Junior Management Science 9(1) (2024) 1178-1210

Junior Management Science

www.jums.academy
ISSN: 2942-1861

Decarbonizing Travel Decisions by Using Digital Nudges

Patrick Riedlsperger

Technical University of Munich

Abstract

The current climate crisis was caused by our everyday, individual decision-making. People have the opportunity to decide between options that contain more or less greenhouse gases. This is particularly relevant for the travel industry which has historically been a major contributor to global emissions. The nudging concept introduced by Sunstein and Thaler (2021) can help people enhance their decision-making to promote environmental stewardship. Every consumption decision in travel is an opportunity as it can be 'decarbonized' to a greener outcome. This thesis provides evidence that the intervention technique is effective to lead to more sustainable decision-making in a digital travel booking process. This research project used a simulated booking process to compare the effectiveness of different digital nudges. Users could choose different options in their booking in the realm of transport, accommodation and restaurants. Overall, 456 online participants completed the process. The digital experiment used one regular booking process, which was used as a reference group, and 9 different types of digital nudges. The effectiveness of the nudges was analyzed by using a binary logistic regression model. Of the 9 experiments which included digital nudging interventions, 6 produced statistically significant results. The most effective nudge in the experiment used a social norm intervention. After its application to the process, odds were more than 4 times higher that users chose the most sustainable option that contained the least amount of greenhouse gases. In general, all regression coefficients (B) were positive, with odds ratios Exp(B) between 2.471 and 4.419. The results of this thesis support the view that nudges are an effective tool to drive more sustainable behavior. The results showed that digital nudges led to the booking of the most sustainable travel offers. User interface designers and other choice architects can use the findings of this thesis to reduce greenhouse gas emissions in travel as one of the many steps we must undertake to fight global warming and its drastic impacts on our economy and society.

Keywords: choice intervention; digital nudging; nudge theory; sustainability; travel

1. Introduction

This thesis addresses one of the most important challenges our society faces in this century. While writing it, Fountain (2022) reported for the New York Times that heat waves in Europe are increasing in frequency and intensity at a faster rate than almost any other part of the planet. Temperature highs hit new records across the continent this summer. Rising temperatures, drought, frequent wildfires, shifting rainfall patterns, melting glaciers and the rise of the average global sea level prove that the impacts of climate change are underway. To mitigate climate change, we must reduce or at least prevent emissions linked to human activities (European Environment Agency, 2021). Schellnhuber (2021) is the originator of the 2 degrees Celsius global temperature target and described the climate crisis as similar to the COVID-19 crisis - just substantially bigger by dimensions and consequences. We have acute emergencies, loss of hundreds of thousands of lives, and other socioeconomic impacts that widen the wealth gap. According to the renowned researcher, the potential damage that climate change can cause is even greater than COVID-19 by a factor of a hundred or even a thousand. In both cases, however, it is a question of acting in a timely manner. When it comes to climate change, we need to turn things around in the next three decades or we will reach an irreversible state.

Global warming is caused by humans and their emissions

DOI: https://doi.org/10.5282/jums/v9i1pp1178-1210

of greenhouse gases, as they blanket the Earth and trap the sun's heat (United Nations, 2022). Every day, each of us makes a host of purchase and consumption decisions. Embedded in every decision is some amount of greenhouse gas. This means all of our many small, individual actions add up to a substantial impact on the climate. The way forward will be determined by the decisions made by millions and our ability to pivot many of those decisions toward a greener outcome (Amram & Kulatilaka, 2009). People can reduce their footprint by buying products such as the Impossible Burger or electric cars. They can change their own personal consumption habits, so that clean products can achieve scale and their costs go down. Decarbonization will be the most incredible feat achieved by humankind (Gates, 2021).

Besides strict regulatory measures and the potential to reduce carbon footprints when delivering services or making products, we must find complementary ways to react to the climate crisis at an individual level of decision-making. During my Executive MBA program at TU Munich and HSG St. Gallen, I came across the book "Nudge: Improving Decisions About Health, Wealth, and Happiness" by Sunstein and Thaler (2021). Nudging is a theory in the field of behavioral economics. In short, a Nudge aims to lead consumers to make more efficient decisions for themselves, and as a result, for society. It challenges the idea that rational humans always choose the option that is 'best for them' and unpacks how to 'nudge' individuals into making better decisions (Spiliakos, 2017).

In their bestselling book, Sunstein and Thaler (2021, p. 8) also mention the potential to use nudging interventions to promote more sustainable consumption behaviors.

> *"Private companies that want to make money and to do good can benefit by creating environmentally friendly nudges, helping to reduce air pollution and the emission of greenhouse-gases."*

Accelerating climate action by reducing our emissions is of utmost importance for travel. This industry is highly vulnerable to climate change. At the same time, it contributes to some of the highest emissions of greenhouse gases of any industry worldwide. It must comply with the global COP26 commitment to halve our emissions by 2030 and achieve net zero by 2050. There is a growing consensus among stakeholders in the travel industry that the future and resilience of tourism will depend on the ability to cut emissions by 50% by 2030 (UNWTO, 2019).

My motivation for this research project was to seize and further explore the idea of Sunstein and Thaler to use nudging interventions for the reduction of greenhouse gases. Based on the relevance of climate action to travel, my goal was to explore how businesses can use Nudging to reduce emissions and fight our climate crisis. The central actor in climate change and this thesis is the individual consumption decisions we make every day and the related impacts.

Nudging seems to be an attractive opportunity to fight climate change, without jeopardizing freedom of choice. Many researchers, including Sunstein (2019), emphasize the importance of evidence when implementing nudges, as some interventions seem promising in the abstract, but fail in practice. Sunstein (2017b) even published an article on "Nudges that fail" explaining why nudging is sometimes ineffective, or at least less effective than we hope and expect. Empirical tests, including randomized controlled trials, are the solution to overcome this issue. Researchers should investigate which types of nudges tend to have larger effects on outcomes. Empirical tests can reveal the best nudging techniques to achieve a specific goal.

Schneider et al. (2018) encourages fellow scholars to engage in research on nudging in digital choice environments, because of the ubiquitous digitalization of our private and professional lives. According to Lehner et al. (2016), the evidence base for the effectiveness of nudges in sustainable consumption remains an important research topic. Furthermore, to take full advantage of digital nudging, Mirsch et al. (2018) stress that interventions must be developed systematically, applied on the user, and then tested for their effectiveness. Quantitative research to test the effectiveness of Nudging has been conducted before. Most research in this domain is limited to a certain context such as energy (Allcott, 2011; Ebeling & Berger, 2015; Lade et al., 2020), diet (Hanks et al., 2012; Jesse et al., 2021; Tett, 2021), or finance (Franklin et al., 2019; García & Vila, 2020; Thaler & Benartzi, 2004). In a travel-specific context current research projects on nudging people towards more sustainable options is restricted to transport (Nijhuis, 2020) or the qualitative feedback of research participants (Andersson, 2019).

Furthermore, systematic literature reviews across domains (Hummel & Maedche, 2019; Mertens et al., 2022; Szaszi et al., 2018) investigate whether nudging interventions across techniques and behavioral domains are effective. If these results can be generalized is questionable as the virtue of nudges is context specific (Kosters & van der Heijden, 2015; Sunstein & Thaler, 2021)

The purpose of this thesis is to reduce greenhouse gas emissions. More specifically, this study aims to quantitatively identify the most effective ways to nudge users towards more sustainable options in a travel-specific context. The goal is to add value to the topic by testing if nudges are effective for more sustainable decisions and which nudges are most effective. Upon the completion of this research project, the following questions should be answered:

> *Are Nudges an effective way to promote more sustainable travel decisions?*
>
> *Which Nudges are effective in promoting more sustainable travel decisions?*

Companies in the travel industry should be able to utilize the results to drive sales of the most sustainable products on their channels. It is one of the many small steps we need to take for this major challenge of humankind to reach net zero by 2050 and tackle climate change.

2. Theoretic Background

2.1. The Climate change challenge

In 'An Inconvenient Truth', Gore (2006) made an impassioned call for immediate climate action. The film focused on the grave state of our environment, earned two Academy Awards and was one of the highest grossing documentaries of all time. A major audience, for the first time, was confronted with one of the biggest challenges of our modern society. The film changed viewers' attitudes towards global warming. 73% of all viewers even indicated that they would change their habits because of the climate crisis (Mazar et al., 2020; Nielsen, 2007).

