NUDGING MEAT EATERS TOWARDS PLANT-BASED MEAT
ALTERNATIVES: AN ONLINE SUPERMARKET EXPERIMENT

A Thesis

presented to

the Faculty of the Graduate School
at the University of Missouri-Columbia

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

NO-YA YU

Dr. Michelle Segovia, Thesis Supervisor

July 2021

The undersigned, appointed by the dean of the Graduate School, have examined the thesis entitled

NUDGING MEAT EATERS TOWARDS PLANT-BASED MEAT
ALTERNATIVES: AN ONLINE SUPERMARKET EXPERIMENT

presented by No-Ya Yu,

a candidate for the degree of master of science,

and hereby certify that, in their opinion, it is worthy of acceptance.

Professor Michelle Segovia

Professor Harvey James

Professor Mary Hendrickson

Professor Nicholas Kalaitzandonakes

Professor Ellen Van Loo

DEDICATION

I would like to dedicate this work and all of the efforts put forth to obtaining my master's degree to my beloved family. A special gratitude to my mom, Hsiu Ling Lin whose words of encouragement and support throughout the process. Our relationship is much similar to sisterhood in which I am able to share every little thing and celebrate each accomplishment. I am proud to be your daughter and I always love you.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my advisor, Dr. Michelle Segovia for her invaluable guidance, continuous support and encouragement. I am deeply thankful for her time and contribution to my master's study by assisting me in all aspects of my research, supporting my attendance at workshops and conferences, and demanding a high quality of work in all my endeavors. To me, she is also a mentor who is willing to listen and share personal experience and encourage me to explore every possibility in life. I was fortunate to have the chance to work with her and engage in learning experimental and behavioral economics.

I would also like to thank the rest of my committee members, Drs. Harvey James, Mary Hendrickson, Nicholas Kalaitzandonakes, and Ellen Van Loo for spending time reading this thesis and providing insightful comments and suggestions.

My sincere thanks also go to the faculty and graduate students in the Division of Applied Social Sciences. They have provided me irreplaceable support during each stage of my study. I cannot express how grateful I am to all of them. Last but not the least, I would like to thank my family members whose love and support are with me in whatever I pursue. Their love motivates me to strive for better and push myself further because I know they will be there when I fall.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
LIST OF FIGURES	v
LIST OF TABLES	vi
ABSTRACT	vii
Chapter	
1. INTRODUCTION	1
2. LITERATURE REVIEW	6
Behavioral nudges and food choice	6
Reducing meat consumption	9
Preferences for meat alternatives	13
3. METHODS	16
Experimental Design	16
Participants	18
Experimental Procedures	18
4. HYPOTHESES	25
Hypothesis 1	26
Hypothesis 2	27
5. RESULTS AND DISCUSSION	28

Descriptive analysis	28
Result 1	30
Result 2a.....	34
Result 2b	37
Behavioral drivers of meat purchases	38
Econometric analysis	41
Latent class analysis.....	48
6. CONCLUSION AND IMPLICATIONS.....	58
REFERENCES	64
APPENDIX.....	83
A1. Recruitment material.....	83
A2. Experimental protocol.....	84
Table B1. List of health and environmental attributes used in two implicit association tests.....	104
Table B2. Sample size by treatments and sessions	104

LIST OF FIGURES

Figure	Page
1. Meat/plant-based meat choice task with health, environment and combined messages.	17
2. Example of one of the health IAT blocks.	25
3. Example of one of the environment IAT blocks.	25
4. Proportion of plant-based meat purchases by treatment.	34
5. Health IAT D-score by treatment.	37
6. Environment IAT D-score by treatment.	38
7. Level of importance of factors when purchasing meat products by treatment.	40
8. Favorable views towards four food technologies by treatment.	41
9. Proportion of plant-based meat purchases by latent class.	58

LIST OF TABLES

Table	Page
1. Balance test across treatment groups	29
2. Estimates of logit regressions on plant-based meat purchases	46
3. Comparison of latent class models	51
4. Latent class parameter estimates for three-class model	53
5. Demographic, viewpoint towards other food technologies and IATs by latent class	55
B1. List of health and environmental attributes used in two implicit association tests	104
B2. Sample size by treatments and sessions	104

Abstract

We implement a non-hypothetical online grocery shopping experiment to study the impact of health and environment related information nudges on consumers' purchases of meat and plant-based meat alternatives. More specifically, we exogenously manipulate an information message to appear next to meat and plant-based meat products while subjects make purchasing decisions. Subjects receive one of four treatments at random: 1) Health treatment, which displays information about the health benefits of eating less meat; 2) Environment treatment, which presents a message related to the environmental impact of reducing meat consumption; 3) Combined treatment, which displays a message that combines the information from the health and environment messages; and 4) Control, where no information is provided. Moreover, we elicit subjects' implicit association between healthiness and environmental impact of meat and plant-based meat using two implicit association tests. We find the environmental message to be an effective instrument for motivating meat eaters to purchase plant-based meat products. We also find that, on average, meat eaters in our sample implicitly perceive meat to be healthier but environmentally unsustainable compared to plant-based meat products. Furthermore, using a latent class analysis (LCA), we identify three distinct latent classes based on subjects' preferences for purchasing meat products and their plant-based meat purchases frequency. Members in Class 1 are driven by the taste and price of meat products, whereas Class 2 expresses high attention for health and environmental impact attributes and Class 3 is open to reduce their meat consumption. The LCA indicates heterogeneity of preferences across meat eaters, suggesting future interventions can target to specific consumer segments, instead of focus on general meat eaters. Overall, our findings provide implications for policy makers and food marketers as to whether

meat eaters can be steered toward purchasing plant-based meat under different behavioral nudges.

Introduction

Growth in global meat consumption is expected to increase over the period of 2019 to 2028. The United States is expected to stay at the top list of meat consumption per capita, with each American consuming an average of 97 kg per year in 2028 (OECD and FAO, 2019). The rising income level and population growth, particularly among large middle classes of Asian and Latin American countries, have made meat more affordable to consumers (OECD and FAO, 2019). However, no matter for industrialized societies or developing countries, the world has to confront the increased risk of health problems involved with high meat consumption (e.g., cardiovascular diseases and cancer mortality) (Sinha et al., 2009; Wang et al., 2016) as well as the environmental negative consequences caused by the increasing production of meat (e.g., greenhouse gas emission) (Gerber et al., 2013; Herrero et al., 2011). In the US, meat-based diets create more environmental pressure than plant-based diets as meat production requires greater usage of energy, land and water resources (Pimentel and Pimentel, 2003). Health and environmental benefits have shown to be strong motivators for consumers to reduce meat consumption (Cheah et al., 2020). According to The Good Food Institute, the US plant-based meat category is worth \$939 million with dollar sales of plant-based meat growing 18% in 2019 (The Good Food Institute, 2020).¹ Currently, there are several plant-based meat alternatives available to consumers in grocery stores and restaurants across the US. Product types range from beef patties, breakfast sausages and meatballs to chicken nuggets.

Although plant-based meat alternatives have existed for a long time, Beyond Meat

¹ Plant-based meat is made from plants. It is designed and created to look like, taste like and cook like conventional meat. Plant-based meat can be developed in the form of burger patties, nuggets, crumbles, sausages, among other products (Osmanski, 2019).

and Impossible Foods have introduced a new wave of plant-based meat products that more closely mimic animal meat compared to the previously established vegetable protein such as tofu.² Moreover, due to the increase in plant-based meat popularity and consumers' awareness of their food choices, major food companies like Nestlé, Tyson, Perdue, Smithfield and Kellogg's have launched different plant-based meat products (Yaffe-Bellany, 2019).

The increasing criticism of animal agricultural production and human health associated with high levels of meat consumption raises the question as to whether consumers can be steered toward purchasing more plant-based meat alternatives. It is often the case that the health and sustainable related attributes of food products cannot be directly observed by consumers before purchasing them or cannot be experienced during consumption (Van Loo et al., 2017). Thus, to increase consumers' motivation and involvement in healthy and sustainable diets, nudges emerge as a key trigger to change consumers' behavior while maintaining their freedom of choice (Thaler and Sunstein, 2009). For example, by conducting a menu choice experiment in campus dining halls, Camp-Arvai et al. (2014) found that participants nudged by the default menu option were more likely to choose a meat-free option both with and without receiving environmental information. The authors also found that on average, respondents who received information about the negative effects of meat consumption reported higher intention to reduce meat intake than those who did not receive any information, this effect was particularly effective for information related to negative effects on human health and animal welfare. This indicates that using methods such as

² Beyond meat is made with a variety of plant proteins (e.g., pea, mung bean, fava bean and brown rice) and beet juice extract is used for coloring and delivering the cooking experience as traditional meat (Beyond Meat, 2020). Impossible Foods differentiate themselves from using a critical component called "heme" which can be found in plants and animals. They used soy leghemoglobin that carries heme to create the meat flavor (Impossible Foods, 2020).

default options and providing related meat and plant-based meat's information may motivate consumers to shift away from old consumption patterns.

In our study, we conduct a non-hypothetical online supermarket experiment to examine the impact of different types of information messages on consumers' purchases of meat and plant-based meat alternatives. In particular, we examine the impact of two broad types of messages related to meat consumption: health-related messages and environment related messages. Previous consumer research has utilized hypothetical surveys to study consumers' attitudes toward meat alternatives and plant-based diets. Additionally, researchers have implemented experimental methods such as choice experiments and experimental auctions, to examine the effect of provision of information on healthy food choice and meat consumption reduction. Yet, there is scant literature on consumers' true preferences for plant-based meat alternatives during their real-life grocery shopping experience. Our study aims to close this research gap. More importantly, we implement two implicit association tests to improve the understanding of consumers' mental association between meat/plant-based meat and their health/environmental impact attributes, while previous studies used these tests for examining healthy food choices' hedonic attributes such as healthiness and tastiness (Werle et al., 2013).

The objectives of this research are to: 1) examine the effect of health and environmental messages on consumers' online purchasing behavior of meat and plant-based meat alternatives; 2) measure consumers' implicit association between meat/plant-based meat and their health and environmental attributes; and 3) examine heterogeneity in food preferences across different consumer segments by categorizing subjects into different latent classes. To address these objectives, we implement a between-subjects design in which 122 participants are randomly assigned to one of

four treatments: 1) Health (information of health benefits of reducing meat consumption); 2) Environment message (information of the environmental benefits of reducing meat consumption); 3) Combined (combination of health and environmental messages); and 4) Control (no information). Following the manipulation, participants are asked to complete a shopping task, two implicit association tests (IAT), and a socio-demographic and behavioral questionnaire. During the shopping task, participants are asked to shop for four ingredients in different food categories, including vegetables, carbohydrates, sauces and meat/plant-based meat. Besides a fixed participation fee, subjects receive an endowment to be used to purchase the food products during the shopping task. At the end of the experiment, subjects are able to curbside pickup the chosen bundle of goods at the University's parking lot, which makes our experiment non-hypothetical. The online experiment is conducted through an experimental grocery supermarket created in the Qualtrics platform.

Our experimental results show a positive and significant effect of the Environment treatment in the proportion of plant-based meat purchases. Whereas, there are no treatment effects in the Health and Combined treatments. The health and environment IATs can help explain the findings in the shopping task. Subjects in the Combined treatment and the Control exhibit an implicit association between meat (plant-based meat) and healthiness (unhealthiness); however, participants in the Health and Environment treatments implicitly associate meat (plant-based meat) with unhealthiness (healthiness). Regarding the environment IAT, participants demonstrate an implicit association between meat (plant-based meat) and unsustainability (sustainability) in all treatments.

Moreover, we conduct a latent class analysis (LCA) to better understand the heterogeneous effects of meat/plant-based meat purchasing characteristics across

consumer segments. Three latent classes are identified based on their: 1) important factors when purchasing meat products; 2) plant-based meat purchases frequency; and 3) meat consumption frequency. Class 1 is composed of mostly males who consume meat frequently and have lower plant-based meat purchases frequency. Preferences from subjects in Class 1 are driven by taste and price of meat products, and an implicit association between meat (plant-based meat) and healthiness/sustainability (unhealthiness/unsustainability) attributes. Class 2 is composed mainly of higher income females who are conscious about their meat/plant-based meat purchases. In contrast to Class 1, Class 2 purchase plant-based meat more frequently and consume less meat. In accordance with their meat/plant-based meat purchasing decisions, subjects in Class 2 perceive meat to be implicitly unhealthier/unsustainable than plant-based meat. Importantly, the meat related preferences of subjects in Classes 1 and 2 are reflected in their purchases in the shopping task, with the proportion of plant-based meat purchases being significantly higher for Class 2 ($p=0.04$ in proportion test). Individuals in Class 3 share similar meat consumption and plant-based meat purchasing frequency as Class 2; however, Class 3 demonstrates an implicit association between meat (plant-based meat) and healthiness (unhealthiness), but implicitly perceive meat (plant-based meat) to be unsustainable (sustainable). Similarly, the proportion of plant-based meat purchases is higher for subjects in Class 3 compared to those in Class 1 ($p=0.07$ in proportion test).

Our study provides several contributions. First, we provide insights into the effectiveness of messages on meat/plant-based meat purchases under real economic incentives. While most of the methods used in previous studies are hypothetical choice experiments and surveys, our non-hypothetical experiment allows us to elicit consumers' true preferences for meat and plant-based meat products. Second, we

bring in important policy implications. Understanding how consumers respond to different informational nudges is critical to understanding the complex food related decision-making process, as well as designing effective interventions aimed at improving dietary choices. Our findings can also provide marketers with insights as to how to engage consumers into healthier and sustainable food purchases under different types of information. Third, we contribute to the literature by implementing implicit association tests that can help explain consumers' implicit associations between meat/plant-based meat and health and environmental impact attributes. Finally, we conduct a latent class analysis to identify and characterize meat eaters based on their observed meat/plant-based meat purchasing and consuming factors. Our analysis indicates heterogeneity in preferences among meat eaters, suggesting the design of customized marketing strategies that reach specific groups of meat eaters.

Literature Review

Behavioral nudges and food choice

Behavioral interventions, such as nudges and choice architectures, are ways that strategically change elements in the decision environment and alter people's behavior in a predictable way without forcing any options or changing their economic incentives (Thaler and Sunstein, 2009). In addition to policy tools such as fiscal measures (e.g., fat or soft drink taxes) and required nutritional standard information (e.g., salt and sugar content), governments and private organizations have implemented nudges in an attempt to improve people's dietary choices (Nayga, 2008; Reisch et al., 2017). Examples include disclosure warnings, reminders and feedback to prevent obesity problems (Halpern, 2016; Hawkes et al., 2015), and the visualize food guide created by the US government (USDA, 2020). USDA's Choose My Plate

is an example of nudges that have been implemented as policies in the US (Sunstein, 2014). The ease to understand food plate graphically provides a simple guide for healthy eating as it helps people remember the illustration of what their own plate should look like. In this regard, Miller et al. (2016) conducted an experiment to examine the effects of students pre-ordering with and without a behavioral intervention on healthy food selection during school lunch. The authors found that pre-ordering students who received behavioral nudges, in the form of messages based on USDA MyPlate recommendation, selected more fruits, vegetables and low-fat milk than students who simply ordered online in the absence of nudges.

Several experimental studies have examined the effects of providing health and nutrition information on individuals' food choice. For example, Øvrum et al. (2012) found that individuals presented with health-related information were willing to pay a price premium for low-saturated-fat cheese and low-fat cheese compared to those who did not receive the information. Likewise, in a study by Rusmevichientong et al. (2014), subjects were exposed to three types of advertising—healthy food, unhealthy food and anti-obesity food—in a laboratory environment. The authors found that increasing the frequency of exposure to healthy food advertising nudged people to reduce calorie intake than when unhealthy food advertising and mixed food advertising (i.e., combination of healthy foods, anti-obesity, and unhealthy food advertisements) were used. Health related information has also been used in real settings such as restaurant menus and campus dining halls. For example, Burton et al. (2006) found that most consumers underestimated the high levels of calories, fat, and sodium offered in restaurant menu items, concluding that provision of nutritional information could have a positive impact in reducing consumption of less healthy food. Similarly, Wisdom et al. (2010) stated that providing calorie information at a

fast-food sandwich restaurant could promote healthier food choices. In addition, displaying health benefit messages of whole grain pasta at point-of-purchase in a campus dining setting could help increase healthier food choices (Sogari et al., 2019). Cadario and Chandon (2020) identified seven types of healthy eating nudges which they classified into three categories: cognitively oriented (what people know), affectively oriented (how people feel), and behaviorally oriented nudges (what people do). The authors found behaviorally oriented nudges to be the most effective in promoting healthy eating followed by affectively oriented nudges and cognitively oriented nudges. In addition, they showed that interventions worked better in reducing unhealthy eating than increasing healthy eating. However, they further examined the effectiveness and acceptance of those interventions and reported that nudge acceptance was inversely related to its effectiveness (Cadario and Chandon, 2019). Thus, there may be a tradeoff between people's motivation and effectiveness in behavior change.

A nudge can influence consumers' food choices through different ways such as specific item placement and the use of labels. In this regard, studies have investigated the effects of front-of-package nutritional labeling on consumers' health perceptions of food and beverages (Becker et al., 2015; Kim et al., 2012). For example, Hanks et al. (2012) created a "convenience line" that offered only healthier options such as sandwiches, salad bar, fruits and vegetables in one of two lunch lines to make healthy foods more convenient and salient. As a result, sales of healthier options increased by 18% and students consumed less unhealthy foods. Likewise, Thorndike et al. (2014) assessed the effectiveness of increasing visibility and accessibility of healthy foods by labeling products based on three levels of healthiness, green (healthy), yellow (less healthy) and red (unhealthy) labels, in a

hospital cafeteria setting. After implementing the labeling nudges, the sales of red items decreased from 24% at baseline to 20%, whereas green items sales increased from 41% to 46%.

Behavioral approaches have also been used to encourage sustainable and environmentally friendly food choices. For example, using traffic-light labels with three levels in the amount of CO₂ in meat, fish and vegetarian warm dishes was found to reduce meat dishes sales in a cafeteria setting (Slapø and Karevold, 2019). Similarly, enhancing the visibility for the size of a sustainable meat product (poultry) displayed area in a supermarket helped increase its sales (Coucke et al., 2019). While some types of behavioral interventions have proven effective in promoting sustainable food choices, other experimental field studies have failed to observe significant effects. For example, Zhou et al. (2019) found that setting plant-based dish as the default of “dish of the day” did not influence participants’ meal choices. Similarly, dos Santos et al. (2018) showed that designating vegetable-based meal as “dish of the day” in school cafeterias had no impact on plant-based meal selection between the control and intervention groups. In the following sections, we provide a summary of the main findings related to the use of behavioral interventions to reduce meat consumption, due to either health or environmental concerns.

