211	-0.323
Would buy Gourmey foie gras regularly <sup>‡</sup>	24.7	37.9	36.9	0.286	0.265
Would buy Duck Farm foie gras regularly <sup>‡</sup>	17.7	30.7	50.5	0.306	0.712
ProGourmey	0	0.11	0.04	-0.098	-0.137
ProDuckFarm	0	0.31	0.55	-0.267	-0.381
N	158	272	1020		

Notes: The Student and Representative samples are weighted by the importance weights reported by the polling institute.

<sup>‡</sup>: frequencies expressed in percentage points. We use Cohen's h rather than Cohen's d for proportions.

Third, we see that the experimental sample tends to have a lower attraction for both types of foie gras. Indeed, only 24.7% would be ready to buy cultured foie gras regularly against 37.9% of the student sample and 36.9% of the representative sample. Second, we also observe that the experimental sample is less likely to regularly buy duck farm foie gras (17.7%) than the student sample (30.7%) or the general population (50.5%). As a result, we observe that the experimental sample has less favorable views of cultivated and duck farm foie gras than the student sample or the representative sample. Altogether, this suggests that our above analysis might underestimate the average WTP for cultured foie gras in the general population.

We now investigate the external validity of our estimates. First, recall that the average WTP in our experimental data was 2.90 euros. In the survey, we find an average WTP of 3.76 Euros for the sample of students, and 3.06 Euros for the representative sample (using the sampling weights of the polling institute). Three factors can explain the difference in WTPs between our experimental sample and the survey samples: differences in observables, in unobservables, or in the elicitation method. To reduce the difference in observables, we use a Covariate Balancing Propensity Score (CBPS) matching to define weights in the experimental and student survey samples such as to obtain comparable samples with respect to the variables presented in Table 8.<sup>25</sup> The CBPS matching reduces the Average Standardized Bias by 67%.<sup>26</sup> Pooling the data of the experimental and student survey samples, we obtain a difference in WTP of 0.93 Euro ( $p < 0.001$ ) between the two samples using an unweighted interval regression with robust standard errors. Using the CBPS weights, the difference shrinks to 0.54 Euro ( $p = 0.104$ ). The difference in observables is thus likely to account for about half of the difference in WTPs between the experimental and student survey samples.

The remaining difference between the experimental and survey data can result either from the difference in unobservables or in the elicitation method. It is likely that the unobservables play a limited role here: we consider two samples of students, and control for food consumption habits, dietary concerns, perception of meat consumption, food neophobia, perception of the product at stake (ProGourmey), and perception of the conventional alternative (ProDuckFarm). Although we cannot conclude on the role of unobservables, it is likely that the lower WTP in the experimental sample is due to the mitigation of the hypothetical bias achieved by our experimental procedure.

## 7 Discussion

In this paper, we have designed an experiment to estimate the willingness-to-pay (WTP) for cultured meat using real incentives, despite the fact that the product cannot be delivered to subjects. We asked for subjects' WTP under a veil of ignorance about whether the product will be delivered, and elicited their beliefs about the probability of delivery. We found that most subjects have a strictly positive, but modest, WTP. We also found a significant price elasticity and identified some factors that significantly affect WTP. Only about 10% of subjects attribute zero probability to the delivery

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<sup>25</sup>Except for *center* which contains missing values.

<sup>26</sup>We compute the Average Standardized Bias as the average difference in standardized means between the two samples used in the matching procedure.

scenario, suggesting that most subjects report sincere WTPs. Our results have implications for future food markets as well as the experimental research on novel products. We now briefly discuss these implications in turn.

A recent survey of experts found that cultured meat could represent about one third of global meat consumption in 2040 (ATKearney, 2019). Our work here helps us to understand whether such a major transition is possible. We find that prices matter a great deal: if the price of cultured meat is the same as that of conventional meat, only a small minority (about 15% of subjects) would buy the former. This low figure is similar to that in previous hypothetical WTP work such as Van Loo et al. (2020) and Carlsson et al. (2021) for other cultured-meat products, and it is also consistent with our hypothetical survey done on a representative French population sample. This emphasizes that production cost is probably the main issue regarding the future development of cultured meat. It is not yet clear whether cultured meat will be affordable in the near future, in particular if it needs to be produced at a large scale. Indeed, there currently exists wide uncertainty, and even high controversy, regarding the ability to create a cost-competitive product (Specht, 2020; Delft, 2021; Fassler, 2021; Humbird, 2021). Note that the relative price here also depends on future changes in the price of conventional meat, in particular to better account for the externalities on, for example, the climate and the environment (Poore and Nemecek (2018); Pieper et al. (2020)). Moreover, we note that previous studies have found that French consumers are significantly less accepting of cultured meat than consumers in other countries (Siegrist and Hartmann, 2020), suggesting that our results may underestimate the WTP for the food innovation at a global scale.

As in previous consumer acceptance studies, factors such as neophobia and disgust matter. However, it is not clear whether these concerns will persist once the product becomes commercialized and widely available. As emphasized by Hopkins and Dacey (2008), neophobia and disgust may be evolutionary reactions to danger, and grounded in affective mechanisms (Wilks et al., 2021). They may also be partly cultural (such as eating pork versus eating dogs), and could be due, for instance, to some perceived immorality of the innovation. These concerns might thus dissipate as people become educated about or familiar with the new product, and learn about the possible benefits for the environment and animals. We furthermore found, as in Vivaldi and MacDonald (2020), that exposure to the product during our experiment can change beliefs about conventional meat, which may in turn further increase acceptance. A related conjecture is that the mere availability of cultured meat in supermarkets or restaurants will raise the awareness and salience of the environmental and moral impacts of food choices, further diverting consumption away from conventional animal products. In other words, it is possible that increasing the set of choice options will produce a virtuous cycle of more sustainable consumption. If confirmed, this result has wide implications for the development of greener products in general.

We now discuss some implications of our experimental method. Our design to obtain the WTP for a novel product relies on uncertainty about product delivery, as well as asymmetric information between the experimenter and the subjects. One important issue, especially in experimental economics, is that of deception. This issue naturally arises for new products, where the experimenter



may want to establish consumer demand for a non-existent product. For instance, Lusk (2019) asks: "in the case of new food products that have not yet been developed, does the sin of hypothetical bias outweigh the sin of deceiving subjects in a non-hypothetical experiment?". Our method offers an alternative pathway towards incentivized WTP elicitation without explicit deception, by exploiting participants' uncertainty about the availability of the novel products.

One may worry a priori that our proposed experimental procedure induces a loss of control, as the experimenter does not know what subjects really believe regarding the delivery of the new product. It may also "contaminate" future subject pools, who might learn and thus anticipate that the product will not be delivered, creating an increasing proportion of zero-probability participants. First, let us note that the issue of contamination might be a lesser concern in places that run only a few food experiments. In most universities, participants only take part in experiments for a few years and might thus be exposed to a small number of experiments using this mechanism, which limits the risk of learning. In addition, laboratory managers can track subjects who already participated in an experiment that uses our protocol and exclude them from future experiments that use this protocol to further limit the risk of contamination.