However, beliefs and concerns often do not result in climate action. Hornsey et al. (2016) meta-analyzed 196 studies and polls, and found that environmental-friendly attitudes and intentions can only be modestly associated with environmental-friendly behavior. Jacobsen (2011) tested if people took action after they watched 'An Inconvenient Truth' and found that effects faded quickly after initial actions. It seems that we as a society fail to act to protect the environment, because we lack concern on the issue. Our concern about climate change has grown globally, but on an individual level, our decision behaviors do not seem to reflect that concern (Mazar et al., 2020).

The primary driver of the human-caused climate change is the rise of atmospheric levels of carbon dioxide and other greenhouse gases. Since the Industrial Revolution, humans have released nearly 2,500 metric gigatons of CO2 into earth's atmosphere. If we do not implement any significant changes, global temperatures could increase by 2.3 degrees Celsius by 2050. Multiple scientists predict that this could be a point of no return. Feedback loops such as the thawing of permafrost, which will lead to an additional emission of greenhouse gases could ultimately turn earth into a 'hothouse' state. Potential impacts will rise over time if levels of greenhouse gases in our atmosphere continue to rise. Corporates and governments alike must integrate climate change into their decision-making to accelerate the pace and scale of adaptation, and decarbonize at scale to mitigate risks (Woetzel et al., 2020).

Between 2022 and 2026, the annual mean global surface temperature is predicted to be 1.1 and 1.7 degrees Celsius higher than preindustrial levels. The chance of this five-year mean being higher than the last five years (2017-2021) is 93% (World Meteorological Organization, 2022). Even if our emissions came to a sudden halt, Earth's atmosphere will continue to warm. This illustrates the difficulty of reversing climate change (Frölicher et al., 2013).

The amount of warming largely depends on the choices we make now and in the next decades. The IPCC (2021) illustrates five different scenarios, based on Shared Socioeconomic Pathways (SSPs). These scenarios include natural events like volcano activity and a broad range of social and economic forces, which are driving greenhouse gases. SSP1-1.9 represents the low end of emissions, leading to a warming below 1.5 degrees Celsius in 2100. Together with the SSP1-2.6 scenario these calculations are based on declining CO2 emissions to net zero around 2050. At the other end, the SSP5-8.5 scenario calculates that humans will double their emissions by 2100 compared to today's levels. The report even reaffirms a near-linear relationship between cumulative CO2 emission and the global warming they cause. Each 1,000 gigatons is assessed to cause an increase of global surface temperature of 0.45 degrees Celsius.

The global momentum towards decarbonization continues to grow. Most developed countries, leading companies and other organizations have reached broad consensus to pursue net-zero emissions (Engel et al., 2022). The international, legally-binding "Paris Agreement" (2016) is the most far-reaching in our history. Currently, 194 states and the European Union signed to:

> *Article 2 – 1. (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;*

According to climate scientists many of the direst effects of human-caused climate change can still be avoided. There are severe and currently uncertain impacts such as ice-sheet collapse, deforestation or an abrupt change in ocean circulation. However, the biggest uncertainty in all climate change projections is how humans will act. It is still possible to limit global warming to within 1.5 degrees Celsius by immediate, rapid and large-scale reduction of all greenhouse gases. The climate future can be changed, if we change our behavior with new ideas and actions (Tollefson, 2021). If we are able to transform our economy, reach political agreements and public buy-in to sharply reduce our emissions, there is still hope to limit the destruction caused by the climate crisis (Fischetti, 2021). Environmental improvements in companies were traditionally focused on pollution control. However, companies and regulators must find ways to prevent environmental harmful emissions before they occur (Porter & van der Linde, 1995). To contribute to systemic change and substantial reduction of our greenhouse gas accumulation, we must also empower individuals. Climate change is the aggregation of billions of individual decisions. Climate actions such as living car-free, avoiding airplane travel or switching to a plant-based diet have tremendous potential to reduce the pace of greenhouse gas accumulation in our atmosphere (Wynes & Nicholas, 2017).

2.2. The travel industry and it's footprint

The World Travel & Tourism Council (2022) reports on the economic and employment impact of the travel industry for 185 countries around the world. According to the report, the travel industry accounted for 1 in 4 of all newly-created jobs across the world in 2019 when accounting for its direct, indirect and induced impacts. The sector contributed 10.3%

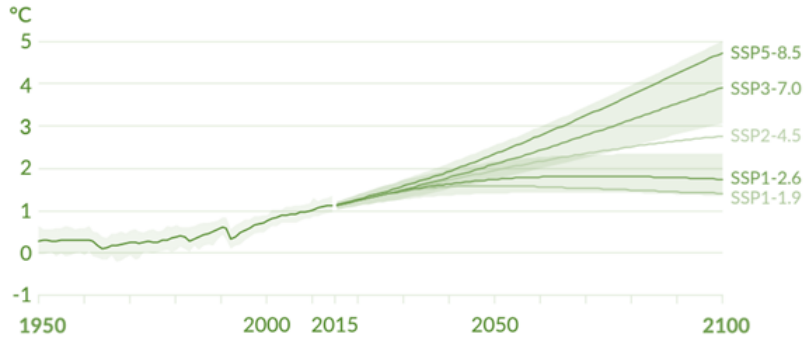

Figure 1: *Global surface temperature change relative to 1850-1900 (IPCC, 2021)*

to global GDP and comprised 6.8% of total exports. Due to the necessary restrictions in mobility during the COVID-19 pandemic, global GDP share decreased to 5.3% in 2020 and recovered to 6.1% in 2021.

Research undertaken by Lenzen et al. (2018) quantified tourism-related global carbon flows between 160 countries and indicated that the travel industry will constitute a growing part of our greenhouse gas emissions. About 8% of global greenhouse gas emissions are currently tied to tourism. The global footprint of tourism increased from 3.9 to 4.5 metric gigatons carbon dioxide between 2009 and 2013. Consumer demand for travel has grown much faster than their consumption of other products and services. This global demand is outstripping the decarbonization efforts of tourism operations. When we evaluate the carbon burden of different travel activities, there is significant variation, with aviation being the most critical component. The majority of this footprint is caused by high-income countries. Breaking down carbon emissions to different tourism-related activities, the highest proportions occur in transport (especially by air), goods (shopping) and hospitality (accommodation and restaurants).

The number of international travelers is expected to reach 1.8 billion per year in 2030. Based on a current scenario, transport related CO2 emissions alone from travelers will grow 25% from 2016 levels. The predicted growth will bring opportunities such as socioeconomic development and job creation, but also challenges to meet climate targets (UNWTO, 2019).

According to the World Tourism Organization (2008) consumers should be encouraged to consider the climate and environmental impacts of their options before making a decision. Whenever possible, tourists should try to reduce their carbon footprint and opt for environmentally friendly activities at the destination. Exemplary measures are raising awareness for the issue among customers, promoting public modes of transport, improving awareness and transparency around emissions, and creating standardized carbon footprint labeling on all tourism products.

2.3. Our operating systems

People employ a very limited number of heuristics to simpler judgmental operations. While this reduction in complexity of our decision-making processes is usually effective, it can also lead to severe and systematic errors (Tversky & Kahneman, 1974). In his behavioral economics memoir, *"Thinking Fast and Slow",* Kahneman (2013) says that our minds process information in two distinct ways. In System 2, our minds are concerned with effortful mental activities that demand brainpower, including complex computations. However, most of the time, people operate on System 1 which allocates attention to automated, intuitive decisions with little or no effort and no sense of voluntary control. System 1 is the dominating mode, which is also guiding and steering our analytical System 2 to a very large extent.

The theory of the Homo Economicus is fiction. Real humans embrace irrelevant information, see patterns where none exist and are subject to serious inertia. All our minds are dichotomous. The first half's seize is resolute, farsighted and reflective. However, the other reptile half often seizes the levers of choice in an impulsive, myopic and emotional way. This is why we smoke, drink, eat too much, or exercise and save too little. People can better be described as Homer Economicus than the theoretical rational ideal. The key claim in behavioral economics is not that people are fallible; it is that humans make mistakes systematically (Leonard, 2008).