Reducing meat consumption

Given the increasing world population, the UN Food and Agriculture Organization estimated that the world would need to produce around 50% more food in our current food system by 2050 (FAO, 2018a). An Intergovernmental Panel on Climate Change (IPCC) special report stated that the increase in food production may generate some significant environmental impacts, including more greenhouse gas emissions and loss of biodiversity (Mbow et al., 2019). There is rising evidence that

meat consumption has a negative impact on human health and the environment. Academic research (Fehrenbach et al., 2015) along with the 2015-2020 Dietary Guidelines for Americans (USDA, 2015) have suggested that most US consumers exceed the recommended level of meat consumption. Excess of red meat consumption, especially processed meat, is associated with increasing risk of health conditions such as Type 2 diabetes, coronary heart disease and obesity (Micha et al., 2010; Pan et al., 2011; Rouhani et al., 2014). As research findings continue to support adverse health consequences of meat intake, US consumers report in surveys that they have been reducing (or hope to reduce) the amount of meat they consume (Neff et al., 2018). However, from an environmental perspective, consumers' willingness to reduce meat consumption is generally low (Hartmann and Siergrist, 2017). People willing to change their meat consumption for environmental reasons represent a minority. When it comes to mitigating climate change, reducing meat consumption is not a major motivation compared to other non-food related activities like driving less (Sanchez-Sabate and Sabaté, 2019). A survey by Food Insight showed that consumers struggle to know whether their food choices are environmentally sustainable, thus environmental concerns may represent the least purchase driver compared to other factors such as health, taste and price (Food Insight, 2019).

Animal agriculture production could create pollution under improper management practices, including greenhouse gas emissions (GHG) and methane (McMichael et al., 2007). In fact, livestock activities represent 14.5% of all anthropogenic GHG emissions coming from enteric fermentation from ruminants' animals, with cattle being the main source of livestock emissions (FAO, 2013). Different foods produce different amounts of carbon pollution. In general, beef and lamb have the largest kilograms of CO₂ emissions per 100g protein, followed by

cheese, pork and chicken. On the other hand, plant-based foods such as fruits, vegetables, nuts and peas have the smallest environmental impact in terms of GHG emissions and land use (Poore and Nemecek, 2018). Although producers are a critical part in alleviating the effect of climate change and reducing GHG emissions, research shows that not only the way in which food is produced and distributed matter, but also what consumers choose to eat (Garnett, 2011). In other words, consumers' dietary patterns play a crucial role in mitigating climate change.

Shifting to a variety of sustainable dietary patterns has brought environmental and public health benefits to some populations (Aleksandrowicz et al., 2016). For example, Nelson et al. (2016) concluded in their systematic review that lower animal-source foods and higher plant-based food' diets are associated with lesser environmental impact, including GHG emissions, energy, land and water used. Approaches used to reduce the health and environmental impact of meat consumption include the implementation of regulatory fiscal instruments such as carbon taxes on meat products, and behavioral interventions such as the Meatless Monday campaign implemented in New York City public schools (Bonnet et, al., 2020; Meatless Monday, 2019). Another instrumental approach involves the provision of information associated with the health and environmental benefits of reducing meat consumption. In this regard, the effectiveness of several strategies has been tested using experiments. For example, social norms (dynamic norm) have proven effective in increasing consumers' interest in meatless lunch orders (Sparkman and Walton, 2017). Also, by manipulating participants' goals, researchers have helped them form a higher intention to reduce meat consumption despite their strong habit of eating meat (Rees et al., 2018). Experimental studies have explored the effects of message framing on reducing meat consumption, with the results being mixed (Harguess et al.,

2020). For example, Carfora et al., (2017) examined the impact of consumers' meat reduction intention when additional intervention components were added to the informational messages. They found that participants who received information on recommended processed meat consumption through daily text messages reduced self-reported consumption of processed meat compared to participants who did not receive the text messages. Likewise, Vainio et al., (2018) found that participants who read health and climate messages highlighting the negative effects of red meat and the positive effects of plant-based alternatives intended to reduce meat consumption and increase the consumption of plant-based alternatives. On the other hand, Verain et al. (2017) found no effects of health and sustainable diets' messages when targeting pro-self and average consumers.³ The authors suggested that information provision may increase consumers' awareness of the issues but may not result behavioral intention changes.

As research showed, providing information could help increase consumers' awareness and influence the acceptance of meat alternatives at a certain degree; strategies like nudging, message framing, and marketing campaigns could give consumers the opportunity to make healthier and sustainable food choices (Weinrich, 2019). Even though reducing meat consumption is not directly linked to increasing plant-based meat's purchases, the appearance of plant-based alternatives may offer consumers new choices.

³ Pro-self consumers view products' pro-self attributes such as price, taste and health more important than average consumers. Average consumers view pro-self attributes and sustainability attributes as average in importance for all product categories.

Preferences for meat alternatives

The Food and Agriculture Organization (FAO) of the United Nations define sustainable diets as “diets with low environmental impact which contribute to food and nutrition security and to healthy life for present and future generations” (FAO, 2012). Plant-based protein requires fewer resources than animal-based protein, thus the diet transition could help reduce the burden on land use, fresh-water resources and biodiversity (Aiking, 2011). In recent years, major food companies and start-ups have made substantial investments in the research and development of plant-based meat (Yaffe-Bellany, 2019). The protein ingredients used in developing meat alternatives are perhaps the most important components. Meat alternatives are primarily plant-based food products that contain soy protein, cereal protein, legume protein and mycoprotein, with soy proteins being the most commonly used type of protein and legume proteins (e.g., pea, lentil, mung bean) gaining popularity (Bohrer, 2019). Meat alternatives have been created to resemble the texture, flavor and appearance of meat products. Nowadays, consumers can find meat alternatives at grocery stores and restaurant chains like Burger King, White Castle and TGI Fridays throughout the United States. Popular plant-based meat products in the marketplace include brands like Beyond Meat, Impossible Foods, MorningStar Farms (Kellogg’s), Boca (Kraft Foods), Gardein (Pinnacle Foods) and LightLife (Maple Leaf Foods) (Guedim, 2017). Several companies that produce meat alternatives are already providing information to consumers on the environmental benefits that accompany their products. According to Beyond Meat and a study conducted by the University of Michigan, the production of Beyond Burger uses significantly less water, land, energy and generates less greenhouse gas emissions than a regular beef burger (Beyond Meat, 2020; Heller and Keoleian, 2018). Impossible Foods has also shown their concern about reducing

environmental impact as well as upgrading their Impossible Burger to make it healthier (Impossible Foods, 2020). However, in terms of nutrition, some studies suggest that novel plant-based meat alternatives should not be viewed as a true nutritional replacement for animal meat, and consumers should take into account what other foods are routinely consumed at different life stages (e.g., infancy and pregnancy) before replacing meat with plant-based alternatives (van Vliet et al., 2020).

In spite of the highly valued meatless options in the industry, meat alternatives are not being purchased by most consumers on a regular basis. By using a hypothetical choice experiment to elicit consumers' preferences for plant-based meat, cultured meat, and beef burgers, Slade et al. (2018) found that almost two thirds of participants would still prefer to buy a beef burger if prices among the three products were equivalent. Similarly, Van Loo et al. (2019) conducted a choice experiment to study the effects of brand names, environmental and technology production information on consumers' purchase intention of conventional beef, lab-based meat alternatives, plant-based meat with pea protein, and plant-based meat with animal-like protein. Their findings showed that information had only minor effects on market share and meat alternatives may not replace conventional meat even at price discounts. These results suggest that livestock production still play a critical role in current markets with meat alternatives fitting better into niche markets. The difficulty to establish broad acceptance of meat alternatives is partly explained by consumers' unfamiliarity with the product, perceived product quality and food neophobia (Hoek et al., 2011). In fact, Hoek et al. (2011) showed that non-meat substitutes' users and light meat substitutes' users are unfamiliar with the products and tend to believe meat substitutes have less sensory attractiveness compared to meat. Individuals' attitudes

towards meat substitutes could be driven by the link between the products' value and its characteristics. If consumers are not looking for the benefiting features of meat alternatives, then they would not be attracted by the products.

While consumers may not pick meat alternatives as their first choice, researchers have explored ways to encourage meatless meals and promote more sustainable diets. Meat alternatives are not normally eaten individually like in sensory panels. They are usually cooked in a dish as part of a bigger meal. That is, while meat alternatives' taste and texture could determine consumers' eating experience, meal context could influence the acceptance of meat alternatives (Elzerman et al., 2011). Hoek et al. (2013) used a long-term in-home test (over 10 weeks) to examine consumers' acceptance of relatively new products like meat alternatives in a meal pattern. The authors suggested that repeated exposure to meat alternatives might increase acceptance by some consumers but initial liking and willingness to try the products are crucial. Compared to meat products, the unfamiliarity with meat alternatives may restrain consumers' acceptance and in turn decrease meat alternatives' orders in restaurants. Attwood et al. (2020) used two hypothetical online studies to test whether the price-based decoy effect could encourage consumers to select plant-based alternatives instead of meat-based items. The authors manipulated the decoy presence in a series of menus. However, the findings from both studies showed no significant treatment effect on consumers choices of sustainable vegetarian diets compared to meat-based meals. They pointed out that the null effects may be due to the hypothetical nature of the studies.

In summary, previous experimental studies indicate that nudges, in the form of informational messages, can help promote healthier and sustainable diets. Relatively few studies have examined the effectiveness of information on meat and plant-based

meat choices during real-life grocery shopping experience. Furthermore, it is important to note that consumer preferences are not fixed, and they may change after having better knowledge and more complete information about meat and meat alternatives. In our shopping task, subjects are asked to make purchases for an entire meal rather than a single meat or plant-based meat product; this is intended to resemble consumers' real-life experience when preparing their meals. Furthermore, our real incentivized experiment provides insights into meat and plant-based meat to academic research and the industry as most of the previous studies have used hypothetical methods (i.e., hypothetical surveys and experiments).

Methods

Experimental Design

Our main research question is whether regular meat eaters would switch from purchasing meat to plant-based meat after being exposed to health and environmental messages. To answer this question, we implement a between-subjects design with three treatments and a control condition. The treatments differ in the type of information that is presented next to the meat and plant-based meat products via descriptive messages: health, environment, or combination of both (see Figure 1). The health message (N=27) emphasizes the health benefits of consuming less meat; the following message is displayed on the computer screen when participants are choosing between meat and plant-based meat products: “To reduce your risk of diabetes by 40%,⁴ eat one less serving of meat every day (The Economist, 2019)”. Likewise, the message in the Environment treatment (N=29) highlights the environmental impact of lower meat intake by displaying the following message: “To

⁴ Percentage is relative to the health risk on consuming one serving of vegetables.

reduce your environmental impact by 40%*,⁶ eat one less serving of meat every day (The Economist, 2019)”. The Combined treatment (N=31) combines the information from the health and environmental messages as follows: “To reduce your risk of diabetes and help reduce the environmental impact by 40%, eat one less serving of meat every day (The Economist, 2019)”. All treatment messages are framed relative to the health risk and environmental impact of consuming one serving of vegetables. Furthermore, diabetes, rather than other cardiovascular disease, is used in the health message in order to keep the impact of the reduction in meat consumption constant across treatments (i.e., 40% reduction in health and environmental impact). Finally, the control group receives no information when making the purchasing decisions.

Figure 1. Meat/plant-based meat choice task with health, environment and combined messages.

⁶ Percentage is relative to the environmental impact of consuming one serving of vegetables.

Participants

A total of 122 participants are recruited through bulk emails and flyers at campus main facilities (see Appendix A1 for recruitment material). The sign-up process takes place 2 weeks before the experiment starts. To be eligible, participants have to be at least 18 years old, consume meat on a regular basis (i.e., consume 4 ½ servings of red meat per week, Kolata, 2019), and be willing to pick up their payment at the University's parking lot the next day after completing the experiment. Approval from the University's Institutional Review Board (IRB) is obtained prior to data collection and written informed consent is acquired from participants at the beginning of the experiment. Participants are informed that they would receive \$5 in cash plus two food products purchased during the study as compensation. The cost of the bundle (approximately \$10) is deducted from an additional \$17 endowment received at the beginning of the experimental session; that is, subjects do not have to cover the cost of the food products out of their pocket.

Experimental Procedures

Subjects who qualified for the study receive a Zoom invite via email. The experimental sessions are conducted through Zoom, with each session lasting approximately 30 minutes. A total of 36 sessions are conducted at different times throughout the day (from 9:00 am to 6:00 pm) in order to minimize time-of-the-day effects.⁵ The treatments are randomized at the session level where participants in the same session receive the same treatment. To reduce social gatherings and increase payment pickup rate,⁶ participants are asked to report their preferred pickup time slot

⁵ Participants' physical and emotional states may vary depending on the time of the day, which in turn may affect their decision-making (Gullo et al., 2019).

⁶ We followed public health directives to prevent the spread of the coronavirus disease by asking participants to stay in the car during their curbside pickup; both participants and experimenters wore face masks at all times.

in the survey and curbside pickup their payment the next day after completing the experiment (between 12pm to 5pm).⁷ Data was collected starting December 7 of 2020 and was resumed on April 15 of 2021.⁸

Upon joining the Zoom session, participants are asked to read and sign a consent form. They are then issued an anonymous identification number to be used as their identity throughout the session. Instructions are read aloud by the experimenter where participants are given information on the experimental tasks they would perform and the payment structure. All participants receive a \$5 fixed participation fee and an additional \$17 endowment to be used for purchasing food products in the shopping task. The experiment is non-hypothetical in nature, meaning that two out of the four food products that participants purchase during the shopping task are randomly selected for payment. If participants do not spend all of the endowment, then the rest of the amount goes back to the experimenter. After ensuring that all participants understand the experimental instructions, they are provided a Qualtrics link in the Zoom's chat box to enter the online experimental grocery supermarket and are asked to complete the study right away after leaving the Zoom meeting. Data confidentiality is emphasized, and the experimenters' contact information is provided to subjects in case they have any questions about the study, their payment, and/or their rights as participants.

During the experiment, participants complete four tasks in the following order: a) a non-hypothetical grocery shopping task; b) two implicit association tests, the first aimed to measure participants' implicit association between meat/plant-based meat and healthiness, and the second test aimed to measure the association between

⁷ Pick up rate for payments was 95%.

⁸ We had a total 112 participants as of December 2020 and we stopped data collection because of holidays and the Covid-19 situation. Data collection was resumed in April 2021. At the end of data collection, our sample size increased to 147 participants total.

meat/plant-based meat and environmental impact; and c) a survey to collect their socio-demographic and behavioral characteristics.

The grocery shopping task is adapted from Lars et al. (2020) which consists of purchasing four food products in four different categories. At the beginning of the shopping task, participants are provided with a shopping list. The list consists of four categories of food items including vegetables, carbohydrates, sauces and meat/plant-based meat, and participants are asked to purchase one product from each category.⁹ These four categories are presented in the same order across subjects, with the order mimicking the way in which the category items are displayed in a real grocery shopping setting (e.g., vegetables are often located at the entrance of the store, packaged and canned items are mostly placed in the center aisles and meat/dairy section are at the back of the store) (Hutchinson, 2017). Furthermore, each product is displayed with its name, front image, brand and price. All products in the experiment are commercially available at physical grocery stores and prices are the same as in the stores (at the moment of the experiment). We select products commonly used by consumers in the US, making sure there is no overlap between product categories (i.e., tomatoes vs. red pasta sauce). The same number of varieties (four) is available for each product type, for a total of twelve available options for each category; that is, subjects have a wide variety of selection to choose from. Different kinds of broccoli, mushrooms and sweet peas are available for the vegetable's category. Sliced bread, penne pasta and rice are categorized as carbohydrates, and mayonnaise, red pasta sauce and curry are provided under the sauce category. Lastly, burger patties, chicken and sausages are made available in the meat/plant-based meat category. Participants

⁹ Consumers' preferences for meat and plant-based meat may differ depending on the way the products are offered; for example, whether the product is consumed alone or as part of a dish (Elzerman et al., 2011). Thus, the shopping task is framed as grocery shopping for different ingredients required to prepare a meal.

have four options for each type of meat/plant-based meat with two conventional meat and two plant-based meat products. To account for the order in which meat and plant-based meat product images are presented on the screen, we randomize the display order across subjects; that is, half of the subjects see the meat products on the left-hand side of the screen and plant-based meat products on the right-hand side, and the other half are presented the two types of products in the opposite order. Since the study aims to examine the effect of health and environmental messages on consumers' meat/plant-based meat purchasing behavior, messages are displayed at the top left of the meat/plant-based meat's section/screen in order to make it salient to the subject.¹⁰ The grocery shopping task is incentivized. Subjects are endowed \$17 at the beginning of the shopping task and are notified that they would use the \$17 endowment to purchase four food products from the four categories (vegetables, carbohydrates, sauces and meat/plant-based meat). The \$17 endowment is calculated based on the summation of the highest product prices from the four food category. The next day after the experiment, subjects are asked to curbside pickup the two food products they purchased during the shopping task along with their \$5 participation fee at the University's parking lot.¹¹

Following the shopping task, participants are asked to complete two implicit association tests (IATs), which are intended to measure people's mental associations between target pairs (e.g., insects vs. flowers) and category attributes (e.g., pleasant vs. unpleasant) via a stimulus sorting task (Greenwald et al., 1998). The IAT has been previously used to study implicit associations in a variety of research areas such as

¹⁰ Findings from experimental studies using eye tracking has shown that Westerners read following a "Z" pattern. People fixate the most in the top left position and tend to choose the products located at the top right position most frequently (Palma et al., 2016; Segovia et al., 2020).

