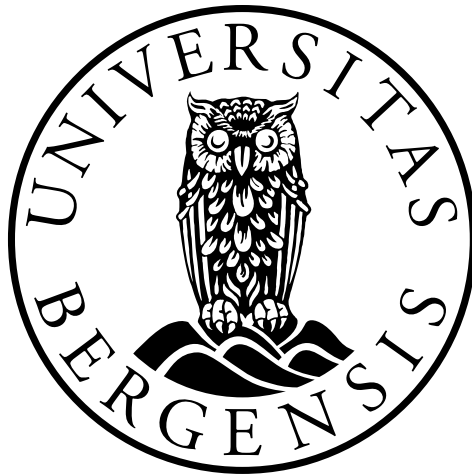UNIVERSITY OF BERGEN

Department of Information Science and Media Studies

MASTERS THESIS

Using explainable food swaps to nudge users towards more sustainable products in grocery websites

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Abstract

The growing concern for climate issues has prompted both consumers and the grocery retail industry to prioritize environmental sustainability. This thesis aims to examine the effectiveness of nudging users towards more sustainable food options in an online grocery store using food swaps. Further, the study utilizes different motivational explanations accompanying the swaps, to investigate their impact on swap acceptance and perceived understanding. A mockup supermarket interface was created and screenshots uploaded to an online survey tool, where participants (*N=202*) were assigned to one of four conditions (baseline, health, sustainability or money). Results indicate that motivational framing did not significantly influence swap acceptance. However, perceived understandability was significant in affecting swap acceptance, with the sustainability framing being better understood. Participants were more likely to swap when the cost of the alternative product increased, suggesting other factors influenced consumer behavior. Finally, perceived similarity between the original and alternative product significantly affected the swap acceptance and perceived similarity, where meat swaps showed a strong positive, statistical significance. This thesis provided novel work within the field of encouraging more sustainable products in online grocery shopping services, which can further be expanded by implementing sustainable food swaps in a recommender system.

Acknowledgment

First and foremost, I would like to express my sincere appreciation to my supervisor Prof. Dr. Christoph Trattner, for sharing his profound knowledge and innovative ideas, plus providing me with insightful feedback and expertise throughout the completion of my master's thesis. In addition, I am deeply grateful to my co-supervisor, Dr. Alain D. Starke, for his thorough review of my work, helpful advice, and his extensive knowledge in statistics, which significantly enhanced my research and helped me overcome different challenges.

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Tiril Taalesen

Bergen, Norway, May 2023

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Chapter 1

Introduction

1.1 Motivation

"No corner of the globe is immune from the devastating consequences of climate change."
[67]. The climate change is the biggest crisis of our time and is more relevant than ever
as our ecosystems are rapidly destabilizing [67]. With rising temperature, we are already
facing consequences, such as rising sea levels, burning forests, natural disasters, and weather
extremes [67, 68]. Collective action is demanded to mitigate the climate crisis's devastating
effects before it reaches irreversible highs. In a press release published by United Nations
[67] from the climate action summit in 2019, Secretary-General Antonio Guterres states that
"The climate emergency is a race we are losing, but it is a race we can win". However, we
need to take significant measures to turn the ship around before the window of opportunity
is closed.

An area that has excellent opportunity for improvement is the food sector. Studies show that
around a third of all human-caused greenhouse gases is related to the food industry [69, 38].
Agriculture, deforestation, and other land-use changes are three of the most significant fac-
tors in this equation[69]. Consequently, is the production of animal-based products asso-
ciated as the most detrimental impact in food production emissions. This is because meat
require a wide-range of grassland, as well as cows and sheep emits methane when digesting
their food [69]. In addition to methane emissions, nitrous oxide is emitted by cattle waste
and chemical fertilizers used for cattle food. The two latter have higher global warming po-

tential than carbon dioxide, subconsequently linking red meat to the highest greenhouse gas emissions. Altogether, meat is considered to account for nearly 60 % of all greenhouse gas emissions in the food industry [38].
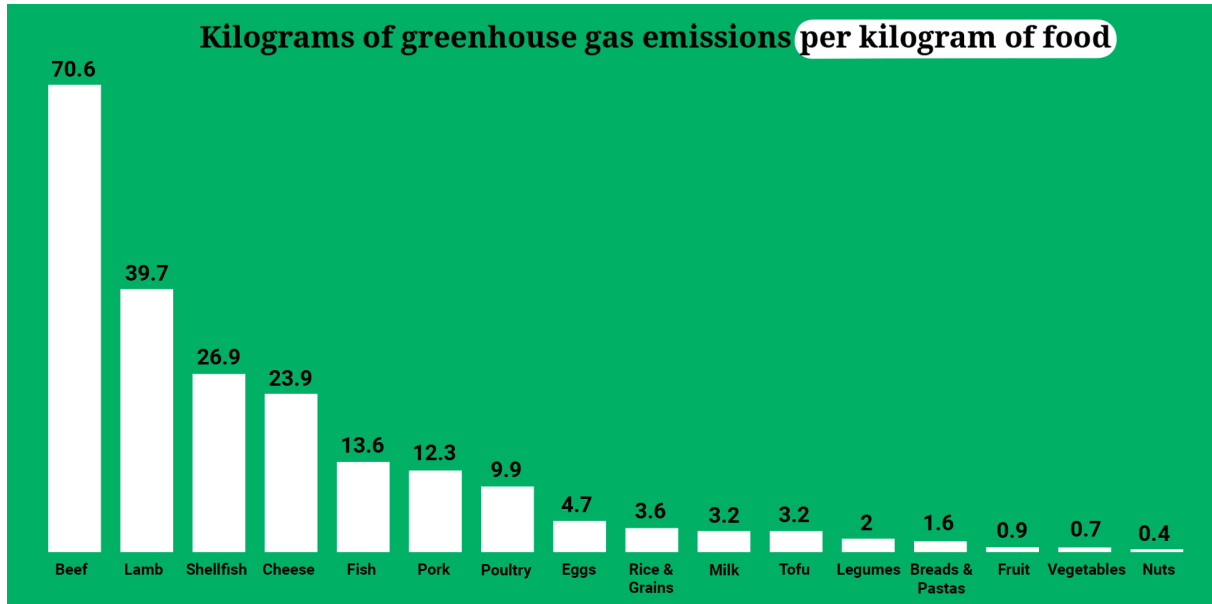
Figure 1.1: A visualization of gas emissions per kilograms of food of different food types, taken from [69]. The emissions are measured in kilograms of CO2, but includes other greenhouse gases such as methane and nitrous oxide by converting them to carbon dioxide.

Even though there has been a growing awareness of the environmental impact of food production and transportation recent years [25, 19], a lot of consumers are misinformed about how their diets affect the environment [40]. A phenomenon termed the "negative footprint illusion", denotes consumers' tendencies to misjudge their individual environmental impact, specifically when there is a combination of items involved[1] [57]. In addition, the information may not be as easily accessible unless the consumer is actively searching for it. However, ensuring that the information is more accessible to the population could make the process much easier and make choosing more sustainable alternatives more manageable and navigable. As digital platforms are a massive part of our life, promoting sustainability via digital media would be an effective way to reach consumers [41].

An example of encouraging consumers to choose sustainable alternatives via digital media could be promoting more environmentally friendly products online through grocery platforms. In today's digital age, online grocery shopping has become increasingly popular due

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[1]An example of this is when the consumer believes that combining a meal of red meat with a side dish labeled "eco-friendly" somehow reduces the high carbon footprint of red meat [57]

to its convenience and accessibility. However, current methods for product recommendations on these platforms are typically based on personalized or popular feedback, such as past purchases or user ratings [42]. This means that users with a meat-based diet may not receive recommendations for more sustainable food options, as their previous purchases or ratings may not reflect this preference. Therefore, there is a need for alternative research that go beyond personalized or popular recommendations and find methods that can promote sustainable food choices on online grocery platforms.

It is important to mention that even though eating more plant-based and reducing meat consumption is an important aspect to reduce emissions, there is also consequences to completely discarding meat from out diet. Breene [5] stated "risk of desertification, loss of biodiversity and increased growth of cities" as three possible impacts of global veganism. Like everything in our diet, it should be about moderation, so the focus of this thesis is to reduce mass meat production instead of completely removing it. Besides, it is important to avoid creating dissatisfaction with consumers who already live an unsustainable lifestyle (e.g. consume large amounts of meat), subsequently making them choose a different online supermarket. Thus, the goal should be to promote more sustainable alternatives while simultaneously making the consumer return.

1.2 Relevance

In December 2019, a Eurobarometer public-opinion survey revealed a widespread concern among European citizens regarding climate change, where 94% answered that protecting the environment is a crucial matter to them [13]. This underscores a public desire for a stronger focus on environmental issues, and that tackling the issues requires everyone to take on their shared responsibility, including governments, companies, and industries [13]. Multiple European grocery stores have also expressed their commitment to the issue. The Norwegian grocery stores Oda and Kiwi, and the Finnish grocer Kesko, aim to be carbon neutral by 2025 and climate neutral by 2030 [17, 43, 27], whereas the leading English grocery store Tesco has set their target to be carbon neutral by 2035 and reach net zero by 2050 [61].

Facilitating sustainable choices among consumers is critical for achieving these goals. The

Norwegian store Oda, for instance, express that while the company aims to become climate neutral, they also want to help consumers lead climate-friendly lives [43]. A survey completed by Günday et al. [19] revealed that customers expect grocery retailers to take action and prefer shopping at brands that use and promote sustainable products, which indicates that consumers are also willing to make changes. Examining ways to nudge users to make more sustainable food choices could be an imperative study for further development in the field of encouraging more sustainable eating behaviors on digital platforms, and help grocery services that strive to reach their targets.

However, the majority of research on nudging has been conducted in offline environments, leading to potential challenges when applying these methods in digital contexts [52]. Furthermore, the concept of digital food swaps is still relatively new, with existing studies primarily focusing on enhancing healthier eating behavior [24, 28, 15]. As a result, there is a significant gap in research regarding sustainable food swaps, highlighting the need for further investigation and understanding in this field.

1.3   Problem statement

The approach of this study is to explore the effectiveness of using food swaps to promote a more sustainable alternative. The food swaps involve offering alternative food choices that are more sustainable than the original product. Conjecturing that informing the consumer about a similar option that is more sustainable would influence users to choose differently while simultaneously gaining the user insight that provides more trust in the system.

The current implementation of food swaps in retail settings is often limited and less visible, as illustrated in Figure 1.2, which reduces their potential impact. By proposing an actual swap while simultaneously informing the user of the benefits of choosing the alternative product, we aim to make it easier for users to choose more sustainable products. In this study we setup a prototype in which we investigate this, as depicted in Figure 1.3, which compared to the swap possibility in Figure 1.2, is more proactive and informative.
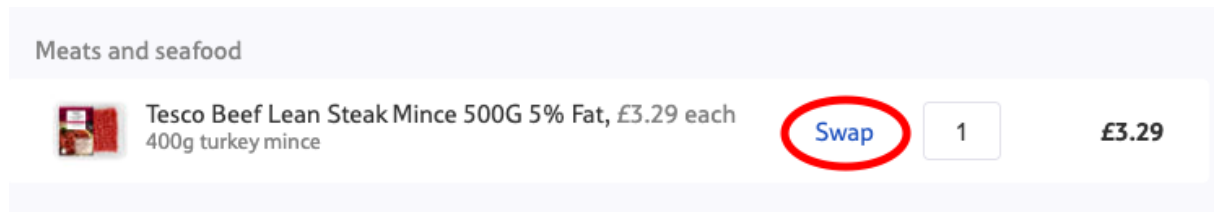
Figure 1.2: Partial screenshot of a Tesco grocery basket. The red circle represents the swap option, where assumptions can be made that only users actively wanting to change the product would press.
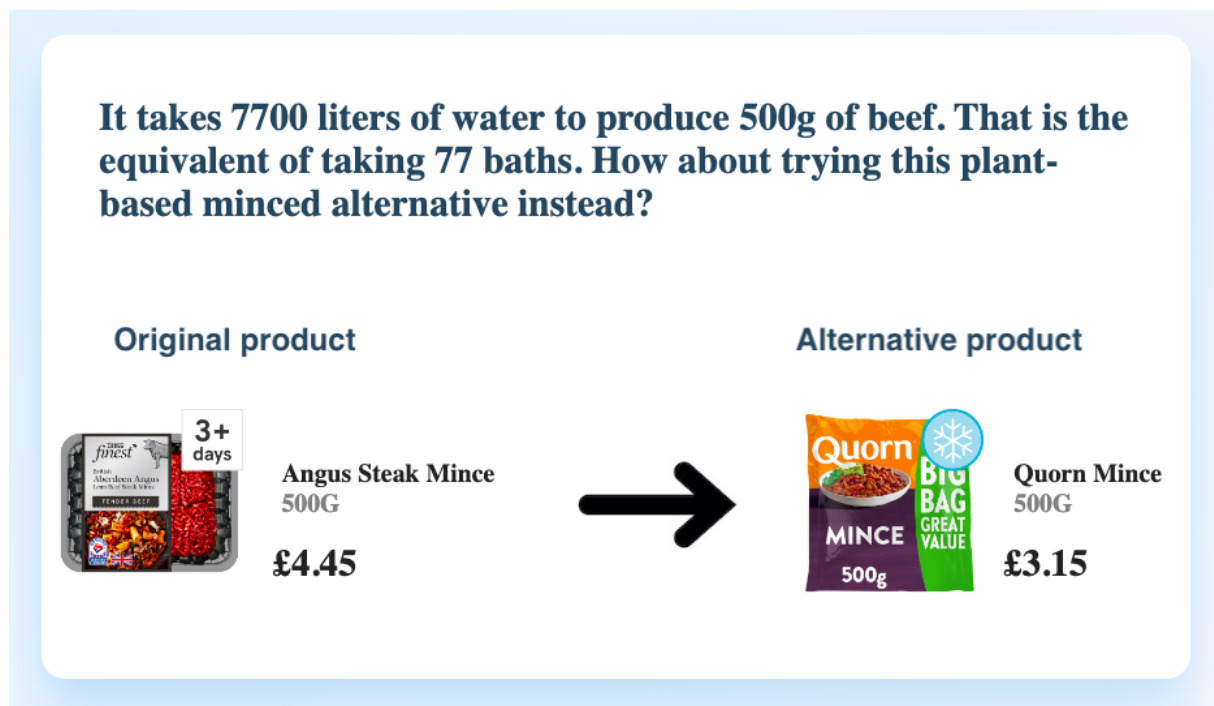
Figure 1.3: An example of a swap offer from the prototype, with an environmental impact explanation to encourage users to choose the more sustainable product instead.

By implementing explainable food swaps, we aim to make information regarding individual environmental impact more accessible and steer consumer behavior towards more sustainable products. Preliminary research indicate that consumers struggle to accurately evaluate the environmental consequences of certain items due to the, previously mentioned phenomenon, "negative illusion footprint" [57]. By making information more obtainable to users via digital media and better communicating the environmental impacts of certain food products, we aim to steer users towards more pro-environmental behavior.

1.4   Research questions

The primary goal of this research is to examine the effect of nudging users to choose more sustainable products. The study aims to investigate how to design and present explanations in a way that motivates and facilitates food swaps adoption by consumers and examine which factors are the most effective in encouraging more sustainable consumption. We test the effectiveness of using sustainability motivated explanations against food swaps with nonspecific explanations, but also against two other possible motives. One of these motives is health, as it has been a popular motive researched in the food domain. The other motive is money, as financial consideration is assumed to affect users consumer behavior. Based on this, the following research questions are addressed:

- **RQ1.1:** *To what extent can specific motivational explanations focused on sustainability, money, and health increase the acceptance of food swaps in an online grocery shopping service?* In section 4.1, analyses are conducted to examine swap acceptance across the different explanation frames. We examine if the different explanation frames were successful in increasing swap acceptance, and if existing relationship with sustainability, money and health had an impact on swap acceptance, specifically for the corresponding frame. Lastly, we looked into what motivational frames where more likely to influence the decision-making process, as well as affecting participants desire for swaps in the future.