2.4. Stone Time Psychological Biases

Human social behavior has developed in the course of the evolution. However, people still have behavioral patterns, which stem from the Stone Age and can lead us to erroneous decision-making. Our modern environmental problems are caused by these biases. At the same time, we can employ identical biases, to systematically develop influence strategies towards environmental conservation and change (Thorun et al., 2017; Vugt et al., 2014).

New research from scholars at INSEAD and the University of Southern California has shown that there is an attitude-behavior gap in sustainable habits. Governments and businesses can reduce this gap by interventions that draw on the insights of psychology and behavioral economics (Mazar et al., 2020). People make decisions quickly under pressure,

Table 1: *Economic impacts of the travel industry from 2019 to 2021 – Adapted from* World Travel & Tourism Council (2022)

	Total GDP contribution (year-on-year change)		*Total jobs in the travel industry*	
2019	9,630 billion USD	+4.7%	333 million	1 in 10 jobs
2020	4.775 billion USD	-50.4%	271 million	1 in 12 jobs
2021	5.812 billion USD	+21.7%	289 million	1 in 11 jobs

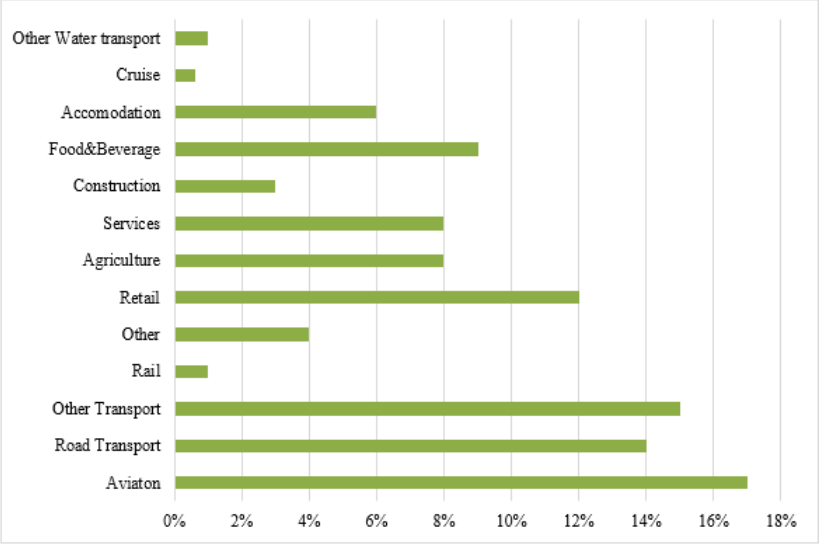

Figure 2: *Carbon Footprint of Global Tourism – Adapted from* World Travel & Tourism Council (2021)

Figure 3: *Homer deciding on System 1 mode, Spock operating in System 2 logic* Gilbert (2021)

based on system 1 and guided by biases and psychological fallacies. There are many pitfalls to reasonable decision making – taking the most beneficial choice (Sperling & Güntner, 2017).

2.5. The Nudging Concept

Nudging uses biases and other systemic errors in our decision-making processes. Instead of appeals, tax incentives or bans, nudging applies psychological methods (Rauner, 2015). Introduced by Harvard professor Cass Sunstein and University of Chicago professor Richard Thaler, these interventions are aimed at getting people to act in their own best interest. Nudges alter people's decision behavior in predicable ways and help them to improve their lives, while maintaining freedom of choice. Hansen (2016, p. 168) defines nudging as an attempt to influence the behavior of people in a predictable way without forbidding or adding any rationally relevant choice options or changing incentives. The goal of nudging is to make life simpler and easier to navigate for choosers. A good example of an application of nudging is a GPS system, which people use in their cars or on their smartphones. The GPS nudges people to steer in a certain direction, while having the freedom of selecting their own route instead (Sunstein, 2019). To count as a nudge, interventions must be easy and cheap to avoid. Nudges are never mandating. Imagine a parent that wants their children to eat healthier. The overall goal is to teach children to decide in their own best interest, which practically means increasing their consumption of fresh fruits and vegetables

Table 2: *Constraints and Obstacles of Psychological Biases – Adapted from* Vugt et al. (2014)

Psychological Bias	**Constraints on behavior change**	**Ways of intervention**
Self-interest	People prioritize personal over collective interests	Persuade individuals to value the collective more than their own interests
Shortsighted	People value the present more than the future	Persuade individuals to value the future more than the present
Status	People value relative over absolute status	Persuade individuals to accept a lower relative status associated with environmental conservation
Social imitation	People copy what others around them are doing	Persuade people to behave environmentally despite not many others behaving in this way
Sensory mechanisms	People ignore threats and dangers they cannot see, smell or touch	Persuade individuals to be concerned about distant, global, and slow-moving environmental problems

and decreasing their consumption of junk food:

- **Nudge:** Fruits and vegetables are placed closer to locations where children usually play to steer them towards healthier choices. At the same time, place junk food is placed in a cupboard, to reduce their consumption of unhealthy foods
- **Not a nudge:** Unhealthy food choices are completely banned from the children's diet and they are forced to only eat fruits and vegetables (Pereira, 2019).

Nudges have been used by both large and small, public and private sector organizations around the world. Most recently, health organizations have used nudges to educate citizens on COVID-19 testing and vaccination. Nevertheless, the main goal of nudges may not always be to protect the chooser. Nudges also help to protect third parties such as our climate (Thaler & Sunstein, 2021). Private companies that want to do good and make money at the same time can implement nudges to reduce air pollution and the emissions (Sunstein & Thaler, 2021).

Nudges are always based on an underlying choice architecture. Similar to traditional architecture, it is crucial to understand that there is no such thing as a neutral design. Small details can have a major impact on people's actual behavior. Good architects are aware that although there is no such thing as a perfect building, they make some choices which will have beneficial effects. For example, workplace interaction may be influenced by the location of the coffee machine when they design an office building. Choice architects have the responsibility of organizing the context in which humans make decisions and have the power to steer people's choices in a direction that will improve their lives. Most people are actually choice architects without realizing it. Some examples of day-to-day choice architects in our lives include:

- A medical doctor describing different medical treatment options to patients,
- A sales manager presenting different products to clients
- A caterer deciding how food and beverages are presented in a cafeteria,
- A web developer who designs interactions on websites (Sunstein & Thaler, 2021).

2.6. Why Libertarian Paternalism

Nudging is a technique that uses the idea of Libertarian Paternalism. This term might not be endearing to many readers as both concepts seem to be contradictory (Sunstein & Thaler, 2021). As many economists are libertarians, the term paternalism may even be derogatory. This is based on the false assumption that people always make choices which are in their best interest. While people should be "free to choose" as Friedman and Friedman (1990) put it, paternalistic measures help them to take better decisions for themselves. Furthermore, in many cases, a choice architect must make choices affecting others and paternalism does not always involve coercion by definition. As in the caterer example, the choice architect must make a decision on how to present food and beverages in a cafeteria. Libertarian Paternalism means that the person can arrange the products in an order, which benefits the health of guests. However, there is the liberty of every individual to make their own selection (Sunstein & Thaler, 2003). Nudges can alter behaviors towards climate-friendly actions and are the subject of enthusiasm to steer without having to resort to 'hard' public regulation (Siipi & Koi, 2022).

2.7. Nudging Toolbox

Choice architecture can succeed in many managerial settings. There are a variety of nudges which have been studied by scholars in many different academic disciplines (Beshears & Kosowsky, 2020). There are different ways to categorize nudges. One example is by educational or non-educational

Table 3: *Categories and examples of policy interventions – Adapted from* House of Lords (2011)

Regulation of the individual	Fiscal measures directed at the individual	Non-regulatory and non-fiscal measures with relation to the individual
	Guide and enable choice	
Eliminate choice (prohibiting goods/services) **Restrict choice** (outlaw smoking in public)	**Fiscal incentives** (tax cuts/breaks) **Fiscal disincentives** (taxation on cigarettes)	**Non-fiscal incentives and disincentives** (time-off work to volunteer) **Persuasion** (marketing campaigns) **Choice Architecture** (nudges)

nudges, which evaluates whether people like or dislike being nudged in a particular way (Sunstein, 2017a), whether it triggers our described system 1 or system 2 (Sunstein, 2016) and how the nudge influences the choice of individuals (Lehner et al., 2016). Sunstein (2019) also mentions there is an exceedingly wide range of interventions and their number and variety is constantly growing. Hence, he created an overview of 10 important nudges, which choice architects can use.