One way of addressing the potential belief and contamination issues is to elicit subjects' beliefs about the probability of delivery (as we proposed) and then account explicitly for zero-probability participants in the econometric analysis, as discussed in Section 5. We could also consider changes to the design, for instance by looking at the choice between a number of products (e.g., conventional, organic, plant-based and cultured meat), where all products are delivered except that which is not yet on the market. This kind of multi-product experiment would still rely on the asymmetry of information and non-delivery, but the design might mitigate the contamination of future subject pools, as some of the products will actually be delivered. Furthermore, while our single-product experiment may be viewed as a "proof of concept" for eliciting valuations under the veil of ignorance regarding the product delivery, multi-product experiments may in addition be useful to distinguish the new product from either existing products or alternative formulations of the potential new product.

Another concern is about whether our method can be applied to a wide variety of novel products. Consider for instance a product in a very early development stage. Although it seems still possible in principle to elicit valuation under the veil of ignorance, it is not clear how this product can be presented to participants so that delivery remains credible. In addition, it is not clear how to apply our method to high cost products, such as a fridge or a car, namely to products that cannot be credibly delivered to all participants for budgetary reasons. A possibility may be to include an additional layer of uncertainty where participants can buy lottery tickets and where the lottery prize is the product. However, the exact design and the effectiveness of such a complex experiment remains unclear at this stage.

An additional difficulty with experiments on novel products is that participants lack initial experience with the product. Moreover, since the product cannot be purchased, participants cannot test and learn about the product through (e.g.) touching, smelling, tasting, or cooking it. Therefore,

the informativeness of an experiment on novel products is inevitably limited, in particular, because it does not provide information about regular purchases once the product has been tried effectively. We believe however that such an experiment is informative since it elicits the willingness to pay to try the product for the first time, which is a necessary step toward regular purchases. Moreover, in the case of cultured meat, it is likely that the product is similar to the conventional product. Note that the producer’s marketing used in our experiment mentions that this is “the same meat” which offers “the same experience”. Therefore, the importance of consuming effectively the product in order to learn about it might be limited in the case of cultured meat.

A natural follow-up to our study would be to test the gain of this new method on an existing product. Researchers could for instance consider an experimental setting where they compare the reported WTPs with certain delivery, certain non-delivery (hypothetical WTP), and with pre-selected but unknown decision of delivery (our method). They could then assess the informational gain of the method by comparing the average WTP obtained with our technique with the average WTPs obtained with the two standard methods. The closer the average WTP to the hypothetical (resp. certain delivery) WTP, the smaller (resp. larger) the informational gain. Alternatively, researchers could seek to investigate which type of individuals do not believe in the delivery scenario, i.e., whether there is selection on the latent WTP for the product and the beliefs about delivery.

Finally, we emphasize that our experimental method may be used in pre-market research. To evaluate consumer demand for novel products, common methods in economics, marketing and operations research involve hypothetical approaches such as contingent valuation or conjoint analysis (Frewer et al., 1997; Lusk, 2003). As noted above, the main problem with these methods is hypothetical bias (Loomis, 2011). This bias can be addressed by calibration factors using experimental methods (Fox et al., 1998), but calibration factors for novel products based on real purchase data are not available as these products are not yet marketed. Other techniques have been proposed to address hypothetical bias, such as cheap talk (Cummings and Taylor, 1999) and elicitation under oath (Jacquemet et al., 2013). However, methods like cheap talk might vanish over time (Howard et al., 2017). The main advantage of our method is that it is incentive-compatible, and thus de facto eliminates the hypothetical bias. However, it is not clear whether our specific design involving uncertainty and additional complexity introduces other biases into participants’ decisions and beliefs. The exploration of the relative (de)merits of our method for eliciting the WTP for novel products is a topic for future research.

## Compliance with Ethical Standards

**Disclosure of potential conflicts of interest:** The authors acknowledge financial support from the ANR, the Burgundy School of Business, and the FDIR and SCOR chairs at the Toulouse School of Economics (TSE-Partnership).

**Research involving Human Participants and/or Animals:** This research has received the approval of the Institutional Review Board of the University of Rennes 1.

**Informed consent:** All participants in the experiment expressed informed consent for participating in the experiment.

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## Appendix: Theory background and methodology

### Eliciting the WTP for a new product

The object of the experiment is to elicit a subject's WTP for a new product. The subject receives income  $w$  for her participation in the experiment, and can use that income to buy the product. The originality of the experiment is that the WTP is elicited under uncertainty about whether the product will be delivered. That is, there are two scenarios: either the product is delivered or it is not. One scenario was selected before the experiment, but the subject does not know which. We assume that the subject is an expected-utility maximizer, and that she holds a subjective probability  $p$  regarding the product-delivery scenario.

In the first step, the subject faces a list of prices at which the product can be bought or not, given that only one price will be randomly selected. Under expected utility, this decision problem amounts to report a cutoff value so that the subject buys the product if and only if the price is below that value (Karni and Safra, 1987). Therefore, when facing a sequence of binary choices as in our experiment, the subject conditionally agrees for each choice to buy the product if and only if the drawn price is below this cutoff value. Formally, a price  $c$  is drawn from a distribution  $F(\cdot)$ , the subject reports a cutoff value  $v$ , and she buys the product at price  $c$  if  $v > c$ ; otherwise she does not buy the product. If the product is not bought, the utility of current income is  $u_0(w)$ ; otherwise it is  $u_1(w - c)$ . We assume that both utilities  $u_1$  and  $u_0$  are strictly-increasing and twice-differentiable. Crucially, this value is elicited under delivery contingency. That is, the subject knows that the product may not be delivered even if she "buys" it. As such, under the non-delivery scenario, the subject does not pay anything and does not receive the product, even if  $v > c$ .

The subject's problem is then given by choosing the value  $v$  maximizing expected utility:

$$\max_v p \left[ \int_v^v u_1(w - c) dF(c) + \int_v u_0(w) dF(c) \right] + (1 - p) u_0(w),$$

which, under  $p > 0$ , has the following first-order condition (FOC):

$$u_1(w - v^*) = u_0(w),$$

so that revealing the true WTP  $v^*$  for the product is the best strategy for the subject despite the uncertainty about product delivery. Note also that  $v^*$  does not depend on  $F(\cdot)$ , as is well known. Hence, if the subject holds subjective beliefs  $p > 0$ , the WTP elicitation mechanism is incentive compatible in a "strict" sense; i.e. the subject strictly prefers to report the true value  $v^*$  than anything else.

Hence, for incentive compatibility, we only require that the subjective probability of delivery is strictly positive. Note that if this probability is replaced by a nondegenerate random variable and ambiguity attitude toward this probability is introduced, this should not change that prediction (and thus the incentive compatibility property) for common smooth ambiguity aversion theories.