¹¹ All food products are purchased the morning after the session to maintain freshness. Bundles are prepared and sanitized by experimenters, and products are placed in brown lunch bags containing participants' identification number.

preferences between brand food products and generic food products (Friese et al., 2006), prejudice (Fazio and Olson, 2003), consumers attitudes towards fruit juices and sodas choices (Maison et al., 2001), among others. In our study, the first IAT allows us to elicit participants' mental association between meat/plant-based meat and healthiness. The IATs are conducted through the platform iatgen, which consists of seven blocks with three practice blocks and four critical combined blocks (Carpenter et al., 2019). One type of combined block is referred to as the compatible block which represents meat (plant-based meat) paired with healthy (unhealthy) attributes, whereas the other type of combined block is referred to as the incompatible block and represents meat (plant-based meat) paired with unhealthy (healthy) attributes. Subjects are asked to place their hands on the computer keyboard and press either the "E" or "I" key to sort the word or image on the screen (see Figure 2). The seven blocks are: 1) practice block showing only target (meat and plant-based meat); 2) practice block showing categories only (healthy and unhealthy); 3) practice incompatible combined block; 4) critical incompatible combined block; 5) another practice block with the side of categories reversed; 6) practice compatible combined block; and 7) critical compatible combined block. Subjects always complete both combined blocks (compatible and incompatible blocks) as part of the procedure in random order. For example, if the subject perceives plant-based meat to be healthier than meat, then the compatible block refers to meat (plant-based meat) and unhealthy (healthy), while the incompatible block represents meat (plant-based meat) and healthy (unhealthy). That is, the person should respond faster when using the same key for meat and unhealthy attributes and the other key for plant-based meat and healthy attributes. Conversely, if the subject perceives meat to be relatively healthier than plant-based meat, then the compatible block refers to meat (plant-based meat)

and healthy (unhealthy) attributes, while the incompatible block represents meat (plant-based meat) and unhealthy (healthy) attributes. Thus, the person should respond faster when using the same key for meat and healthy and the other key for plant-based meat and unhealthy attribute. People tend to respond slower when pairings are reversed in the incompatible block, as they need to override their mental associations. Therefore, the main outcome in this test represents the difference in participants' response time between compatible and incompatible blocks. If participants respond faster in one condition relative to the other, this is indicative of an association at the implicit level.

The second IAT measures subjects' implicit association between meat/plant-based meat and sustainability (see Figure 3). The same process as that used for the first IAT is implemented, but in this case the category attributes refer to the environmental impact of meat/plant-based meat purchases. That is, the compatible block represents meat (plant-based meat) and sustainable (unsustainable) attributes, while the incompatible block refers to meat (plant-based meat) and unsustainable (sustainable) attributes. The IATs are a relative measure as they do not reveal whether meat or plant-based meat are implicitly associated with healthy/unhealthy and sustainable/unsustainable in absolute terms. Instead, the IATs show which target (meat/plant-based meat) is seen as relatively healthier/unhealthier and more sustainable/unsustainable at the implicit level. The results from the two IATs not only help us explain participants' preferences for meat and plant-based meat but also measure participants' mental association between these two types of products and their healthy and environmental impact attributes. To account for ordering effects, we randomize the order of the two IATs across subjects; that is, half of the subjects first complete the test associated with healthiness followed by the test associated with

sustainability; the other half complete the tests in the opposite order. The list of attributes used in the IATs are displayed in Table B1. The attributes for the health IAT are chosen based on health benefits or costs associated with consuming meat/plant-based meat products, whereas the attributes for environment IAT are selected according to the environmental benefits or negative consequences of meat production and consumption.

After completing the two IATs, subjects fill out a survey regarding their purchasing behavior and attitudes towards the consumption of meat and plant-based meat as well as their socio-demographic characteristics. A manipulation check is included in the survey to test whether participants saw the messages in the treatments. At the end of the experiment, the computer randomly selects two purchased food products for payment and subjects are asked to select their availability between 12pm to 5pm on the next day to curbside pickup their payment. Information required to curbside pickup are reminded again. Subjects are asked to text or call the experimenters with their identification number when they arrive at the University's parking lot based on their reported time and then payment is brought to the participants' car. The two food products are packed in a brown lunch bag along with the \$5 participation fee placed in an envelope. The complete experimental protocol can be found in Appendix A2.

Figure 2. Example of one of the health IAT blocks.

Figure 3. Example of one of the environment IAT blocks.

Hypotheses

Since meat alternatives are relatively new in the market, the relationship between meat alternatives and health/environmental impact has not been explored yet. By implementing our online supermarket experiment, we aimed to test the following hypotheses. Hypotheses *1a-1c* are focused on the treatment effects on plant-based meat purchases. We expect that providing health and/or environmental information of reducing meat consumption would steer regular meat eaters to purchase plant-based meat alternatives. Hypotheses *2a* and *2b* elicit participants' implicit association

between meat/plant-based meat and healthiness and sustainability. We are not looking at the treatment effects on IATs but rather using subjects' implicit association (if any) to support the observed treatment effects found in hypothesis 1.

Hypothesis 1

H1a: Information on the health benefits of reducing meat consumption increases the proportion of plant-based meat purchases compared to the Control.

Hypothesis 1 is in line with previous evidence suggesting that human health is the primary motivation for people to reduce meat consumption (Clonan et al., 2015; Hopwood et al., 2020; Neff et al., 2018). We expect the provision of information on the health benefits of reducing meat consumption to have a positive effect on plant-based meat purchases.

H1b: Information on the environmental benefits of reducing meat consumption increases the proportion of plant-based meat purchases compared to the Control.

Graham et al. (2017) showed that information provision on the environmental impact of meat consumption is associated with a lower intention to consume meat. Similarly, Cordts et al. (2014) found a positive effect on meat reduction when participants are presented with information about the negative environmental impact of meat consumption. In line with previous evidence, we expect that providing environmental information can steer individuals toward purchasing plant-based meat compared to the control group with no information.

H1c: Information that combines the health and environmental benefits of reducing meat consumption increases the proportion of plant-based meat purchases compared to the Control.

Health and environmental benefits of meat intake reduction are significant factors in consumer's decision-making (Cheah et al., 2020). Wolstenholme et al.

(2020) showed that participants who received messages on the health and environmental impacts of red and processed meat consumption reduced their meat intake significantly more than the control condition (no message). Thus, compared to the control group, we expect that providing both health and environment related messages would raise the levels of concern about meat consumption and increase purchases of plant-based meat alternatives. Moreover, we hypothesize that combining the health and environmental messages would have a stronger treatment effect than presenting both messages separately.

Hypothesis 2

H2a: There is an implicit association between meat (plant-based meat) and healthiness (unhealthiness).

Previous evidence has shown that omnivores often perceived meat products to be healthier than meat alternatives in terms of protein and fat content (Michel et al., 2021). Ruby (2012) found that omnivores have positive attitudes toward meat associated primarily with its luxury status, taste and good health attributes. The IAT scores allows us to measure subjects' homegrown preferences for meat and plant-based meat products; that is, the preferences subjects bring to the experiment (in the absence of a manipulation). Based on the literature, we expect to see an implicit association between meat and healthiness.

H2b: There is an implicit association between meat (plant-based meat) and unsustainability (sustainability).

Meat eaters often agree that vegetarian diets are better for the environment as they recognize the environmental benefits of avoiding animal products, including the reduction of greenhouse gas emissions (Bryant, 2019). This perception is observed mainly among female consumers as they show higher concerns about the

environmental impact of meat consumption compared to men, who care mostly about the hedonic aspects of meat consumption (Michel et al., 2021; Tobler et al., 2011). Thus, we expect participants (meat eaters) to exhibit a negative implicit association between meat products and environmental impact.

Results and Discussion

Descriptive analysis

Table 1 describes the sample population and provides a balance check across treatments. Around 76% of participants are female, with an average age of 34 years old. Our sample's median age is 30 years old which is a relative younger population, but higher than the median age of 28 years old for Columbia, Missouri where the experiment was conducted (Data USA, 2018). Since the recruitment process was conducted mainly at the University's campus, most of the subjects happen to be affiliated with the University either as students, staff or faculty members. About 85% of subjects report being the primary grocery shopper of their household, with an average household size of 2.47 members and average household income of \$59,918.¹² By design, all of our participants are regular meat eaters (consume meat at least 4 ½ servings a week) with around 30% of them consuming meat every day of the week, and 63% eating meat at least 3 times per week or more. Approximately, 73.8% of subjects identify themselves as White, 13.9% as Asian and 5.7% as African American.¹³ In terms of subjects' demographic characteristics, our sample is balanced across treatments, showing successful randomization of the treatments ($p \geq 0.10$ for all Kruskal-Wallis tests). As manipulation check, we asked participants to indicate

¹² Our sample represents the US consumers' population as average (Walmart) shoppers are mainly females with an annual household income of \$56,482 (Peterson, 2016).

¹³ Of the remaining 6.6%, 4.92% identify themselves as "other" race, and 0.82% as Native American or Hispanic.

whether they saw the health and/or environmental messages displayed on the screen during the shopping task. We exclude 25 participants who did not see the treatment information (i.e., health/environment or combined message), leaving us with 122 observations to be used in the analyses (see Table B2 in Appendix B for detailed sample size by treatments and sessions).

Table 1. Balance Test across Treatment Groups

Variable	Description	Mean (Std. Err.)	Mean (Std. Err.)	Mean (Std. Err.)	Mean (Std. Err.)	Mean (Std. Err.)	Kruskal- Wallis tests
		All Sample	Control	Health	Environment	Combined	<i>p-values</i>
Male	DV = 1 if male, 0 otherwise	0.24 (0.04)	0.20 (0.07)	0.26 (0.09)	0.28 (0.08)	0.23 (0.08)	0.90
Age	Age in years, 18-71 years	33.89 (1.25)	35.97 (2.23)	33.11 (2.82)	34.21 (2.87)	31.90 (2.25)	0.42
Household size	Number of people in the household, 1-6 people	2.47 (0.13)	2.63 (0.26)	2.48 (0.29)	2.76 (0.27)	2.00 (0.19)	0.18
White	DV = 1 if Caucasian, 0 otherwise	0.74 (0.04)	0.80 (0.07)	0.67 (0.09)	0.76 (0.08)	0.71 (0.08)	0.66
African American	DV = 1 if African American, 0 otherwise	0.06 (0.02)	0.06 (0.04)	0.04 (0.04)	0.07 (0.05)	0.06 (0.04)	0.96
Asian	DV = 1 if Asian/Pacific Islander, 0 otherwise	0.14 (0.03)	0.09 (0.05)	0.22 (0.08)	0.10 (0.06)	0.16 (0.07)	0.42
Other race	DV = 1 if Native American, Hispanic or other race, 0 otherwise	0.07 (0.02)	0.06 (0.04)	0.07 (0.05)	0.07 (0.05)	0.06 (0.04)	0.99
High school	DV = 1 if High school diploma or less, 0 otherwise	0.05 (0.02)	0.03 (0.03)	0.04 (0.03)	0.10 (0.06)	0.03 (0.03)	0.49
College degree	DV = 1 if Bachelor's degree, Associate's degree or Some college, 0 otherwise	0.43 (0.05)	0.37 (0.08)	0.52 (0.10)	0.41 (0.09)	0.45 (0.09)	0.70
Graduate school	DV = 1 if Graduate school, or Some graduate school, 0 otherwise	0.52 (0.05)	0.60 (0.08)	0.44 (0.10)	0.48 (0.09)	0.52 (0.09)	0.65
Republican party	DV = 1 if Republican party, 0 otherwise	0.17 (0.03)	0.26 (0.07)	0.04 (0.04)	0.14 (0.07)	0.23 (0.08)	0.11
Democratic party	DV = 1 if Democratic party, 0 otherwise	0.40 (0.04)	0.40 (0.08)	0.41 (0.10)	0.45 (0.09)	0.35 (0.09)	0.91
Other political party	DV = 1 if political other than Republican or Democratic, 0 otherwise	0.43 (0.04)	0.34 (0.08)	0.56 (0.10)	0.41 (0.09)	0.42 (0.09)	0.70
No political affiliation	DV = 1 if no political affiliation, 0 otherwise	0.33 (0.04)	0.29 (0.08)	0.41 (0.10)	0.31 (0.09)	0.32 (0.09)	0.78
Income	Average yearly income	59917.71 (3826.07)	60999.67 (6944.54)	52962.69 (7736.09)	69309.98 (7993.68)	55967.44 (8060.31)	0.42
N		122	35	27	29	31	

Notes: Mean comparisons are tested using Kruskal-Wallis rank tests.

Our main outcome is whether regular meat eaters would switch from purchasing animal meat to plant-based meat products when they are exposed to health and/or environmental messages in the online shopping task. Hypotheses 1a-1c state that the Health, Environment, and Combined treatments will have a positive effect on the proportion of plant-based meat purchases compared to the control condition.

Although we expect that providing information on the health and environmental benefits of reducing meat consumption would increase plant-based meat purchases, based on our findings, we reject hypotheses *1a* and *1c*. Yet, there is a weakly significant difference in the proportion of plant-based meat purchases in the Environment treatment compared to the Control.

Result 1

Relative to the Control, there are not significant treatment effects in the proportion of plant-based meat purchases for the Health and Combined treatments. Whereas, there is a weakly significant and positive effect of the Environment treatment on the proportion of plant-based meat purchases.

Figure 4 shows the proportion of plant-based meat purchases by treatment. Compared to the Control, there are no statistically significant treatment effects for the health and combined messages on the proportion of plant-based meat purchases. These results show that providing information about the health benefits of reducing meat consumption, and its combination with environmental information, do not motivate subjects to increase their purchases of plant-based meat products. This supports the finding by Tonsor, Lusk and Schroeder (2021) that showing consumers nutritional information of beef burgers and plant based (Beyond) burgers does not affect their food selection. In particular, the authors found that among all consumers, only 27% chose the Beyond Meat option; this estimate decreases to 18% when considering only regular meat eaters. Among meat eaters in our sample population, only 18.52% and 16.13% decided to purchase a plant-based alternative when being exposed to the health and combined messages, respectively.

Previous literature has shown that providing health-related information offers consumers flexibility to make food purchasing decisions that work best in their

interests and not controlling for specific behaviors. In this regard, Barreiro-Hurlé et al. (2010) indicated that nutritional fact panels or claim labels could promote consumer's choice of healthier food products. Likewise, Wisdom et al. (2010) showed that providing calorie information can help reduce calorie intake. Ideally, information provision would influence consumer choices and nudge them to be well-informed about their choices when making their own trade-offs. However, studies also suggested that the actual use of health and nutritional information during consumers' food purchases may be low. According to Cowburn and Stockley (2005)'s systemic review, consumers only understand some of the terms used in nutritional labelling and are confused by other types of information such as the role that different nutrients mentioned on labels played in their diet, or converting metrics (e.g., g per 100g) to serving sizes. Moreover, several of the studies in the related literature rely on self-reported measures, making it difficult to reflect how consumers behave when they are making real food purchasing decisions. In our study, around 61% of subjects have never purchased plant-based meat products before, which suggests that plant-based meat alternatives may not be familiar to them. Thus, our information provision intervention may not be as effective as approaches used in other studies with commonly consumed food products (Rusmevichientong et al., 2014).

While previous studies have shown that consumers appear to be more concerned about health than the environment when it comes to meat consumption reduction (Clonan et al., 2015; Neff et al., 2018), our findings show a significant and positive effect on the proportion of plant-based meat purchases only in the Environment treatment. A potential explanation for this discrepancy is that previous studies looking at the effects of environmental impact on food choice have used stated preference methods that usually do not require individuals to actually change their

behavior. While prior research suggests that personal health message framing is more successful in motivating meat consumption reduction than environment related framing, Fesenfeld et al. (2021) found no robust evidence in people's actual behavioral change. The authors stated that despite health framed messages increasing individuals' concern about the impact of meat and fish consumption, these increased levels of concern did not translate into changes in behavioral intentions, willingness to pay, and demand-side policy support. A potential reason for this effect, noted by the authors, is the use of hypothetical surveys rather than field experiments to investigate the impact of strategic framing on behavioral intentions. In our non-hypothetical experiment, participants are incentivized to purchase either meat or plant-based meat products; therefore, our message interventions aimed to reveal their true preferences based on their purchasing decisions. Another possible reason for the mixed results in the literature relates to individuals' anticipated emotions. Consumers' decision-making processes may be influenced by anticipated guilt and pleasure of making or not making certain pro-environmental decisions (Rezvani et al., 2017). Ye and Mattila (2021) suggested that using a social appeal advertisement (e.g., "Good for the environment and animal welfare") was more effective in increasing demand for plant-based burgers compared to a health appeal (e.g., "Good for your health-no cholesterol and more fiber"). The authors stated that a social appeal can increase consumers' anticipated pleasure by eliciting the feelings of doing something good for the society, which in turn increases consumers' preferences for plant-based burgers. That is, promoting social benefits can increase consumers' anticipated pleasure steering them towards the desired behavior.

On the other hand, a potential explanation for the ineffectiveness observed in the Health treatment relates to individuals' skepticism of whether plant-based meat

products are healthier than conventional meat as plant-based meat may give the impression of being highly processed foods (Capritto, 2019; Fernstrom, 2019). Current news articles report that people are cautious about the ingredients included in the production of plant-based meat products. For example, The Impossible Whopper seems to be lower in calorie content, but it contains more sodium than the regular (meat) Whopper burger as well as other highly processed ingredients (Ewing-Chow, 2020; Roos, 2019). In addition, the health benefits of reducing meat consumption used in the current study are based on the reduction of risk of diabetes, which may be thought of as less beneficial in the meat consumption context compared to sugar intake. According to a report by the Centers for Disease Control and Prevention (CDC), 10.5% of the US population has been diagnosed with diabetes (CDC, 2020). Although the likelihood that subjects in our sample population suffer from diabetes is low, it is possible that the health message was perceived as useless for those already combating diabetes. Taken together, our findings from the Health and Combined treatments indicate that health-related information is not sufficient to steer consumers towards purchasing plant-based meat alternatives, whereas the environmental message seems to be more effective when presented separately.

Figure 4. Proportion of plant-based meat purchases by treatment.

Notes: Values on y-axis indicate the proportion of plant-based meat purchases during the online shopping task; * $p < 0.1$; proportion comparisons are performed using proportion tests.

Result 2a

There is an implicit association between meat (plant-based meat) and healthiness (unhealthiness) in the Combined treatment and Control. Whereas, there is an implicit association between meat (plant-based meat) and unhealthiness (healthiness) in the Health and Environment treatments.