2.7.1. Default rules

Providing a default option is the simplest example of a successful nudge. It is simply what happens if the chooser does nothing. Many people just go with the flow sometimes knowingly and sometimes unknowingly. Default rules are an extremely powerful tool for choice architects to implement. One example of a default rule is in the area of pension policy in the US. In many 401(k) plans, the default is not to join. If you want to join, there is the duty of filling out paperwork. Companies which decided the opposite default option increased enrollment to the pension policy greatly (Thaler, 2009). Defaults can be seen as manufacturer recommendations. They have the potential to enhance customer experience and drive sales. A large national railroad in Europe made a small change to their website where a ticket purchase automatically included a fee-based seat reservation. Before this change was made, only 9% of users chose the reservation option, which increased to 47% after the implementation of the nudge. The railroad earned an additional US$40 million, with only a small fixed cost in programming and infrastructure (Heitmann et al., 2008). Default options can also manage our transition into a carbon-free economy. Default engines of new cars could be set to hybrid or fully electric. Standard temperatures of washing machines could be low and users would need to actively switch to higher temperatures (Berger, 2015). Along with a nationwide energy supplier in Germany, Ebeling and Berger (2015) attempted to use default rules to nudge existing customers to a new green energy contract that stemmed entirely from renewable resources. Setting the default choice to the more sustainable option nearly ten folded purchases of the green energy plan.

2.7.2. Simplification

People struggle to make choices, especially for complex products. The complexity of the information provided greatly affects the outcomes of decisions. Simplification nudges build on the insight that the amount and accessibility of information provided are not the only things that matter to people. Simplifications nudges can support choosers by making information more straightforward and presented in a way that best fits their information processing capabilities and decision-making process. One example of simplifications is food labels. They are often focused on counteracting lifestyle-related health problems such as obesity or diabetes (Mont et al., 2014). Another case of simplification is by labeling the Energy Star brand by the Department of Energy and the Environmental Protection. This label identifies products that meet certain energy efficiency standards. The label increases simplification by decreasing the amount of information that individuals have to process. It allows customers to choose energy efficient options with less research effort (Cooper, 2017).

2.7.3. Use of Social Norms

People tend to make choices based on social influence. Social Norm nudges inform people what other choosers are doing and thereby induce them to alter the same decision (Nahmias, 2019). Humans are nudged by other humans because they tend to think others have better information and understanding of a topic or because they just like to conform to a group. Asch (1951) conducted a series of experiments on how we tend to follow the herd. When the participants were asked to decide individually, and without judgment of

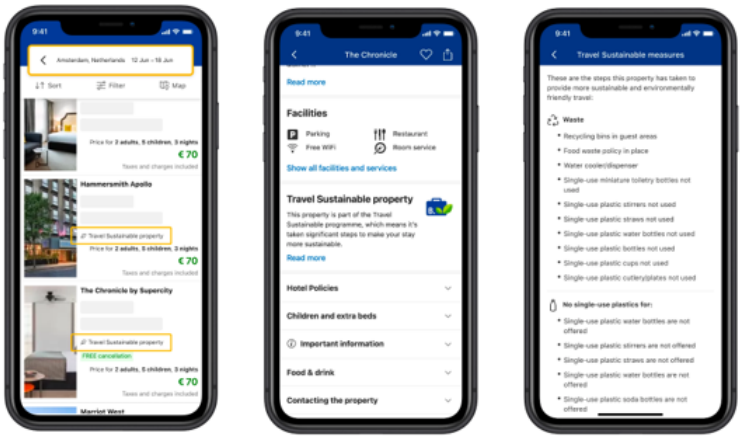

Figure 4: *Booking.com's sustainable travel label – Adapted from Booking.com*

others on a very easy task, they almost never erred. However, on the same task in a group setting, where everyone else gave incorrect answers, nearly three quarters of people erroneously went along with the group at least once. People were defying evidence their own senses observed just for the reason of conformity. Choice architects can use this fact to move people in a better direction (Sunstein & Thaler, 2021). Social norms can influence higher or lower levels of waste sorting, energy consumption or mobility options. To reduce emissions, we must motivate people to shift to more energy-efficient cars and change modes of transport such as by using a bicycle instead of a car for short distances. One specific type of nudge here would be fitness challenges, where information about other people's cycling behavior is evaluated and then used by choice architects. A range of studies in the US, UK and Ireland have documented that social feedback combined with frequent information on energy usage of others, can reduce consumption by 7%. The use of social norms has been shown to be effective when peer comparisons are offered in combination with information on personal consumption behavior. The focus should be on situations where people have a personal point of reference (A. S. E. Nielsen, 2016). For water utilities, nudges can be cheaper and easier than building new dams, wells or plants. Startups such as WaterSmart, H2OScore and DropCount have developed tools which are using the human need for conformity to alter consumer behavior. For instance, they compare the water consumption of an individual with the usage of their neighbors (Wang, 2014).

2.7.4. Increase in ease and convenience

Resistance to change is often not based on disagreement or skepticism. It is often the perceived difficulty of a decision or the ambiguity of arguments which hinders people from making a good choice for themselves (Sunstein, 2019). When speaking of food, convenience is often associated with less healthy choices. Hanks et al. (2012) executed a study where convenience was associated with healthier choices. Healthier foods were made more convenient relative to less healthy foods. One of two lunch lines in a cafeteria was arranged this way and field researchers compared purchases and consumption before and after the conversion. The study provided evidence that the convenience line that offered only healthier food options nudged students to consume fewer unhealthy foods. Sales of healthy foods increased by 18% while the consumption of less healthy foods decreased by nearly 28%. Even small improvements of choice architects in making an option more convenient will have an impact. Experiments in Scandinavia have also shown that when meat-eating consumers are presented with menus that list vegan food at the top of the menu card, most will order vegan. The recycling tendencies of office workers suddenly rise if bins with visual signs are placed next to their desks, and the ease of videoconferencing tools has made us rethink flying (Tett, 2021).

> "My number-one mantra from Nudge is, Make it easy. When I say make it easy, what I mean is, if you want to get somebody to do something, make it easy. If you want to get people to eat healthier foods, then put healthier foods in the cafeteria, and make them easier to find, and make them taste better. So, in every meeting I say, Make it easy. It's kind of obvious, but it's also easy to miss" (Thaler, 2011).

2.7.5. Disclosure

Deliberately disclosing decision-relevant information in an explicit way can also be used to nudge humans towards better choices. Disclosures can be highly effective, but must be comprehensible and accessible to customers. One example of a disclosure nudge would be the communication of the environmental or economic impact of products or services (Sunstein, 2019). Another example of a disclosure nudge has been tested by Gimpel et al. (2020) to fight fake news on social media platforms. In an experiment the researchers simulated the Facebook newsfeed. In the nudging test, they disclosed related articles to the main article. The related ar-

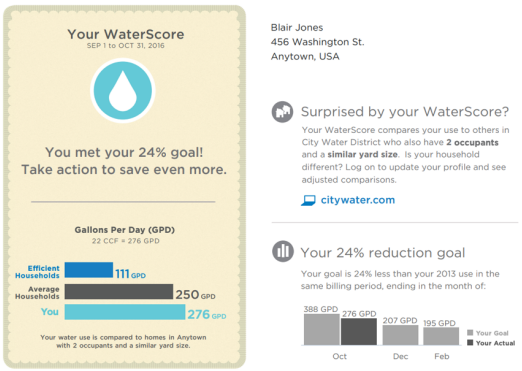

Figure 5: *Social norm nudges in a Generic WaterSmart Report* (Lade et al., 2020)

ticle provided a controversial view on the main topic. The study found that this disclosure nudge led to a positive influence on the detection of fake news on social media platforms.