## Eliciting the probability that the product will be delivered

We now want to elicit the participant's subjective probability  $p$ . In a second step, namely after  $v^*$  has been elicited, and after the price  $c$  has been drawn and revealed to the subject, we use a scoring rule to elicit the subject's beliefs about the probability of the (non)delivery scenario.

The scoring rule provides financial payments  $S_j$ , with  $j = 0, 1$  contingent on the realization of each scenario. The subject reports a probability  $\alpha$  that the product will be delivered; this corresponds to the proportion of tokens chosen by the subject in the experiment. Formally, the subject receives  $S_1(\alpha)$  if the product is delivered and  $S_0(\alpha)$  otherwise. The subject's problem is then to maximize her expected utility over  $\alpha$  in  $[0, 1]$ :

$$pv(w + S_1(\alpha)) + (1 - p)u_0(w + S_0(\alpha)),$$

where the utility function  $v(w)$  is either  $u_1(w - c)$  or  $u_0(w)$ , depending on whether the product was purchased in the first step. Note that since  $u_1(\cdot)$  or  $u_0(\cdot)$  are strictly increasing, so is  $v(\cdot)$ .

From Armantier and Treich (2013), we know that for any "proper" scoring rule (including the quadratic scoring rule we used here), the derivative of the objective above is

$$p(1 - \alpha)v'(w + S_1(\alpha)) - (1 - p)\alpha u_0'(w + S_0(\alpha)).$$

It is immediate from this last expression that  $p = 0$  if and only if  $\alpha = 0$ . Indeed, when  $p = 0$ , this expression is always negative and the objective is thus maximized at  $\alpha = 0$ . Moreover, when  $\alpha = 0$  this last expression is always positive, weakly so when  $p = 0$ , implying that  $\alpha = 0$  cannot maximize the objective unless  $p = 0$ . This simple result, which generalizes Proposition 3 in Harrison et al. (2017), thus predicts that if we observe  $\alpha > 0$  in the experiment then  $p > 0$ , and in turn the WTP elicitation mechanism is incentive-compatible. This is our main theoretical prediction.

## Methodological discussion: risk preferences and stakes

In Section 5, we discuss the possibility that risk preferences and stakes increase the number of zero-token participants, i.e. those who report  $\alpha = 0$ . We note first that, in theory, risk preferences and stakes should not affect the main prediction above, which holds for any proper scoring rule and any increasing utility functions. However, this is not the case in practice as the scoring rules implemented in the lab are typically discrete. In our experiment, subjects bet tokens: Since betting only one token on the delivery scenario corresponds to a 0.1 probability, subjects may rationally make a zero-token choice when they hold sufficiently-small subjective probabilities. Moreover, the point that we emphasize below is that this zero-token choice can be more attractive under some forms of risk preferences and some types of stakes.

We first discuss the impact of risk preferences. Assume that the product is not delivered, i.e.  $v(w) = u_0(w)$ , so that utility and income are the same in each scenario, meaning that the subject has no stake. We then know from Proposition 4 in Harrison et al. (2017) that the subject

reports more-central (respectively more-extreme) beliefs than  $p$  if she is risk-averse (risk-loving). Importantly, this implies that risk aversion cannot inflate the number of zero-token participants, as we state in the main text. However, risk loving leads to a bias with beliefs being reported toward the extremes, including  $\alpha = 0$  possibly under a discrete scoring rule, even for fairly intermediate subjective probabilities  $p$ . A numerical example is sufficient to illustrate. Assume that the quadratic scoring rule is used as in our experiment, and that  $u_0(w) = (k + w)^2$  with  $k > 0$ , so that risk loving  $u_0''(w)/u_0'(w) = 1/(k + w)$  falls with  $k$ . It is then easy to see that the optimal reported probability tends to zero as  $k$  tends to zero provided that  $p < 1/3$ .<sup>27</sup>

We now discuss the impact of stakes. Assume that the subject has bought the new product, i.e.  $v(w) = u_1(w - c)$ , so that utility is state-dependent and the subject has a stake. To illustrate the discussion, we will consider two specific forms of utility functions. First, assume quasi-linear utility  $u_1(w - c) = u_0(w - c) + k$ , where  $u_0$  is the utility of income and  $k$  the hedonic utility derived from buying the product. In this case, the FOC is

$$p(1 - \alpha)u_0'(w - c + S_1(\alpha)) - (1 - p)\alpha u_0'(w + S_0(\alpha)) = 0,$$

implying that  $c$  plays exactly the role of a financial stake. Hence, we know from Armantier and Treich (2013) that the optimal reporting strategy  $\alpha$  always increases with  $c$  under risk aversion. This is because the scoring rule serves as an insurance to compensate for the loss of income due to the payment of the product. This implies that the presence of stakes cannot increase the number of zero-token participants, and instead risk aversion distorts belief-reporting in favor of the product-delivery scenario.<sup>28</sup>

Second, assume  $u_1(w - c) = u_0(w - c + k)$ , so that the benefit of buying the product is commensurable with income and has a monetary value of  $k$  for the subject. Moreover, note that the subject has a stake in the belief-elicitation task only if she buys the product at the current price, implying  $k > c$ . Again, we know from Armantier and Treich (2013) that this implies that buying the product strictly increases income and thus reduces marginal utility in the delivery scenario, thus providing an incentive to reduce  $\alpha$  under risk aversion. Moreover, if this effect is strong enough a risk-averse subject facing a discrete scoring rule may rationally report  $\alpha = 0$  for hedging motives even if she holds a strictly positive subjective probability  $p > 0$ . In this case, the effect of a stake can thus potentially inflate the number of zero-token subjects.

To sum up, we have illustrated theoretically a number of cases where the number of zero-token participants may, or may not, increase under a discrete scoring rule due to risk preferences and stakes. As a result, and in particular when the number of zero-token participants is high, it may be a good idea for the analysis of the experimental outcomes to further explore statistically the role of risk preferences and stakes, as we propose in Section 5.

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<sup>27</sup>This example is available upon request.

<sup>28</sup>Note, however, that this conclusion would be the opposite under risk loving, as stakes could here increase the zero-token choice.

# Online Appendix

## Eliciting Non-hypothetical Willingness-to-pay for Novel Products: An Application to Cultured Meat

Romain Espinosa, Nicolas Treich

January 9, 2024

### Online Appendix 1: Pre-experimental Questionnaire

*The following instructions were originally in French.*

#### First screen

Hello and welcome to this questionnaire.

As part of an experiment in which you are going to participate during the next sessions, you are asked to complete the following questionnaire. It consists of several sets of questions.

Please note that there are no right or wrong answers to the questions you will be asked, and that you are encouraged to answer as honestly as possible.

Please note, it is not possible to go back once you have confirmed your answers on a screen.

Finally, please note that it is important to complete this questionnaire carefully, as the associated experimental payments can only be made if you complete it. You will be paid €2 for this questionnaire on the day of the experiment (later in the semester).