Implicit association is measured by comparing the sorting speed of words or images to its respective pairing groups. A standardized difference score (D-score) is calculated for each participant, indicating in which condition or block (compatible vs. incompatible) participants respond faster. A positive D-score indicates that meat is perceived as healthier than plant-based meat at the implicit level; a negative D-score indicates that meat is implicitly perceived as unhealthier than plant-based meat; and a

D-score of 0 indicates no implicit bias.¹⁴ Two participants are excluded from the analysis due to excessive speed in response time.¹⁵ The average D-score for all participants is 0.0005 (S.E.= 0.055), which implies that there is nearly no implicit bias between meat products (plant-based meat) and healthiness (unhealthiness). Figure 5 shows the results of the health implicit association test (IAT) by treatment. The positive D-scores in the Control and Combined treatment suggest an implicit association between meat (plant-based meat) and healthiness (unhealthiness) for subjects in those conditions. Whereas, the negative D-scores among subjects in the Health and Environment treatments suggest an implicit association between meat (plant-based meat) and unhealthiness (healthiness). Despite subjects in the Health treatment perceiving meat to be unhealthier than plant-based meat at the implicit level, we find that implicit association may not influence regular meat eaters' purchasing decisions between meat and plant-based meat products. That is, compared to people's mental association in terms of health benefits, other attributes such as taste and price are often key determinants when it comes to purchasing meat products (Szejda et al., 2020). Consumers are typically classified into three segments in terms of their meat consumption habits: traditional meat eaters, flexitarians (i.e., meat reducers), and vegetarians (Apostolidis and McLeay, 2016; Szejda et al., 2020). Traditional meat eaters are primarily motivated to consume conventional meat because of its taste, price and affective connection, whereas other factors such as health and environmental concerns are the primary drivers for other consumer

¹⁴ We set the two IATs in the iatgen program with compatible blocks representing meat pairs with positive attributes (healthy/sustainable); and incompatible blocks representing meat products paired with negative attributes (unhealthy/unsustainable). A D-score of 0 indicates no difference in response time between each pairing group; a positive score indicates that participants responded faster in the compatible blocks; and a negative score indicates that participants responded faster in the incompatible blocks (Carpenter et al., 2019). A list of the attributes used in both IATs can be found in Appendix B.

¹⁵ Threshold used to exclude excessive speed's participants is 10000 ms (Greenwald et al., 2003).

segments like vegetarians (Graça et al., 2015; Szejda et al., 2020). Likewise, consumers have identified freshness, naturalness, and food safety as core demand drivers for conventional meat purchases, whereas plant-based protein products are perceived as being lower in fat, cholesterol and high in fiber (Tonsor, Lusk and Schroeder, 2021). It can be seen that apart from the Health and Environment treatments, subjects who received the combined message exhibit an implicit association between meat (plant-based meat) and healthiness (unhealthiness). The Combined treatment and health IAT are positively correlated ($r = 0.08$), whereas the Health and Environment treatments are negatively correlated with health IATs ($r = -0.18$ and -0.07 , respectively). The positive correlation between the Combined treatment and health D-score indicates that participants in the Combined treatment may be less motivated to process the provided health benefits messages, while conflicting their homegrown preferences. Individuals may spend more cognitive effort on searching information and processing it when the task is motivated, whereas people's processing capability may be weaker if they see the task as less important (Guthrie et al., 2015). On the contrary, the Environment treatment results show that when presented with information on the environmental benefits of reducing meat consumption, there are significant treatment effects on the proportion of plant-based meat purchases compared to those who did not see the messages ($p = 0.09$). A possible explanation for this effect is that consumers usually respond positively to plant-based meat's ethical viewpoints such as sustainability (Hwang et al., 2020). Thus, the environmental benefit message could be effective in making consumers aware of their purchase decisions motivating them to switch to plant-based meat purchases.

Figure 5. Health IAT D-score by treatment.

Notes: Values on y-axis indicate the average D-score of each treatment in health IAT sorting task; mean comparisons are performed using Wilcoxon rank-sum tests.

Result 2b

There is an implicit association between meat (plant-based meat) and unsustainability (sustainability) in all treatments.

The results of the environment IAT are displayed in Figure 6. A positive D-score indicates that meat is perceived as more sustainable than plant-based meat at the implicit level; a negative D-score indicates that meat is perceived as less sustainable than plant-based meat implicitly; and a D-score of 0 indicates no implicit bias. The results show a negative D-score for all treatments, suggesting the presence of an implicit association between meat (plant-based meat) and unsustainability (sustainability). Generally speaking, while all participants acknowledge plant-based meat's environmental benefits in the environment IAT, the results show that people may not always act in accordance to their mental association. In this regard, Parry and Szejda (2019) noted that although consumers recognize the altruistic attributes of

plant-based products, foundational drivers such as taste, quality and convenience are more salient when making purchasing decisions. Recall that there is a weakly statistically significant effect on the proportion of plant-based meat purchases in the Environment treatment; the environment D-score supports this finding. In accordance with result 1, plant-based protein products may appeal to certain traditional meat consumers who implicitly perceive plant-based meat to be relatively more sustainable than conventional meat. These results imply that different groups of consumers are at different plant-based meat adoption stage, suggesting that the environmental message of reducing meat consumption can be seen as a bonus benefit to target consumers who are more environmentally conscious.

Figure 6. Environment IAT D-score by treatment.

Notes: Values on y-axis indicate the average D-score of each treatment in the environment IAT sorting task; mean comparisons are performed using Wilcoxon rank-sum tests.

Behavioral drivers of meat purchases

This section outlines consumers' meat and plant-based meat consumption and purchasing behaviors. Respondents were asked questions about their conventional

meat consumption and plant-based meat purchases frequency. About 30% of participants report consuming conventional meat every day of the week, 63% report consuming meat at least 3 times a week, whereas 61% have never purchased plant-based meat before.

Figure 7 displays the level of importance of various factors when purchasing meat products across treatments. Except for the health factor ($p = 0.06$ in Kruskal-Wallis test), the importance level for all other attributes does not differ across treatments ($p > 0.10$ in all Kruskal-Wallis tests). Unsurprisingly, the importance level that regular meat eaters place on taste and price remains the top two among all participants (4.43 and 4.03, respectively).¹⁶ Followed by taste and price, participants rank health attributes as the third important factor when it comes to purchasing meat products. Average importance scores are 3.83 for health, 3.61 for product familiarity, 2.93 for animal welfare, and 2.91 for environmental concerns. This result is supported by previous research showing that altruistic benefits such as animal welfare and environmental impact are often the least influential drivers of purchasing behavior among traditional meat consumers (Parry and Szejda, 2019). Therefore, to appeal to regular meat eaters, an effective nudge message should emphasize the benefits of animal meat being present in plant-based meat products such as having a similar taste and price accompanied by additional health and environmental benefits.

¹⁶ Response categories for important factors when purchasing meat products: 1= not at all important; 2= slightly important; 3= moderately important; 4= very important; 5= extremely important.

Figure 7. Level of importance of factors when purchasing meat products by treatment.

Figure 8 shows participants' favorable views on various food production technologies by treatment.¹⁷ The level of favorability towards the four food technologies does not differ across treatments ($p > 0.10$ in all Kruskal-Wallis tests). Overall, participants have a stronger preference for local food (4.27) than the other three food technologies.¹⁸ While organic food is indicated as the second favorable food technology (3.53), participants' attitudes fall between neither favorable nor unfavorable, and somewhat favorable. On average, participants' views on genetically modified food and lab grown food are between somewhat unfavorable and neither favorable nor unfavorable (2.91 and 2.39, respectively). This result supports the finding by Slade (2018) that consumers typically hold favorable views of local food, a lesser degree toward organic food, and generally unfavorable views for genetically

¹⁷ We did not provide specific information describing each food production technology.

¹⁸ Response categories for views on food technologies: 1= extremely unfavorable; 2= somewhat unfavorable; 3= neither favorable nor unfavorable; 4= somewhat favorable; 5= extremely favorable.

modified and processed foods. A detailed description of the treatment effects on plant-based meat purchases after controlling for behavioral variables is discussed in the next section.

Figure 8. Favorable views towards four food technologies by treatment.

Econometric analysis

In this section, we estimate several logistic regressions to investigate the treatment effects on plant-based meat purchases; the results are presented in Table 2. In the shopping task, participants were asked to purchase either meat or plant-based meat along with three other choice sets of grocery items. The logistic regression models can be expressed as:

$$Y_{is} = \beta_0 + \beta_1 Health_i + \beta_2 Environment_i + \beta_3 Health*Environment_i + \beta_4 X_n + \varepsilon_{is}$$

where the dependent variable, Y_{is} , is a dummy variable representing the probability that individual i purchases plant-based meat in the online shopping task. While the variables $Health_i$ and $Environment_i$ are treatment dummies, the combined message variable, $Health*Environment$, is denoted as an interaction term between the Health

and Environment treatments due to the fact that the combined message is provided with the same information from the health and environment messages ($Control_i$ is the excluded category); X_i is a vector of behavioral and socio-demographic characteristics, and ε_{is} is an error term i.i.d logistic distributed. The standard errors are clustered at the session level given that participants in the same session received the same treatment and several sessions per treatment were implemented. The specification in column (1) considers only the treatments as predictors; the specification in column (2) includes the treatments and health and environment IATs covariates; the specification in column (3) controls for behavioral variables such as important factors when purchasing meat as well as food technologies; and the specification in column (4) controls for socio-demographic characteristics.

The results from specification (1) shows a positive and significant coefficient for the Environment treatment, suggesting that providing subjects with information on the positive impact of meat reduction on the environment increases their likelihood of purchasing plant-based meat relative to the Control. However, this effect disappears when controlling for behavioral and demographic factors. Estimates from column (2) show a negative and significant coefficient for the health IAT score, which indicates that people who implicitly associate meat with healthiness (health IAT increases) are less likely to purchase plant-based meat products compared to those who did not purchase plant-based meat. This finding is expected as people who perceive meat to be healthier than plant-based meat might be less likely to purchase a similar alternative with relatively less health benefits and potentially higher price.

Regarding the behavioral factors influencing plant-based meat purchases (column 3), we find the environmental factor coefficient to be positive and significant, suggesting that individuals who consider the environmental impact of

meat as very important when purchasing meat products are more likely to purchase plant-based alternatives.¹⁹ In contrast, taste has a negative and significant effect, meaning that if people perceive taste to be extremely important when buying meat products, they are less likely to purchase plant-based meat products. Taste seems to remain the number one barrier for plant-based meat purchases as most consumers place high expectations on the taste of alternatives to be as similar as meat (Devenyns, 2019). That is, if plant-based protein was to be viewed more favorably by consumers in terms of taste and texture, it could become a stronger substitute for animal meat products. Furthermore, there is a negative and significant coefficient for plant-based meat purchases frequency, meaning that subjects who have never purchased plant-based meat before are less likely to purchase plant-based meat products relative to those who purchase such products more than once a month.

We also estimate logit models that include food production technologies to understand consumers' attitudes and their comfortability with plant-based meat products which are considered another novel food technology (Slade, 2018). The significant coefficient for genetically modified food favorability shows that subjects are less likely to purchase plant-based meat if they are somewhat favorable to this food technology.²⁰ Splitter (2019) found that the lack of a non-GMO label does not affect people's purchase decisions of plant-based foods and a non-GMO claim is not highly correlated with consumers' purchasing intentions. Conversely, lab grown food favorability has a positive and significant effect, which suggests that subjects are

¹⁹ Response categories for important factors when purchasing meat products are split by median: health, price, taste and familiarity with the food product factors (1= extremely important; 0= very important or less). Environmental impact and animal welfare factors (1= very important or higher; 0= moderately important or less).

²⁰ The food technologies response categories used in estimation are split by median: local food & organic food (1= extremely favorable; 0= somewhat favorable or less); genetically modified food & lab grown food (1= somewhat favorable or more; 0= neither favorable nor unfavorable or less).

more likely to purchase plant-based meat if they have at least a somewhat favorable view about lab grown food. Although lab grown meat is not currently commercially available, it is the most relevant product in terms of lab grown food.²¹ Studies exploring consumer's willingness to try lab grown meat have found mixed responses, which may depend on the sample population, framing of questions, and descriptions of lab grown meat (Wilks and Phillips, 2017; Hocquette et al., 2015; Slade, 2018). For example, Bryant and Barnett (2019) showed that consumer acceptance of lab grown meat is partly dependent on the name of the product. They found that consumers have more positive attitudes towards "clean meat" than "animal free meat" or "lab grown meat". Overall, consumers are willing to try lab grown meat, but only a small portion would choose it over animal meat or other types of meat alternatives. Findings from the study by Arora et al. (2020) suggested that respondents are willing to pay a premium for plant-based meat and lab grown meat; however, those premiums differ across consumer segments. Likewise, Bryant and Sanctorem (2021) found that 21.8% of consumers have positive views towards both plant-based meat and lab grown meat, whereas 41.5% have positive views towards only one of the two. Therefore, the spread of responses across different segments demonstrates the need for a variety of alternative proteins that target different groups accordingly.

Previous studies have shown that plant-based meat appeals to younger generations who tend to have greater health and environmental concerns, and likely to live in larger households with higher education level and growing income (Siegrist and Hartmann, 2019; Szejda et al., 2020; Tonsor et al., 2021). In our study, we found only political affiliation to have a positive and significant effect on plant-based meat purchases. Recall that we control for the order effects by randomizing the display

²¹ Lab grown meat is made by taking stem cells from an animal tissue in the lab (Schaefer, 2018).

order of meat and plant-based meat in the shopping task. The negative and significant coefficient for the order variable indicates that subjects are less likely to purchase plant-based meat products if plant-based meat alternatives are displayed in the right column. This means that the right position is farther to the messages as it aligns with the eye tracking evidence indicating that people fixate the most in the top left position (Palma et al., 2016; Segovia et al., 2020).

Lastly, in order to account for heterogeneous effects on meat/plant-based meat purchasing behaviors, we conduct a latent class analysis which is discussed in the next section.

Table 2. Estimates of Logit Regressions on Plant-based Meat Purchases

Dependent variable	Probability of purchasing plant-based meat products			
	(1)	(2)	(3)	(4)
Health message	0.886 (0.685)	0.54 (0.757)	1.478* (0.817)	1.288 (0.933)
Environmental message	1.222* (0.724)	1.076 (0.797)	1.229 (0.801)	0.611 (1.204)
Combined message	0.718 (0.658)	0.704 (0.716)	0.490 (0.797)	0.000 (1.433)
Health IAT ^a		-1.412*** (0.486)	-0.826* (0.45)	-1.581 (1.29)
Environment IAT ^a		-0.195 (0.687)	0.206 (0.744)	1.060* (1.141)
Meat consumption frequency ^b			1.360 (1.018)	0.863 (1.376)
Plant-based meat purchases frequency ^b			-1.964* (1.004)	-2.356** (1.193)
<i>Important factors when purchasing meat products^b</i>				
Health			0.318 (0.977)	-0.041 (1.279)
Environment			1.422** (0.632)	2.485* (1.306)
Price			-0.196 (0.644)	-0.844 (0.906)
Taste			-1.314** (0.633)	-1.828 (1.386)
Animal welfare			0.992 (0.889)	0.445 (1.089)
Familiarity with the product			0.118 (0.911)	0.329 (1.083)

Table 2. Continued.

Dependent variable	Probability of purchasing plant-based meat products			
	(1)	(2)	(3)	(4)
<i>Favorable food technologies^b</i>				
Local food			0.868 (0.633)	1.375 (1.46)
Organic food			-0.512 (0.825)	-1.696 (1.731)
Genetically modified food			-2.898** (1.171)	-4.600* (2.379)
Lab-grown food			2.566* (1.529)	4.166* (2.291)
<i>Demographics</i>				
Male				0.826 (1.607)
Age				-0.035 (0.056)
Household size				0.030 (0.217)
White ^c				-0.309 (0.766)
Higher education ^d				0.467 (1.076)
Democratic party				17.558*** (2.426)
Other political party				18.883*** (3.431)
No political affiliation				17.200*** (2.917)
Average income				0.000 (0.000)
Order				-2.522* (1.310)
Constant	-2.367*** (0.615)	-2.512*** (0.705)	-2.510** (1.226)	-17.443*** (1.583)
N Observations	122	120	120	120
Log-Likelihood	-52.898	-47.183	-3.871	-30.848

Notes: Standard errors are clustered at the session level; ***p < 0.01, **p < 0.05, *p < 0.1.

^a A positive D-score indicates that meat is perceived as healthier/sustainable than plant-based meat at the implicit level; a negative D-score indicates that meat is implicitly perceived as unhealthier/unsustainable than plant-based meat; a D-score of 0 indicates no bias.

^b Response categories are split by median (1= values above median; 0= median or below).

^c Race variable is split between White and Non-white due to small sample size for other race categories

^d Higher education variable includes bachelor's degree, some graduate school and graduate school.

Bachelor's degree represents the median education level. Results hold if using high school diploma or less, college degree and graduate courses or more as separate categories.

Latent class analysis

In addition to studying consumers' probability of purchasing plant-based meat in response to the treatment messages, we use a latent class approach to understand the differences in a set of behavioral characteristics across various consumer segments.²² Latent Class Analysis (LCA) can help us identify the hidden population subgroups based on individuals' multiple behavioral characteristics. LCA models assume that the population is not homogeneous but consists of a number of unobserved categorical variables such as the latent classes, which are measured by other observed interrelated categorical factors (Collins and Lanza, 2010). In our study, for example, health benefits, environmental impact, price, among other potential factors, might affect the likelihood of consumers purchasing meat/plant-based meat products.

Latent Class Analysis has been previously used to investigate theoretical concepts that cannot be directly observed by researchers such as motivation. For example, Coffman et al. (2007) conducted a latent class analysis to classify high school seniors into four distinct groups based on their drinking motivations and behaviors. Their findings highlight the importance of designing interventions to reduce alcohol-related harm that target different classes of high school seniors. Likewise, Segovia and Palma (2016) estimated a latent class analysis to segment consumers based on observable health related attributes, including food purchasing habits and health status. Two latent classes were identified and characterized as: "Health Conscious" and "Health Redeemers". "Health Conscious" consumers, those

²² Due to the absence of treatment effects for the Health and Combined treatments, and weakly significant effects of the Environment treatment on meat purchases, we conduct a latent class analysis to study the heterogenous effects of meat/plant-based meat preferences across consumer segments. However, we acknowledge the fact that we ignore the presence of the treatments in the LCA model estimation, thus, conclusions are made with precaution.

with healthy lifestyles, were willing to pay price premiums for domestic and local-specialty tomatoes, but did not express price premiums for the health benefits of the products. In contrast, “Health Redeemers” expressed price premiums for healthy products, perhaps to compensate for their unhealthy lifestyles. In addition, LCA has been used in choice experiments to capture heterogeneity in consumers’ food preferences. Ortega et al. (2011) identified four latent classes based on Chinese consumers’ attitudes towards food safety attributes in pork products. They found that consumers were willing to pay a premium for a government certification program that assured the product was inspected for safety, these effect was exhibited in particular among members in the “Certification Conscious” and “Worried Consumers” classes. Likewise, Peschel et al. (2019) segmented consumers into four classes according to their personality traits to explain consumer choices of Medjool dates. The authors found that consumers with higher levels of openness toward originality preferred more production method labels and people whose personality traits are kindness and trustworthiness had no difference in their choice behaviors. In addition, extraverted consumers tend to prefer more food labels, while being conscientious consumers lead to fewer attributes’ choice patterns.