According to Sunstein and Thaler (2021) an obvious nudge in the realm of climate change, would be a law requiring disclosure of all greenhouse gases by every country. Early progress on this initiative has already been made. The Paris Agreement requires a number of nations to disclose their emissions on a national level. A full disclosure via a greenhouse gas inventory would permit people to compare their emissions in detail and track changes over time. Seeing that list would lead to legislative initiatives and draw the attention of the media to the largest emitters by industry, region etc. While the inventory might not produce substantial changes on its own, it will nudge people towards better decisions by drawing attention to emission trends including which areas are of the problem.

2.7.6. Warnings - Graphic or Otherwise

Our attention is a scarce resource. Nudging can help us direct our attention towards a specific focus area (Thaler & Sunstein, 2021). When serious risks are involved, the best nudge might be a warning in large fonts, bold letters and bright colors to drive awareness. Warning nudges try to change the possible bad choice of a user by steering them toward an alternative and better option. A drawback of warnings is based on the human tendency towards unrealistic optimism. People might respond to serious threats by thinking that they will be just fine and discount the long-term disadvantages of their choices. In this case it makes sense to experiment with positive messages, providing some kind of reward for positive behavior which may not be monetary. Rewards in apps can nudge people towards better choices for themselves (Sunstein, 2019).

2.7.7. Precommitment strategies

People have diverse goals in their lives. They want to be more active, quit smoking, use less social media or engage in productive activities. To really achieve those positive changes, a useful nudge is precommitment strategies to engage in a certain action such as a work-out plan together with a fitness coach. People are even more likely to act in accordance with their goals if they commit to a specific action at a precise moment in time (Sunstein, 2019) With the 'Save More Tomorrow' plan, Thaler and Benartzi (2004) nudged employees to bear more responsibility for their own savings, by implementing a prescriptive savings plan. The employees had to commit in advance to allocate a portion of their future salary increases toward retirement savings. The intervention was effective as the savings rate of participants increased from 3.5% to 11.6% over the course of 28 months. Precommitment strategies can also help consumers nurture and facilitate their desire to a more environmentally and socially conscious lifestyle. To propel the sustainable transformation forward, consumers should commit to sustainable choices early on. Interventions could include asking them to sign a pledge or press a button to act in an environmentally-friendly way (DaSilva et al., 2022).

2.7.8. Reminders

Due to their limited attention, people sometimes simply forget something. Reminders are cues to pay attention and help us when we are absentminded. Technology has made it easier for choice architects to implement reminder nudges. With nearly everyone carrying a smartphone in their pockets these days, they can use it to send notifications in well-timed prompts. We get reminders of our restaurant reservations, our doctor's appointment or if a bill is due (Sunstein & Thaler, 2021). In a 693-person mega-study with Walmart, Milkman (2022) tested the effectiveness of text message reminders. The idea was to see which messages most effectively nudged people to get a seasonal flu vaccination. Patients who had previously opted in to receive texts from Walmart's pharmacy took part in the study. 22 different text reminders were tested, which increased vaccination rates by an average of 2%.

2.7.9. Eliciting implantation intentions

Implementation intentions can trigger numerous psychological processes which facilitate positive actions. These processes may relate to the anticipated situation or initiation of a goal-directed behavior (Gollwitzer, 1999). If someone elicits their implementation intentions, people are more likely

Figure 6: *Warning nudges on cigarette packages (U.S. Food and Drug Administration, 2019)*

Figure 7: *Example of a sustainability pledge in travel – Adapted from* Visit Iceland (2022)

to engage in activity. A simple question about future conduct can have significant consequences for decision behavior. Choice architects can use questions such as the below to direct people towards better decisions about health, wealth and happiness:

- Is protecting the environment important to you?
- Do you plan to protect your child with a vaccination?
- Do you plan to vote in the current election? (Sunstein, 2019)

2.7.10. Informing people of the nature and consequences of their own past choices

This tenth, important intervention in a choice architect's toolbox is similar to social norms, except the norm is directed to oneself (Wall et al., 2021). Private and public organizations have detailed information about the past behavior of people such as their monthly expenditures on their electronic bills. The problem is that individuals often lack this information. Giving them visibility of this information can nudge them to better choices (Sunstein, 2019).

Digital technology enables us to make this decision-relevant information available. By continuously monitoring users on activities and choice behavior we can nudge them to make better decisions for themselves (Karlsen & Andersen, 2019).

Thaler and Sunstein (2021) call this tool "smart disclosure". The data of credit cards, smartphones or other devices can be utilized for disclosure nudges, based on privacy-respecting, personal data. As in the WaterSmart example, it uses a social nudge as well as the smart disclosure of water usage. Another example would be using credit card usage to nudge users when something important is happening or the card is getting underfunded. A third example could be a child that has a nut allergy and you are out grocery shopping. The allergy could be contained in your shopper's club information. If you then buy the product which contained nuts, there would be a smart disclosure towards the customer.

Machine-readable information of past personal choices could even for the creation of 'choice engines' - technologies that interpret this data. Just as Netflix or Spotify help you decide which movie to watch or song to hear, choice engines can help you with decisions that have much higher stakes. They will enable consumers to take complex decisions such as finding the best mortgage or cellphone plan in a similar way as they search today for airplane tickets. Currently, it is not a lack of missing ingredients that has kept many choice engines from making the leap from beta testing to marketing disruption. It is easy access to data (Tucker & Thaler, 2013).

2.8. Ethical aspects of nudging

The high profile that Nudge received also led to criticism and ethical discussions on its techniques (Hallsworth & Kirkman, 2020). In 'The Ethics of Nudging', Schmidt and Engelen (2020) outline objections, including:

- Autonomy,
- Manipulation and dignity,
- Illicit ends,
- And structural reform instead of nudging.

First, some objectors worry the nudging undermines autonomy and volitional rational agency. However, nudges are used to closely align people's decisions to their ends and thereby strengthen their individual choices. Sunstein (2014) argues that many nudges are specifically designed to ensure informed personal choice. Preservation of freedom of choice is a vital part of the nudging concept as it guarantees autonomy. As in the GPS example we used to describe paternalism, nudges have the goal of increasing navigability. Nudges make it easier for people to get to their preferred destination, even when it is hard to navigate.

Second there is criticism that nudging is a manipulative tool. Some nudges obviously use manipulative techniques. However, if those interventions produce enough benefit, a minor amount of manipulation can be ethically justified. Painting dashed lines on roads manipulate people as they produce an illusion of speed, but they also reduce crashes. When choice architects use manipulative intentions which are against the overall benefit of a person, this would not be a nudge by definition and unethical behavior (Wilkinson, 2013). Choice architects must ensure that their designs are compatible with human dignity. If a person feels less healthy, sadder or poorer after being nudged, that is unethical behavior (Thaler & Sunstein, 2021).

The same is true for the third worry on the use of nudging. Many nudges are objectionable as the choice architect has the intention of perusing excessive paternalism and other illicit ends. Consider serious ethical issues if people use interventions to discriminate based on race, gender or religion. Even truthful information, for example, on crime rates by the government might fan flames of violence and prejudice (Sunstein, 2015). Nonetheless, in some cases the legitimacy of the goal is not granted. We all agree that people want to be healthier and not die in traffic, while other cases might raise stranger epistemological concerns (Schmidt, 2017).

The last critique on nudging is less directed on the technique itself, and more on its use in a real-world economic and political context. The objection is that nudging falls short on many big issues our society encounters. Obesity, climate change or consumer debt have a complex biological and social etiology. Nudging bears the risk of shifting the focus simply to individual decision-making without looking at the real underlying causes. However, there is no need to take a decision between nudging and other policies implemented by businesses or governments. They can tackle both those current challenges (Schmidt & Engelen, 2020).

The central arguments for the use of nudges are that both nudges and choice architecture are inevitable. Therefore, it is somewhat futile to discuss if their use is ethically right or wrong. Furthermore, these forms of choice architecture come in many forms and can even help us to reach ethical goals such as welfare, autonomy, dignity or other values. Any change in choice architecture must preserve freedom of choice, but still can run into serious ethical objections (Sunstein, 2015). Nudges are small design changes that can markedly affect individual decision behavior. This is why choice architects must ensure to not sway people to choices which they will later regret. They should have good reason to believe that the encouraged behaviors will improve the welfare of those being nudged. Nudges should never be misleading and people should preferably be able to opt out of the nudge with ease (Thaler, 2015).