- **RQ1.2:** *Do a user's perceived understanding of the swap motivation affect it's acceptance?* In section 4.2, analyses are conducted to examine the relationship between perceived understanding of why the swap was offered and users inclination to accept the swap. We further examine if perceived understanding vary across the different frames.

- **RQ1.3:** *To what extent can cost-decreasing swap proposals affect swap acceptance?* In section 4.3, analyses are conducted to examine if a user were affected by the cost of the alternative product, and if they were more inclined to swap a cost-decreasing swap suggestion compared to cost-increasing swaps or (almost) neutral-cost swaps.

- **RQ2.1:** *To what extent does the perceived similarity between the original product and the swap product affect swap acceptance?* In section 4.4, analyses were conducted to

gain insight into other factors affecting swap acceptance such as perceived similarity between the original product and the swap product.

- **RQ2.2:** *Do users existing preferences for specific food types, such as meat, affect their perception of similarity and swap acceptance?* In section 4.5, we dive deeper into the similarity aspect by looking into meat swaps based on the literature. We conduct analyses to examine if meat for meat swaps are perceived more similar than meat for fish or plant-based options, and if it further increased swap acceptance.

1.5 Thesis outline

This master thesis is structured into five chapters. The current introduction chapter presents the motivation, the relevance of this thesis, the problem statement and research questions. The background section of Chapter 2 assess the recent evolution of online grocery stores, including future aspects and a thorough review of related work in the food domain. This includes factors influencing food choices, nudges, food swaps, and explanations. Chapter 3 outlines the materials and methods used for the experiment, including the data employed, prototype development, research design, procedure, and measurements. Chapter 4 presents the study's results, detailing the statistical analysis to indicate whether sustainable swaps made an impact. Chapter 5 discusses the research findings and limitations and suggests possible avenues for future research.

Chapter 2

Background

The following chapter provides a comprehensive review of prior research relevant to the context of this thesis. The chapter is categorized into 6 distinct sections:

Section 2.1 describes the evolution of grocery websites over recent years, more specifically after the pandemic, and consumers' response to this.

Section 2.2 elaborates on factors reportedly affecting a consumer's purchasing behavior and dives deeper into the three frames, health, sustainability, and money. The section also touches on food complexity.

Section 2.3 provides an overview of nudging as a method and how it is used in everyday life.

Section 2.4 provides an overview of food swaps and discusses the shortages of research on sustainable food swaps

Section 2.5 elaborate on explanations as a nudging method, previous research on explanations in a food-related context, and research around designing explanations

Section 2.6 provides a short summary and conclusion of the chapter and specifies the contributions of this thesis.

2.1   Online grocery shopping websites

After the pandemic struck in 2020, sales on online grocery shopping websites skyrocketed with an astonishing growth of 103% in just the US, with an expectation of further development in the coming years [70]. Before the pandemic, these numbers were essentially non-existing, but the monthly online grocery sales doubled due to restrictions forcing people to limit their physical interactions [70, 66]. However, even though most consumers settled into a new normal during the pandemic [70], a European study by Günday et al. [19] from March 2020 to September 2020 reported that some consumers were unsatisfied with online grocery shopping services.

The aforementioned study found that some participants intend to continue shopping at their newfound site for at least some of their grocery needs. At the same time, some satisfied customers concluded that they would return to physical stores and that online grocery shopping was only a short-term solution [19]. Another finding showed that the UK would be the only country in the EU-5[1] expected to increase its online grocery sale after the pandemic. Nevertheless, the numbers are still more prominent than before the pandemic in the countries that showed a reducing trend [19]. However, one of the aspects highlighted as the reason behind the reducing trend was user satisfaction, which was affected by factors such as price sensitivity and the company's morals and principles, but also the capability to keep up with demand [19]. More research within the grocery domain and factors affecting consumer behavior are necessary to overcome this difficulty.

2.2   Factors influencing consumers' online shopping habits

The recently mentioned study by Günday et al. [19] found a consistent factor for all the participating European countries, namely an increased progression in price sensitivity. Consumers would trade a product for a cheaper option, indicating that money is essential to consumer behavior online. Another important discovery in the survey was consumers' expectations of retailers' values and purpose. While striving for a healthier diet has been a priority over a period of time, consumers are now more conscious of the company's morals

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[1]EU-5 = the UK, Germany, France, Italy, and Spain

and principles, increasing overall net sentiment regarding environmental and ethical products [19]. Respondents indicated strong intentions of supporting stores that promoted and used sustainable options. This was backed up by a later study by Gatzer and Roos [17] revealing sustainability as a significant factor in shaping the grocery retail industry in 2021-2022. By acquiring this information, we can argue that shifting the focus to making grocery websites more sustainable could help improve user satisfaction and increase the possibility of consumers returning. So, even though this study won't touch upon the demand issue mentioned in 2.1, it might be able to contribute to consumer satisfaction by promoting sustainable eating behavior.

Importance of food type in shopping,[1] average EU-5 net sentiment[2]
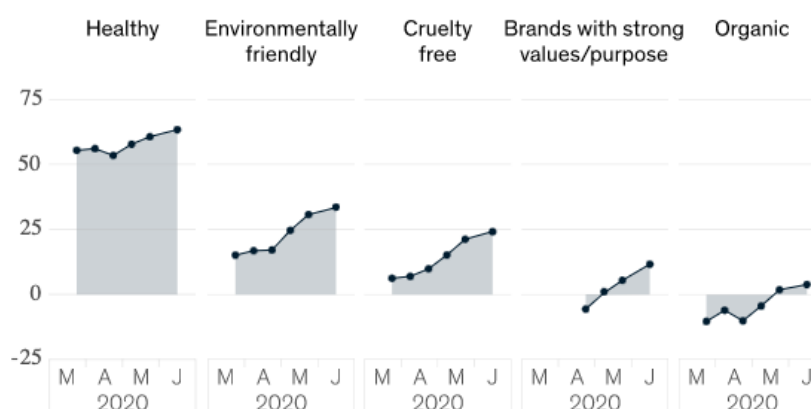
[1]Question: How important were each of these food types in your last week of shopping?
[2]Net sentiment is the % of respondents who answered "very important" or "extremely important" minus the % of respondents who answered "not important."
Source: McKinsey & Company COVID-19 EU-5 Consumer Pulse Surveys across France, Germany, Italy, Spain, and United Kingdom, sampled and weighted to match Europe's general population: 18+ years. Survey dates: 6/18–6/21/2020, 5/21–5/24/2020, 4/30–5/03/2020, 4/16–4/19/2020, 4/2–4/5/2020, 3/27–3/29/2020; n = 1,000 per country, 5,000 total. Note that the 1,000 respondents did not always answer all questions

Figure 2.1: A graphic representation of consumers' priorities while grocery shopping online, copied from [19]

2.2.1 Health, sustainability & money

As depicted in Figure 2.1, consumers consider health as an essential factor when grocery shopping [19], which has been a growing trend among consumers [30, 60]. A study by Adam and Jensen [3] showed that influencing consumers through food labeling, promotions, and campaigns towards healthier products when grocery shopping effectively promoted healthier food purchases. Over the recent years, there has also been an increased interest in exploiting methods and approaches to encourage healthier nutritional decisions on digital platforms [42, 65]. Usually, the studies have included health-aware food recommender sys-

tems[2], which has shown to be an essential part of the solution to a healthier way of living [65].

In addition to health concerns, consumers are also increasingly focused on sustainability when shopping for groceries online, as shown in figure 2.1, with growing awareness among the younger generation [19, 60, 7]. According to a survey in the US, by Kearney [25], nearly one-third of consumers consider the environmental impact products have when shopping in grocery stores. Even though the study found that sustainability was not among the three most important drivers of food purchasing choices, still 80% of the respondents indicated at least some awareness of the correlation between their food choice and the environment [25, 7]. With growing awareness of the environmental impact of food production and transportation, many consumers are looking for ways to reduce their carbon footprint and support sustainable practices [25, 19, 17].

An apparent influencer on a consumer's food choice is money [59]. The factor was measured to be one of the most significant factors when influencing a specific food choice in the previously mentioned study by Kearney [25]. These findings can be supported by a study by Chafin [7], that found that 72% participants valued price highly when purchasing food online. Further, correlations can be drawn to the growing trend of trading for cheaper products in the EU-5 countries [19]. A study by Steptoe et al. [59] found that women tend to rate the cost as more important than men, which they concluded would be because women typically are responsible for food shopping in the U.K. and are, therefore, more aware of budgetary limitations. The study also found that women already experiencing dietary restraints were less influenced by price, which was suspected to be because the desire to eat healthier outweighed the consideration of cost [59].

2.2.2   The complexity of food choices

After reviewing a few factors affecting consumer food choices readily suggest that food is a highly intricate and multifaceted subject. There have been lots of research regarding recommendations and influencing consumers in several domains. Still, historically the food

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[2]A recommender system is fundamentally designed to facilitate users in making decisions by providing suggestions for items that are of interest to the particular user [48]

domain has received little consideration and has just in recent years spiked interest[65, 42]. We can assume that the reasoning behind it is the complexity of the topic and its challenges. As preference and healthiness influence a person's food choice, research also show that convenience, context, and ethical and cultural reasons are essential factors [65, 23]. Adding to the complexity, lifestyle preferences and allergies are also factors that need to be considered. These disputes and challenges are not something other domains have to encounter [65].

Musto et al. [42] narrowed what motivated food choices down to 3 factors: Food-related features like perceptual differences and nutritional information, individual differences like anticipated consequences, and society-related features like norms and values. As the society-related features show a positive trend towards more sustainable food choices [19, 25], other factors may still intervene with the consumer's food choice. Fernandez and Raine [14] concluded in their study that "understanding what matters to consumers is key to developing appropriate interventions that involve emerging digital food retail services." The latter study highlighted that given the immense growth of online grocery platforms, and the limited knowledge about the impacts of new digital food retail environments on eating practices, there is an urgent call for more research on consumer behavior, such as priorities and concerns [14].

2.3 Nudging

Thaler and Sunstein [62] define digital nudging as "any form of choice architecture that alters people's behavior in a predictable way without restricting options or significantly changing their economic incentives." The idea behind it is to make specific options more visible or attractive so that people may be more likely to choose them over other options. It's also important to emphasize that the nudge must be simple and involve minimal intervention in order to qualify as a nudge [62]. The concept of nudging draws from theories in psychology and sociology, which touch on subjects of how the physical environment impacts and restricts our behavior [31].

Even though the food domain may have received comparatively less attention than other domains, existing research on nudging methods, especially in food-related contexts, has shown

positive results [65, 6, 42]. As seen in the study by Bucher et al. [6], digital nudging is proven as an effective strategy to influence the behavior of online users in the desired way, specifically in a food choice scenario, without compromising user satisfaction. Nudging strategies can be applied offline and online to encourage healthier or more sustainable alternatives [31].

A widely known and accepted nudging method consumers are presented with is nutritional labels[8], which is information available for consumers to read before purchasing the product. The nudge is probably most associated with an offline setting but is also presented on grocery shopping websites. It doesn't stop there, as there are a variety of existing nudging strategies [31, 42, 22]. As consumers, we are regularly subject to these strategies without even realizing it, both offline and online and in different societal contexts [52]. For example, Goldstein et al. [18] performed a study to see how social norms could encourage a preferable behavior among hotel guests. The study successfully proved the desired effect of a social norm message, telling guests to reuse their towels as most other guests do so[31].

As portrayed above, nudges can be utilized in both offline and online settings and can come in various forms, but in this thesis we will examine the effect of informational nudges in digital environments. The method involves presenting information in visually and verbally appealing formats, providing individuals with relevant information to subtly shape their decision-making process in the desired direction [40]. A study by Morren et al. [40], successfully utilized informational nudges to encourage more sustainable dietary behavior. The participants would enter the ingredients to their three last home-cooked meals, and would then be presented with either cooking instructions to a healthier or more sustainable meal, or the health/sustainable impact of replacing certain ingredients.

Another essential aspect to remember is that not all nudges are created equal. There has been an ongoing debate about the ethics of using nudges to influence behavior [51]. Nudges are meant to benefit the user by helping them make better decisions; however, the nudges are not supposed to force options upon them [6, 62]. Critics argue that nudges can be perceived as manipulative and can be seen as a violation of human dignity, primarily when it is used to promote particular interests or values of others [51]. A study by Schmidt and Engelen [51] concluded that the arguments fail to reject nudges altogether but that specific ethical assessments should be made when implementing the practice. It is, therefore, vital to ensure

that the nudges that are implemented are done in a transparent and ethical manner and to always consider the potential risks and benefits of using nudges in any given context.

2.4   Food swaps

Food swaps are a method used in digital recommender systems that involve swapping or substituting one food option with another, where prior studies within the field has predominantly focused on investigating how to encourage healthier alternatives [24, 28]. Since food swaps involve changing the digital choice environment, the method is considered a form of nudging. The nudging method has gained popularity in recent years to encourage healthier habits and is meant to provide consumers with more salient and accessible options, usually with a goal in mind [15]. Even though the nudging strategy is mainly used to promote healthier food choices [15, 24, 28], other food swaps exist as well, such as alerting consumers of cheaper options [15]. However, the primary goal of this study is to swap a product for a more sustainable product, even though health and money are also considered factors.

As discussed in section 2.2.2, food is a complex topic where several factors can be a part of the decision-making process. Therefore, the effectiveness of food swaps as a nudging method may depend on other factors such as perceived taste, convenience, lifestyle choices, affordability of the alternative option, and the context in which the swaps are offered. Consequently, previous research on food swaps has been unpredictable. Koutoukidis et al. [28] studied the effect of food swaps promoting reduced saturated fat and altering the default order and concluded that the methods together made a significant impact. Thus, altering the default order was significantly more effective than the food swaps. Another interesting finding was that cheese, butter, and sweets had a higher acceptance swap than milk or meat [28]. This is an essential factor to remember as this study primarily builds on recommendations based on substituting meat. A study by Forwood et al. [15] did not find a statistical significance in promoting reduced energy density food by within-category food swaps. However, the findings also revealed a higher swap acceptance in certain food categories, such as pasta and rice, compared to the low swap acceptance rate in the meat category. The study also found that participants with a higher swap acceptance and more engagement reported a more positive shopping experience [15].

Even though the priorly mentioned studies did not show a positive trend towards food swaps, a study by Jansen et al. [24] showed promising results in promoting healthier purchase behavior with swap offers and Nutri-Score[3] labels in an online environment. It is also important to note that the study found that social norm messages do not have a statistically significant effect. However, the study concluded that even though swap offers can enhance healthier products, it relies on having an attractive offer and suggesting a plausible alternative, as well as explaining the health reason behind it [24], which is a good starting point for this study.

2.4.1   Sustainable food swaps

While existing research on food swaps is relatively limited, it does not compare to the sparsity of sustainable food swaps. Furthermore, the research that does concern sustainable food swaps has predominantly focused on dietary aspects, such as creating guiding principles for food swaps that benefit both health and the environment or examining the impact of sustainable food swaps on nutrient intake among pregnant women [71, 73, 2]. However, limited attention is given to the potential of promoting sustainability swaps on digital platforms. Thus, a knowledge gap exists regarding the effectiveness and feasibility of digital interventions for promoting sustainable food swaps in online grocery shopping settings.