We estimate a Latent Class Analysis to determine whether indicators of observed variables could help identify subgroups of meat eaters with different meat/plant-based meat purchasing behaviors. We use LCA Stata Plugin to conduct the analysis (Lanza et al., 2018). Suppose we estimate a latent class model with $s=1, \dots, k \dots S$ classes from a set of J observed categorical indicators. The number of possible outcomes associated with the variable j is represented by M_j for individuals $i=1, \dots, n$. The individual i ’s responses to the J observed indicators are denoted by $Y_{ij} = (Y_{i1}, \dots, Y_{iJ})$, where the possible values of Y_{ij} are $m=1, \dots, M_j$. Let $I(y_{ij} = m)$ be the

indicator function that is equal to 1 when j variable equals to m response, and 0 otherwise. The probability density function of an individual response pattern is:

$$\begin{aligned} Y_i \sim f_i(y_i; \varphi) &= \sum_{s=1}^S \pi_s f_{i|s}(y_i; \theta_s) \\ &= \sum_{s=1}^S \pi_s \prod_{j=1}^J \prod_{m=1}^{M_j} (\theta_{jm|s})^{I(y_{ij}=m)} \end{aligned}$$

where $\pi = (\pi_1, \dots, \pi_S)$ are the class membership probabilities, and the conditional density functions $f_{i|s}(\cdot)$ are the probability of response m_j to indicator j given the membership in latent class s . The parameters of the component densities, $\theta = (\theta_1, \dots, \theta_S)$ represent the indicator-response probabilities for each class. The purpose of the LCA is to estimate the parameters φ which correspond to probabilities of class-membership and indicator-response (π, θ) given the values of Y and a value of S provided by the analyst. The likelihood function for φ can be expressed as:

$$\mathcal{L}(\varphi|Y) = \prod_{i=1}^n f_i(y_i; \varphi)$$

where the corresponding parameters φ has been estimated through the maximized log-likelihood function, the n individuals are classified into the S classes by assigning each individual to the class with the highest probability (Collart, 2013).

We implement the LCA following two procedures: 1) choose the number of latent classes; and 2) characterize the latent classes. First, a sequence of latent class models with two to nine classes are estimated. The log-likelihood values, Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and adjusted BIC estimates for each model are presented in Table 3. The minimum AIC and adjusted BIC statistics favor a 3-class model, whereas the minimum BIC statistic favors a 2-class model. When the criteria differ, AIC often tends to be overfitting while BIC tends to be underfitting (Collart, 2013). Importantly, when the sample size is small, the most likely error is underfitting, favoring the use of AIC (Dziak et al., 2012). Furthermore, the estimated class-membership probabilities for the 2-class model are

61.09% and 38.91%, whereas the estimated class-membership probabilities for the 3-class model are 24.41%, 34.28% and 41.3%. As discussed by Lanza et al. (2007), the size of each class should be distinguishable from the others based on their probabilities. Therefore, given the estimated values of the information criteria and the estimated class-membership probabilities, a 3-class model is chosen for our analysis.

Table 3. Comparison of Latent Class Models

Number of latent classes	Log likelihood at convergence	Likelihood ratio	AIC ^a	BIC ^b	Adjusted BIC
2	-555.6	150.7	184.7	232.4	178.6
3	-545.2	129.8	181.8	254.7	172.5
4	-539.1	117.7	187.7	285.8	175.1
5	-533.1	105.7	193.7	317.0	177.9
6	-524.7	88.9	194.9	343.5	175.9
7	-522.5	84.5	208.5	382.4	186.4
8	-520.1	79.7	221.7	420.8	196.3
9	-510.5	60.5	220.5	444.8	191.9

Notes: ^a AIC (Akaike Information Criterion); ^b BIC (Bayesian Information Criterion).

After selecting the appropriate number of classes, we identify and characterize each class. Table 4 shows the estimated class-membership probabilities and indicator-response probabilities, along with a description of the observables used in the model. The observed indicator variables correspond to participants' characteristics of purchasing meat/plant-based meat and are chosen based on their: 1) indicated important factors when purchasing meat products; 2) plant-based meat purchases frequency; and 3) meat consumption frequency.²³ The latent class-membership

²³ Response categories for important factors when purchasing meat products are split by median to focus on specific consumers who view such factors as really important. Health, price, taste and familiarity with the food product factors (2= extremely important; 1= very important or less). Environmental impact and animal welfare factors (2= very important or higher; 1= moderately important or less). Plant-based meat purchases frequency and meat consumption frequency are also split by median. Plant-based meat purchases frequency (2= purchase plant-based meat more than once a month; 1=never); and meat consumption frequency (2= consume meat every day of the week; 1= 6 times a week or less).

probabilities identify 24.41% of individuals as members of Class 1, 34.28% as members of Class 2, and 41.3% as members of Class 3. The indicator-response probabilities represent the probability of observed indicator variables for each latent class. For example, there is a 75.2% probability that participants in Class 1 consume meat every day of the week and only 5.4% of them purchase plant-based meat more than once a month. Moreover, 57.3% and 72.9% of participants in this class indicate price and taste factors of meat products as being extremely important when purchasing meat, respectively. 9.4% and 11.1% of subjects in Class 1 consider health concerns and their familiarity with the product as being extremely important, whereas only 1.9% and 12.1% of them indicate environmental impact and animal welfare, respectively, as very important factors when purchasing meat. On the contrary, individuals in Class 2 have only a 4.5% probability of consuming meat every day of the week and a 53.9% probability of purchasing plant-based meat more than once a month. In general, participants in Class 2 seem to be more conscious about their meat purchasing decisions. They show strong concern about meat products' health, environmental impact and animal welfare attributes with probabilities of 40.5%, 70% and 61.5%, respectively. However, the price and taste of meat products are slightly less important for individuals in Class 2. The characteristics of individuals in Class 3 place them in between Class 1 and Class 2. Specifically, 23.2% of subjects in Class 3 consume meat every day of the week and 45.4% purchase plant-based meat more than once a month. While 12.4%, 10.3% and 17.3% of participants in Class 3 indicate health, environmental impact and animal welfare as at least very important factors when purchasing meat, respectively; their concerns about price, taste and familiarity with the product are not as high as those of subjects in Classes 1 and 2 (7.4%, 23% and 7.7%, respectively). Therefore, given the characteristics of each class, we refer to

members in Class 1 as “Meat lovers”, Class 2 as “Health and environment conscious” and Class 3 as “Flexitarians”.

Table 4. Latent Class Parameter Estimates for Three-Class Model

		Class 1	Class 2	Class 3
		Latent class-membership probabilities		
		24.41%	34.28%	41.30%
Variable	Definition	Indicator-response probabilities		
Health	Indicated health factor as extremely important	0.094	0.405	0.124
Environmental impact	Indicated environmental impact factor very important or higher	0.019	0.700	0.103
Price	Indicated price factor as extremely important	0.573	0.506	0.074
Taste	Indicated taste factor as extremely important	0.729	0.661	0.230
Animal welfare	Indicated animal welfare factor very important or higher	0.121	0.615	0.173
Familiarity with the product	Indicated familiarity with the product factor as extremely important	0.111	0.258	0.077
Plant-based meat purchases frequency	Purchase plant-based meat more than once a month	0.054	0.539	0.454
Meat consumption frequency	Consumed meat every day of the week	0.752	0.045	0.232

Table 5 shows a description of demographic characteristics, views toward food technologies, and implicit association scores between meat and healthiness/sustainability by latent class.²⁴ The average age for subjects in Classes 2 and 3 is around 35 years old, with subjects in Class 1 being slightly younger (around 31 years old). All classes are composed mostly of females, with Class 1 having the highest proportion of males among the three classes. Percentages of primary shoppers are over 80% for all classes. Regarding education level, individuals in Class 3 are the most educated as this class includes the highest percentage of participants with a bachelor’s degree and graduate courses or more. Classes 1, 2 and 3 are mainly composed by Caucasian individuals (92.59%, 65.85% and 70.37%, respectively). Political affiliation differs between each latent class. Compared to Classes 2 and 3, Class 1 has the highest percentage of people affiliated with the Republican Party (33.33%) and with no political affiliation (37.04%). Class 2 is mainly composed by participants affiliated with the Democratic Party and no political affiliation (51.22%

²⁴ Implicit associations are measured using the D-scores obtained from the health and an environment implicit association tests.

and 26.83%, respectively). While Class 3 also includes participants affiliated with the Democratic Party and no political affiliation (44.44% and 35.19%, respectively), but it has a slightly higher percentage of participants affiliated with the Republican Party than Class 2. Relative to Classes 1 and 3, households in Class 2 are larger and have a higher yearly household income. Average yearly household income for Classes 1, 2 and 3 is \$58,518, \$60,853, and \$59,907, respectively. In addition to socio-demographic characteristics, participants' views of food technologies and their implicit association between meat and healthiness/sustainability allow us to explain differences in meat purchasing behaviors across segments. While subjects in Class 2 favor local and organic foods the most, those in Class 1 and Class 3 exhibit a preference for genetically modified food and lab-grown food, respectively. Regarding the two IATs, individuals in Class 1 implicitly associate meat (plant-based meat) with healthiness/sustainable (unhealthiness/unsustainable); however, participants in Class 2 perceive meat (plant-based meat) to be unhealthy and unsustainable (healthy/sustainable) at the implicit level. Subjects in Class 3 exhibit an implicit association between meat (plant-based meat) and healthiness (unhealthiness), whereas they implicitly associate meat (plant-based meat) with unsustainability (sustainability).

Table 5. Demographic, Viewpoint towards other food technologies, and IAT scores by Latent Class

Variable	Category	Meat lovers		Health and environment conscious consumers		Flexitarians	
		Mean	Percent	Mean	Percent	Mean	Percent
Age (years)	Average age	30.96		34.59		34.81	
Gender	Male		33.33		12.20		27.78
Education	Higher education		66.67		70.73		77.78
Race	White		92.59		65.85		70.37
Political affiliation	Republican party		33.33		9.76		14.81
	Democratic party		14.81		51.22		44.44
	Other political party		14.81		12.20		5.56
	No political affiliation		37.04		26.83		35.19
Household size (individuals)		2.59		2.66		2.26	
Yearly household income (\$)	Yes	58,518		60,853		59,907	
Primary shopper			81.48		82.93		88.89
Local food	Favorable to local food	4.15		4.34		4.28	
Organic food	Favorable to organic food	3.15		3.85		3.48	
Genetically-modified food	Favorable to genetically-modified food	3.41		2.51		2.96	
Lab-grown food	Favorable to lab-grown food	2.48		2.12		2.54	
Health IAT	D-score	0.197		-0.204		0.062	
Environment IAT	D-score	0.104		-0.228		-0.164	

Notes: ^a Race variable is split between White and Non-white; ^b Higher education variable includes bachelor's degree, some graduate school and graduate school; ^c With 1 being extremely unfavorable to 5 being extremely favorable; ^d A positive D-score indicates that meat is perceived as healthier/sustainable than plant-based meat at the implicit level; a negative D-score indicates that meat is perceived as unhealthier/unsustainable than plant-based meat implicitly.

Figure 9 shows the proportion of plant-based meat purchases by latent class.

There is a statistically significant difference between Class 1 and 2, with a higher proportion in plant-based meat purchases among subjects in Class 2 ($p=0.04$ in proportion test). Similarly, the proportion of plant-based meat purchases is higher for subjects in Class 3 compared to those in Class 1 ($p=0.07$ in proportion test). However, there is no significant difference between Classes 2 and 3.

The LCA results show that preferences towards both conventional meat and plant-based meat products vary across consumers and can be described by three distinct segments. The results are in agreement with previous studies showing that consumers can be classified into three groups: traditional meat consumers, flexitarians (meat reducers), and vegetarians (Apostolidis and McLeay, 2016; Szejda et al., 2020;

Verain et al., 2012). Participants in Class 1 (24.41%) indicate price and taste to be the most important factors when purchasing meat, but they are less concerned about the health, environmental impact and animal welfare attributes associated with the products. This group of people represent traditional meat eaters who are typically driven by the price and taste of products. Relative to Classes 2 and 3, Class 1 includes mostly males, which is in line with evidence suggesting that males consume more meat and often hold more positive attitudes towards meat products compared to females (Dowsett et al., 2018; Kubberod et al., 2002; Latvala et al., 2012; Yen et al., 2008). Moreover, the results of the two IATs for individuals in Class 1 are aligned with their indicated important factors. Subjects in Class 1 implicitly associate meat (plant-based meat) with healthiness/sustainability (unhealthiness/unsustainability); this aligns with their higher (lower) meat consumption (plant-based meat purchases) frequency among three classes. Importantly, this subgroup presents the lower proportion of plant-based meat purchases in the shopping task.

In contrast to Class 1, participants in Class 2 (34.28%) express higher attention for each factor particularly for health, environmental impact and animal welfare. Moreover, individuals in Class 2 consume less meat and purchase plant-based meat products more frequently than those in class 1. Although all of our sample are regular meat eaters (i.e., consume meat at least 4 ½ servings a week) and they cannot be referred to as vegetarians, Class 2 appears to be more conscious about their meat/plant-based meat purchases. Apostolidis and McLeay (2016b) found that “Healthy eaters” and “Green consumers” are composed mainly of females with higher income level and more favorable views of organic food, which align with our findings for Class 2. The political affiliation of Class 2 is consistent with the finding by Bryant et al. (2019) that the more liberal people intent to purchase more plant-based meat in

the US. Recall that Class 2 is composed of individuals with lower meat consumption and higher frequency of plant-based meat purchases. This aligns with their implicit association of meat being relatively unhealthy/unsustainable than plant-based meat, and the high proportion of plant-based meat choices observed among this group. Regarding Class 3 (41.3%), subjects hold weaker opinions for each factor and share similar meat consumption and plant-based meat purchasing frequency as those in Class 2. In addition, the proportion of plant-based meat purchases is significantly higher than Class 1 but similar to Class 2. Individuals in Class 3 exhibit similar behaviors as those of flexitarians who are more open to reduce their meat consumption and are more driven by health and environmental concerns (Neff et al., 2018). Similar to the findings by Hoek et al. (2004), Class 3 is mainly composed of females who have higher education level and earn a higher income.

Overall, the LCA results demonstrate the complexity of meat and plant-based meat preferences across consumer segments. Whether it is reducing meat consumption or switching to purchasing plant-based meat products, such segmentation implies that policy makers and food marketers should adopt different message approaches to target their desired audience.

Figure 9. Proportion of plant-based meat purchases by latent class.

Notes: Values on y-axis indicate the proportion of plant-based meat purchases during the online shopping task; ** $p < 0.05$; * $p < 0.1$; proportion comparisons are performed using proportion tests.

Conclusion and Implications

Given the increasing popularity of meat alternatives, researchers, investors and the media have begun to investigate consumers' preferences for meat and alternative proteins (e.g., plant-based, lab grown). By using a non-hypothetical online experiment, we examine whether regular meat eaters would switch to purchasing plant-based meat products when they are exposed to health and/or environmental messages on reducing meat consumption. We find the environmental message to be an effective instrument for nudging regular meat eaters towards plant-based meat alternatives. While previous studies have shown that consumers appear to be more concerned about health than the environment when it comes to meat consumption reduction (Clonan et al., 2015; Neff et al., 2018), we find no significant effects for the Health or Combined treatments. A potential explanation for this discrepancy in findings relates to the method used to elicit such preferences; that is our experiment

required participants to actually change their behavior which differs to hypothetical approaches used by previous studies. Another possible explanation for the effectiveness of environmental messages is the fact that the social appeal of highlighting the environmental benefits of purchasing plant-based meat increases consumers' anticipated pleasure and elicit feelings of doing something good for the society (Ye and Mattila, 2021).

We also elicit subjects' implicit association between healthiness and environmental impact of meat and plant-based meat products by implementing two implicit association tests. We find that, on average, meat eaters implicitly perceive meat to be healthier but environmentally unsustainable compared to plant-based meat products. In accordance with the significant Environment treatment effect, plant-based meat alternatives may appeal to certain traditional meat eaters who implicitly perceive plant-based meat to be relatively more sustainable than conventional meat. The results imply that the environmental impact message of reducing meat consumption can be seen as an extra benefit to target consumers who are more environmentally conscious and eventually drive their purchasing decisions. Moreover, the logit regressions indicate that people who implicitly associate meat with healthiness are less likely to purchase plant-based meat products; however, individuals who consider environmental impact as a very important factor when purchasing meat are more likely to purchase plant-based alternatives. Although individuals in our sample consume meat on a regular basis, people's attitudes and preferences toward meat and plant-based meat are heterogeneous. In general, taste and price are the main drivers for consumers to purchase conventional meat. This aligns with the logit regression result that subjects who perceive taste to be extremely

important when buying meat products are less likely to purchase plant-based meat products.

To better understand heterogeneity in food preferences among regular meat eaters, we conduct a latent class analysis to segment participants based on their: 1) indicated important factors when purchasing meat products; 2) plant-based meat purchases frequency; and 3) meat consumption frequency. Three latent classes were identified. Subjects in Class 1 (24.41%) represent traditional meat eaters who are mostly males and are typically driven by the price and taste of products. Class 1 presents the lowest proportion of plant-based meat purchases in the shopping task. In accordance with their food preferences, they implicitly associate meat (plant-based meat) with healthiness/sustainability (unhealthiness/unsustainability). On the contrary, participants in Class 2 (34.28%) appear to be the most conscious about their meat/plant-based meat purchases. Class 2 is composed mainly of higher income females with the highest proportion of plant-based meat choices observed among three classes in the shopping task. In line with their plant-based meat purchases, Class 2 implicitly perceive meat (plant-based meat) to be unhealthy/unsustainable than plant-based meat products. Regarding Class 3 (41.3%), they behave more like flexitarians who are open to reducing their meat consumption and are more driven by health and environmental concerns. In the shopping task, Class 3's proportion of plant-based meat purchases is significantly higher than Class 1 but similar to Class 2; however, individuals in Class 3 implicitly perceive meat to be healthier but environmentally unsustainable compared to plant-based meat products. Taken together, when using information messages as nudges, adopting a clear consumer segment approach may be more effective in increasing plant-based meat selection. For example, to target traditional meat consumers like subjects in Class 1, similarities

between meat and plant-based meat products in terms of price and taste may need to be salient. However, Classes 2 and 3 can be seen as the group of consumers potentially willing to change their diets. Therefore, they represent a key population to promote healthier and sustainable food choices. Messages about the health benefits and environmental impact of reducing meat consumption, along with lower price of plant-based meat products and better taste, may be more effective to encourage these types of consumers to change their dietary habits.