2.9. Effectiveness of nudging

Nudges are almost everywhere in our lives today. If you are getting information on how many people booked a room in the last few hours, choosing a default option, or buying a product which has a label that provides proof of energy efficiency, you are being nudged. However, there are limits beyond ethical considerations on nudging, as in any tool for behavior change.

Oreopoulos and Petronijevic (2019) designed online and text message interventions for a sample of nearly 25,000 students to improve their college achievement. They found that these nudging tools had no significant influence on academic outcomes. Cantor et al. (2015) executed a study that examined how the display of calorie information on menu boards of fast-food restaurants in New York City changed consumer food choice. There was no statistically significant change over time in levels of calories or other nutrients purchased or in the frequency of visits to fast food restaurants. However, in research, knowing what does not work is as important as knowing which interventions are effective. Firstly, if choice architects are not able to nudge choosers towards a specific option, the findings could suggest that different and possibly more intensive interventions are needed. Secondly, even null results have implications as those nudges can be determined to not be used for a certain task or environment ("Nudges That Don't Nudge," 2020).

Overall meta-analysis on the effectiveness of the choice architecture method has proven to be effective in many cases. Szaszi et al. (2018) analyzed 2670 papers and found 93% of the studies contained at least one successful intervention. Hummel and Maedche (2019) calculated effect-sizes of nudges from different research areas. In the meta-analysis, nudges had a median relative effect size of 21% and an average relative effect size of 55%. They also split up the studies by context and nudge tool. Both tests showed that results vary based on context and nudging form where default options especially had larger median and average effect sizes than other categories. Precommitment strategies were found to be the least effective nudging tool.

In their meta-analysis, Hummel and Maedche (2019) also analyzed if there were differences between nudges in offline settings and nudges where IT was involved. They found the effect sizes of nudges in a digital setting were not different to the effects in conventional settings.

2.10. Digital Nudging

The digital ubiquity and information overload leads people to the limits of their cognitive processing capacity. This means in the digital space, we are often deciding based on system 1 – automated, fast and not consciously. The increasing use of digital technologies also means that many of our

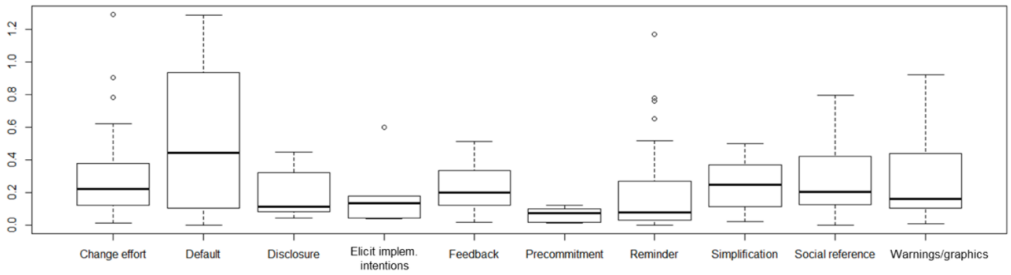

Figure 8: *Boxplot of relative effect sizes per nudging tool* (Hummel & Maedche, 2019)

choices are made in online environments today. User interfaces on our digital devices such as notebooks, smartphones or Internet of Things include choice environments ranging from e-government to e-commerce interactions. Even simple modifications of those environments can influence people's decision behavior. Digital nudging applies the nudging concept to user interface design elements in digital choice environments. It serves as a valuable tool for improving user experience and leading them towards more advantageous decisions for themselves without restricting freedom of choice. Compared to conventional forms of nudging, digital nudging also has the advantage of being easier, faster and cheaper to implement. In addition, user behavior can be tracked and analyzed with appropriate technologies to determine the effectiveness of nudges. One example for choice environments where digital nudges can be implemented are web-based forms (Mirsch et al., 2018; Schneider et al., 2018)

Digital nudging can change socially acceptable group behaviors and spread quickly throughout organizations. It also has the ability to test nudge campaigns in small segments and scale up what works best. A pilot can be a short, low-cost experiment (Dhar et al., 2017). Understanding digital nudges is important for the IT profession, as user interface designers create most of today's choice environments. User interface designers often focus primarily on usability and aesthetics, and neglect the potential of behavioral effects of different designs (Schneider et al., 2018). Nudging in a digital environment follows the same principles as in the physical world. The fundamental difference is the greater versatility and dynamic, which choice architects have in virtual spaces. It is a promising research field for scholars and practitioners in the field or in the areas of user interface, user experience and digital service design (Mirsch et al., 2018). Testing digital nudges is especially important as effectiveness is likely to depend on the context and goal of the digital nudge. While digital nudges work well in the context of hotel bookings, they might be ineffective in other domains. This may be due to different target users or the unique nature of the decision processes. Therefore, techniques such as A/B testing help choice architects find the most effective interventions (Schneider et al., 2018).

Web technologies allow us to track users in real-time and analyze their behavior. They also enable choice architects to generate information on the decision maker's personal characteristics and their environment. They have the ability to implement nudges by modifying a system's user interface. This can include actions such as setting defaults, displaying/hiding design elements or providing information on pledges. Notwithstanding the availability of dynamic adjustment on how options are presented, designers should follow commonly accepted design guidelines such as Apple's Human Interface Guidelines to ensure usability and consistency. If a particular Nudge does not produce the desired effect, choice architects should evaluate whether the Nudge is too obvious or not obvious enough (Schneider et al., 2018). Digital nudging can be used to tackle our current environmental issues. They provide ways to make pro environmental behavior less complicated for consumers (Zimmermann et al., 2021).

2.11. The importance of online experiments

People commonly assume the greater the investment, the larger the impact it will create. However, in the digital space, success is more about getting many small changes right to achieve progress. This 'learn fast' philosophy is based on the Lean Startup (Ries, 2011) where the premise is to get feedback early and validate that you are on the right path. It can be difficult to assess the potential of new ideas. Based on that, it is important to have the capability to run tests cheaply. The digital world is often viewed as turbulent and full of peril, but controlled experiments can help us navigate. They can show us answers, which were not obvious and provide proof on the value of an idea. Controlled online experiments can transform decision-making into a scientific, evidence-driven process rather than an intuitive reaction. They can help managers to make better decisions (Kohavi & Thomke, 2017).

> *"The premature outlay of huge amounts of money in pursuit of the wrong strategy is the thing to avoid. You need to have an experimental mindset." (Christensen, 2020)*

These tests can be run in a laboratory or in the field. Their purpose is to test a hypothesis in order to accept or reject it, based on measurable results. For any experiment there is no need for a fully functional app or website. A digital prototype acts as a proof of concept that allows testing before fully building the solution. Prototypes can be used to test the general feasibility or usability of a product and allow us to iterate, review, and refine big and small ideas. Some popular

Table 4: *Example applications of digital nudging – Adapted from* Weinmann et al. (2016)

Use case/ Information system	***Nudging example/behavior change intervention***
Business process management	Structuring complex input screens
E-business and e-commerce	Displaying limited room inventory during a hotel-booking process
E-finance and insurance	Setting defaults for frequently selected insurance plan options
E-government	Setting defaults to opt in for organ donation
E-health	Step counter app that provides feedback on activity levels
E-learning	Reminder to learners to engage with course content
Green IS	Smart meters to encourage energy savings
Security and privacy	Displaying the strength of selected passwords
Social media	Giving incentives, such as badges, for sharing or other activities

tools for rapid prototyping include Adobe XD, Figma, and Sketch (Levy, 2015).