2.5   Explanations

In line with existing research, our study aims to enhance user experience by providing transparent and informative explanations, accompanying the food swaps. As mentioned in the previous section 2.4, the study by Jansen et al. [24] indicate that for a food swap to be effective, we should consider offering a credible alternative by offering an explanation informing the participant about the meaning behind the swap offer, which in their case was a health explanation. Tintarev and Masthoff [63] highlight 7 different advantages explanations can yield, such as increased efficiency, trust, and overall satisfaction. Furthermore, they underline the persuasiveness of explanations by, for example, convincing users to buy certain

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[3]Nutri-score is a front-of-pack nutritional label that indicates the overall nutritional quality of a food product

products [63]. Even though this can be considered manipulative and can come across as highly beneficial for the system, explanations are primarily used to benefit the consumer, such as recommending healthier options in a food domain [63, 24]. Providing the user with an explanation is considered an effective nudging method that aims to influence behavior by providing information that may encourage consumers to make more informed and thoughtful choices.

The approach has not received substantial consideration in food domains but has been successfully deployed in other domains. Reportedly, explanations are considered transparent, plus the method increased users' trust and affected their decision-making process [42]. According to a study by Herlocker et al. [22], users showed appreciation for being elaborated on the reasoning behind their recommendations, where explanations were used in a movie domain using an automated collaborative filtering method[4]. The explanations specify the reasoning behind the prediction, making the user involved in the decision process and providing the user with a better understanding of the strengths and limitations of the system [22].

As the previously mentioned study made suggestions based on similar people's interests and ratings, the current study will base the recommendation solely on if the alternative product is better for the environment, a healthier option, and is presumed to be a working alternative for the current product. In this case, the alternative product is generated upon a specific product; therefore, it will not be necessary to elaborate on how the system specifically concluded with that product. However, the user will be provided an explanation as to why the product was suggested to them, depending on which frame the user is assigned (baseline, sustainability, money, or health). Even though the justification is not in line with the study by Herlocker et al. [22], it will still provide insight for users by disclosing the potential consequences of different choices, which may help consumers choose options that align with their values and goals.

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[4]Collaborative filtering-based recommendation systems make recommendations based on active users preferences and other similar users' behavior [48].

2.5.1   Explanations in food-related context

In the context of food choices, explainable food swaps aim to guide consumers toward healthier or more sustainable food options by presenting them in a clear and accessible way. There is a particular innovation to explanations in a food-related context [65]. Nonetheless, a study by Elahi et al. [12] includes explanations in their food recommender system to reveal to the user why the specific recipe was suggested to them. The prototype is designed to make recommendations based on meal ratings and tags users have added to specific ingredients or meal characteristics disclosed in the recommendation. A study by Harvey and Elsweiler [21] provides explanations with the meal recommendations by revealing nutritional value while explaining how this fits the user's ideal values.

Another study that addresses the topic of explanations in a food-related context is a study performed by Musto et al. [42], which analyzes the effects of natural language justifications, which is a variation of an explanation, in food recommender systems. The study shows that even though most users prefer the more popular recipes when no explanation is presented, it also indicates that health-aware recommendations were favored over the popularity-based ones when they were given alongside a comparative elaboration [42]. They concluded that the most promising method was to compare and connect each recipe's different aspects while displaying its various features and goals. They also tested for single justifications, but the comparative method did significantly better. Even though the comparative method can be disposed to higher false-positive rates, conclusions were made that the overall results indicated that the different explanation strategies would either promote healthier food choices or they would have no net effect at all. Though this study was conducted for recipe platforms with a primary goal of promoting healthier options, the positive effect of a comparative method is a good starting point for this study.

2.5.2   Designing explanations

Designing effective explanations is a critical aspect of encouraging sustainable food choices. This is because how the explanations are designed and structured can play a huge role in how much of an impact the explanation will have. Tintarev and Masthoff [64] offer guidelines for designing and evaluating a good explanation. Some of these guidelines reflect the benefits

of using explanations and consider the presentation of recommendations and how the interaction with them can impact the recommendations as well. To encourage sustainable food swaps, explanations should be designed to be motivating and persuasive and highlight the benefits of making more environmentally friendly choices.

A clear and informative explanation example is ingredient and nutritional content. In many countries, it is a requirement to disclose this information, such as calories, fat, carbohydrates, sugar, and fiber [72]. Consequently, consumers are exposed to this information regularly, which provides the consumer with the level of healthiness of a product or recipe. As shown in figure 2.2, Tesco also provides users with this information when shopping for groceries, which helps users identify if the product suits their needs and assists their decision-making process. However, a study by Kreuter et al. [29] concluded that participants who already lead a healthy lifestyle were more likely to read the nutritional contents than those who don't. The study also revealed that participants with diet-related health problems use the information to conclude which product they can or cannot ingest. Suppose this applies to an environmental context as well. Assumptions can be made that participants who already consider the environment to be an essential factor in their diet are more likely to accept the sustainable food swap.
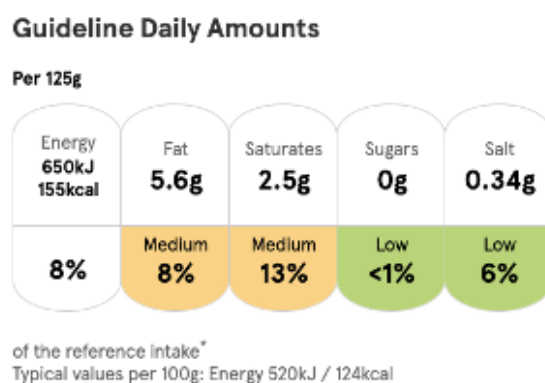
Figure 2.2: Screenshot of a front-of-pack Multiple Traffic Lights label representing the nutritional content of a product on Tesco's online grocery store.

Another critical aspect of designing compelling explanations is ensuring the target audience efficiently understands them. Shine et al. [53] found in their examination that some participants either had trouble understanding nutritional labels while some found it time-consuming. Rothman et al. [49] also identified a correlation between participants with less income and less education background and having trouble reading and understanding the

meaning of the nutritional values. These results strongly indicate that considerations must be made toward the perception and inclusiveness of the displayed information. Explanations should be clear and concise, especially when dealing with complex information such as the environmental impact of food consumption.

2.6   Summary & Contribution

This chapter aimed to examine prior research relevant to the context of this thesis. The sections showed a recurring theme of scarcity, revealing that little attention has been devoted to helping users make more sustainable choices in online grocery stores. Recent surveys show a growing interest among consumers to make environmental choices when grocery shopping, and also an increasing trend of choosing grocery retailers based on decent values. However, research within food domains has recently gained popularity, which have primarily focused on promoting healthier consumer behavior. Consequently, leaving research involving encouraging sustainable consumer behavior, and more specifically environmental food swaps limited.

Currently, no studies exist where online grocery stores apply sustainable food swaps to encourage more sustainable products. This thesis will contribute to the mentioned limitations by addressing the following:

- The main contribution of this study is to investigate the effectiveness of explainable food swaps as a nudging strategy in online grocery shopping services to encourage more sustainable consumer behavior. By testing swap acceptance and perceived understanding of different frames of explanations (health, sustainability, and money), this study provides insight into which type of motivation may have been the most effective for different users.

- In addition, we provide insight into how a cost-decrease, cost-increase or an almost neutral price difference between the original product and suggested product, can affect swap acceptance.

- The inclusion of other factors, such as perceived similarity and food types, in the anal-

ysis can provide a more nuanced understanding of the factors that influence users'
perception and acceptance of sustainable food swaps.

- Overall, this study provides practical proposals for designing more effective sustain-
able food choice interventions on digital platforms. It contributes to the development
of further research within the encouragement of more sustainable consumer behavior
in online grocery shopping services.

Chapter 3

Methodology

3.1 Dataset

The dataset used to create the mockup supermarket was collected from Tesco's grocery website [1], using a web crawler to identify 30 recipes. This resulted in a collected dataset with initially 30 dinner recipes with their belonging ingredients, making up a variety of 30 premade baskets with a total of 349 food items. Using Python along with Selenium, the information was stored in a JSON file, and product images were stored in directories with the recipe's name.

A separate dataset was collected for the swap products. To be able to retrieve products that fit the requirement for at least one of the three frames (health, sustainability, and money), manually searching for the products was the best-suited solution. By matching the different recipes to suitable, alternative products from Tesco's grocery website, 18 alternatives were identified and distributed to each pre-filled basket. To be able to retrieve the products, a user was created, and the selected products were added to a basket. The same web crawler, with a few alterations, signed in and retrieved the necessary information. Finally, we were left with a dataset of 18 ingredients, with the necessary information, such as name, price, and quantity, stored in a new JSON file and product images stored in a swap directory.

Later in the process, a decision was made to reduce the dataset to 6 pre-filled baskets, which

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[1]https://realfood.tesco.com/recipes/courses/dinner-recipes.html

evidently reduced the swap alternatives to 6 as well. The 6 basket and swap alternatives were selected based on the three frames; health, sustainability, and money. All swap alternatives were now healthier and more sustainable, and to further understand the money frame, we arranged the alternatives to have either a decrease, increase, or almost neutral cost. All redundant information was omitted from the dataset.

This process contributed to collecting a detailed dataset with all the essential information needed for this research. Ultimately, we were left with a dataset containing information such as the recipe name, protein, and fat intake, but most importantly, information about the original and alternative products such as name, image, quantity, and price.

3.1.1   Identifying plausible alternative products

While introducing more plant-based options and vegetables to consumers should be the primary goal, replacing red meat with poultry and fish can also significantly amplify consumers' personal impact [20, 19]. However, negative perceptions of meat replacers, particularly regarding taste, still exist [36]. Research indicates that many consumers hesitate to purchase vegan/vegetarian products due to concerns about being labeled by their food preferences [19]. Therefore, including swap alternatives that are more sustainable but also in the meat category might increase the acceptance of the swap.

A study by McIlveen et al. [36] concluded that Quorn products offer "similar texture and flavor attributes to those consumers who wish to avoid meat products." Including a swap offer with this plant-based product and an explanation could educate users and attract consumers to accept the given product. Additionally, inspiration for alternative swap products was derived from articles in women's health magazines about meat replacements [39, 37], as well as observing a positive trend of replacing significant portions of meat in a meal with vegetables and legumes [58, 11]. However, it is essential to mention that in these successful studies, the meat was not entirely replaced, which is a factor to be taken into account in this study.

By examining existing research and considering various factors, we decided to include various food options to promote sustainable consumer behavior. Even though we acknowledge

the importance of introducing more plant-based options and encouraging consumers to reduce their meat consumption, we also recognize the existing challenges related to negative perceptions and attitudes. Consequently, food groups such as meat, fish, vegetables and legumes, and plant-based options were included among the swap alternatives. By including a wide range of food alternatives, we aim to contribute to a broader understanding of how different food swaps can promote more sustainable consumer behavior.

3.2   Prototype

In this section, we will address the thought process and factors considered during the development of the prototype. To be able to conduct the study, a mock-up grocery basket was created. Most of the interface was built from the ground up using standard web-development technologies such as HTML, CSS, and JavaScript. As the study is conducted using a survey tool, the baskets were not made to be interactive but primarily as a visualization tool for both the basket and the food swap. An example of one of the pre-filled baskets presented to the user is depicted in figure 3.1
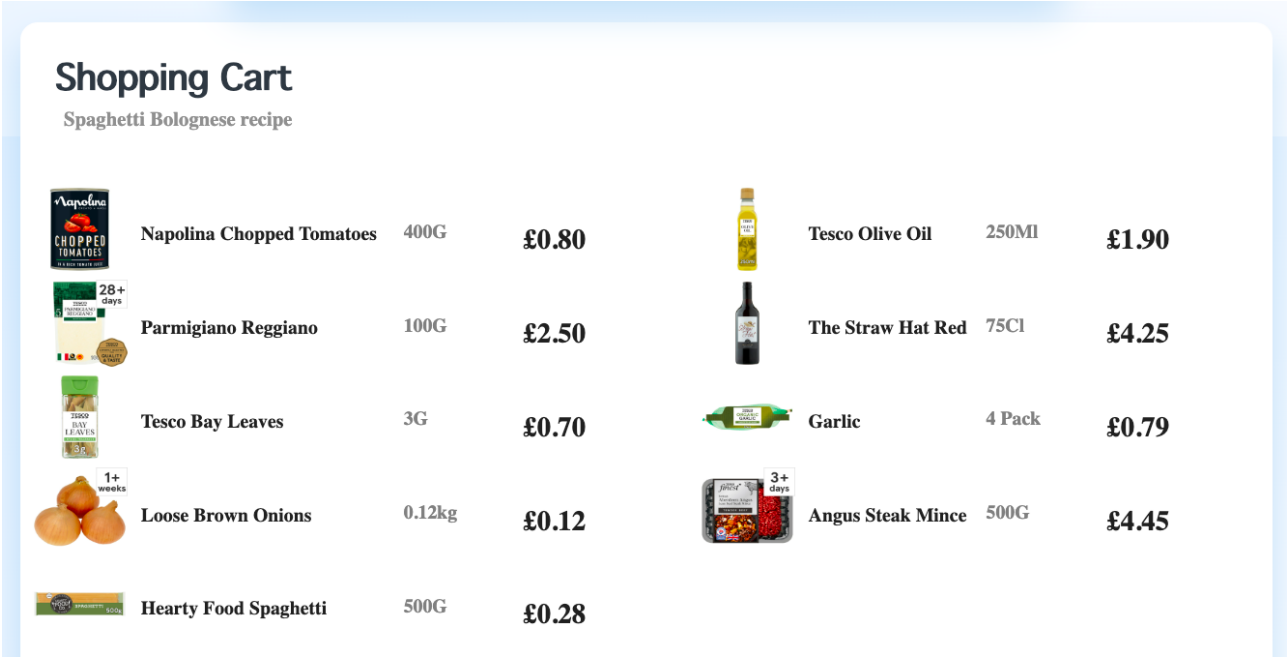
Figure 3.1: Screenshot of one of the premade baskets uploaded to the survey tool. This basket would make up the dinner recipe of spaghetti bolognese.

3.2.1 Designing baseline explanations

The explanations presented to participants assigned to the baseline frame were straightforward and lacked any persuasive elements. The overview of the baseline explanations is depicted in table 3.1.

Table 3.1: Overview of the recipe baskets, the food swaps, the cost frame, and the baseline explanations.

Baseline			
Recipe	**Swap**	**Cost**	**Explanation**
Spaghetti Bolognese	500g minced beef → 500g Quorn mince	Decrease	Quorn minced is an excellent alternative for minced beef. How about swapping these products?
Beef enchiladas	500g minced beef → 400g Black beans	Decrease	Black beans work well as a substitute for minced beef in this recipe. Why not try swapping these products for some variety to your dish?
Smash burgers	4 beef burgers (454g) → 4 chicken fillets (300g)	Increase	This recipe can also be prepared with chicken fillets instead of burgers. How about a swap?
Pesto chicken one-pot	Chicken thighs 1kg → 980 g of Wild-caught salmon	Increase	Salmon is a great replacement for chicken in this recipe. How about swapping for some wild-caught salmon instead?
Buffalo chicken wings	Chicken wings 900g → cauliflower florets 900g	Neutral	Cauliflower have been used in various recipes as a similar replacement for chicken wings. How about swapping to cauliflower instead?
One-pot Mexican beef stew	Tesco beef stir fry strips (375g) → chicken fillets (470g)	Neutral	Chicken fillets are a good replacement for beef stir fry strips in this recipe. How about swapping them?