#### Second screen

Please indicate how often you consume the following items: Never, a few times a year, a few times a month, a few times a week, almost at each meal.

- Red meat
- White meat
- Fish
- Eggs
- Dairy products
- Vegetables
- Pulses
- Fruit
- Starchy foods

### Third screen

Please indicate to which extent you agree with the following statements. Your answers must take values between 1 (totally disagree) and 7 (totally agree).

- It is acceptable to eat meat because the animals killed for our consumption do not really suffer.
- It is acceptable to eat meat because the animals killed for our consumption have lower intellectual capacities than humans.
- It is acceptable to eat some animals because they are raised for this purpose.
- God created animals for us to eat.
- Eating meat is healthy.
- It's natural to eat meat, it's written in our genes.
- It's normal to eat meat.
- I like meat too much to stop eating it.
- Eating meat is necessary for good health.
- Eating meat may be bad for the environment, but no more so than eating vegetables or cereals.

### Fourth screen

Please indicate to which extent you agree with the following statements. Your answers must take values between 1 (totally disagree) and 7 (totally agree).

- I am careful to eat products that are as natural as possible.
- I am careful not to eat too much processed food.
- I am careful to eat food that emits the least greenhouse gases.
- I am careful to eat healthy products for my health.
- I avoid eating prepared meals and prefer home-made.
- I avoid eating products like GMOs.
- I am careful to choose products that create the least amount of animal suffering.
- I am careful to eat products that are as natural as possible.

### Fifth screen

Please indicate to which extent you agree with the following statements. Your answers must take values between 1 (totally disagree) and 7 (totally agree) regarding your dietary habits. Once again, there are no right or wrong answers. Try to answer as honestly as possible.

- I am constantly sampling new and different foods.
- I don't trust new foods.
- If I don't know what is in a food, I won't try it.
- I like foods from different countries.

- Ethnic food looks too weird to eat.
- At dinner parties, I will try a new food.
- I am afraid to eat things I have never had before.
- I am very particular about the foods I will eat.
- I will eat almost anything.
- I like to try new ethnic restaurants.

### **Sixth screen**

Thank you for your participation in this questionnaire.

To save your answers and to enable us to check that you effectively completed the questionnaire, please indicate your e-mail address. This will allow us to pay you during the next experiment.

## Online Appendix 2: Experiment

*The following instructions were originally in French.*

### First screen

Hello and welcome to this experimental session.

You will be participating in an experiment in a moment. During this experiment, the usual experimental rules apply: you will be asked not to communicate with the other participants in the room and not to communicate with the outside (no telephone, no internet use). If this rule is violated, we will be forced to exclude you from the room and cancel all your payments.

In this experiment, you will receive a lump sum of €8 that you will be able to use to eventually purchase a product. We will first show you the product. Next, we will provide you with a price list for that product and you will be asked to indicate whether you wish to purchase this item at each of the prices offered.

Before the experiment, given the availability of the product, a selection between two scenarios was made concerning the delivery of the product. In the first scenario, if you have purchased the product, it will be delivered to you at school from November 2<sup>nd</sup> to the 6<sup>th</sup> or from November 9<sup>th</sup> to the 13<sup>th</sup> (you can choose the day of the week, but only in these two weeks). During the same period, you will receive the money that remains after the purchase (€8 minus the price paid for the product). In the second scenario, whether you bought the product or not, the product will not be delivered to you and you will receive your lump sum of €8 on the same dates.

To sum up the experiment:

1. Product presentation
2. Decision to purchase the product
3. From November 2<sup>nd</sup> to the 13<sup>th</sup>: delivery of the product (if this scenario has been selected) and payment of the remaining money.

Please enter your e-mail so that we can proceed to payment and, if applicable, deliver the product.

### Second screen

Here is the description of the product that you will be able to buy (if this scenario is selected) on the next screen.

Please note that this corresponds to the description generated by the company itself.

Did you read the project description correctly?

Figure OA2.1: Screenshot of the presentation of GourmeY

## THE FOIE GRAS THAT WE'VE BEEN WAITING FOR

GOURMEY is developing a delicious and 100% ethical foie gras without force-feeding or slaughter from duck cells. An uncompromising foie gras, better for you, for animals and for the planet.




### GOURMEY SAVOIR-FAIRE

A revolutionary culinary feat at the crossroads of innovation and gastronomy.



**It all starts with an egg.**  
We select a freshly laid duck egg and carefully extract a few cells.



**Our cultivator, a cell paradise.**  
We place these cells in our cultivator, where they benefit from its ideal conditions of perfect temperature, basic nutrients and space to grow. The cells multiply naturally and we harvest real duck foie gras.



**Culinary preparation**  
From here our chefs take over and cook up our foie gras without compromise. A pinch of salt, freshly ground pepper, a drop of Armagnac... ready for the table!

### THE GOURMEY MISSION

Beyond foie gras, a delicious, ethical and sustainable meat.



**Reinventing the meat we love**  
Our mission is to bring you delicious meat that is respectful of our health, the environment and the animals.



**The impact of meat**  
The industrial production of meat has a detrimental impact on the environment. It produces more greenhouse gas emissions than all the cars and planes in circulation on the planet.



**The same meat - better**  
We do not want to give up meat. However we urgently need a method of sustainable production. Producing meat by cultivating natural animal cells means offering the same experience with around 90% less water, land surface and CO2 emissions. No antibiotics and of course no animal suffering. In short, it is the meat of our dreams.

### Third screen

You have received €8 as we announced previously. This money will be given to you either the week of November 2<sup>nd</sup> to the 6<sup>th</sup> or the week of November 9<sup>th</sup> to the 13<sup>th</sup> if you decide to keep it.

You also have the option to use this money to purchase 100g of the Gourmey product that was shown to you on the previous screen. The product will be delivered to you on the same dates if you decide to buy the product and if this scenario is retained (in the other scenario, the product will not be delivered to you and you will receive the €8).

We will present you with a price list. For each price, you must indicate whether you wish to buy the product. At the end of the experiment, the computer will choose a random price from the price list and apply your purchase decision for that price:

- If you indicated "Buy": The computer will consider that you are willing to purchase this product at that price. It will deduct the price indicated from your €8. In November, you will receive the product and the remaining money (if that is the scenario that was chosen).
- If you indicated "Don't buy": The computer will consider that you are not purchasing the product. In November, you will receive the €8.

List of prices: Free, €0.50, €1, €1.50, €2, €2.50, €3, €3.50, €4, €4.50, €5, €5.50, €6, €6.50, €7, €7.50, €8.