2.12. A/B Testing

Once thought to be exclusive to large technology firms, A/B testing has become a viable and cost-effective way to identify and test value-creating ideas for many businesses. In statistical terms, it is a method of two-sample hypothesis testing. The A and B method are compared by outcomes of a controlled experiment. What sounds like a simple test of two variants has been a revolutionary approach to decision-making driven by data. This iterative approach is a key success factor for many Silicon Valley giants that have a deeply rooted so-called 'testing culture'. A/B tests enable companies to advance decision-making from gut feeling, assumptions or a battle of long-winded arguments to facts based on statistics. What has not been tested and thus proved or disproved is only a personal opinion. The method is often discussed in the context of digital marketing, web design or other marketing or technology-focused applications. A/B testing methods are sometimes referred to as split testing (Vallee, 2016; Witzenleiter, 2021). Fung (2017) who founded the applied analytics program at Columbia University, explained A/B testing as a way to compare two versions of something to figure out which performs better. A simple example of an A/B test is the size of a subscribe button on a website. In this case, the metric to evaluate performance is the number of visitors who click on the button. To run the A/B test, two groups of randomly assigned users visit two different versions of a website. The only difference between both sites is the size of the button, which enables an analysis of which button size caused more visitors to click. However, sometimes other variables such as mobile versus desktop, will drive results on average. While randomization is an important part of testing, this may result in set A containing slightly more mobile users than set B, which may cause set A to have a lower click rate regardless of the button size users are seeing. Statistical blocking should be used in this example by first dividing users by mobile and desktop and then randomly assigning them to each version.

On websites, A/B tests can be run on diverse elements such as headlines, call to action text, call to action location, pop-ups, featured images or copy. Each and every design element which can be changed can also be tested. Accurate testing can drive a substantial effect on the effectiveness to achieve a certain goal. There is a possibility that one variation can work two, three or even four times better, with only minor investment or effort (Pateil, 2022). The power of A/B testing is that it provides evidence to understand why something happened. In other words, it lets us establish causality by making a change and measuring its effect compared to a control group. In addition to statistical significance, effect sizes can be calculated between the control and experimental group. Understanding these causes of behavioral effects can help designers explore what will happen if they make changes in a user interface. This enables us to understand with accuracy how design changes cause changes in our users behavior. Furthermore, A/B testing can protect companies against the very human tendency to see patterns in data and behaviors that confirm what we already think, and mitigate the risks of investing time and resources on assumptions that are not proven (King et al., 2017).

Before comparing the A version and the B version against each other, it is important to decide which score will be measured as a success factor. To start an A/B test effectively, there must be a clear understanding of the overall purpose of the website or one quantifiable, specific element which should be improved after the testing process. E-commerce businesses could define revenue per visitor as a success metric, fundraising sites could use completed donation forms. or Google's search engineering team could use abandonment rate as a metric, which indicates when a user leaves a search results page without clicking anything. Without a clear quantifiable success factor, it is tempting to focus on vanity metrics, which are not relevant to the overall goal (Siroker & Koomen, 2015).

3. Methodology

The function of all science is to investigate answers to questions with as much objectivity, ethical diligence, and rigour as possible (Jackson et al., 2007). Certain types of research questions call for specific approaches. Researchers should use a qualitative approach if the defined problem refers to:

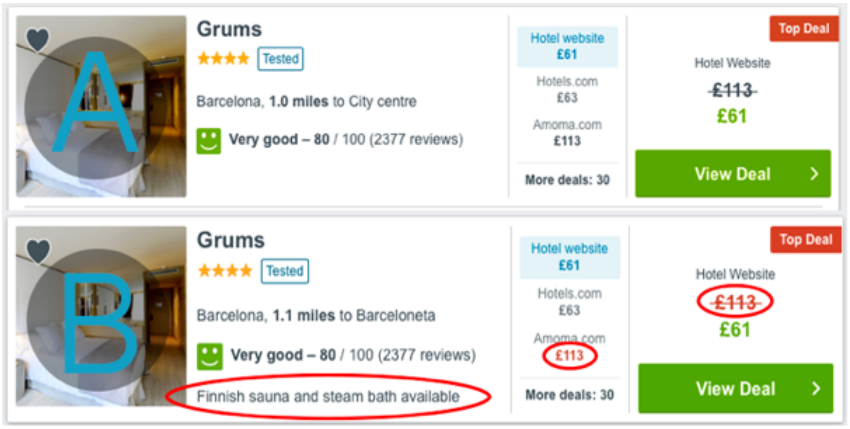

Figure 9: A/B Testing on the metasearch platform trivago (Satouri, 2019)

Table 5: *A/B Testing goals per site type – Adapted from* Siroker and Koomen (2015)

Website Types	Common Conversions & Aggregate Goals
E-Commerce Selling products online	– Complete purchase – Products added to cart – Product page views
Media/Content Focused on article or other content consumption	– Page Views – Articles read – Bounce Rate
Lead Generation Acquiring new business through name capture	– Form Completion – Clicks to a form page (links may read “Contact Us”)
Donation Sites aiming to collect donations	– Form completion – Clicks to a form page (links may read “Donate Now”)

- The identification of factors that influence an outcome
- The utility of a planned intervention
- Or understanding the best predictors of outcome.

On the other hand, if little research has been done on a certain topic and the merits of a concept or phenomenon need to be explored, a quantitative approach should be used. These approaches are plans and procedures of data collection, analysis and interpretation. Quantitative research statistically assesses some aspect of a research problem through the use of experimental or survey designs. Experimental research seeks to determine if a specific treatment of one group creates different outcomes from another. In those experiments, hypotheses are often used to answer research questions. They help to focus on the purpose of the study and inquire about the relationship of variables (Creswell, 2009).

Chambliss and Schutt (2016) also emphasize that experimental research provides the most powerful design for testing whether an association exists between an independent and dependent variable. These causations are then tested. One group receives some ‘treatment’ which is a manipulation of value of the independent variable. The other group is termed the control group and does not receive that treatment. As a simple example, consider a research question of whether drinking coffee improves one’s writing of a Master’s thesis. To test this question in an experiment, two groups would be compared. One group would be comprised of participants who always drink two cups of strong coffee while writing the thesis and the second group would be the control group comprised of people who will not drink coffee. At the end, all cases will be compared based on which group received the better grading. To test these or any other causal relationships, experimental research has three common features:

1. ***Two comparison groups*** (Experimental and control group)
2. ***Variation in the independent variable*** before assessment of change in the dependent variable, to establish time order
3. ***Random assignment*** to the two (or more) comparison groups

This thesis aims to understand the utility and effectiveness of digital nudges in a quantitative, experimental research approach. Specifically, this study aims to examine if nudges can effectively influence decision behavior towards

more sustainable choices in a travel context. Based on findings from current literature, we already know which travel activities cause greenhouse gas emissions, how and why nudges are working, as well as which nudging tools are available to choice architects. Additionally, current literature indicates the potential to nudge people towards more sustainable options in a travel context and on digital channels. Therefore, it is expected that the implementation of digital nudges has a causal relationship to the choice of the most sustainable travel products.

3.1. Hypothesis Development

The term hypothesis has already been mentioned in this thesis. In general, hypotheses are predictions that researchers make about the expected outcomes of a relationship among variables. Hypotheses make specific testable links between theories and their measurement. The goal is to form this information into a predictive statement. These statements are tested and may be confirmed, partially confirmed or proved false (Creswell, 2009; Williams et al., 2021). Going back to the coffee drinking experiment example, the test hypothesis for this research question would be: Coffee drinking improves the writing skills of students writing their Master's thesis.

These hypotheses reflect the purpose of the study. In the absence of any evidence to the contrary, the simplest starting point for researchers is to assume there is no relationship between the dependent and independent variable. This defines the null hypothesis. It is important to note that testing hypotheses has nothing to do with what the researcher wants to be true. It simply reflects an agnostic position based on the data of two samples. In order to test any quantitative hypothesis, measurable variables are necessary. The data must be generated by the same process before comparing them in statistical tests (Easterby-Smith et al., 2015).

In this experiment, the null hypothesis (H0) represents there is no relationship or significant difference between the group which received specific Nudges and the control group which received no Nudges. However, the theoretical background posits a causal effect of Digital nudges on the choice of offers, which emit the least greenhouse gases such as CO2. This causal relationship is formulated in the alternative hypothesis (H1). The literature meta-analysis by Szaszi et al. (2018), Mertens et al. (2022) as well as Hummel and Maedche (2019) provides evidence that Nudges are effective in certain contexts such as health, energy and finance.

> *H1: Digital nudges lead to the booking of the most sustainable travel offer*
>
> *H0: Digital nudges do not lead to the booking of the most sustainable travel offer.*

3.2. Study Design

To obtain the data and test the hypothesis afterwards, this experiment uses two sample groups which are compared against each other. In an online travel booking process, one group receives the regular process without any nudging intervention (G1). The other group (G2) receives one specific Digital nudge in the same booking process. To test the effectiveness of different forms of Nudges, various interventions are tested in G2 and compared against the control group, G1.