3.2.2 Designing health motivated explanations

The health explanations differed from how in-depth the information was. Some of the swaps included nutritional comparisons, such as caloric differences, which were retrieved from Tesco's product website. Furthermore, a food comparison tool was utilized to gather information on health comparison between two food products. The food comparison tool is available at a site called Foodstruct [2], which works as an Encyclopedia of Food & Nutrition [33, 32]. For the plant-based options, various studies have researched the health benefits of meat alternatives, which was used as an inspiration for some of the explanations [11, 50, 34, 35]. Table 3.2 depicts an overview of the health-motivated explanations.

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[2]https://foodstruct.com/

Table 3.2: Overview of the recipe baskets, the food swaps, the cost frame, and the health explanations.

			Health
Recipe	**Swap**	**Cost**	**Explanation**
Spaghetti Bolognese	500g minced beef → 500g Quorn mince	Decrease	How about reducing your calorie intake by swapping to this plant-based minced alternative instead?
Beef enchiladas	500g minced beef → 400g Black beans	Decrease	How about increasing your vegetable intake and reducing your cholesterol intake by swapping minced beef for black beans instead?
Smash burgers	4 beef burgers (454g) → 4 chicken fillets (300g)	Increase	A beef patty contains 206 kcal, which is 65 kcal more than the caloric content of chicken fillets. How about reducing your calorie intake by swapping to chicken instead?
Pesto chicken one-pot	Chicken thighs 1kg → 980 g of Wild-caught salmon	Increase	Even though both salmon and chicken are excellent sources of protein, salmon also covers 120% of your daily vitamin B12 needs and is high in omega3 content. How about swapping to salmon instead?
Buffalo chicken wings	Chicken wings 900g → cauliflower florets 900g	Neutral	Chicken contains over six times more calories than cauliflower, as well as 17 times more fat. How about swapping to cauliflower instead?
One-pot Mexican beef stew	Tesco beef stir fry strips (375g) → chicken fillets (470g)	Neutral	Beef contains more calories and fat than chicken, while chicken meat is higher in protein and vitamin B9 and B12. How about swapping the beef stir fry for chicken fillets?

3.2.3 Designing money framed explanations

For the money-framed swaps, it is essential to include the price differences of the food products in the explanation. This parameter was extracted and stored in the dataset together with the quantity unit. However, the quantity of the products had to be converted to roughly equivalent mass units. Consequently, the price had to be converted accordingly. For instance, if the recipe needs 1 kg of chicken to be replaced by salmon sold in 230g packages, the price needs to be multiplied by a factor of 4 to account for the required quantity. The overview of the money-framed explanations is presented in Table 3.3.

Table 3.3: Overview of the recipe baskets, the food swaps, the cost frame, and the money explanations.

Money			
Recipe	**Swap**	**Cost**	**Explanation**
Spaghetti Bolognese	500g minced beef → 500g Quorn mince	Decrease	How about saving 1.5£ by trying this plant-based minced alternative instead?
Beef enchiladas	500g minced beef → 400g Black beans	Decrease	Black beans work well as a substitute for minced beef in this recipe. How about swapping your product to save £3.99?
Smash burgers	4 beef burgers (454g) → 4 chicken fillets (300g)	Increase	This recipe can also be prepared with chicken fillets instead of burgers. How about making chicken burgers instead, for just £1.45 more?
Pesto chicken one-pot	Chicken thighs 1kg → 980 g of Wild-caught salmon	Increase	This recipe is great with salmon too. For £24.30 more, would you like to try the wild-caught salmon instead?
Buffalo chicken wings	Chicken wings 900g → cauliflower florets 900g	Neutral	Cauliflower wings has been used as a similar replacement for meat-based wings. How about saving 0.80£ and trying cauliflower wings instead?
One-pot Mexican beef stew	Tesco beef stir fry strips (375g) → chicken fillets (470g)	Neutral	It is a nice variety for this recipe to replace the beef with chicken. How about swapping to chicken fillets for just £0.20 more?

3.2.4   Designing environmental impact explanations

The environmental impact explanations can be sorted into three categories; general approach, carbon-focused, or water-focused. However, of the 6 explanations, only one is based on broad-ranging numbers, which was retrieved from an article by Wilde [72]. For the carbon-focused and water-focused explanations, environmental score calculators were adopted. The Meat Carbon Footprint calculator by Kilgore [26] generated the carbon footprint, which was the most user-friendly carbon footprint calculator. It required plotting the kg and meat type, and would then present the total carbon emission. We cross-checked some of the values with a Meat Footprint calculator by Pamula and Zajac [44], and the numbers were essentially equal, even though plotting the numbers here was not as straightforward. The latter calculator provided the water footprint of every meat type as well. In Figure 3.4, you can see

a rough estimate of the calculators' measurements of carbon and water footprint for 1kg of meat.

As previously discussed, it is imperative to make the explanation understandable and transparent; therefore, to create a context for the users, other features were also included. Some of these features were retrieved from the latter calculator, such as the equivalent carbon footprint to charging your phone or a comparison to how much water one or more people drink in a year. In addition, we used a bathtub comparison to put the water footprint into a bigger perspective. 100 liters of water per tub was used as a measurement, as the average person with the standard alcove bathtub fills their bathtub halfway up with 100 liters of water [3].

For the plant-based options, there was no environmental calculator available. To get these measurements, several sources were explored. For the minced Quorn product, the carbon footprint calculations were retrieved from Tesco's product site[4] and cross-checked with the carbon footprint of soy with other sources to confirm that the product site was not affected by a bias, as well as retrieving the water footprint[10]. The carbon emission showed a higher measurement for soy than what Tesco listed on its website; however, the emission is still significantly low. The remaining measurements were gathered from a climate table with an overview of different products with their corresponding carbon emission and water footprint. The climate table is available at a Norwegian site called Framtiden.no (translated to Future) [16]. All measurements used in this research, is also available and presented in Figure 3.4.

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[3]https://bathbarn.co.uk/bathtub-capacity-how-much-water-does-a-bath-hold/
[4]https://www.tesco.com/groceries/en-GB/products/265387631

Table 3.4: A rough estimate of the carbon and water footprint of the items used in the food swap of this study. Including two values of the estimate to provide a range that better represents the possible carbon footprint.

Carbon & water footprint		
Item (1kg)	**Carbon footprint (kg)**	**Water footprint (l)**
Beef	71 / 85.2	15,400
Chicken	10 / 9.8	4,300
Wild seafood	7 / 12.5	2,000
Black beans	0.7	5,053
Cauliflower	0.7 / 12.5	280 / 285
Quorn mince	0.16/0.60	31

It is also important to note that the numbers are rough estimates as it is generally harder to compare greenhouse gas emissions of food products than other factors affecting the climate. Factors such as transportation, deforestation, and gas emissions when the animal is digesting the food, etc., are all part of the calculation for food products gas emission [56, 4, 54, 55]. Consequently, the numbers will fluctuate between countries and the individual meat product. However, based on numerous measurements, there is no doubt that the gas emission is considerably more significant for some meat products than others, as well as the plant-based options [56, 4, 54].

Finally, it should also be highlighted that the measurements for the plant-based option were never actually used in the explanations but served more as a confirmation of their beneficial sustainability value to increase the explanation's credibility. The environmental explanation is depicted in Table 3.5.

Table 3.5: Overview of the recipe baskets, the food swaps, the cost frame, and the sustainability explanations.

		Sustainability	
Recipe	**Swap**	**Cost**	**Explanation**
Spaghetti Bolognese	500g minced beef → 500g Quorn mince	Decrease	It takes 7700 liters of water to produce 500g of beef. That is the equivalent of taking 77 baths. How about trying this plant-based minced alternative instead?
Beef enchiladas	500g minced beef → 400g Black beans	Decrease	While animal-based foods account for 57% of food emissions, plant foods are only responsible for 29% (17). How about switching minced beef for this plant-based option instead?
Smash burgers	4 beef burgers (454g) → 4 chicken fillets (300g)	Increase	Producing 500 g of beef emits 35.5 kg of CO_2, compared to the 5 kg emitted when producing 500g of chicken. How about reducing your carbon footprint by swapping to chicken fillets?
Pesto chicken one-pot	Chicken thighs 1kg → 980 g of Wild-caught salmon	Increase	It takes 3 kg more of CO_2 to produce the chicken, compared to wild-caught salmon. That is the equivalent of charging your smartphone 365 times. How about swapping to salmon instead?
Buffalo chicken wings	Chicken wings 900g → cauliflower florets 900g	Neutral	It takes 3,870 liters of water to produce the amount of chicken needed for this recipe. That is the equivalent of what 4 people drink in a year. A more sustainable, but alternative that works well in this recipe is cauliflower. How about a swap?
One-pot Mexican beef stew	Tesco beef stir fry strips (375g) → chicken fillets (470g)	Neutral	The beef by itself produces 25 kg of CO_2 emissions for this recipe. How about reducing your carbon footprint with approx. 22 kg by swapping to chicken instead?

3.3   Research design

To evaluate the effectiveness of the food swaps and different explanation frames described above, an online survey research was performed. The explanations were implemented and displayed above the food swaps and then uploaded to a survey tool together with the pre-filled basket.

The research is subject to both between- and within-subject variables. The framing condition represents the between-subject variable and has 4 levels: sustainability, health, money, and baseline. Each participant is assigned one condition to minimize the salience of the manipulations and facilitate a comparison of the effects of the different frames. It is considered a between-subject variable as participants are only subject to one of four conditions. The within-subject variable is represented by the cost framing of the three different food swaps the participant is presented with. The variable has three levels: a decrease, an increase or an almost neutral price difference. Each participant experience all three cost framings regardless of their assigned condition. In conclusion, the research has a 4x3 mixed between- and within-subjects design, with the assigned framing condition as a between-subjects variable and the different cost frames as the within-subjects variable.

The survey tool utilized to collect the extensive population-based data for this thesis was Qualtrics[5]. A survey research approach involves gathering information from a sample of users using consistent, standardized questions [46]. This approach ensures collecting large samples of data relatively swiftly, from a group of specific individuals. Ponto [46] deduce the survey research approach as an expedient, valuable and accurate method with benefits that help survey analysts describe variables and explore paradgims of interest. The research was used to collect both quantitative and qualitatitve data, termed mixed method, however with greater emphasis on quantitative data. Accordingly, the method allows us to gather demographic characteristics of individuals and obtain thoughts and attitudes towards specific topics and products [46].

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[5]https://www.qualtrics.com/

3.4 Procedure

As depicted in Figure 3.2, the study's procedure consists of five distinct steps. These steps includes providing an introduction and presenting instructions, completing a demographic questionnaire, completing three surveys consecutively by reviewing pre-filled baskets and associated food swaps, and completing an end survey. Each of these steps is elaborated upon in this section.
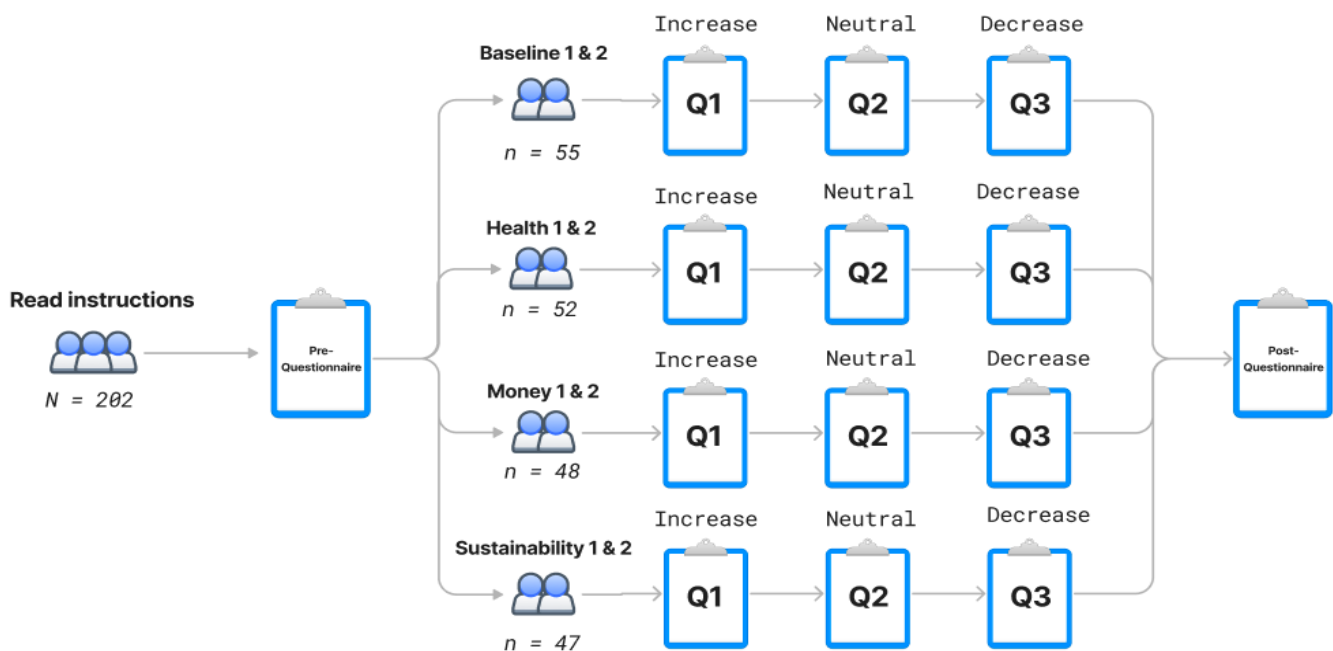
Figure 3.2: An overview of the procedure in the online survey. Participants are first asked to answer a few questions in a pre-questionnaire. Then they are randomly assigned one of the four conditions; baseline, health, money, or sustainability. They are further divided into two versions, with different pre-filled baskets and swap alternatives. Then they are presented with 3 questionnaires, including the pre-filled baskets and 3 food swaps with condition-based explanations and follow-up questions. Each participant will receive one increase, one almost neutral, and one decrease in price. Lastly, the participants are asked to answer a post-questionnaire.

3.4.1 Introduction, Instructions & Consent

Participants were presented with a short description of their contribution and what the research concerned, without revealing the sustainability aspect. The introduction shortly specified that "this study aims to examine people's product preferences when online grocery shopping." A brief instruction informed them that they would be asked to evaluate pre-filled

shopping baskets and possible food swap suggestions and then answer follow-up questions. Lastly, they were informed that they consented to participate in the research by proceeding further and that collected information would only be reported at group level. After reading the introduction and instructions and consenting to participate in the research, participants proceeded to the demographic questionnaire.

3.4.2   Demographic questionnaire

The second step of the procedure is the pre-questionnaire which gather information about the participant's demographics, including gender, age, dietary restrictions, and online grocery habits. The questions are depicted in Table 3.6. This questionnaire does not include questions regarding perceptions and viewpoints on health, sustainability, and money to prevent bias and avoid making the manipulation obvious. After completion, the participants were randomly assigned one of the four conditions and further divided into two versions. The versions differ in initial pre-filled baskets and the corresponding suggested product, but the explanation and cost frames are identical across both versions.

3.4.3   Main task

After completing the pre-questionnaire, participants continued to the third step, which was the main task. As previously stated, users were randomly assigned either the baseline, health, money, or sustainability frame. All the procedures were executed the same, with 3 pre-filled baskets and their corresponding swap suggestions. However, the explanation differed depending on the assigned frame. Every swap suggestion had a sustainability motive explanation if the user received the sustainability frame. Under each pre-filled basket, the participant was asked to answer a statement on a 5-point Likert scale if the list of ingredients was attractive. An example of a pre-filled basket is depicted in Figure 3.1.

Under the pre-filled basket, the participants were presented with an explanation and a swap suggestion for one of the items in the basket. After reviewing the food swap, they were asked to answer 3 statements on a 5-point Likert scale. The statements would be based on their level of agreement and regarded their swap acceptance, understandability of why the swap

was offered, and similarity of the products. All the questions for the main task are depicted in Table 3.6, under "Main Questionnaire." Figure 3.1 depicts the corresponding swap to Figure 1.2.