Our study provides four contributions to the literature. First, we test the effectiveness of health and/or environmental messages on consumers' meat/plant-based meat purchases in a non-hypothetical incentivized setting. That is, our experiment reflects consumers' real-life online grocery shopping behavior, allowing us to elicit their true preferences for meat and plant-based meat products. Second, our findings provide insights to policy makers and food marketers as to how consumers respond to different informational nudges in the context of reducing meat consumption. We conclude that a general intervention involving the provision of information associated with the health and environmental benefits of reducing meat consumption may not be effective for all meat eaters. In fact, our results suggest that providing only health-related information is not attractive enough to nudge consumers to purchase plant-based meat products. Meat eaters' preferences towards meat/plant-based meat are complex and vary across segments. For example, compared to health and environmental mindful individuals, traditional meat eaters are mostly driven by the taste and price of the products. When framing the information message for this group, the fundamental factors such as similar taste and lower price should be highlighted first prior to adding health and environment-related information. However, it is possible that consumer preferences can change, particularly when more

consumers are able to taste plant-based meat alternatives and are more familiar with the products. Our third contribution relates to the two implicit association tests we use to elicit consumers' implicit associations between meat/plant-based meat and health and environmental impact attributes. Previous studies have used implicit association tests for examining healthy food choices' hedonic attributes such as healthiness and tastiness (Werle et al., 2013). Yet, our experiment brings in this methodology to understand consumers' implicit health and environmental impact perceptions toward meat and plant-based meat alternatives. Finally, our study demonstrates the heterogeneity of meat/plant-based meat preferences among meat eaters by using a latent class analysis. The LCA results show that meat eaters can be described by distinct segments, whereas previous research usually categorize consumers into traditional meat eaters, vegetarians and flexitarians (Apostolidis and McLeay, 2016; Szejda et al., 2020). While conventional meat often represents the main source of protein in people's meals, the continuing innovation of plant-based meat products' manufacturing technologies such as taste improvement along with lower price may attract health and environment conscious meat eaters such as members of Class 2.²⁵ That is, when plant-based alternatives represent a stronger protein option for these individuals, the use of health and environmental messages may be more effective in guiding their food choices and steering them towards plant-based meat alternatives.

The present study represents one of the few research exploring consumers' meat/plant-based meat preferences under real economic incentives. A limitation of

²⁵ According to a panel discussion with industry experts hosted by the AAEEA (Agricultural & Applied Economics Association) FAMPS and AEM Sections, companies representing plant-based meat alternatives acknowledged their barriers in terms of price and taste. They indicated that their efforts are put into improving their product and expecting to be able to scale up production by increasing demand and eventually reducing prices. On the contrary, the traditional meat sector stated their efforts to reduce the environmental impact of livestock production and are concerned about the exaggerate product claims that may mislead consumers (The Meatless Revolution: A Panel with Industry Experts, 2021).

this study is the relatively small sample size by treatment. The non-hypothetical experiment component along with the public health directives due to the COVID-19 pandemic created challenges during the recruitment processes such as limited recruiting locations and lack of motivation from consumers to participate. Thus, the limitation of our sampling process may restrict our findings to be generalizable to the US population at a certain degree as most of the subjects are affiliated to the University. Furthermore, we recognize the methodological challenges of conducting the latent class analysis without taking into account the presence of the manipulations. We note that our findings need to be taken with precaution as they may be confounded by the treatment messages presented at the beginning of the experiment.

While plant-based meat alternatives have been available in the market for some time, these new generation meat alternatives haven't been explored in real incentivized online settings. Future research can examine the effectiveness of behavioral nudges such as the presence of sustainable labeling on the products, ingredient lists or controlling for taste and price factors when framing the messages. Moreover, it is worth conducting comparative studies in European and Asian markets given the differences in meat consumption habits across different cultures. Finally, with more plant-based meat alternatives available in the market, it would be interesting to see whether the demand for conventional meat, plant-based meat, and lab grown meat would change given the availability of more meatless alternatives.

References

- Aiking, H., 2011. Future protein supply. *Trends in Food Science & Technology* 22 (2-3), 112-120
- Aleksandrowicz, L., Green, R., Joy, E. J. M., Smith, P., Haines, A., 2016. The Impacts of Dietary Change on Greenhouse Gas Emissions, Land Use, Water Use, and Health: A Systematic Review. *PLoS ONE* 11 (11), e0165797
- Apostolidis, C., McLeay, F., 2016. It's not vegetarian, it's meat-free! Meat eaters, meat reducers and vegetarians and the case of Quorn in the UK. *Social Business* 6 (3), 267–290
- Apostolidis, C., McLeay, F., 2016b. Should we stop meating like this? Reducing meat consumption through substitution. *Food Policy* 65, 74–89.
- Arora, R. S., Brent, D. A., Jaenicke, E. C., 2020. Is India ready for alt-meat? Preferences and willingness to pay for meat alternatives. *Sustainability (Switzerland)* 12 (11)
- Attwood, S., Chesworth, S. J., Parkin, B. L., 2020. Menu engineering to encourage sustainable food choices when dining out: An online trial of priced-based decoys. *Appetite* 149, 104601
- Barreiro-Hurle, J., Gracia, A., Magistris, T. de., 2010. Does nutrition information on food products lead to healthier food choices? *Food Policy* 35 (3), 221–229
- Becker, M. W., Bello, N. M., Sundar, R. P., Peltier, C., Bix, L., 2015. Front of pack labels enhance attention to nutrition information in novel and commercial brands. *Food Policy* 56, 76-86
- Beyond Meat. 2020. Our impact. Available at: <https://www.beyondmeat.com/about/>
- Beyond meat. 2020. Our Ingredients. Available at: <https://www.beyondmeat.com/about/our-ingredients/>

- Bohrer, B. M., 2019. An investigation of the formulation and nutritional composition of modern meat analogue products. *Food Science and Human Wellness* 8 (4), 320-329
- Bonnet, C., Bouamra-Mechemache, Z., Réquillart, V., Treich, N., 2020. Viewpoint: Regulating meat consumption to improve health, the environment and animal welfare. *Food Policy*, in press
- Bryant, C. J., 2019. We can't keep meating like this: Attitudes towards vegetarian and vegan diets in the United Kingdom. *Sustainability*, 11 (23)
- Bryant, C. J., Barnett, J. C., 2019. What's in a name? Consumer perceptions of in vitro meat under different names. *Appetite* 137, 104–113
- Bryant, C., Barnett, J., 2018. Consumer acceptance of cultured meat: a systematic review. *Meat Science* 143, 8–17
- Bryant, C., Sanctorem, H., 2021. Alternative proteins, evolving attitudes: Comparing consumer attitudes to plant-based and cultured meat in Belgium in two consecutive years. *Appetite*, 161
- Bryant, C., Szejda, K., Parekh, N., Desphande, V., Tse, B., 2019. A survey of consumer perceptions of plant-based and clean meat in the USA, India, and China. *Frontiers in Sustainable Food Systems* 3, 11
- Burton, S., Creyer, E. H., Kees, J., Huggins, K., 2006. Attacking the Obesity Epidemic: The Potential Health Benefits of Providing Nutrition Information in Restaurants. *American Journal of Public Health* 96 (9), 1669-1675
- Butcher, T., Collins, C., Rollo, M. E., McCaffrey, T. A., De Vlieger, N., Van der Bend, D., Truby, H., Perez-Cueto, F. J.A., 2016. Nudging consumers towards healthier choices: a systematic review of positional influences on food choice. *British Journal of Nutrition*, 115 (12), 2252-63

Cadario, R., Chandon, P., 2019. Viewpoint: effectiveness or consumer acceptance? Tradeoffs in selecting healthy eating nudges. *Food Policy* 85, 1–6

Cadario, R., Chandon, P., 2020. Which Healthy Eating Nudges Work Best? A Meta-Analysis of Field Experiments. *Marketing Science* 39 (3), 465-486

Campbell-Arvai, V., Arvai, J., Kalof, L., 2014. Motivating Sustainable Food Choices: The Role of Nudges, Value Orientation, and Information Provision. *Environment and Behavior* 46 (4), 453-475

Capritto, A., 2019. Impossible Burger vs beef: Which is healthier?. CNET. Available at: <https://www.cnet.com/health/nutrition/is-the-impossible-burger-healthier-than-beef/>

Carfora, V., Caso, D., Conner, M., 2017. Randomised controlled trial of a text messaging intervention for reducing processed meat consumption: The mediating roles of anticipated regret and intention. *Appetite* 117, 152-160

Carpenter, T., Pogacar, R., Pullig, C., Kouril, M., Aguilar, S., LaBouff, J. P., Isenberg, N., Chakroff, A., 2019. Survey-software Implicit Association Tests: A methodological and empirical analysis. *Behavior Research Methods* 51, 2194-2208

CDC. 2020. National Diabetes Statistics Report, 2020. Available at: <https://www.cdc.gov/diabetes/data/statistics-report/index.html>

Cheah, I., Shimul, A. S., Liang, J., Phau, I., 2020. Drivers and barriers toward reducing meat consumption. *Appetite* 149, 104636

Clonan, A., Wilson, P., Swift, J.A., Leibovici DG., Holdsworth M., 2015. Red and processed meat consumption and purchasing behaviours and attitudes impacts for human health, animal welfare and environmental sustainability. *Public Health Nutrition* 18 (13). 2446 – 2456

Coffman, D. L., Patrick, M. E., Palen, L. A., Rhoades, B. L., Ventura, A. K., 2007. Why Do High School Seniors Drink? Implications for a Targeted Approach to Intervention. *Prevention Science* 8 (4), 241

Collart, D. A. J., 2013. *Econometric Methods to Analyze Consumer Behavior Using Hypothetical and Non-hypothetical Approaches*. Dissertation, Department of Agricultural Economics, Texas A&M University

Collins, L. M., Lanza, S. T., 2010. *Latent Class and Latent Transition Analysis: With Applications in the Social, Behavioral and Health Sciences*. Hoboken, NJ: Wiley

Cordts, A., Nitzko, S., Spiller, A., 2014. Consumer Response to Negative Information on Meat Consumption in Germany. *International Food and Agribusiness Management Review* 17 (A), 83-106

Coucke, N., Vermeir, I., Slabbinck, H., Van Kerckhove, A., 2019. Show Me More! The Influence of Visibility on Sustainable Food Choices. *Foods* 8 (6)

Cowburn, G., Stockley, L., 2005. Consumer understanding and use of nutrition labelling: a systematic review. *Public health nutrition* 8 (1), 21-28

DATA USA. 2018. Available at: <https://datausa.io/profile/geo/columbia-mo/>

Devenyns, J., 2019. How taste, protein and ingredients are barriers to plant-based meat adoption. Food Dive. Available at: <https://www.fooddive.com/news/how-taste-protein-and-ingredients-are-barriers-to-plant-based-meat-adoption/567356/>

dos Santos, Q., Nogueira, B. M., Rodrigues, V.M., Hartwell, H., Giboreau, A., Monteleone, E., Dinnella, C., Perez-Cueto, F. J., 2018. Nudging using the ‘dish of the day’ strategy does not work for plant-based meals in a Danish sample of adolescent and older people. *International Journal of Consumer Studies* 42, 327–334

Dowsett, E., Semmler, C., Bray, H., Ankeny, R. A., Chur-Hansen, A., 2018. Neutralising the meat paradox: cognitive dissonance, gender, and eating animals. *Appetite* 123, 280–288

Dziak, J. J., Coffman, D. L., Lanza, S. T., Li. R., 2012. Sensitivity and Specificity of Information Criteria. The Methodology Center. Technical Report Series #12-119, Pennsylvania State University

Elzerman, J. E., Hoek, A. C., Boekel, M. A. J. S. van., Luning, P. A., 2011. Consumer acceptance and appropriateness of meat substitutes in a meal context. *Food Quality and Preference* 22 (3), 233-240

Ewing-Chow, D., 2020. Not All ‘Meatless Meats’ Are Good For Your Health Or The Environment. Forbes Media. Available at:
<https://www.forbes.com/sites/daphneewingchow/2020/06/28/not-all-meatless-meats-are-good-for-your-health-or-the-environment/?sh=2aea427a2482>

FAO, 2018a: The Future of Food and Agriculture: Alternative Pathways to 2050. Food and Agriculture Organization of the United Nations, Rome, Italy, 228

Fazio, R. H., & Olson, M. A., 2003. Implicit measures in social cognition research: Their meaning and use. *Annual Review of Psychology* 54, 297–327

Fehrenbach, K. S., Richter, A. C., Santo, R. E., 2015. A critical examination of the available data sources for estimating meat and protein consumption in the USA. *Public Health Nutrition* 19 (8), 1358-1367

Fernstrom, M., 2019. Impossible and Beyond: Are meatless burgers really healthier?. NBC News. Available at: <https://www.nbcnews.com/know-your-value/feature/impossible-beyond-are-meatless-burgers-really-healthier-ncna1068181>

Fesenfeld, L. P., Sun, Y., Wicki, M., Bernauer, T., 2021. The role and limits of strategic framing for promoting sustainable consumption and policy. *Global Environmental Change* 68

Food and Agriculture Organization of the United Nations (FAO). 2013. Key Facts and Findings. Available at: <http://www.fao.org/news/story/en/item/197623/icode/>

Food and Agriculture Organization of the United Nations. 2012. Sustainable Diets and Biodiversity. Directions and solutions for policy, research and action. Available at: <http://www.fao.org/3/i3004e/i3004e.pdf>

Food Insight. 2019. Interest in Sustainability, Plant-Based Diets Among Trends in IFIC Foundation's 2019 Food & Health Survey. Available at: <https://foodinsight.org/interest-in-sustainability-plant-based-diets-among-trends-in-ific-foundation-2019-food-and-health-survey/>

Food Insight. 2020. Consumer Survey on Plant Alternatives to Meat Shows That Nutrition Facts Are More Influential Than the Ingredients List. Available at: <https://foodinsight.org/consumer-survey-plant-alternatives-to-meat/>

Friese, M., Wänke, M., Plessner, H., 2006. Implicit consumer preferences and their influence on product choice. *Psychology & Marketing* 23, 727–740

Garnett, T., 2011. Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)?. *Food Policy* 36 (Suppl. 1), S23-S32

Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., Falcucci, A., Tempio, G., 2013. Tackling climate change through livestock – A global assessment of emissions and mitigation opportunities. Food and Agriculture Organization of the United Nations (FAO), Rome

- Graça, J., Oliveira, A., Calheiros, M. M., 2015. Meat, beyond the plate. Data-driven hypotheses for understanding consumer willingness to adopt a more plant-based diet. *Appetite*, 90, 80–90
- Graham, T., Abrahamse, W., 2017. Communicating the climate impacts of meat consumption: The effect of values and message framing. *Global Environmental Change* 44, 98–108
- Greenwald, A. G., McGhee, D. E., Schwartz, J. L. K., 1998. Measuring Individual Differences in Implicit Cognition: The Implicit Association Test. *Journal of Personality and Social Psychology* 74, 1464–1480
- Greenwald, A. G., Nosek, B. A., Banaji, M. R., 2003. Understanding and using the Implicit Association Test: I. An improved scoring algorithm. *Journal of Personality and Social Psychology* 85, 17-216
- Guedim, Z., 2017. Lab Burger Update: The Food Industry Moves Toward Meatless Meat. EDGY Labs. Available at: <https://edgy.app/lab-burger-food-industry-meat-production>
- Gullo, K., Berger, J., Etkin, J., Bollinger, B., 2019. Does Time of Day Affect Variety-Seeking? *Journal of Consumer Research* 46 (1), 20–35
- Guthrie, J., Mancino, L., Lin, C.-T. J., 2015. Nudging consumers toward better food choices: policy approaches to changing food consumption behaviors. *Psychology & Market.* 32 (5), 501–511
- Halpern, D., 2016. Behavioural Insights and Healthier Lives. Victorian Health Promotion Foundation, Melbourne
- Hanks, A. S., Just, D. R., Smith, L. E., Wansink, B., 2012. Healthy convenience: nudging students toward healthier choices in the lunchroom. *Journal of Public Health* 34 (3), 370-376

- Harguess, J. M., Crespo, N. C., Hong, M. Y., 2020. Strategies to reduce meat consumption: A systematic literature review of experimental studies. *Appetite* 144, 104478
- Hartmann, C., Siegrist, M., 2017. Consumer perception and behaviour regarding sustainable protein consumption: A systematic review. *Trends in Food Science & Technology* 61, 11-25
- Hawkes, C., Trenton, G.S., Jewell, J., Wardle, J., Hammond, R.A., Friel, S., Thow, A. M., Kain, J., 2015. Smart food policies for obesity prevention. *The Lancet* 385 (9985), 2410-2421
- Heller, M. C., Keoleian, G. A., 2018. Beyond Meat's Beyond Burger Life cycle assessment: A detailed comparison between a plant-based and an animal-based protein source. CSS Report CSS18-10 (v3.1.). Center for sustainable systems, University of Michigan: Ann Arbor 1-38
- Herrero, M., Gerber, P., Vellinga, T., Garnett, T., Leip, A., Opio, C., Westhoek, H. J., Thornton, P. K., Olesen, J., Hutchings, N., Montgomery, H., Soussana, J-F., Steinfeld, H., McAllister, T. A., 2011. Livestock and greenhouse gas emissions: The importance of getting the numbers right. *Animal Feed Science and Technology* 166-167 (23), 779-782
- Hocquette, A., Lambert, C., Siquin, C., Peterolff, L., Wagner, Z., Bonny, S. P. F., Lebert, A., Hocquette, J. F., 2015. Educated consumers don't believe artificial meat is the solution to the problems with the meat industry. *Journal of Integrative Agriculture* 14 (2), 273–284
- Hoek, A. C., Elzerman, J. E., Hageman, R., Kok, F. J., Luning, P. A., Graaf, C. de., 2013. Are meat substitutes liked better over time? A repeated in-home use test with meat substitutes or meat in meals. *Food Quality and Preference* 28 (1), 253-263

Hoek, A. C., Luning, P. A., Stafleu, A., Graaf, C. de., 2004. Food-related lifestyle and health attitudes of Dutch vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers. *Appetite* 42 (3), 265–272