**Figure OA2.2:** Screenshot of the purchase decisions

**For the price range shown below, please indicate whether you wish to purchase the product or not.**

	Buy	Don't buy
Free	<input type="radio"/>	<input type="radio"/>
0.50 €	<input type="radio"/>	<input type="radio"/>
1 €	<input type="radio"/>	<input type="radio"/>
1.50 €	<input type="radio"/>	<input type="radio"/>
2 €	<input type="radio"/>	<input type="radio"/>
·	·	·
·	·	·
·	·	·
6.50 €	<input type="radio"/>	<input type="radio"/>
7 €	<input type="radio"/>	<input type="radio"/>
7.50 €	<input type="radio"/>	<input type="radio"/>
8 €	<input type="radio"/>	<input type="radio"/>

#### Fourth screen

How do you perceive the Gourmey product that was presented to you on the following scales? 1 (totally disagree) to 7 (totally agree).

1. Healthy



2. Natural
3. Environmentally-friendly
4. Tasty
5. Animal-friendly
6. Nourishing
7. Disgusting

Would you be ready to buy this product on a regular basis? Yes/No.

### **Fifth screen**

How do you generally perceive the foie gras produced in duck farms? 1 (totally disagree) to 7 (totally agree).

1. Healthy
2. Natural
3. Environmentally-friendly
4. Tasty
5. Animal-friendly
6. Nourishing
7. Disgusting

Would you be ready to buy foie gras produced in duck farms on a regular basis? Yes/No.

### **Sixth screen**

Please indicate to which extent you agree with the following statements. Your answers must take values between 1 (totally disagree) and 7 (totally agree).

- It is acceptable to eat meat because the animals killed for our consumption do not really suffer.
- It is acceptable to eat meat because the animals killed for our consumption have lower intellectual capacities than humans.
- It is acceptable to eat some animals because they are raised for this purpose.
- God created animals for us to eat.
- Eating meat is healthy.
- It's natural to eat meat, it's written in our genes.
- It's normal to eat meat.
- I like meat too much to stop eating it.
- Eating meat is necessary for good health.
- Eating meat may be bad for the environment, but no more so than eating vegetables or cereals.

## Seventh screen

Your decisions from the previous screen have been saved. As we indicated, prior to the experiment one of two scenarios was chosen:

1. The Gourmey product-delivery scenario was selected. In this case, we will look at your decision to purchase the product at the randomly-chosen price. If you have purchased the product, it will be delivered to the Business School the weeks of November 2<sup>nd</sup>-6<sup>th</sup> or 9<sup>th</sup>-13<sup>th</sup> (you can choose the day of the week). You will receive the remaining money the same week.
2. The Gourmey product-delivery scenario was not selected. In this case, whether you decided to buy the product or not, you will keep all the experimental money (€8) that will be paid to you on the same dates.

We would now like to know more about your beliefs regarding the scenario that was selected. On the rest of this screen, you can earn money by correctly guessing which scenario was selected (delivery of the Gourmey product, or no delivery of the Gourmey product). You have 10 tokens that you can allocate between the two scenarios. The more tokens you allocate to a scenario, the more money you will earn if this scenario was actually chosen. You can use the graph below to simulate your income in each scenario if it is chosen.

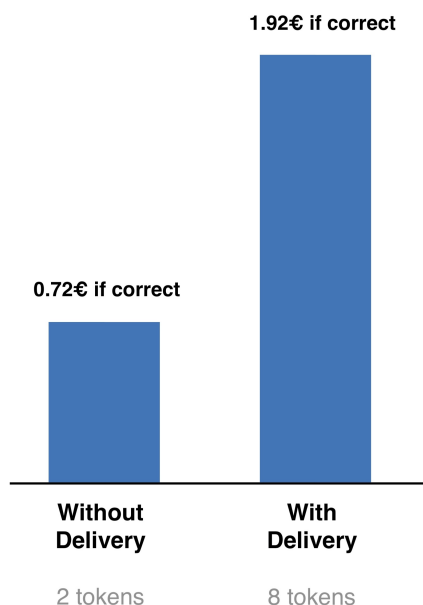
For information, the price chosen by the computer for the Gourmey product is €XX.

At that price, your decision was "Buy" / "Don't buy".

Please note that even if you did not buy the product, we ask you below to bet on the fact that the product would have been delivered had you decided to buy at this price (delivery scenario) or not (no delivery scenario).

Please indicate the number of tokens you wish to put on the scenario "The Gourmey product will be delivered" (between 0 and 10).

**Figure OA2.3:** Screenshot of the dynamic graph for token allocations



### Eighth screen

This is the penultimate screen of the experiment.

You will see a series of options below. For each line you have to choose between two options: A and B. Option A gives you a fixed amount of money which varies on each line, while option B is a lottery which gives you either €1.20 (1 chance in 2) or €0 (1 chance in 2).

At the end of the experiment, one line will be chosen randomly by the computer. If you have chosen the lottery option for this row, the computer will randomly draw the result of the lottery.

Please indicate the option you prefer for each line.

- Option A: €0.10 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.20 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.30 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.40 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.50 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.60 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.

- Option A: €0.70 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.80 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €0.90 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.
- Option A: €1.00 for sure. Option B: 1 in 2 chance of having €1.20, otherwise €0.

### **Ninth screen**

- How do you define yourself? (Man/Woman/Other)
- How old are you?
- Did you grow up in the city or in the country?
- The French are usually classified according to a political dimension that goes from Left to Right. You, personally, where would you rank on a scale of 1 (Far Left) to 7 (Far Right)?
- How do you assess the standard of living of the family in which you grew up?
  - Among the poorest of the French.
  - A little poorer than the French average.
  - Neither richer nor poorer than the French average.
  - A little richer than the French average.
  - Among the richest of the French.
- Did you receive honors with your High-School diploma? (No / Fairly Good / Good / Very Good/ Other)

## Online Appendix 3: Additional tables

**Table OA3.1: Consumption habits in the sample (%).**

	Red meat	White meat	Fish	Eggs	Dairy
Never	2.5	0	5.1	3.2	1.9
A few times a year	10.8	1.9	13.3	1.27	3.2
A few times a month	32.9	25.3	53.8	37.97	8.2
A few times a week	44.3	65.2	26.0	51.90	42.4
At almost every meal	9.5	7.6	1.9	5.70	44.3
Total	100	100	100	100	100

**Table OA3.2: Correlations between the questions relating to the perception of Gourmey**

	Healthy	Natural	Environment-friendly	Tasty	Animal-friendly	Nourishing
Natural	0.563*** (p<0.001)					
Environment-friendly	0.487*** (p<0.001)	0.346*** (p<0.001)				
Tasty	0.228*** (p=0.004)	0.419*** (p<0.001)	0.126 (p=0.116)			
Animal-friendly	0.402*** (p<0.001)	0.152* (p=0.057)	0.795*** (p<0.001)	0.021 (p=0.7898)		
Nourishing	0.383*** (p<0.001)	0.326*** (p<0.001)	0.267*** (p<0.001)	0.519*** (p<0.001)	0.290*** (p<0.001)	
Disgusting	-0.198** p=0.013	-0.346*** (p<0.001)	-0.206** (p=0.010)	-0.598*** (p<0.001)	-0.198** (p=0.013)	-0.489*** (p<0.001)