In summary, the participants are each presented with a pre-filled basket of food items that make up a specific dinner and are then asked to consider a food swap with an explanation based on the frame they are assigned. Specifically, participants are presented with three baskets and three associated food swaps: one with a price decrease, one that increases the price, and one with an almost neutral price difference. However, the recommended item is healthier and more sustainable than the original product. After completing the three main questionnaires, participants continued to the post-questionnaire.

3.4.4   Post-questionnaire

As previously stated, to avoid any bias, the participants would not be introduced to any of the aspects until the post-questionnaire. Therefore, upon completing the main tasks, participants were prompted to rate five statements on a 5 Likert scale. The statements addressed general food consumption habits, specifically the participant's perception of health, money, and sustainability in a food-related context. These questions are designed to assess the participant's attitude and behavior towards sustainable food choices and map out if money and health play a noteworthy role. These statements were adapted from a study by Steptoe et al. [59]. The remaining two statements addressed food swap satisfaction and if the explanations had any influence.

Additionally, 2 open-ended questions were included in the post-questionnaire, and one of the questions was voluntarily answered. The qualitative responses are intended to gain a better insight and understanding of the motive behind the participant's answers, independently from which frame the user was represented with. However, some of the responses here are assumed to be highly affected by which frame the participants were assigned. All the questions from the post questionnaire and their scales are presented in 3.6.

Table 3.6: *An overview of the questions used in the different questionnaires and which aspect they are measuring.*

Phase	Aspect	Questions
Pre-questionnaire	Demographics	Age, Gender
	Shopping habits	How often do you shop your groceries online?
	Eating behavior	Please list any relevant dietary restrictions you may have.
Main-questionnaire	Basket satisfaction	The list of ingredients is attractive
	Swap acceptance	I would swap the two products
	Perceived understandability	I understand why the swap was offered to me.
	Perceived Similarity	I think the suggested alternative product is similar to the original product.
	Eating behavior	It is important that I eat healthy food on a typical day.
		The food I eat on a typical day should not be expensive.
		The food I typically eat should be environmentally friendly.
	Explanation influence	The explanations of the swaps influenced my decision-making process
Post-Questionnaire	Future swaps	I would like to receive product swaps while grocery shopping in the future.
	Qualitative responses	Could you describe what factors were the most effective in influencing you to swap out the original product?
		Do you have any additional comments or suggestions for how this or any other online supermarket could improve its product swap offerings or explanation of them?

3.5   Measures

3.5.1   Personal characteristics

In the pre-questionnaire, information about the participant's age, gender, and online shopping habits was collected. Inquires about any dietary restrictions were also retrieved in the first questionnaire, specifically to omit participants with a restrictive diet regarding meat. In the post-questionnaire, participants were asked how money, health, and sustainability affect their everyday eating behavior. They rated it on a 5-point Likert scale ranging from strongly disagree to strongly agree.

3.5.2   User evaluation aspects

To address the research questions, after each pre-filled basket and food swap suggestion, users were asked about their apparent contentment with the pre-filled basket, swap acceptance, perceived understanding of the swap offer, and how similar they perceived the products to be. All questions were asked to be assessed on a Likert scale (i.e., strongly disagree to strongly agree) to what extent they agreed with each statement. In the post-questionnaire, the participants were asked to assess their everyday eating behavior regarding health, sustainability, and money, as stated in the previous paragraph 3.5.1. The statements are based on previous research [59], and are designed to measure motives related to food choices. Finally, inquiries about perceived happiness with receiving swap offerings and the effect of the explanation were asked on the same scale as previously mentioned, as well as open-ended questions regarding factors influencing participants' product choices.

3.5.3   Condition

We implemented four different conditions, each corresponding to one of the between-subject variables (baseline, health, money, and sustainability), in order to minimize the participants' awareness of the manipulation and facilitate comparisons of the impact of the different explanation frames. Within each condition, participants received a pre-filled basket and a food

swap with an explanation based on their assigned condition. To further establish the money impact, participants received three swaps: one with an increase in price, one with a neutral price difference, and one with a decrease in price. The participants followed the same procedure, regardless of the condition.

3.6   Participants

Participants were recruited via the online research platform Prolific[6], with an addition of a few family members and friends[7]. A study performed by Peer et al. [45] concluded that Prolific is a recruiting platform that can produce high-quality data from users. The platform also makes it possible to recruit participants from all over the world, which makes it ideal for this study. After completing the study, we had 57.64% participants who identified as female, 41.87% who identified as male, and 0.49% as non-binary/third gender, as depicted in Figure 3.3. The mean age was 42.42, with a standard deviation of 14.5.

Figure 3.3: Distribution of Gender
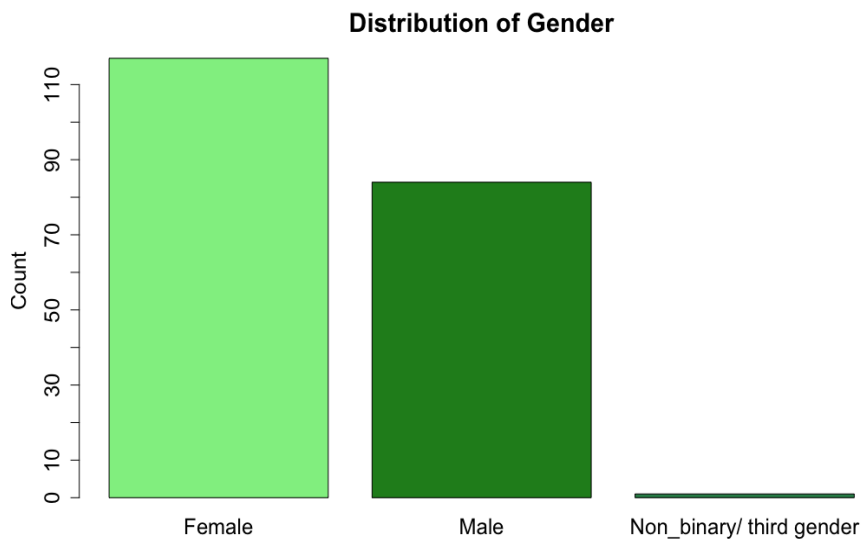
Prolific allows users to be pre-screened before the study is available, making it possible to filter out participants that do not fit the criteria. A filter was applied to ensure that the mock-up basket was relevant to the participants, limiting the survey to users in the UK, where the

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[6]https://www.prolific.co/

[7]Important to note that only family members and friends who were not aware of the primary goal of the study were asked to participate.

Tesco-based dataset was collected. Further, a language filter was applied, requiring participants to be fluent in English since the study's questions and explanations were presented in English. The language criteria are essential for participation, as the users have to understand the explanation. Lastly, we also applied a filter that prohibited mobile users from taking the survey due to the poor resolution of the pre-filled basket and food swaps on mobile devices. Participants were also discouraged from joining the study if they were on a vegetarian, vegan, or pescetarian diet. However, some participants had to be omitted after completion as their diets restricted them from eating meat. After completion and omitting participants, the total number of participants was *N=202*, with *n=55* in the baseline condition, *n=52* in the health condition, *n=48* in the money condition, and *n=47* in the sustainability condition. The distribution is depicted in Figure 3.4. Each user was granted 0.8£ to complete the study, estimated to take about 5 minutes.
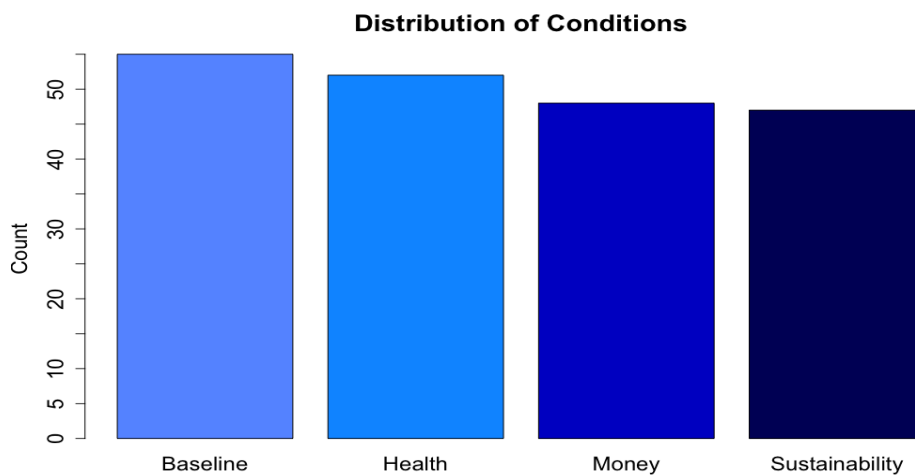
Figure 3.4: Distribution of the number of participants randomly assigned to each condition.

In the study, participants were queried about the frequency of their online grocery shopping habits. The result showed a mean frequency of 1-2 times per month, where 60.59% shopped their groceries online 1-2 times per month or more. Most participants reported that they shopped their groceries online approximately once or twice per week, while 14.78% reported that they never shopped their groceries online. The distribution is depicted in Figure 3.5. In the post-questionnaire, participants self-reported their eating habits regarding health, money, and sustainability. Figure 3.6 depicts a stack bar plot of these results.

Figure 3.5: Frequency plot of the participant's shopping habits.
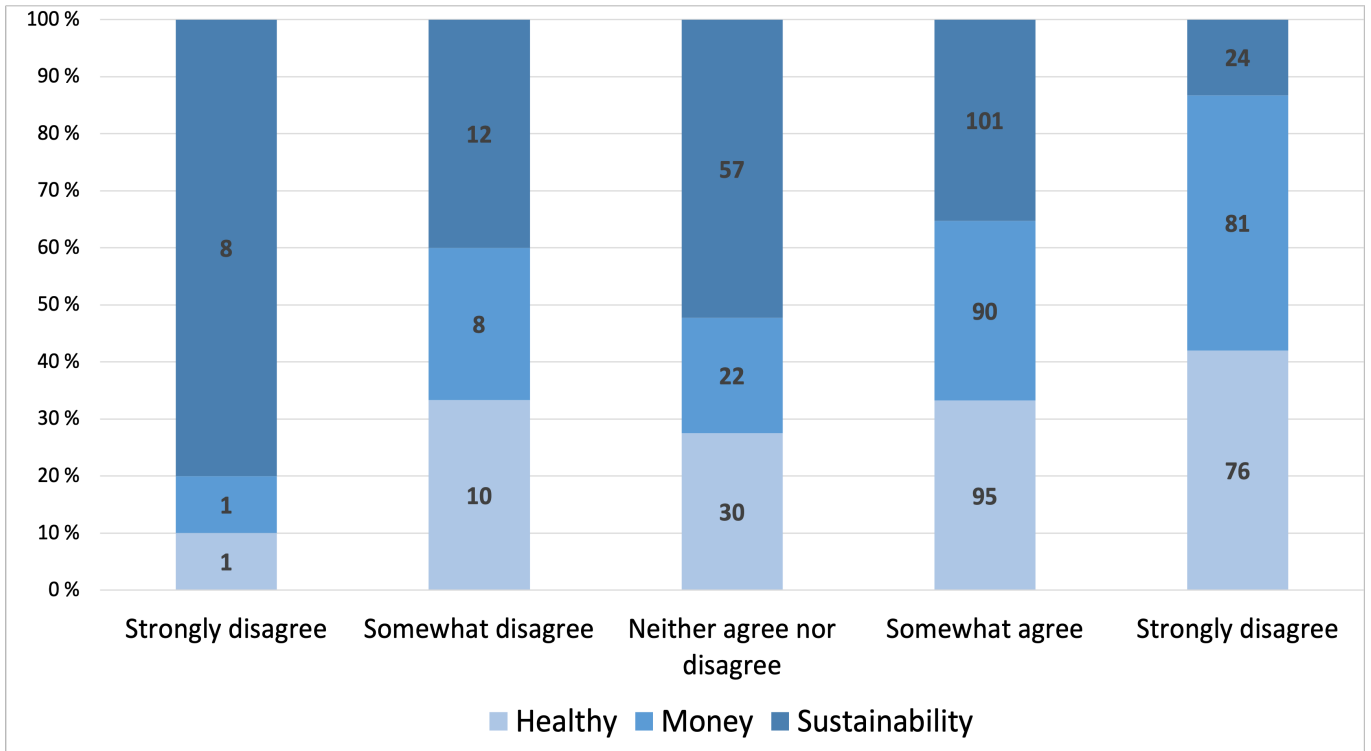
Figure 3.6: A stack bar plot of participants' self-reported eating habits regarding health, money, and sustainability.

3.6.1 Qualitative responses

At the end of the survey, we asked two open-ended questions to collect qualitative responses from the users to gain a deeper insight into the thought process and general impression of the food swaps. The responses revealed remarkable diversity in appreciation. It ranges from finding swap offers annoying and patronizing to indicating enjoyment and a desire to receive such suggestions in the future. Some of the participants requested more context, while others suggested including cooking instructions, nutrition labels, and more visual representations, such as the multiple traffic light system. However, the majority of participants answered price as the most influential factor in their responses. In addition, many participants answered that focusing on cost reduction could increase swap acceptance in the future. Another repeated factor was taste and personal preference. Participants expressed diversity here as well, as some participants claimed they had done the same substitutions previously themselves, while others claimed the suggestions were either not similar or that meat swaps were a more reasonable suggestion. Environmental impact was also mentioned several times as an influencing factor.

Chapter 4

Results

The following section presents the research results, which aimed to promote sustainable products through explainable food swaps using different explanation frames. The survey included presenting users with a pre-filled basket and inquiring about perceived contentment with the ingredients in the list. Further, the user was offered a food swap for a more sustainable, healthier product with an associated explanation based on the assigned condition. The participants were then asked to answer 3 questions inquiring about swap acceptance, understandability of the swap, and product similarity. The study strives to examine whether or not explainable food swaps can encourage more sustainable behavior and which factors are better suited to influence the decision-making process. Participants were recruited from Prolific, with an addition of a few family members and friends(*N=202*). An examination of the results is required to answer this study's research question. The following chapter will present the results, followed by descriptions of the data analysis.