Hoek, A. C., Luning, P. A., Weijzen, P., Engels, W., Kok, F. J., Graaf, C. de., 2011. Replacement of meat by meat substitutes. A survey on person- and product-related factors in consumer acceptance. *Appetite* 56 (3), 662-673

Hopwood, C. J., Bleidorn, W., Schwaba, T., Chen, S. 2020. Health, environmental, and animal rights motives for vegetarian eating. *PLoS ONE* 15 (4): e0230609

Hutchinson, C. A., 2017. Grocery shopping for your health. *BU Well* (2), 11-12

Hwang, J., You, J., Moon, J., Jeong, J., 2020. Factors Affecting Consumers' Alternative Meats Buying Intentions: Plant-Based Meat Alternative and Cultured Meat. *Sustainability* 12 (14) 5662

Impossible Foods. 2020. 2019 Impact Report. Available at:
<https://impossiblefoods.com/mission/2019impact/>

Impossible Foods. 2020. What is soy leghemoglobin, or heme?. Available at:
<https://faq.impossiblefoods.com/hc/en-us/articles/360019100553-What-is-soy-leghemoglobin-or-heme->

Kim, H., House, L. A., Rampersaud, G., Gao, Z., 2012. Front-of-Package Nutritional Labels and Consumer Beverage Perceptions. *Applied Economic Perspectives and Policy*. 34 (4), 599-614

Kolata, G., 2019. Eat Less Red Meat, Scientists Said. Now Some Believe That Was Bad Advice. *The New York Times*. Available at:
<https://www.nytimes.com/2019/09/30/health/red-meat-heart-cancer.html>

- Kubberod, E., Ueland, O., Rodbotten, M., Westad, F., Risvik, E., 2002. Gender specific preferences and attitudes towards meat. *Food Quality and Preference* 13 (5), 285–294
- Lanza, S. T., Dziak, J. J., Huang, L., Wagner, A. T. , Collins, L. M., 2018. LCA Stata plugin users' guide (Version 1.2.1). University Park: The Methodology Center, Penn State. Available from methodology.psu.edu
- Lanza, S.T., Collins, L. M., Lemmon, D. R., Schafer, J. L., 2007. PRO LCA: A SAS Procedure for Latent Class Analysis. *Structural Equation Modeling* 14 (4), 671- 694
- Lars, et. al., 2020. Exploring the effect of positively phrased messages on the attitude-behavior gap towards purchasing meat substitutes.
- Latvala, T., Niva, M., Makela, J., Pouta, E., Heikkila, J., Kotro, J., Forsman-Hugg, S., 2012. Diversifying meat consumption patterns: Consumers’ self-reported past behaviour and intentions for change. *Meat Science* 92 (1), 71–77
- Lusk, J. L., 2020. Consumer Preferences for Beef Alternatives. Available at: <http://jaysonlusk.com/blog/2020/7/3/consumer-preferences-for-beef-alternatives>
- Maison, D., Greenwald A. G., Bruin, R., 2001. The Implicit Association Test as a Measure of Implicit Consumer Attitudes. *Polish Psychological Bulletin* 32 (1), 61-69
- Mbow, C., Rosenzweig, C., Barioni, L. G., Benton, T. G., Herrero, M., Krishnapillai, M., Liwenga, E., Pradhan, P., Rivera-Ferre, M. G., Sapkota, T., Tubiello, F. N., Xu, Y., 2019. Food Security. In: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J.

Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)). In press.

McMichael, A. J., Powles, J. W., Butler, C. D., Uauy, R., 2007. Food, livestock production, energy, climate change, and health. *Lancet* 370 (9594), 1253-1263

Meatless Monday. 2019. NYC Expands Meatless Monday to All Public Schools. Available at: <https://www.mondaycampaigns.org/meatless-monday/news/nyc-expands-meatless-monday-schools>

Micha, R., Wallace, S. K., Mozaffarian, D., 2010. Red and Processed Meat Consumption and Risk of Incident Coronary Heart Disease, Stroke, and Diabetes Mellitus A Systematic Review and Meta-Analysis. *Circulation* 121 (21), 2271-2283

Michel, F., Hartmann, C., Siegrist, M., 2021. Consumers' associations, perceptions and acceptance of meat and plant-based meat alternatives. *Food Quality and Preference* 87, 104063

Miller, G. F., Gupta, S., Kropp, J. D., Grogan, K. A., Mathews, A., 2016. The effects of pre-ordering and behavioral nudges on National School Lunch Program participants' food item selection. *Journal of Economic Psychology* 55, 4-16

Nayga, R. M., 2008. Nutrition, obesity and health: policies and economic research challenges. *European Review of Agricultural Economics* 35 (3), 281-302

Neff, R. A., Edwards, D., Palmer, A., Ramsing, R., Richter, A., Wolfson, J., 2018. Reducing meat consumption in the USA: a nationally representative survey of attitudes and behaviours. *Public Health Nutrition* 21 (10), 1835-1844

Nelson, M. E., Hamm, M. W., B Hu, F., Abrams, S. A., Griffin, T. S., 2016. Alignment of healthy dietary patterns and environmental sustainability: A systematic review. *Advances in nutrition* 7 (6), 1005–1025

- OED-FAO. 2019. Agricultural Outlook 2019-2028. Available at:
<http://www.fao.org/3/ca4076en/ca4076en.pdf>
- Ortega, D. L., Wang, H. H., Wu, L., Olynk, N. J., 2011. Modeling heterogeneity in consumer preferences for select food safety attributes in China. *Food Policy* 36 (2), 318–324
- Osmanski, S., 2019. What is Plant-Based Meat? Green Matters. Available at:
<https://www.greenmatters.com/p/plant-based-meats>
- Øvrum, A., Alfnes, F., Almli, V. L., Rickertsen, K., 2012. Health information and diet choices: Results from a cheese experiment, *Food Policy* 37 (5), 520-529
- Palma, M. A., Behe, B. K., Hall, C. R., Huddleston, P. T., Fernandez, T., 2016. Tracking position premiums in discrete choice experiments. *Applied Economics Letters*, 23: 1269–1273
- Pan, A., Sun, Q., Bernstein, A. M., Schulze, M. B., Manson, J. E., Willett, W. C., Hu, F. B., 2011. Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis. *American Journal of Clinical Nutrition* 94 (4), 1088-1096
- Parry, J., Szejda, K., 2019. How to drive plant-based food purchasing: Key findings from a Mindlab study into implicit perceptions of the plant-based category. Research Report. Washington, DC: The Good Food Institute. Available at
<https://go.gfi.org/Mindlab-Strategic-Recommendations>
- Peschel, A. O., Grebitus, C., Alemu, M. H., Hughner, R. S., 2019. Personality traits and preferences for production method labeling - a latent class approach. *Food Quality and Preference* 74, 163–171

Peterson, H. 2016. This is what the average Walmart shoppers look like. Business Insider. Available at: <https://www.businessinsider.com/walmart-shopper-demographics-2016-10>

Pimentel, D., Pimentel, M., 2003. Sustainability of meat-based and plant-based diets and the environment. *American Journal of Clinical Nutrition* 78 (3), 660S-663S

Poore, J., Nemecek, T., 2018. Reducing food's environmental impacts through producers and consumers. *Science* 360 (6392), 987-992

Rees, J. H., Bamberg, S., Jäger, A., Victor, L., Bergmeyer, M., Friese, M., 2018. Breaking the Habit: On the Highly Habitualized Nature of Meat Consumption and Implementation Intentions as One Effective Way of Reducing It. *Basic & Applied Social Psychology* 40 (3), 136-147

Reisch, L. A., Sunstein, C. R., Gwozdz, W. 2017. Beyond carrots and sticks: Europeans support health nudges. *Food Policy* 69, 1–10

Rezvani, Z., Jansson, J., Bengtsson, M., 2017. Cause I'll Feel Good! An Investigation into the Effects of Anticipated Emotions and Personal Moral Norms on Consumer Pro-Environmental Behavior. *Journal of Promotion Management* 23 (1), 163–183

Roos, O., 2019. Is fake meat better for you, or the environment?. NBC News. Available at: <https://www.nbcnews.com/news/us-news/fake-meat-better-you-or-environment-n1065231>

Rouhani, M. H., Salehi-Abargouei, A., Surkan, P. J., Azadbakht, L., 2014. Is there a relationship between red or processed meat intake and obesity? A systematic review and meta-analysis of observational studies. *Obesity Reviews* 15 (9), 740-748

Ruby, M. B., 2012. Vegetarianism. A blossoming field of study. *Appetite* 58 (1), 141–150

- Rusmevichientong, P., Streletskaia, N. A., Amatyakul, W., Kaiser, H. M., 2014. The impact of food advertisements on changing eating behaviors: An experimental study. *Food Policy* 44, 59-67
- Sanchez-Sabate, R., Sabaté, J., 2019. Consumer Attitudes Towards Environmental Concerns of Meat Consumption: A Systematic Review. *International Journal of Environmental Research and Public Health* 16 (7), 1220
- Schaefer, G. O., 2018. Lab- Grown Meat. *Scientific American*. Available at: <https://www.scientificamerican.com/article/lab-grown-meat/>
- Segovia, M. S., Marco A. P., Testing the Consistency of Preferences in Discrete Choice Experiments: An Eye Tracking Study. *European Review of Agricultural Economics* (forthcoming)
- Segovia, M. S., Palma, M. A., 2016. Buying your way into a healthier lifestyle: a latent class analysis of healthy food purchases. *Applied Economics* 48 (21), 1965–1977
- Shan, Z., Li, Y., Baden, M. Y., Bhupathiraju, S. N., Wang, D. D., Sun, Q., Rexrode, K. M., Rimm, E. B., Qi, L., Willett, W. C., Manson, J. E., Qi, Q., Hu, F. B., 2020. Association Between Healthy Eating Patterns and Risk of Cardiovascular Disease. *JAMA Intern Med* 180 (8), 1090-1100
- Siegrist, M., Hartmann, C., 2019. Impact of sustainability perception on consumption of organic meat and meat substitutes. *Appetite* 132, 196–202
- Sinha R., Cross, A. J., Graubard, B. I., Leitzmann, M. F., Schatzkin, A., 2009. Meat Intake and Mortality: A Prospective Study of Over Half a Million People. *Arch Intern Med* 169 (6), 562-571
- Slade, P., 2018. If you build it, will they eat it? Consumer preferences for plant-based and cultured meat burgers. *Appetite* 125, 428-437

Slapø, H. B., Karevold, K. I., 2019. Simple Eco-Labels to Nudge Customers Toward the Most Environmentally Friendly Warm Dishes: An Empirical Study in a Cafeteria Setting. *Frontiers in Sustainable Food Systems*, 3

Sogari, G., Li, J., Lefebvre, M., Menozzi, D., Cirelli, M., Gómez, M. I., Mora, C., 2019. The influence of health messages in nudging consumption of whole grain pasta. *Nutrients*, 11 (12), 2993

Sparkman, G., Walton, G. M., 2017. Dynamic Norms Promote Sustainable Behavior, Even if It Is Counternormative. *Psychology Science* 28 (11), 1663-1674

Splitter, J., 2019. Fake Meat Fight: Can The Plant-Based Movement Get Past The ‘Processed Food’ Debate?. *Forbes*. Available at: <https://www.forbes.com/sites/jennysplitter/2019/09/16/fake-meat-fight-can-the-plant-based-movement-get-past-the-processed-food-debate/?sh=ac75c5570179>

Sunstein, C. R., 2014. Nudging: A Very Short Guide. *Journal of Consumer Policy* 37, 583-588

Szejda, K., Urbanovich, T., Wilks, M., 2020. Accelerating consumer adoption of plant-based meat: An evidence-based guide for effective practice. Five Working Papers. Washington, DC: The Good Food Institute. Available at: go.gfi.org/plant-based-meat-consumer-adoption

Thaler, R. H., Sunstein, C. R., 2009. *Nudge: Improving Decisions About Health, Wealth and Happiness*. Penguin Group

The Economist. 2019. How much would giving up meat help the environment?. Available at: <https://www.economist.com/graphic-detail/2019/11/15/how-much-would-giving-up-meat-help-the-environment>

The Good Food Institute. 2020. Plant-Based Market Overview. Available at: <https://www.gfi.org/marketresearch>

The Meatless Revolution: Panel with Industry Experts. 2021. Agricultural & Applied Economics Association. Available at: <http://blog.aaea.org/2020/10/the-meatless-revolution-panel-with.html>

Thorndike, A. N., Riis, J., Sonnenberg, L. M., Levy, D. E., 2014. Traffic-Light Labels and Choice Architecture: Promoting Healthy Food Choices. *American Journal of Preventive Medicine* 46 (2), 143-149

Tobler, C., Visschers, V. H. M., Siegrist, M. 2011. Eating green. Consumers' willingness to adopt ecological food consumption behaviors. *Appetite* 57, 674–682

Tonsor, G. T., Lusk, J. L., Schroeder, T. C., 2021. Impacts of New Plant-Based Protein Alternatives on U.S. Beef Demand. *AgManger.info*. Available at: <https://agmanager.info/livestock-meat/meat-demand/meat-demand-research-studies/impact-new-plant-based-protein-0>

United States Department of Agriculture (USDA). 2020. What is MyPlate?. Available at: <https://www.choosemyplate.gov/eathealthy/WhatIsMyPlate>

US Department of Health and Human Services, US Department of Agriculture. 2015. Dietary Guidelines for Americans 2015-2020. Available at: https://health.gov/sites/default/files/2019-09/2015-2020_Dietary_Guidelines.pdf

Vainio, A., Irz, X., Hartikainen, H., 2018. How effective are messages and their characteristics in changing behavioural intentions to substitute plant-based foods for red meat? The mediating role of prior beliefs. *Appetite* 125, 217-224

Van Loo, E. J., Caputo, V., Lusk, J. L., 2019. Consumer Preferences for Farm-Raised Meat, Lab-Grown Meat, and Plant-Based Meat Alternatives: Does Information or Brand Matter?

- Van Loo, E. J., Hoefkens, C., Verbeke, W., 2017. Healthy, sustainable and plant-based eating: Perceived (mis)match and involvement-based consumer segments as targets for future policy. *Food Policy* 69, 46-57
- van Vliet, S., Kronberg, S. L., Provenza, F. D., 2020. Plant-Based Meats, Human Health, and Climate Change. *Frontiers in Sustainable Food Systems* 4, 128
- Vandenbroele, J., Vermeir, I., Geuens, M., Slabbinck, H., Van kerckhove, A., 2020. Nudging to get our food choices on a sustainable track. *Proceedings of the Nutrition Society* 79 (1), 133–146
- Verain, M. C. D., Bartels, J., Dagevos, H., Sijtsma, S. J., Onwezen, M. C., Antonides, G., 2012. Segments of sustainable food consumers: a literature review. *International Journal of Consumer Studies* 36 (2), 123–132
- Verain, M. C. D., Sijtsma, S. J., Dagevos, H., Antonides, G., 2017. Attribute Segmentation and Communication Effects on Healthy and Sustainable Consumer Diet Intentions. *Sustainability* 9 (5), 743
- Wang, X., Lin, X., Y Ouyang, Y., Liu, J., Zhao, G., Pan, A., B Hu, F., 2016. Red and processed meat consumption and mortality: dose–response meta-analysis of prospective cohort studies. *Public Health Nutrition* 19 (5), 893-905
- Weinrich, R., 2019. Opportunities for the Adoption of Health-Based Sustainable Dietary Patterns: A Review on Consumer Research of Meat Substitutes. *Sustainability* 11 (15), 4028
- Werle, C. O. C., Trendel, O., Ardito, G., 2013. Unhealthy food is not tastier for everybody: The “healthy = tasty” French intuition. *Food Quality and Preference* 28. 116-121
- Wilks, M., Phillips, C. J. C., 2017. Attitudes to in vitro meat: a survey of potential consumers in the United States. *PLoS ONE* 12 (2), 14

Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., Garnett, T., Tilman, D., DeClerck, F., Wood, A., Jonell, M., Clark, M., Gordon, L. J., Fanzo, J., Hawkes, C., Zurayk, R., Rivera, J. A., De Vries, W., Majele Sibanda, L., Afshin, A., ... Murray, C., 2019. Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems. *The Lancet* 393 (10170), 447–492

Wisdom, J., Downs, J. S., Loewenstein, G., 2010. Promoting Healthy Choices: Information versus Convenience. *American Economic Journal: Applied Economics*, 2 (2), 164-178

Wolstenholme, E., Poortinga, W., Whitmarsh, L., 2020. Two Birds, One Stone: The Effectiveness of Health and Environmental Messages to Reduce Meat Consumption and Encourage Pro-environmental Behavioral Spillover. *Frontiers in Psychology* 11, 577111

Yale-Bellany, D., 2019. The new makers of plant-based meat? Big meat companies. *The New York Times*. Available at: <https://www.nytimes.com/2019/10/14/business/the-new-makers-of-plant-based-meat-big-meat-companies.html>

Ye, T., Mattila, A. S., 2021. The effect of ad appeals and message framing on consumer responses to plant-based menu items. *International Journal of Hospitality Management*, 95

Yen, S. T., Lin, Biing-Hwan, Davis, C. G., 2008. Consumer knowledge and meat consumption at home and away from home. *Food Policy* 33 (6), 631–639

Zhou, X., Perez-Cueto, F. J. A., Santos, Q. dos, Bredie, W. L. P., Molla-Bauza, M. B., Rodrigues, V. M., Buch-Andersen, T., Appleton, K. M., Hemingway, A., Giboreau, A., Saulais, L., Monteleone, E., Dinnella, C., Hartwell, H., 2019. Promotion of novel

plant-based dishes among older consumers using the “dish of the day” as a nudging strategy in 4 EU countries. *Food Quality and Preference* 75, 260–272

Appendix A

A1. Recruitment Material

MU Info mass email:

Regular meat-eaters needed for online study on consumer's decision-making

The Division of Applied Social Sciences is looking for 18 years old or older regular meat-eaters (consume meat at least 4 ½ servings a week) to participate in an online supermarket study. The study lasts approximately 40 minutes and participants will receive \$5 in cash and 2 food products as compensation. You will curbside pickup your payment one day after your study session at Memorial Union Visitor Parking Lot. If you are interested in participating, please sign up for a session using the following link: <https://calendly.com/dassonlinestudy/an-online-study-on-consumer-s-food-purchases>. For more information on the study, please contact Dr. Michelle Segovia at segoviam@missouri.edu or No-Ya Yu at ny6b3@mail.missouri.edu.