Notes: (1) The figures here are Pearson correlation coefficients, with p-values in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

**Table OA3.3: Interval regressions of the willingness-to-pay for Gourmey on dietary concerns**

	Willingness-to-pay							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Natural	0.423 (0.726)							-1.310 (1.085)
Unprocessed		1.151* (0.667)						1.732* (1.020)
Low GHG			0.924 (0.729)					0.276 (0.825)
Healthy				1.074 (0.733)				0.917 (0.952)
Home-made					0.467 (0.687)			0.435 (0.757)
No GMO						-0.116 (0.638)		-1.090 (0.785)
Low animal pain							0.646 (0.667)	0.529 (0.758)
Observations	158	158	158	158	158	158	158	158
LL	-444.322	-443.016	-443.693	-443.425	-444.260	-444.475	-444.025	-440.834

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) All regressions include controls for age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

**Table OA3.4: The probability of assigning zero tokens to the delivery scenario (Probit)**

	Zero token on Gourmey delivery scenario										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Risky Choices	0.195** (0.0820)										0.238** (0.0983)
WTP		-0.0675 (0.0724)									0.00401 (0.148)
ProGourmey			-0.0243 (0.0908)								-0.0332 (0.129)
ProDuckFarm				-0.118 (0.0921)							-0.218* (0.130)
ABC					1.026 (0.980)						0.750 (1.510)
Generally concerned						0.256** (0.103)					0.434*** (0.165)
Externality concerned							-0.0333 (0.166)				0.0271 (0.215)
Neophobia								-0.634 (1.026)			-1.167 (1.498)
Selected Price									-0.136** (0.0678)		-0.276** (0.119)
Stakes dummy										-0.103 (0.365)	-0.830 (0.754)
Observations	128	128	128	128	128	128	128	128	128	128	128

Notes: (1) The figures here are the estimated coefficients, with standard errors in parentheses.

(2) \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

(3) The controls are age, gender, raised in the countryside, High-School diploma honors, relative wealth and political self-placement.

(4) Some observations were dropped because failure was perfectly predicted.