4.1 Motivational framed explanation to support food swaps acceptance (RQ1.1)

To answer RQ1.1, *To what extent can specific motivational explanations focused on sustainability, money and health increase the acceptance of food swaps in an online grocery shopping service?* we examined the swap acceptance across the different frames. By looking at the

descriptive statistics, it looks like the sustainability framed explanation does slightly better regarding swap acceptance than the other incentives, as depicted in Figure 4.1.
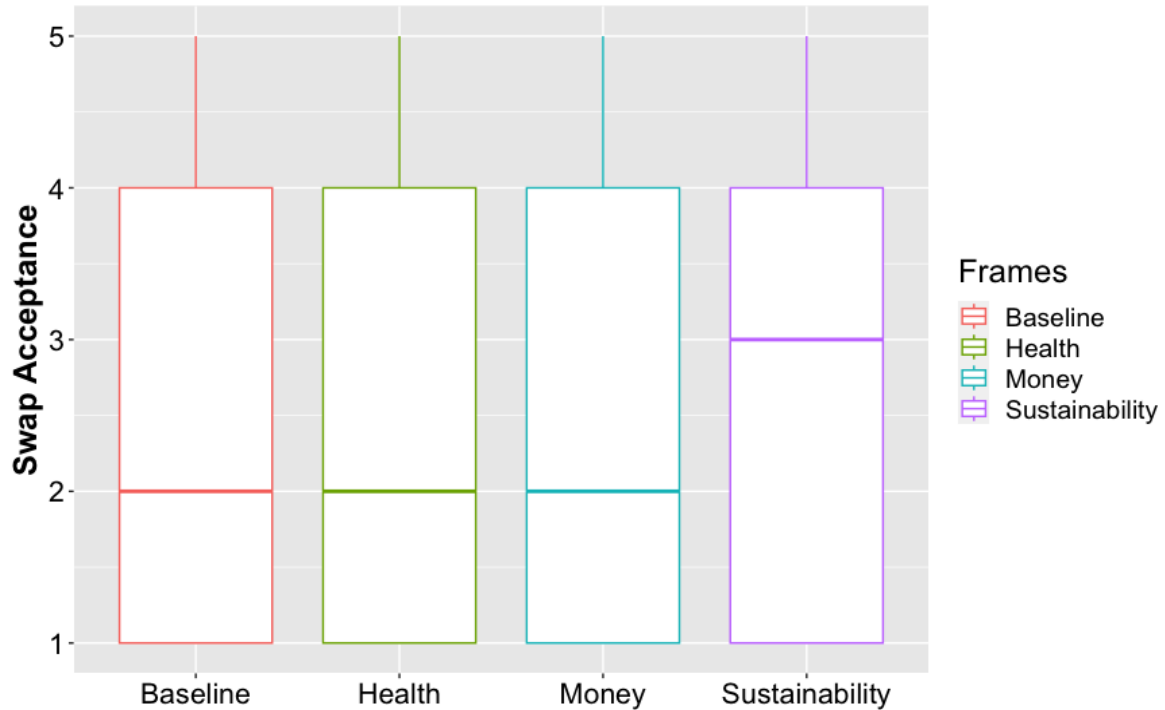
Figure 4.1: A boxplot representing the distribution of swap acceptance across the four frames; baseline, health, money, and sustainability.

However, further examination is necessary to conclude the effectiveness of the explainable food swaps, specifically if the sustainability frame significantly impacted the participants. A one-way repeated measures ANOVA was conducted to determine if there is a statistically significant difference in the means of swap acceptance across the different explanation frames. A cluster on user level was incorporated to account for the three questions per user, and that the participants could differ in preference. The results are reported in Table 4.1.

Table 4.1: Results of the one-way repeated measures ANOVA of swap acceptance across the different explanation frames. The analysis is clustered on user level.

	Df	Sum Sq	Mean Sq	F value	p
frame	3	14.5	4.849	2.234	0.083
Residuals	602	1306.9	2.171		

As reported in Table 4.1, we found no statistically significant interaction between swap acceptance and the different explanations frames($p > 0.05$). Consequently, there is not enough evidence to suggest that at least one of the frame means is significantly different from each other. To further examine the relationship we did a pairwise comparison of the different frames by conducting a post-hoc Tukey test as depicted in Table 4.2 and Figure 4.2. The result supports the ANOVA result with no statistical significance between the different frames ($p > 0.05$). It is essential to mention that the sustainability frame did slightly better than the other frames. However, there is insufficient evidence to conclude that there is a statistically significant difference between the different frames in terms of their effect on swap acceptance.

Table 4.2: Result of the post-hoc Tukey test comparing the swap acceptance across the different explanation frames.

	diff	lwr	upr	p
Health-Baseline	-0.070	-0.493	0.354	0.975
Money-Baseline	-0.093	-0.525	0.340	0.946
Sustainability-Baseline	0.305	-0.130	0.740	0.271
Money-Health	-0.023	-0.462	0.416	0.999
Sustainability-Health	0.375	-0.066	0.816	0.127
Sustainability-Money	0.398	-0.052	0.848	0.104

Tukey Mean-Difference Plot
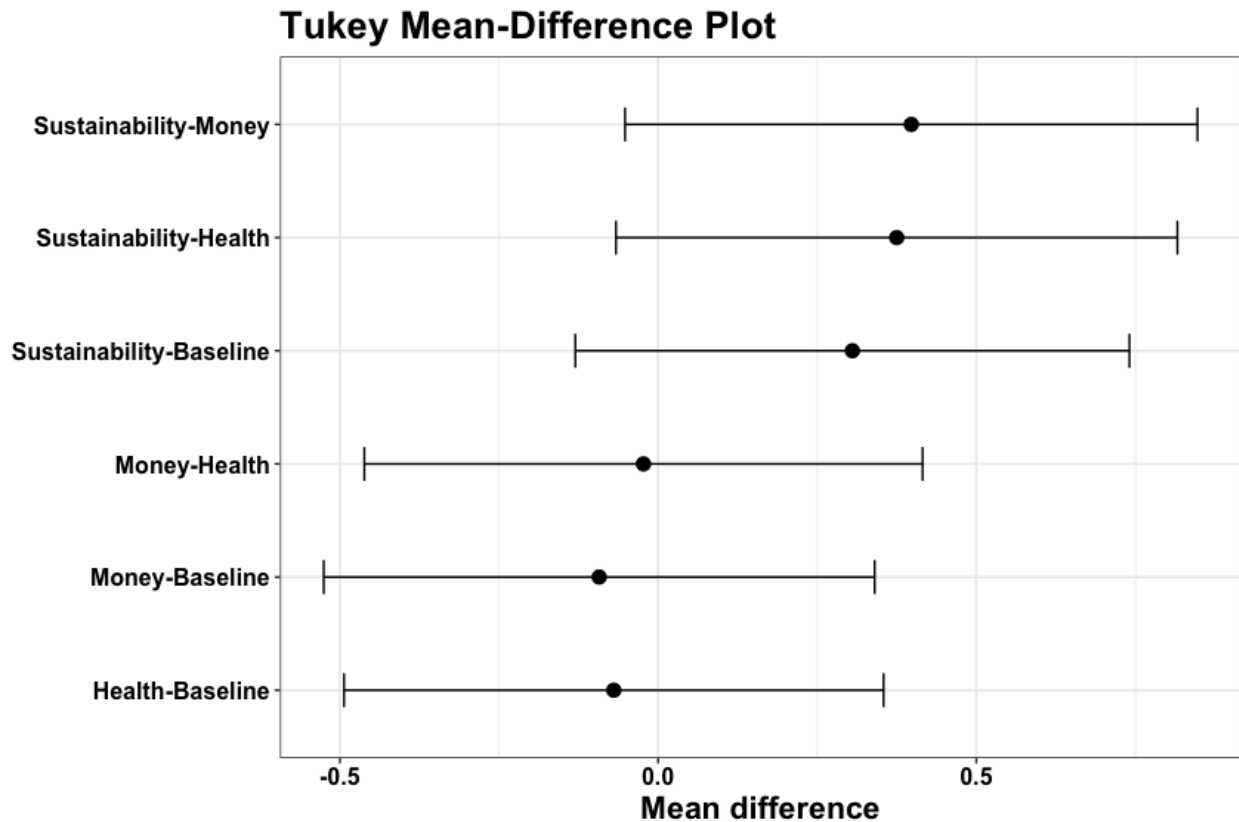
Figure 4.2: A Tukey mean-difference plot displaying the pairwise comparisons of swap acceptance of the different explanation frames. The frames include sustainability, money, health and baseline. Each mean difference line represents the difference in swap acceptance between two frames.

Considering existing consumer behavior in terms of health, sustainability and money. To gain insight into the effectiveness of the various explanation frames while including participants existing perceived health, money, and sustainable behavior, we conducted a multilevel linear regression analysis with a cluster at user level. To be able to do so, we created dummy variables for the health, money, and sustainability frame in the collected data. For example, if a participant was assigned the sustainability condition, the variable sustainable equals 1, while health and money equal -1. This way, we could look at swap acceptance across the sustainability frame, participant's self-reported sustainability perception, and then the two variables multiplied. The result of the multilevel linear regression analysis is depicted in Table 4.3.

Table 4.3: Result of a multilevel linear regression analysis examining swap acceptance across the different explanation frames, the self-reported importance factor and the interaction between them. The analysis is clustered on user level.

	Estimate	Std. Error	df	t value	p
(Intercept)	0.143	0.610	192	0.235	0.815
Health frame	-1.243	0.799	192	-1.556	0.121
Health perception	0.148	0.097	192	1.524	0.129
Health frame X Health perception	0.248	0.186	192	1.331	0.185
Money frame	0.540	0.739	192	0.731	0.466
Money perception	-0.055	0.088	192	-0.618	0.537
Money frame X Money perception	-0.170	0.175	192	-0.973	0.333
Sustainability frame	-1.121	0.741	192	-1.513	0.132
Sustainability perception	0.519	0.101	192	5.152	< 0.001
Sustainability frame X Sustainability perception	0.341	0.194	192	1.756	0.081

As depicted in Table 4.3, we see that the sustainability perception have a p-value lower than the significance level ($p < 0.001$), indicating that users existing attitude towards sustainability have a meaningful impact on the outcome of swap acceptance. In addition, the estimated value is a positive coefficient, which indicates an increase in swap acceptance for each unit increase in self-reported sustainability perception. The other predictor variables have a p-value higher than the significance level($p > 0.05$), indicating that neither of their coefficients is statistically significant. However, the interaction between the sustainability frame and sustainability perception show a positive trend towards statistical significance.

Influencing the decision-making process and receiving swaps in the future. In addition, we looked into the self-reported perceived motivational effect of the different explanation frames, as well as looking into how it affected a want for food swaps in the future. We conducted linear regressions for both analyses, depicted in Table 4.4 and 4.5, and the findings here are more promising. The participants receiving the health or sustainability framed explanations, reported the explanation to have a statistically higher influence on their decision-making process(estimate = 0.373, *p > 0.05*). In addition, participants receiving the sustainability frame had a statistically significant positive value in wanting to receive swaps in the future (Health frame estimate = 0.479, *p < 0.001* and Sustainability frame estimate = 0.491 *p < 0.001*).

Table 4.4: Result of a linear regression analysis comparing which frames where most successful in influencing participants decision-making process based on self-reported values.

	Estimate	Std.Error	t value	*p*
(Intercept)	2.636	0.089	29.735	< 0.001
Health frame	0.479	0.127	3.766	< 0.001
Money frame	0.114	0.130	0.875	0.382
Sustainability frame	0.491	0.131	3.761	< 0.001

Table 4.5: Result of a linear regression analysis comparing the different frames in terms of participant wanting to receive swaps in the future.

	Estimate	Std.Error	t value	*p*
(Intercept)	2.818	0.094	30.102	< 0.001
Health frame	0.240	0.134	1.783	0.075
Money frame	0.140	0.137	1.022	0.307
Sustainability frame	0.373	0.138	2.707	0.007

Considering basket satisfaction. To make sure that satisfaction with the original basket would not be an influencing factor on the swap acceptance, we had a quick look at the relationship between the two variables. The correlation between the two was a weak, negative relationship (correlation =-0.008). The swap acceptance decreased when the participants valued the pre-filled basket higher. However, the relationship is not strong, and a regression analysis neither showed any significant result (p>0.05). Therefore, we can conclude that the satisfaction with the pre-filled basket did not statistically affect the swap acceptance.

4.2 Perceived understandability and swap acceptance (RQ1.2)

To answer RQ1.2, *Do a user's perceived understanding of the swap motivation affect it's acceptace?*, a similar approach to RQ1.1 was employed, with an addition to a multilevel linear regression analysis.

Table 4.6: Results of the multilevel linear regression analysis of swap acceptance and perceived understanding of why the swap was offered, with a cluster on user level.

	Estimate	Std. Error	df	t value	p
(Intercept)	0.710	0.149	491.933	4.783	< 0.001
Perceived understandability	0.509	0.039	546.683	12.934	<0.001

Whether or not the explanation provided insight and clarity to the participant is assumed to be imperative. To examine if users perceived understandability impacted participants swap acceptance, we conducted a multilevel linear regression analysis. The results are depicted in Table 4.6, and suggest that perceived understandability did indeed affect participants swap acceptance ($p < 0.001$). Further, we want to examine if there was a difference between the different explanation frames in terms of understanding why the swap was offered. Preliminary descriptive statistics suggest that users had a generally positive perceived understandability in each frame. However, sustainbility and health have slighlty higher values, as depicted in Figure 4.3.
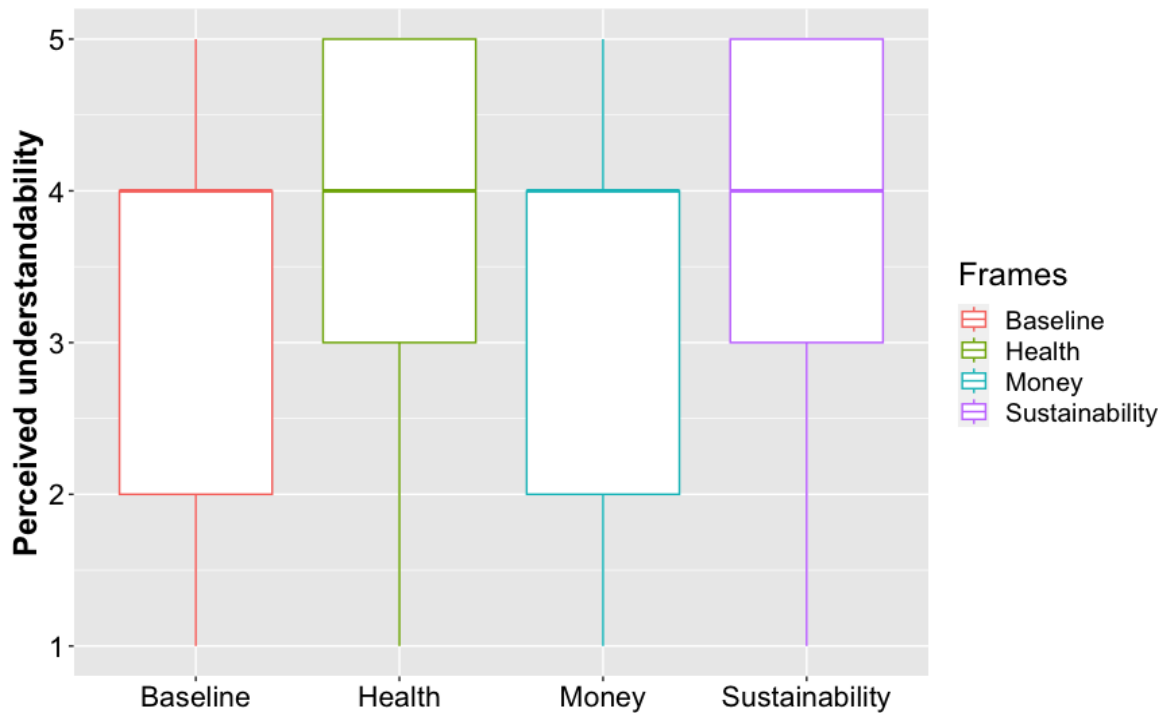
Figure 4.3: A boxplot representing the distribution of perceived understandability across the four frames; baseline, health, money, and sustainability.

We performed a one-way repeated measures ANOVA to further examine this relationship. The result is depicted in Table 4.7, and reveal a statistically significant differences in the mean perceived understandability across the four frames (F(3,602) = 6.077, $p < 0.001$). This indicates that the frames have an impact on participants understanding of why the swap was offered.

Table 4.7: Results of the one-way repeated measures ANOVA of perceived understandability across the different explanation frames. The analysis is clustered on user level.

	Df	Sum Sq	Mean Sq	F value	p
Frame	3	33.1	11.048	6.077	< 0.001
Residuals	602	1094.4	1.818		

The ANOVA analysis was followed up by a post-hoc Tukey test, to make a pairwise comparison of the different frames' perceived understandability. The result is depicted in Table 4.8 and Figure 4.5. The result reveals that there were statistically significant differences for both money and baseline when compared to the sustainability frame (sustainability-money diff=0.484, $p < 0.05$ and sustainability-baseline diff = 0.607, $p < 0.001$). Further, the mean difference suggest that participants receiving the sustainability frame had a significantly positive perceived understanding in terms of why the swap was offered, compared to money and baseline.