Flyer:

Regular Meat-eaters Needed for an Online Study on Consumer's Food Purchases

The Division of Applied Social Sciences is looking for individuals to participate in an online study on decision-making.

Who is eligible?

Participants must be:

- 18 years or older
- Eat meat regularly (consume meat at least 4 ½ servings a week)
- Living in Columbia, MO and willing to pick up your payment at the Memorial Union Visitor Parking Lot

Description of study

The research is designed to better understand how consumers make food purchasing decisions. You will receive \$5 in cash and 2 free food products depending on your decisions as compensation. Participation in the online study is completely voluntary, and the study lasts approximately 40 minutes.

Interested?

Contact No-Ya Yu at ny6b3@mail.missouri.edu or (573) 825-1498 to sign up for the most convenient session.

A2. Experimental Protocol

Informed Consent

Project title: An Online Study on Consumer's Food Purchases
IRB number: 2040265

You are being asked to participate in a research study being conducted to understand how consumers make food purchasing decisions.

Your participation is voluntary. You do not have to be in the study if you do not want to. You may refuse to be in the study, and nothing will happen. You may stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

What am I being asked to do?

You will be asked to: 1) complete an online grocery shopping task, in which you will purchase 4 food products; 2) complete 2 stimulus sorting tasks; and 3) fill out a survey.

Will I be compensated?

You will get \$5 in cash and 2 additional food products depending on the decisions you make during the study. Your \$5 participation fee will be put in an envelope along with your bundle of goods and will be available for you to curbside pick-up at University of Missouri's "Memorial Union Visitor Parking Lot" one day after you complete today's session. You will be endowed \$17 to purchase the food products in the online grocery shopping task, and the purchase price will be deducted from the \$17 compensation amount. If you do not spend all of the endowment, then the rest of the amount goes back to the experimenters.

Who do I contact if I have questions, concerns, or complaints?

Please contact the University of Missouri – Columbia Institutional Review Board (IRB) if you have questions about your rights as a research participant. The IRB can be reached by phone at 573-882-3181 or email irb@missouri.edu. If you want to talk privately about your rights or any issues related to your participation in this study, you can contact University of Missouri Research Participant Advocacy by calling 888-280-5002 (a free call), or emailing MUResearchRPA@missouri.edu. You may also contact Dr. Michelle Segovia (segoviam@missouri.edu) or No-Ya Yu (ny6b3@mail.missouri.edu) if you have questions, concerns, or complaints about the research.

Inclusion criteria

Q1. Do you consume meat at least 4 ½ servings a week?

- Yes, I do
- No, I don't

Q2. Have you purchased groceries online in the past 6 months?

- Yes, I have
- No, I haven't

Q3. Do you commit to carefully reading and providing your thoughtful and honest answers to the questions in this study?

- a. I will read carefully and provide my best answers
- b. I will not read carefully and provide my best answers
- c. I can't promise either way

Welcome

Welcome! Thank you for participating in our study.

The purpose of today's study is to help us understand consumer purchasing behavior in online grocery supermarkets. This is a real experiment. By completing today's study, you will get \$5 in cash as participation fee plus 2 food products that will be randomly selected from your chosen products during the shopping trip. The selected food products will be displayed on your screen at the end of the session.

As a reminder before we start today's session, your participation is completely voluntary. At any time, you may select to end your participation. However, in order to receive the compensation, you must complete the whole session. Participation takes approximately 40 minutes.

Before you begin, please make sure you are using a computer/laptop with a keyboard, and your screen size is set to 100%. Mobile phones are considered as illegible to participate in the study. We appreciate your cooperation!

Please move on to the next page, which will provide you with more details on the procedures.

Study procedure

1. You will enter into an online experimental grocery supermarket to purchase 4 food products. You will find your shopping list on the next page.
2. You will purchase 4 food products you desired based on each of the 4 food categories on your shopping list. You can only purchase one food product from each of the 4 categories.
3. After you finish the online grocery shopping task, you will be asked to complete 2 stimulus sorting tasks.
4. After completing the stimulus sorting tasks, you will be asked to fill out a short socio-demographic survey.
5. At the end of the study, 2 food products will be randomly chosen for payment. Your \$5 participation fee along with the 2 food products will be able for you

to curbside pick-up one day after today's session.

Please proceed to the next page to start with the online grocery shopping task.

Shopping list

For this task, you now receive an additional \$17 endowment to be used to purchase the food products. The shopping list below displays the four categories of food items from which you will select the products you would like to purchase. This task is real, we will randomly select 2 out of the 4 chosen food products at the end of the study, and you will receive the two food products as part of your payment. The price of the items will be deducted from the \$17 endowment. If you do not spend all of the endowment, then the rest of the amount goes back to the experimenters.

Please take a moment to carefully review the categories on the following list:

Shopping List

For your grocery food shopping, you need to purchase:

☒

One kind of **Vegetables**

☒

One type of **Carbohydrates**

☒

A **Sauce**

☒

One **Meat** or **Plant-based meat**

Please go to the next page to start your online supermarket trip.

Store opening

You will start by going to the N&M online grocery supermarket website, in which you will see the following screen:

As a reminder, this task is real, two food products will be randomly selected at the end of the study as part of your payment. The price of the food items will be deducted from the \$10 endowment. If you do not spend all of the endowment, then the rest of the amount goes back to the experimenters.

Please go to the next page to start your grocery food shopping.

Shopping task-vegetable

The first item you look for is **Vegetable**.

After you type “vegetables” in the online grocery supermarket’s search bar, these are the search results with a selection of vegetables available for you to purchase:

1 - 40 of 1,000+ results **Refine by** Price Too Brand Store Availability **Sort by** Best Match

Category

- ☐ Fresh Broccoli
- ☐ Frozen Broccoli
- ☐ Fresh
- ☐ Mushrooms
- ☐ Sliced
- ☐ Mushrooms
- ☐ Canned Peas
- ☐ Frozen Peas
- [See More Categories](#)

Delivery & Pick up

- ☐ Show all
- ☒ Free pick up
- ☐ 2-day delivery

Weight

- ☐ Under 5 lbs
- ☐ 5 to 10 lbs
- ☐ 11-15 lbs

Price

\$ min - \$ max

- ☐ \$0 - \$5
- ☐ \$5 - \$10
- ☐ \$10 - \$15

<p>\$1.33 each Broccoli Florettes</p> <p>Add to Cart</p>	<p>\$1.00 12 oz Great Value Broccoli Florets</p> <p>Add to Cart</p>	<p>\$1.97 10.8 oz Birds Eye Steamfresh Broccoli Florets</p> <p>Add to Cart</p>	<p>\$1.00 10.8 oz Birds Eye Steamfresh Broccoli Cuts</p> <p>Add to Cart</p>
<p>\$1.88 8 oz Fresh White Mushrooms</p> <p>Add to Cart</p>	<p>\$1.98 8 oz Sliced White Mushrooms</p> <p>Add to Cart</p>	<p>\$2.08 8oz Whole Baby Bella Mushrooms</p> <p>Add to Cart</p>	<p>\$1.98 10 oz Great Value Sliced Mushrooms</p> <p>Add to Cart</p>
<p>\$1.00 10 oz Birds Eye Steamfresh Selects Sweet Peas</p> <p>Add to Cart</p>	<p>\$0.77 12 oz Great Value Sweet Peas</p> <p>Add to Cart</p>	<p>\$1.28 15 oz Le Sueur Very Young Small Sweet Peas</p> <p>Add to Cart</p>	<p>\$1.14 15 oz Del Monte Fresh Cut Sweet Canned Peas</p> <p>Add to Cart</p>

Please go to the next page to purchase one of your preferred vegetables.

Please purchase the vegetable product you would like to purchase by clicking in the product's image, the item will then be added to you shopping cart.

After you make your one selection, please move on to the next page to purchase your item from the second food category.

[Restart Survey](#) [Place Bookmark](#) Mobile view off Tools

<p>\$1.33 each Broccoli Florettes</p>	<p>\$1.00 12 oz Great Value Broccoli Florets</p>	<p>\$1.97 10.8 oz Birds Eye Steamfresh Broccoli Florets</p>	<p>\$1.00 10.8 oz Birds Eye Steamfresh Broccoli Cuts</p>
<p>\$1.88 8 oz Fresh White Mushrooms</p>	<p>\$1.98 8 oz Sliced White Mushrooms</p>	<p>\$2.08 8oz Whole Baby Bella Mushrooms</p>	<p>\$1.98 10 oz Great Value Sliced Mushrooms</p>
<p>\$1.00 10 oz Birds Eye Steamfresh Selects Sweet Peas</p>	<p>\$0.77 12 oz Great Value Sweet Peas</p>	<p>\$1.28 15 oz Le Sueur Very Young Small Sweet Peas</p>	<p>\$1.14 15 oz Del Monte Fresh Cut Sweet Canned Peas</p>

[Next](#) Powered by Qualtrics

Shopping task-carbohydrates

The second item you look for is **Carbohydrates**.

After you type “carbohydrates”, in the online grocery supermarket’s search bar, these are the search results with a selection of carbohydrates available for you to purchase:

Please go to the next page to purchase one of your preferred carbohydrates.

Please select the carbohydrate product you would like to purchase by clicking in the product’s image, the product will then be added to you shopping cart.

After you make your one selection, please move on to the next page to purchase your item from the third food category.

Shopping task-sauce

The third item you look for is **Sauce**.

After you type “sauce”, in the online grocery supermarket’s search bar, these are the search results with a selection of sauces available for you to purchase:

Please go to the next page to purchase one of your preferred sauces.

Please select the sauce product you would like to purchase by clicking in the product’s image, the product will then be added to your shopping cart.

After you make your one selection, please move on to the next page to purchase your item from the last food category.

Shopping task-meat and plant-based meat (Control)

The last item you look for is **meat or plant-based meat**.

After you type “meat and plant-based meat”, in the online grocery supermarket’s search bar, these are the search results with a selection of meat and plant-based meat available for you to purchase:

Please go to the next page to purchase one of your preferred meat or plant-based meat.

Please select the meat or plant-based meat product you would like to purchase by clicking in the product's image, the product will then be added to your shopping cart.

After you make your one selection, please proceed to the next section of the study.

Shopping task-meat and plant-based meat (Health)

The last item you look for is **meat or plant-based meat**.

After you type “meat and plant-based meat”, in the online grocery supermarket’s search bar, these are the search results with a selection of meat and plant-based meat available for you to purchase:

Please go to the next page to purchase one of your preferred meat or plant-based meat.

Please select the meat or plant-based meat product you would like to purchase by clicking in the product’s image, the product will then be added to your shopping cart.

After you make your one selection, please proceed to the next section of the study.

Shopping task-meat and plant-based meat (Environment)

The last item you look for is **meat or plant-based meat**.

After you type "meat and plant-based meat", in the online grocery supermarket's search bar, these are the search results with a selection of meat and plant-based meat available for you to purchase:

Please go to the next page to purchase one of your preferred meat or plant-based meat.

Please select the meat or plant-based meat product you would like to purchase by clicking in the product's image, the product will then be added to your shopping cart.

After you make your one selection, please proceed to the next section of the study.

Shopping task-meat and plant-based meat (combine)

The last item you look for is **meat or plant-based meat**.

After you type “meat and plant-based meat”, in the online grocery supermarket’s search bar, these are the search results with a selection of meat and plant-based meat available for you to purchase:

Please go to the next page to purchase one of your preferred meat or plant-based meat.

Please select the meat or plant-based meat product you would like to purchase by clicking in the product's image, the product will then be added to your shopping cart.

After you make your one selection, please proceed to the next section of the study.

IATs

Stimulus sorting task 1

You will now be asked to complete 2 stimulus sorting tasks.

Please read the instructions on the next page carefully. Each task takes approximately 5 minutes.

As a reminder, please make sure you are using **a computer with a keyboard** to proceed.

Health IAT

[Restart Survey](#)

[Place Bookmark](#)

Mobile view off ☐

Tools

Meat**Plant-based meat**

+

Instructions: Place your left and right index fingers on the E and I keys. At the top of the screen are 2 categories. In the task, words and/or images appear in the middle of the screen.

When the word/image belongs to the category on the left, press the E key as fast as you can. When it belongs to the category on the right, press the I key as fast as you can. If you make an error, a red X will appear. Correct errors by hitting the other key.

Please try to go as *fast as you can* while making as few errors as possible.

When you are ready, please press the [Space] bar to begin.

Part 1 of 7

Powered by Qualtrics

Stimulus sorting task 2

Next, you will complete the second stimulus sorting task.

The procedure is the same as the last stimulus sorting task, but the category has been changed. Please read the instruction carefully.

As a reminder, please make sure you are using **a computer with a keyboard** to proceed.

Environmental Impact IAT

Restart Survey

Place Bookmark

Mobile view off

Tools

Meat

Plant-based meat

+

Instructions: Place your left and right index fingers on the E and I keys. At the top of the screen are 2 categories. In the task, words and/or images appear in the middle of the screen.

When the word/image belongs to the category on the left, press the E key as fast as you can. When it belongs to the category on the right, press the I key as fast as you can. If you make an error, a red X will appear. Correct errors by hitting the other key.

Please try to go as *fast as you can* while making as few errors as possible.

When you are ready, please press the [Space] bar to begin.

Part 1 of 7

Powered by Qualtrics

Restart Survey Place Bookmark Mobile view off Tools

The figure is a 2D plot with a white background and a black border. It compares two food types: Plant-based meat and Meat. The x-axis represents Sustainability, with 'Unsustainable' on the left and 'Sustainable' on the right. The y-axis represents Pollution, with 'Low' at the top and 'High' at the bottom. The text 'Plant-based meat or Unsustainable' is in the top-left quadrant, and 'Meat or Sustainable' is in the top-right quadrant. The word 'Pollution' is centered in the plot area.

Food Type	Sustainability	Pollution
Plant-based meat	Unsustainable	Low
Meat	Sustainable	High

Survey

We would like you to answer some few more questions about your socio-demographics and behavioral characteristics. Your responses are very important for us and they will be kept confidential.

1. To what extent are these factors important to you when you make your purchase decision? (1 = Very Unimportant; 5 = Very Important)
 - a. Health
 - b. Environmental impact
 - c. Price
 - d. Taste
 - e. Animal welfare
 - f. Your familiarity with the food product
2. How often do you purchase **conventional meat** from a grocery store?
 - a. More than weekly
 - b. Weekly
 - c. Two or three times a month
 - d. Once a month
 - e. Less than once a month
 - f. Never
3. How often do you purchase **plant-based meat** from a grocery store?
 - a. More than weekly
 - b. Weekly
 - c. Two or three times a month
 - d. Once a month
 - e. Less than once a month
 - f. Never
4. How many times per week do you have **conventional meat** with your evening meal?
 - a. Less than once a week
 - b. Once a week
 - c. 2 times a week
 - d. 3 times a week
 - e. 4 times a week
 - f. 5 times a week
 - g. 6 times a week
 - h. Every day of the week
5. To what extent are these food technologies favorable to you? (1=Strongly Unfavorably; 5=Strongly Favorably)
 - a. Local food
 - b. Organic food
 - c. Genetically modified food
 - d. Lab-grown food
6. Are you the primary shopper in your household?

- a. Yes
- b. No

7. What is your gender?

- a. Male
- b. Female
- c. Other

8. What is your age? (in years)

9. Including yourself, how many people live in your household?

10. Do you have children?

- a. Yes
- b. No

11. What is your ethnicity?

- a. Caucasian
- b. African American
- c. Native American
- d. Hispanic/ Latino
- e. Asian/ Pacific Islander
- f. Other (please specify)

12. What is the highest level of education that you obtained?

- a. Some high school or less
- b. High School diploma
- c. Some college
- d. 2 year/Associates degree
- e. 4 year/Bachelor's degree
- f. Some graduate school
- g. Graduate school

13. What is your political affiliation?

- a. Republican party
- b. Democratic party
- c. Other (please specify)
- d. None

14. What was your 2019 household income before taxes?

- a. Less than \$30,000
- b. \$30,000-\$39,999
- c. \$40,000-\$49,999
- d. \$50,000-\$59,999
- e. \$60,000-\$69,999
- f. \$70,000-\$79,999
- g. \$80,000-\$89,999
- h. \$90,000-\$99,999

- i. \$100,000-\$149,999
- j. \$150,000 or more

15. Please indicate if you have seen this message during the online grocery shopping task.

	Yes	No	I don't recall

Thank you for participating in our study. Please move on to the next page for instructions on the payment.

Display the 2 food products

Thank you for your order!

These are the two products available for you to pick up.

[Restart Survey](#) [Place Bookmark](#)

Mobile view off ☐ Tools ▼

Thank you for your order!

These are the two products available for you to pick up.

\$1.14 15oz
Del Monte Fresh Cut
Sweet Canned Peas

[Add to Cart](#)

\$4.84 8oz
Beyond Meat Beyond
Burger Patties

[Add to Cart](#)

Please move on to the next section of the study.

[→](#)

When should I pick up my payment?

You can pick up your 2 food products along with your \$5 participation fee one day after today's session (will specify date in here)

Please choose one time slot listed below that works best for you to pick up your payment.

- 8:00 am – 10:00 am
- 10:00 am – 12:00 pm
- 12:00 pm – 2:00 pm
- 2:00 pm – 4:00 pm
- 4:00 pm – 6:00 pm

Where should I pick up my payment?

You will curbside pickup at University of Missouri's "Memorial Union Visitor Parking Lot". The address is: Memorial Union Visitor Lot, Columbia, MO 65201.

If you have any questions regarding to your payment information, please contact Dr. Michelle Segovia at segoviam@missouri.edu or No-Ya Yu at ny6b3@mail.missouri.edu.

Would you be interested in participating in our future studies?

Please leave your name and email address below so we add you to our database:

Appendix B

Table B1. List of Health and Environmental Attributes Used in Two Implicit Association Tests

Health IAT attributes		Environment IAT attributes	
Healthy	Unhealthy	Sustainable	Unsustainable
Beneficial	Bad	Biodiversity	Climate change
Fresh	Cholesterol	Clean air	Deforestation
Good	Greasy	Energy efficiency	Food waste
Natural	Harmful	Environmentally friendly	Global warming
Nourishing	Obesity	Green	Pollution
Nutritious	Processed	Natural	Soil degradation
Wholesome	Unwholesome	Renewable	Water scarcity

Table B2. Sample Size by Treatments and Sessions

Treatment	Number of sessions	Number of participants	Number of participants pass manipulation
Control	11	35	35
Health treatment	9	36	27
Environment treatment	7	42	29
Combined treatment	9	34	31
Total	36	147	122