## Online Appendix 4: Additional figures



Figure OA4.1: The distribution of WTP profiles

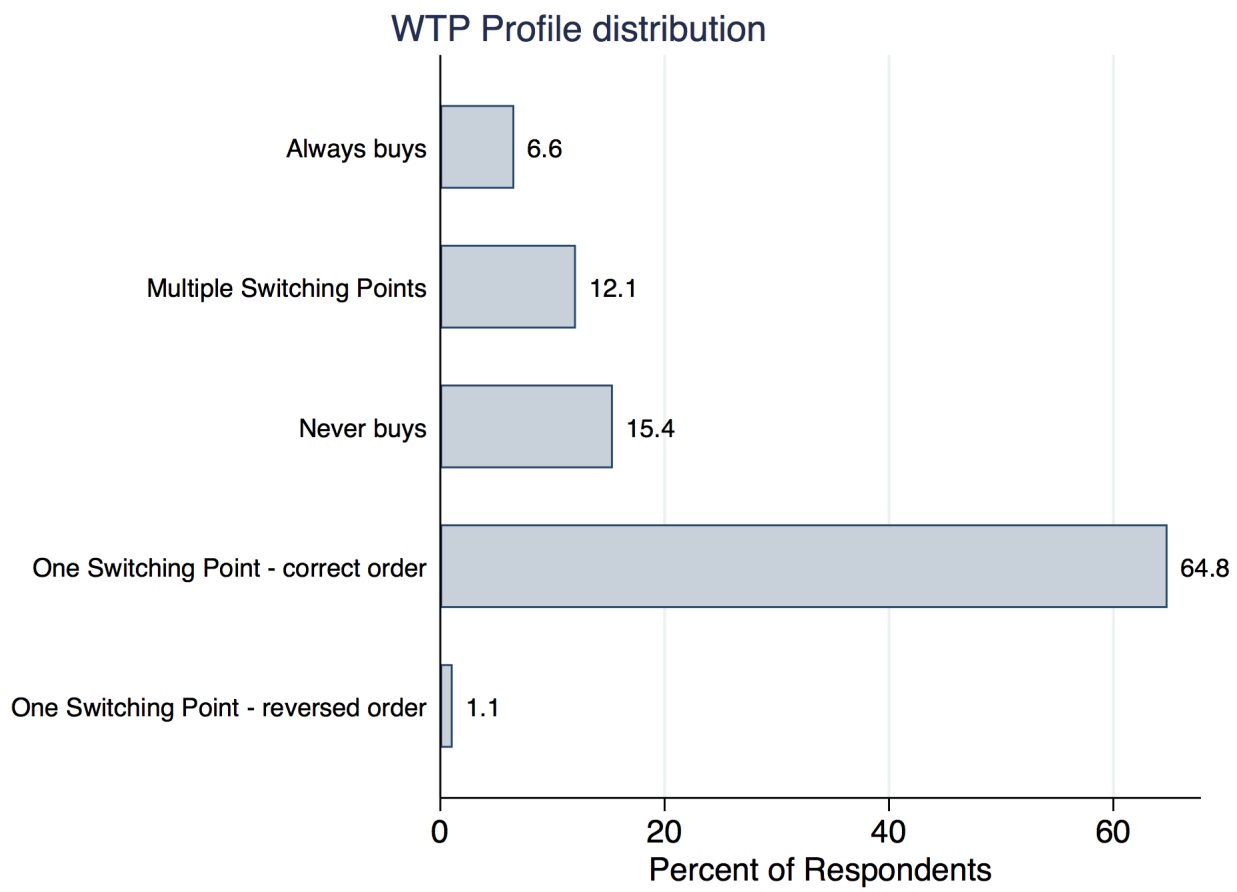
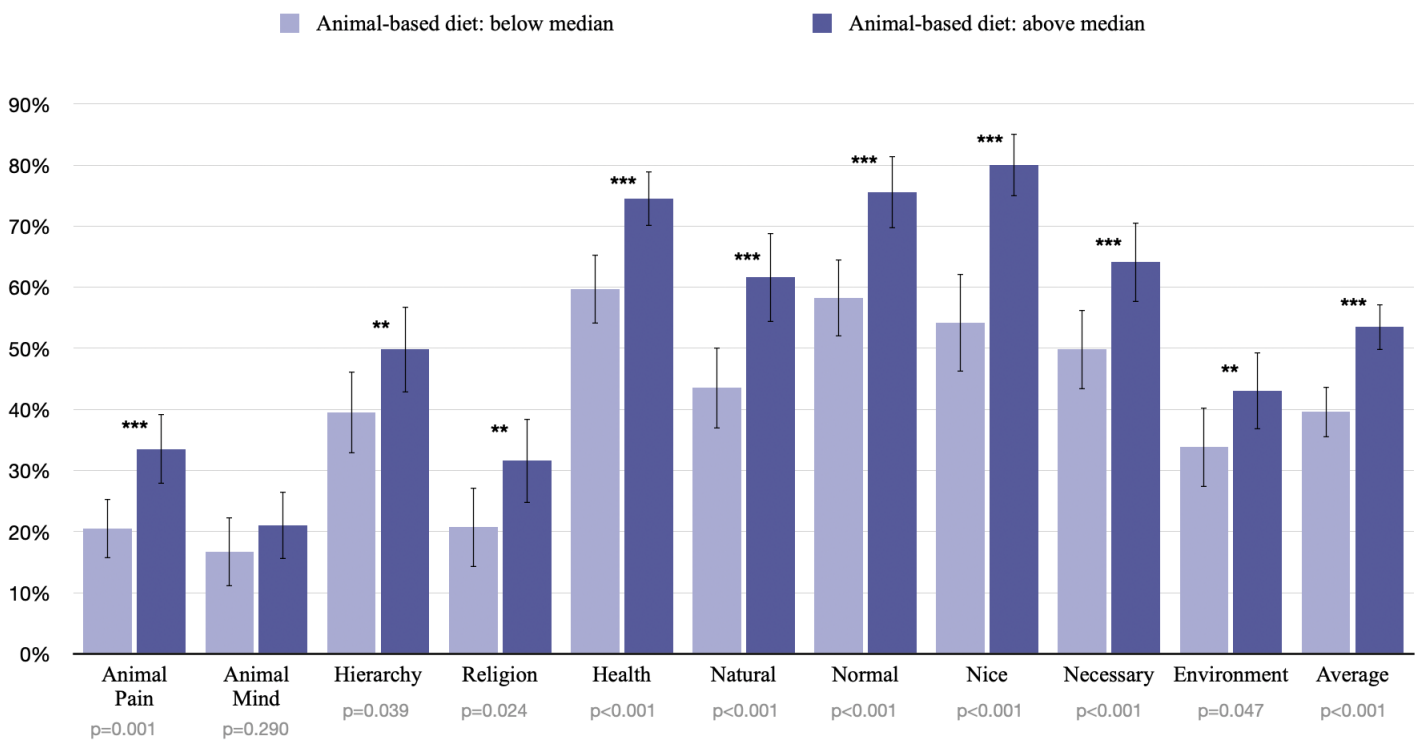
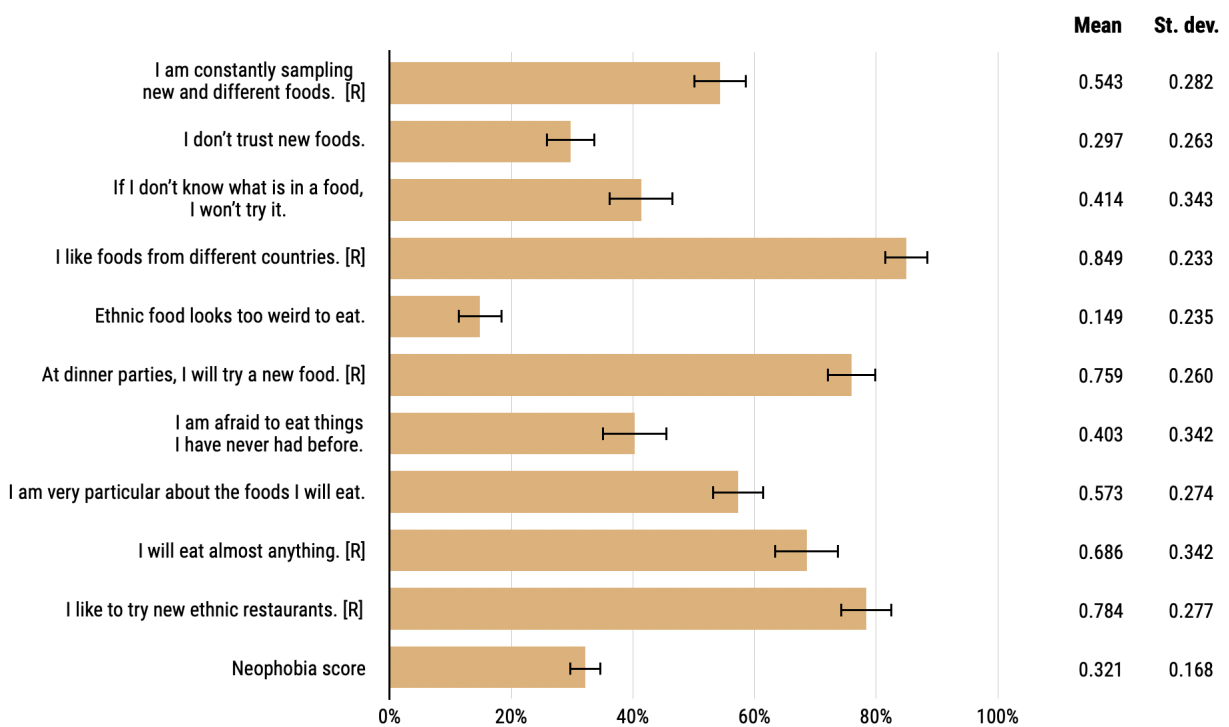


Figure OA4.2: Average pro-meat justification per diet category



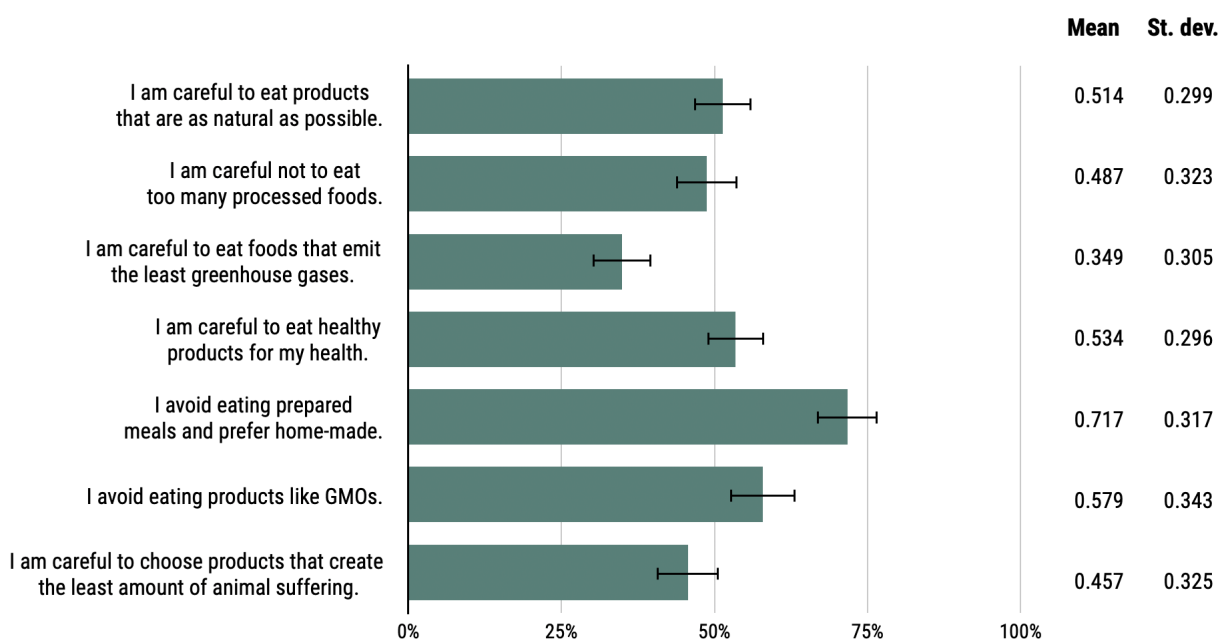
Notes: The spikes represent the 95% confidence intervals. Group comparison t-tests: \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Figure OA4.3: Average Neophobia scores