Table 4.8: Result of the post-hoc Tukey test comparing the perceived understandability across the different frames

	diff	lwr	upr	p
Health-Baseline	0.385	-0.0028	0.7729753	0.053
Money-Baseline	0.124	-0.272	0.5199779	0.852
Sustainability-Baseline	0.607	0.208	1.0049345	< 0.001
Money-Health	-0.261	-0.663	0.1401859	0.337
Sustainability-Health	0.221	-0.182	0.6251131	0.491
Sustainability-Money	0.483	0.0712	0.8942376	0.014
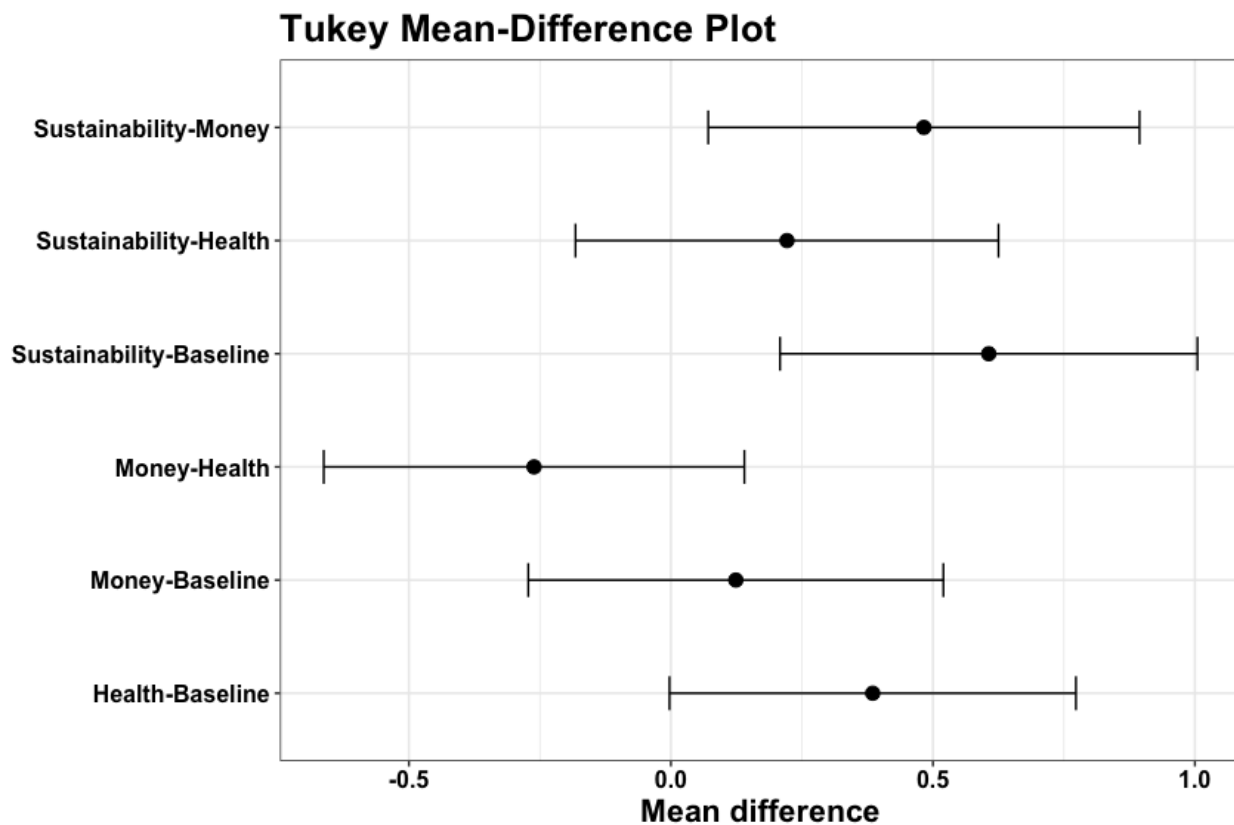
Figure 4.4: A Tukey mean-difference plot displaying the pairwise comparisons of perceived understandability of the different explanation frames. The frames include sustainability, money, health and baseline. Each mean difference line represents the difference in perceived understandability between two frames.

4.3 Cost-decreasing swaps (RQ1.3)

To be able to examine RQ1.3, *To what extent can cost-decreasing swap proposals affect swap acceptance?*, we used the variance of the decrease, increase and almost neutral price difference assigned to each swap, which each participant was presented with. We added the variable cost to the collected data, where each swap either had the value Increase, Decrease or Almost neutral. We then performed a one-way repeated measures ANOVA with a cluster on user level, where we examined swap acceptance across the three different cost frames. The result is depicted in Table 4.9.

Table 4.9: Results of the one-way repeated measures ANOVA of swap acceptance across the three different cost frames(Increase, decrease and almost neutral. The analysis is clustered on user level.

	Df	Sum Sq	Mean Sq	F value	p
Cost frame	2	29.4	14.680	6.851	0.001
Residuals	603	1292.1	2.143		

As depicted in 4.9 the ANOVA result reveals a statistically significant difference in means between the different cost frames on swap acceptance ($p < 0.01$). To further examine the relationship, we conducted a post-hoc Tukey test to do a pairwise comparison of the different cost frames. The result is depicted in Table 4.10, and suggest that there is a statistical significant difference between decrease and almost neutral (diff = -0.514 and $p = 0.001$), which indicate that the likelihood of participants swapping was higher when there was a neutral price difference compared to a decrease in price. There was also a statistical difference between increase in price and decrease (diff = 0.369 and $p < 0.05$), which surprisingly, suggest that participants were more likely to swap the product when there was an increase in price compared to a decrease in price.

Table 4.10: Result of the post-hoc Tukey test comparing swap acceptance across the three different cost frames.

	diff	lwr	upr	p adj
Decrease-Almost neutral	-0.515	-0.857	-0.173	0.001
Increase -Almost neutral	-0.119	-0.461	0.223	0.693
Increase -Decrease	0.396	0.0538	0.738	0.018
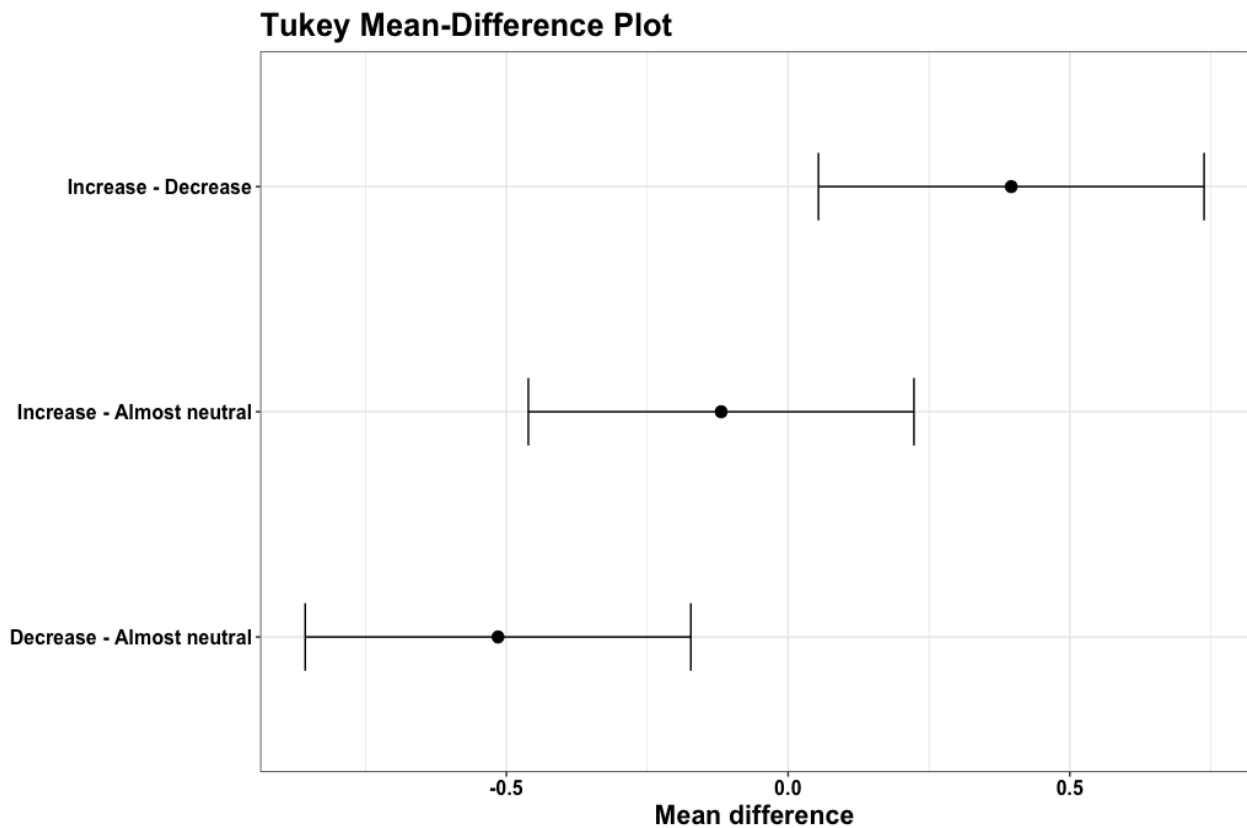
Figure 4.5: A Tukey mean-difference plot displaying the pairwise comparisons of swap acceptance across the different cost frames. The frames include increase, almost neutral and decrease. Each mean difference line represents the difference in swap acceptance between two frames.

4.4 Perceived similarity and swap acceptance (RQ2.1)

To gain deeper insights into factors affecting acceptance of food swaps, we looked into the connection between participants' perceived similarity of the products and their inclination to accept or reject the suggestion.

Therefore, to answer RQ2.1, *To what extent does the perceived similarity between the original product and the swap product affect swap acceptance?*, we performed a multilevel linear regression analysis. The result is depicted in Table 4.11, and show a statistically significant relationship between perceived similarity of the original and alternative products, and participants swap acceptance ($p < 0.001$). It further indicates a strong association of higher similarity ratings with a higher likelihood of swap acceptance (Estimate = 0.699).

	Estimate	Std. Error	df	t-value	p
(Intercept)	0.904	0.0998	541.408	9.053	< 0.001
Perceived similarity	0.699	0.0371	598.910	18.832	< 0.001

Table 4.11: Multilevel linear regression analysis examining the impact perceived similarity of the alternative product to the original has on swap acceptance

4.5 Meat swaps, perceived similarity and swap acceptance (RQ2.2)

To answer RQ2.2, *Do users existing preferences for specific food types, such as meat, affect their perception of similarity and swap acceptance?*, we looked into types of swaps that were offered and divided them into two categories: meat swaps and non-meat swaps. To examine the perceived similarity of meat swaps and non-meat swaps, we created a binary dummy variable in the collected data where 0 equal non-meat swaps and 1 equal meat swaps. Then we performed a multilevel linear regression analysis with perceived similarity as the dependent variable and the meat variable as a predictor, with a cluster on user level. The results are depicted in Table 4.12.

Table 4.12: Multilevel linear regression analysis examining the perceived similarity of meat swaps vs. non-meat swaps

	Estimate	Std. Error	df	t-value	p
(Intercept)	2.059	0.064	363.291	31.960	< 0.001
Meat swaps	0.634	0.103	403	6.155	< 0.001

As depicted in Table 4.12, meat swaps are statistically significant in participants perceived similarity of the suggested product to the original($p < 0.001$). The effect is positive, so for every meat swap their is an associated 0.634 increase in the perceived similarity of the product suggestion.

Swap acceptance. Given the findings from the aforementioned result, the research aim to delve deeper into the impact of meat swaps on the acceptance of food swaps. We there-

fore examined the relationship between swap acceptance on meat swaps by performing a multilevel linear regression analysis, presented in Table 4.13. The regression model suggest that there was a high statistically significance of meat swaps on swap acceptance. Similar to perceived understandability, the relationship is positive indicating a higher swap acceptance when the participant is presented with a meat swap in contrast to non-meat swaps (estimate = 1.015, $p < 0.001$). The relationship is visualized by creating a density plot of the relationship, as depicted in Figure 4.6.

Table 4.13: Results of the multilevel linear regression analysis of swap acceptance of meat swaps vs non-meat swaps

	Estimate	Std. Error	Df	t-value	p
(Intercept)	2.153	0.073	334.949	28.803	< 0.001
Meat swaps	1.015	0.111	403	9.143	< 0.001
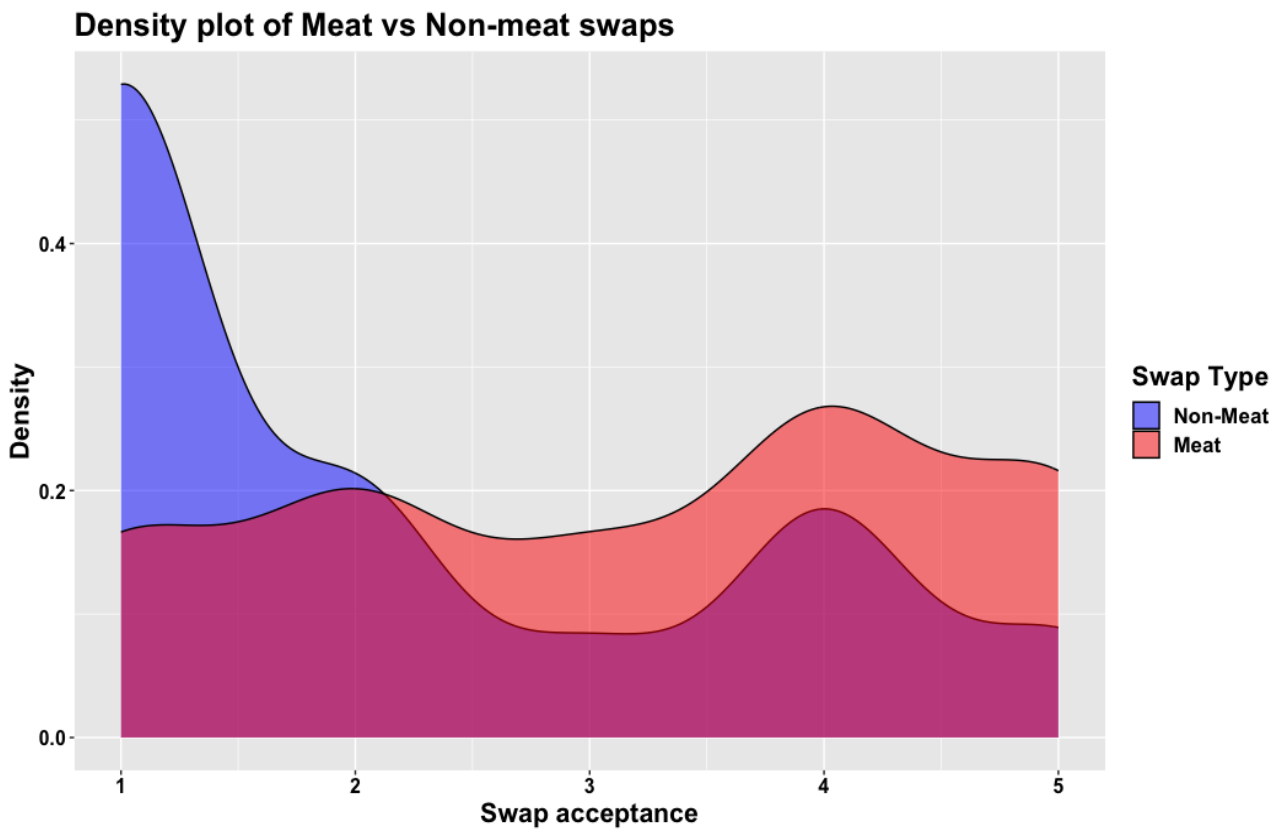
Figure 4.6: A visual representation of the distribution of swap acceptance based on the two levels of the meat swaps (non-meat and meat). The red color represent the density distribution of meat swaps, while the blue represent the non-meat swaps. The non-meat swaps peak where swap acceptance is 1 with a decreasing trend until 4, where it slightly increase. Meat swaps show a gradual increase in swap acceptance with a peak where swap acceptance equals 4, and then slightly decrease. The density plot exhibits higher swap acceptance among meat swaps compared to non-meat swaps.