The original scores (from 1 to 7) have been rescaled between 0 and 1, and the means are expressed in percentages. [R] indicates the items that have been reversed. The neophobia score was computed following Pliner and Hobden (1992). Spikes represent 95% confidence intervals.

Figure OA4.4: Average Dietary concerns



The original scores (from 1 to 7) have been rescaled between 0 and 1, and the means are expressed in percentages. Spikes represent 95% confidence intervals.

## Online Appendix 5: Control variables

We introduce a number of control variables from the pre-experimental survey and the main experiment. We first measure the participants' consumption of animal-based products. To do so, we assign numerical values to the frequencies of food consumption (Never=1, A few times a year=2, A few times a month=3, A few times a week=4, Almost every meal=5). We then carry out a Principal Component Analysis (PCA), retaining the consumption of animal-based products (red meat, white meat, fish, eggs and dairy). The first dimension of the PCA explains 34.7% of the variation and is positively associated with the consumption of animal-based products (see Table OA5.1). The contributions of the meat items are the strongest, but the correlations with fish and dairy products are also positive. This first dimension captures participant heterogeneity in terms of the consumption of animal-based products: participants with higher scores eat more meat, fish, eggs and and dairy products. We rescale the projections of the PCA on the first dimension between 0 and 1 and call this score animal-based consumption (ABC).

Second, we establish a measure of pro-meat justifications (see Table OA5.2 for the statements). To do so, we add up the scores for the ten statements supporting meat consumption to produce a pro-meat justification (PMJ) score, as in Espinosa and Treich (2021). This can theoretically take on values between 0 and 70, and we divide it by 70 to obtain values between 0 and 1. The observed PMJ scores in the pre-experimental survey range from 0.017 to 0.900, with an average of 0.466. The associated Cronbach's alpha is 0.84, indicating substantial reliability. We test the robustness of our PMJ index by running a PCA. The first dimension is positively correlated with all items and explains 42.9% of the variation in the sample. The correlation between the additive and PCA scores is above 0.995 in our sample. We retain the additive PMJ index as in Espinosa and Treich (2021), where the weights given to the individual items are constant (whereas they will change according to sample composition in the PCA method).

Third, we explore the perception of the two products of interest, i.e. cultured and duck-farm foie gras. We run a PCA on the seven items related to each product (healthy, natural, environment-friendly, tasty, animal-friendly, nourishing, and disgusting). Table OA5.3 shows the results of the first dimension for each product. The first dimension of each PCA is positively correlated with all of the items, apart from that related to disgust. These explain 44.5% (Gourmey) and 47.5% (FoieGras) of the variance. We retain these first dimensions and label them *ProGourmey* and *ProDuckFarm* respectively.

Last, we consider consumers' concerns related to food choices. We run a PCA on the variables associated with the reported concerns about eating natural, unprocessed, environmentally-friendly (low GHG), healthy, home-made, without GMO, and animal-friendly (low animal pain) food. The first two dimensions account for 46.4% and 16.2% of the variance respectively (Table OA5.4). The first dimension represents *generally-concerned consumers*, as it is positively associated with all items with the highest correlation scores for health concerns (natural, unprocessed, and healthy). The second dimension represents *externality-concerned consumers* and is positively associated with concerns for externalities (GHG and animal pain) and negatively with home-made food.

**Table OA5.1:** Results of the Principal Component Analysis on diets.

	Animal-based consumption (ABC)
	Eigenvector
White meat	0.591
Red meat	0.556
Fish	0.319
Eggs	0.142
Dairy products	0.465
Explained variation	34.7%
Eigenvalue	1.733
Observations	158

Note: The ABC score corresponds to the first component of the PCA.

**Table OA5.2:** Pro-meat justifications.

Pro-meat justifications.		
(1)	<i>Animal Pain</i>	It is acceptable to eat meat as the animals killed for our consumption do not really suffer.
(2)	<i>Animal Mind</i>	It is acceptable to eat meat as the animals killed for our consumption have lower intellectual capacities than humans.
(3)	<i>Hierarchical Justification</i>	It is acceptable to eat some animals because they are raised for this purpose.
(4)	<i>Religious Justification</i>	God created animals for us to eat.
(5)	<i>Health</i>	Eating meat is healthy.
(6)	<i>Naturalness</i>	It's natural to eat meat, it's written in our genes.
(7)	<i>Normality</i>	It's normal to eat meat.
(8)	<i>Niceness</i>	I like meat too much to stop eating it.
(9)	<i>Necessity</i>	Eating meat is necessary for good health.
(10)	<i>Environment</i>	Eating meat may be bad for the environment, but no more so than eating vegetables or cereals.

Note: The answers take on values between 1 (totally disagree) to 7 (totally agree).

**Table OA5.3:** The results of the Principal Component Analyses to determine ProGourmey and ProDuckFarm scores.

	Eigenvector	
	ProGourmey	ProDuckFarm
Healthy	0.404	0.389
Natural	0.387	0.417
Environmental-friendly	0.393	0.412
Tasty	0.329	0.394
Animal-friendly	0.345	0.341
Nourishing	0.400	0.399
Disgusting	-0.363	-0.272
Explained variation	44.5%	47.6%
Eigenvalue	3.111	3.331
Observations	158	158

Note: The columns correspond to the first components of the PCA on the Gourmey-related and FoieGras-related items.

**Table OA5.4:** The results of the Principal Component Analysis of dietary concerns.

	Eigenvectors	
	Generally concerned	Externality concerned
Natural	0.466	-0.004
Unprocessed	0.468	-0.085
Low GHG	0.263	0.648
Healthy	0.419	0.031
Home-made	0.282	-0.492
No GMO	0.3829	-0.3638
Low animal pain	0.307	0.445
Explained variation	46.4%	16.2%
Eigenvalue	3.249	1.136
Observations	158	158

Note: Columns 1 and 2 correspond respectively to the first and second components of the PCA on the items related to dietary concerns.