Chapter 5

Discussion

In the past decade, the climate crisis has emerged as a pressing an attention-worthy topic that demands immediate action. Several grocery stores has expressed a commitment to the battle, and have initiated measures to decrease their climate impact [17, 43, 27, 61]. A part of this endeavor is to inspire consumers to live more climate-friendly lives [43]. Digital platforms, such as online grocery websites, have a great potential to encourage more sustainable food consumption to users [41]. As a mean to reach this goal, we have examined how to nudge users to choose more low-impact options. Preliminary studies on sustainable food swaps have primarily focused on dietary and nutritional aspects [71, 73, 2], thus this thesis holds a particular novelty. The following chapter will summarize and discuss the research findings and limitations, and address future work within the field.

The primary focus of this study is to examine the effectiveness of four different explanation frames in promoting user to choose more sustainable options. Additionally, this research examined other factors that could interfere with the decision-making process, which can lead to a broader understanding of how the sustainability frame can be utilized in the future to encourage sustainable food choices.

Motivational framed explanation to support food swap acceptance (RQ1.1). To examine the effectiveness of the different explanation frames in regards to food swap acceptance a one-way repeated measures ANOVA was conducted, followed up by a post-hoc Tukey test. We expected that the sustainability, health and money framed explanations would lead users to have a higher swap acceptance compared to the baseline. However, the results from the

analysis showed no statistically significant interaction between swap acceptance and the different explanation frames.

While no previous works have been conducted utilizing explainable food swaps to promote more sustainable alternatives, previous findings on healthy food swaps indicate that pairing the suggestion with a health-motivated explanation increased the possibility of swap acceptance [24]. These findings are in contrast to the result in our study, as there were no statistical indication of higher swap acceptance with any of the explanation frames, including the health motivated explanations. However, descriptive statistics revealed a higher swap acceptance for the sustainability frame and a trend towards positive statistical significance in the post-hoc Tukey test. Even though, we can't establish a definitive association since the statistical evidence is weak, the result suggest there may be a potential relationship between the sustainability frame and accepting sustainable food options. However, considering the weak relationship, the results may suggest that the sustainable frame might have been more effective when presented with a specific food item, than just the sustainable framed explanation. These findings are supported by prior studies conducted by Forwood et al. [15] and Koutoukidis et al. [28], which found that there is a difference in rate of swap acceptance in specific food categories. In conclusion, the results suggest that the sustainability frame might have had some influence or potential impact, however further research is needed to confirm this relationship, as well as exploring other factors impacting the swap acceptance.

Existing eating and consumer behavior, in terms of health, sustainability and money. In addition, we investigated if users' existing lifestyle and consumer behavior in terms of the three aspects (health, money and sustainability), would impact participants willingness to swap. To examine the relationship we performed a multilevel linear regression analysis. The dependent variable was swap acceptance, and the predictor variables were the different frames, self-reported consumer behavior in terms of the three aspects and the interaction between them. We expected that the self-reported consumer behavior would lead to a higher swap acceptance, specifically in combination with the corresponding frame. However, the results indicates only a statistical significance of participants self-reported sustainable lifestyle on swap acceptance. These results contradicts preliminary studies in health-aware food recommender systems, which has shown participants that already lead a healthy lifestyle or who had diet-related health problems were more inclined to read information,

such as nutritional content, as well as use the information to conclude which product they would consume [29, 59]. The result provided no statistical evidence for neither the health perception nor the interaction with the corresponding frame, to have an affect on swap acceptance. In addition, the result did not provide statistical evidence that the sustainability frame had a significant affect on participants that already lead a sustainable lifestyle, but did show a trend towards positive statistical significance. However, the results indicate that participants' perception of their own eating habits in regards to sustainability, positively affected their swap acceptance regardless of the assigned frame.

In conclusion, the results imply that suggesting a food swap with an sustainability motivated explanation might have some influence or potential impact on promoting sustainable behavior. In addition, users' who already make conscious food choices in terms of sustainability, are more likely to accept a sustainable swap, independently of the explanation frame. However, further research with a larger sample size or different experimental design is needed to confirm the relationships, as well as exploring the associations comprehensively.

Influencing the decision-making process and receiving swaps in the future. Additionally, we examined how users perceived the influential affect of the different explanation frames in terms of affecting their decision-making process, and if it affected their desire for food swaps in the future. Preliminary studies within health-aware informational nudges have been successful in influencing users[42, 24]. Similarly, in this study, participants receiving the health frame perceived that they had been more influenced than participants receiving the money or baseline frame. In addition, participants receiving the sustainability frame were also more inclined to perceiving the explanations as influencing to their decision-making process, as well as reporting a want for food swaps in the future. A study by Abrahamse [1] support these findings which found informational nudges to influence consumers' food choices effectively by providing them with the environmental impact and making sustainable products more visible. However, even though the frames were more successful in being a part of the decision-making process it did not significantly affect the swap acceptance, and therefore led to no change in individual environmental impact. Nevertheless, participants receiving the environmental impact explanations were more likely to enjoy food swaps in the future.

Perceived understandability and swap acceptance (RQ1.2). Based on preliminary studies, perceived understanding of the explanations provided and the motivation behind the food

swap is assumed to impact swap acceptance [53, 49, 57]. To examine this relationship we conducted a multilevel linear regression analysis, with swap acceptance as a dependent variable and perceived understanding as predictor. The result supported preliminary research, by revealing a significant association between perceived understandability and swap acceptance. The finding highlights the importance of participants comprehending the underlying rationale behind the offered swap, providing further support for the assumption that it influence the participants decision-making process. Further, we examined the impact of the different explanation frames on participants perceived understanding, and found a statistical difference in perceived understanding across the four frames. Descriptive statistics suggested that users' had higher perceived understanding of the health and sustainability frame. However, a post-hoc Tukey test revealed that the sustainability frame had a statistically significant effect on users' perceived understanding compared to the baseline and money frame. In addition, the health frame showed a positive trend towards statistical significance compared to the baseline explanations. A prior study conducted by Musto et al. [42] concluded that the most promising method in nudging users' towards healthier meals, was to apply a comparative method. In both the sustainable and health framed explanations, a comparison of the items in the respective conditions was generally applied, which we can presume positively affected the users' perceived understanding of why the swap was offered. We are also not disregarding the motivating factors behind the specific aspect to influence participants, as preliminary research showed an increasing trend in considering these factors while grocery shopping [19, 17].

In conclusion, the findings emphasizes the necessity of designing explanation frames that are easily understandable, and also capable of effectively communicating the purpose behind the swap. In addition the result revealed that among the various frames analyzed, the sustainability frame exhibited a statistically significant relationship with participants' perceived understanding. Since consumers are showing an increasing interest for the environment and conscious consumer behavior in terms of sustainability, prioritizing sustainability-related explanations can potentially increase participants acceptance of sustainable food suggestions.

Cost-decreasing and cost-increasing swaps (RQ1.3). With regards to different cost framings of the swap offers, it was expected that an offer that decreased in price or had an al-

most neutral price difference would lead to a higher swap acceptance. Preliminary research found an increasing progression in price sensitivity, where consumers would trade a product for cheaper options [19]. We examined the relationship between cost and swap acceptance in our analysis, which revealed that cost had an impact on participants' swap acceptance. However, by further analyses, the result indicated surprisingly that participants were more inclined to swap when the cost of the alternative product increased. This counter intuitive finding contradicts preliminary studies [19, 7, 25], and challenges the conventional assumption that consumers prioritize saving money while they grocery shop. Especially, taking into account the qualitative responses where several participants listed price as an important influential factor. Considering this, the relationship might indicate that the swapping decision was overshadowed by other influential factors.

In conclusion, that even though the relationship between cost and swap acceptance was statistically significant, we can draw the assumption that other factors than financial consideration may play a bigger role in shaping individuals' behavior when grocery shopping. The finding implies that individuals might be willing to pay a higher price for a more sustainable or healthier alternative, as long as it accords to their preferences or there is a perceived benefit to choosing a different option. A drawback however, is that promoting sustainable food choices by emphasizing cost savings is not sufficient in encouraging more sustainable options in an online grocery environment.

Perceived similarity and swap acceptance (RQ2.1). Preliminary research suggest that influencing and recommending food items is a tricky process, as several factors must be accounted. A motivational aspect behind food choices are cognitive factors, such as attitude, liking and preferences [9]. Consequently, we expect perceived similarity to have a significant effect on swap acceptance. To examine this, we conducted a multilevel linear regression analysis of the perceived similarity of the original and alternative product effect on swap acceptance. The result supported preliminary research, and indicated a statistically significant relationship between the two factors, where the participants were more likely to accept the swap if they perceived a greater similarity between the products. The analysis highlights the importance of perceived similarity as a determinant for participants willingness to accept a sustainable food swap, which yield personal preference as an important factor to consider when making food suggestions. Recognizing and leveraging this relationship is imperative

for further development efforts aimed at encouraging sustainable food swaps.

Meat swaps, perceived similarity and swap acceptance (RQ2.2) Lastly, it was hypothesized that meat swaps compared to non-meat swaps would lead to an increase in perceived similarity and swap acceptance. The result indicated that meat swaps exhibit statistical significance in participants perceived similarity of the alternative product compared to the original one. Moreover, this effect is positive, indicating that for each meat swap, there is an increase in perceived similarity of the suggested product. The findings highlight the considerable impact meat swaps can have on participants' perception of product similarity and we can assume that it potentially will increase the likelihood of swap acceptance.

Swap acceptance. We further examined the relationship by exploring the influence of meat swaps on swap acceptance. Findings from previous studies indicate a higher rate of swap acceptance in specific food categories [28, 15]. The studies indicated higher swap acceptance in food categories such as cheese, butter, pasta and rice, than food types such as meat and milk. The result in this research, further support these findings, as the analysis indicates a statistical significance with a strong positive relationship between swap acceptance and swapping meat for meat, compared to swapping meat for non-meat options. The findings are supported by preliminary research, which enlightens negative attitude towards plant-based products and suggest that negative perceptions to meat replacers still exists [36, 19]. Therefore, accepting a low-impact meat swap instead of a plant-based option, might come across as less invasive. In addition, a study by Povey et al. [47] examined differences in attitudes and beliefs of meat eaters, meat avoiders, vegetarians and vegans. The findings showed a positive attitude towards their own diets, while displaying a negative attitude towards the diet most different from their own. The study conclusions of attitudes is consistent with the findings in this research, as we omitted users with vegan/vegetarian diets. Considering these findings, further research within encouraging users towards more sustainable meat options, can significantly reduce individuals environmental impact.

5.1   Limitations

This research is subject to a few limitations that we will address in this section. Firstly, by conducting the study through an online survey tool, the study restricted users from directly interacting with the application, which yield some disadvantages. The lack of presence for an actual product swap and interacting with a mock-up supermarket, restricts participants form exploring the interface in a fully naturalistic environment. In addition, users were presented with a pre-filled basket. Conducting the research in a setting where participants add groceries they normally would by or intend to purchase, can result in different outcomes. Furthermore, recruiting participants from crowd-sourcing platforms (Prolific), can yield disadvantages like participants wanting to finish the survey as quickly as possible or recruiting users who are not interested in food. However, as previously mentioned there are advantages to recruiting via crowd-sourcing platforms, such as greater sample sizes from any part of the world.

A qualitative response from the online survey, implied that the study showed a huge bias against meat. As meat is one of the environmental culprits it made sense targeting this food group to reduce the magnitude of environmental impact the food sector has. However, it is important to recognize that meat holds cultural and dietary significance[65, 47], which suggests that changing users' perspective on this issue may require more than providing explanatory food swaps. Exploring other non meat-products swap would have been valuable, such as milk for plant-based milk, but the availability of environmental data for non-meat products was limited. Moreover, the environmental impact of reducing emissions from red meat is considerably more significant compared to non-meat products.

Furthermore, participants were not required to physically purchase the items in their basket, nor items they swapped or decided not to swap. This is a recurring limitation within food swaps studies, where the experiment is conducted within a real-world-like environment, and therefore does not represent real-life purchasing [15, 28, 24]. Still, the research do provide strength in analyzing user behavior, but has less external validity as the result represent more intention, than actual consumer behavior.

Lastly, recommendations was not based on user preference or taste, but solely based on environmental impact and health benefits. Thus, the thesis focused primarily on analyzing

the explainable food swaps approach, leaving sustainable, explainable food swaps in food recommender systems to future work.

5.2 Future work

For future work, an approach could be receiving suggestions for sustainable food swaps based on predictions made by a recommender system. Our results showed that the different motivational explanations were not statistical significant in nudging users towards sustainable products, while the perceived similarity had a significant impact on swap acceptance. Therefore, making recommendations based on user preference could increase the chances of participants to be influenced by an informative nudge as the motive would not be outweighed by taste and preference. In addition, even though the qualitative responses indicated that numerous participants enjoyed receiving food swaps and wanted this to be a standard practice, there were also a few users indicating a distaste to receiving nudges. Maybe by implementing recommendations that better fit the individual user, we could change the latter opinion.

The recommender system could be implemented with a hybrid approach, using collaborative, content-based and knowledge-based filtering. The collaborative filtering method make recommendations based on other similar users' behavior [23, 48]. By identifying other users with similar taste based on the active user's preference, the method then makes suggestion based on the similar users likes and purchases. Thus, we can use the collaborative filtering method to identify food swaps that have been popular among other users with similar preferences and purchase history.

Furthermore, we can combine the collaborative method with a content-based filtering approach. The approach base predictions on similarity of item features and make recommendations based on the active users taste [23, 65]. Accordingly, content-based filtering can be implemented to identify food swaps that are similar in terms of nutritional value, taste and cooking methods already in the users' shopping basket.

Lastly, knowledge-based method make recommendations based on domain-specific knowledge that align with users' needs, and preferences [48]. The method can be incorporated to

make recommendations based on environmental impact by having the recommender system recommend products with lower carbon and water footprint. In conclusion, the system could identify popular and effective food swaps with collaborative filtering, while content-based consider the users specific needs and preferences. Lastly, knowledge-based method can provide knowledge about the recommended swap to build trust in the recommendation. This way, the user would be presented with more personalized suggestions while simultaneously receiving a more sustainable recommendation.

Another interesting avenue for future sustainable food swaps in online grocery services, could be to incorporate labels such as the eco-score in combination with explanations to enlighten users what the label represent. Including cooking instructions could also help improve the acceptance of more plant-based options, as expressed in the qualitative responses and also supported by previous research [40]. Limited cooking skills can restrict participants from choosing unfamiliar options.

5.3   Open science

In order to make this study reproducible, all code implementations have been uploaded to a GitHub repository[1]. This includes the web crawler utilized to collect pre-filled baskets and swap suggestions, the prototype code, and the code used to analyze the user study data. In addition, the collected datasets, an excel sheet for descriptive statistics and data from the user study has also been made available in the repository.

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[1]https://github.com/sfimediafutures/MA_Tiril-Staveteig-Taalesen.git

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