According to Mirsch et al. (2018) Digital nudges must always be developed and tested for a specific application context and should not be considered as best practices without reflection. They developed a systematic approach to design effective and user-centric Nudges at the Competence Center Digital Service Innovation at the University of St. Gallen. Going beyond a solely trial-and-error procedure when designing user interfaces, it aims to avoid unnecessarily long test and evaluation cycles. The model is used in this experiment to test the hypothesis and evaluate the effectiveness of different nudging tools.

3.2.1. Definition and Analysis of the Digital Nudging Environment

In the first phase of the systematic approach by Mirsch et al. (2018) specific goals of the interventions should be defined. In the case of this research project, the goal is to move consumers to choose sustainable options when booking their holidays. Furthermore, it is necessary to select the examined user interface in the first step. This is important as mobile applications for example have different design guidelines, strengths, weaknesses and requirements for designing digital nudges. This research is limited to mobile testing as according to Arora (2021) it is the primary device for travel planning in the majority of the world and mobile booking is set to soon surpass desktop booking in volume.

After defining the goal of the intervention and the user interface, the desired behavior is determined. It states which decision behavior is expected based on the Nudge. The nudged and desired behavior in this thesis is always the option that emits the least greenhouse gases. As a result, there are two possible outcomes per decision:

- The user chooses the option with the least greenhouse gas emissions. In the case of G2, this option includes one specific Nudge.
- Or (0) the user chooses an alternative option. This is any option which is not the most sustainable travel offer and is not designed with a Digital nudge.

Before implementing Nudges and testing their effectiveness in a travel context, it is necessary to develop the travel booking process. The user interface design process starts with developing the general version without Nudges. This is the version which is later tested by the control group G1. The experiment uses a simulated travel booking process where users can choose different services. These offered services have different levels of greenhouse gas emissions.

Based on the emissions analysis of the travel industry in the theory section, experiment participants receive 4 differ-

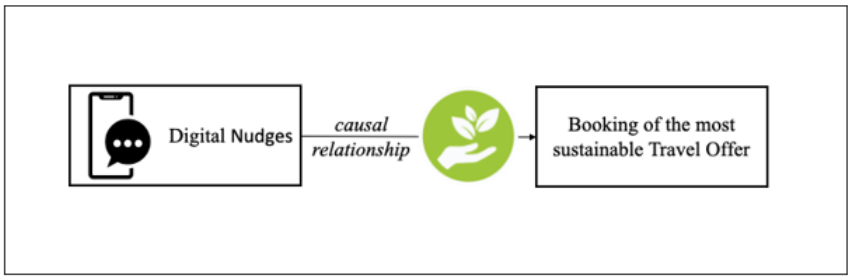

Figure 10: *Hypothesis of Decarbonizing Travel Decisions by Using Digital nudges*

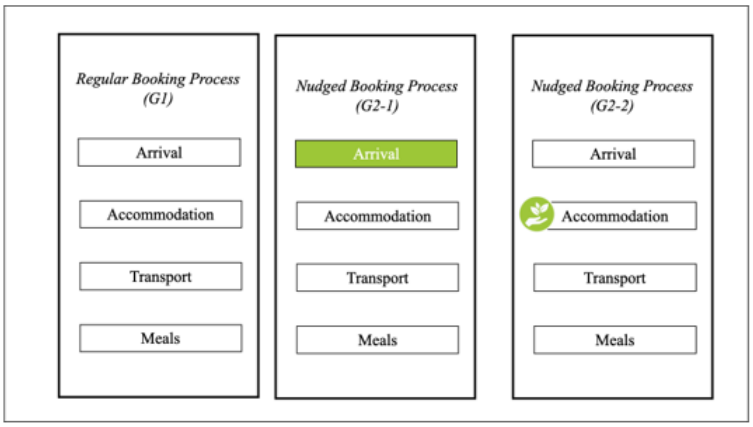

Figure 11: *Regular and nudged booking process*

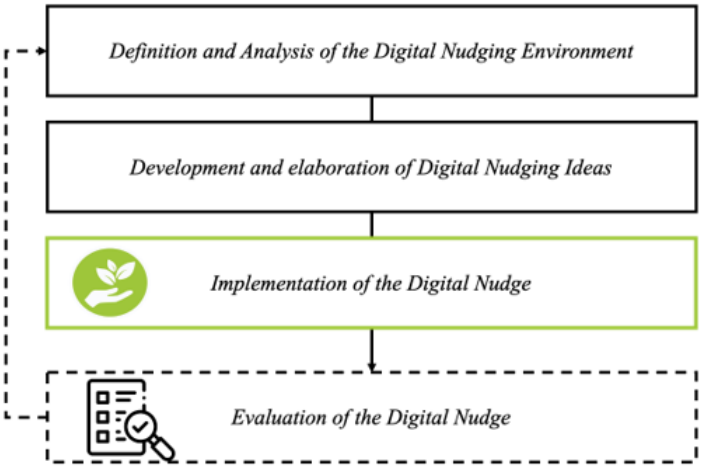

Figure 12: *Systemic approach for Digital Nudging – Adapted from* Mirsch et al. (2018)

ent booking questions. Users can choose freely for their preferred option in the realm of transport, accommodation and restaurants.

- ***Arrival*** – How to get there?
- ***Accommodation*** – Where to stay?
- ***Transport*** – How to get around?
- ***Meals*** – What to eat?

Transport causes the majority of greenhouse gas emissions and thereby is the most powerful lever in sustainable behavior that is included with two decisions. Arrival asks participants to choose their preferred option to travel to the desired destination from their starting point. The transport decision is focused on local mobility options at the destination.

Additionally, the booking process also includes two questions in the hospitality field. Users can select one of the offered accommodation options. The last question relates to

which meals guests want to have during their stay. This question is formulated in a generic way as the decision can relate to the booked hotel, but also other aspects of the journey such as individual restaurant visits. Shopping, which is another significant cause of CO2 emissions in the travel industry, is not covered in the booking process. This is due to the fact that shopping decisions take place during the journey and are not pre-booked on digital channels.

The environment of our experiment is a simulated booking process. It can be defined as a laboratory experiment in the digital space to test the hypothesis. Although researchers conduct experiments in various settings, laboratory or simulated domains have unique advantages including the ability to create and simulate artificial conditions, direct comparisons, replications, and measurement technologies. They allow researchers to build the necessary conditions for hypothesis testing and provide causal inference. Furthermore, laboratory experiments can simplify complex theories about human behavior, communication, and perception. Beyond those advantages of the simulated booking process, critiques of laboratory experiments stress the associated disadvantage of lacking external validity. The sterility of the approach is criticized too as it provides situations which are too abstract and differ too much from the real-world decisions that individuals make. Therefore, researchers should use field context rather than abstract terminology in their experiments. In search of greater relevance, this enables preventing unnatural behavior of experiment participants in a controlled environment (Allen, 2017; Harrison & List, 2004).

To provide users with context in this research project, the experiment starts by setting the scene. Users are asked to book a journey from Munich to Milano. Their task is to decide on their desired accommodation, transport and food options during their journey. The trip will start in Munich at noon on Friday, 12th August. The introductory remarks also include the information that they will travel with one companion and will return to Munich on the evening of Sunday, 14th August. The participants of the experiment are asked to choose the options that suit them best. The data on prices, routes and times was also calculated for the same dates and accessed on 16th July 2022 to make the simulated booking realistic.

The first question arrival refers to the transport from Munich to Milano. For the simulated booking process, we need the duration of the option and the prices. Additionally, the total emissions were calculated to gain information on which option is the most sustainable. Additionally, the total emissions are needed at a later time for the disclosure nudge. Information on prices, distance and duration were ascertained using Google Maps, Google Flights, Flixbus and Deutsche Bahn. The total average emissions are according to the Umweltbundesamt (2021) and include CO2, CH4 and N2O. These emissions are declared in a CO2 equivalent.

The price of travelling to Milano per car is not calculated as the related costs depend on the car ownership of the user. The journey by bus is the option that creates the least emissions – 13.635 g CO2 equivalent. As the most sustainable mode of transport, it is the option which will later be nudged. All emissions were calculated for the outbound and return journey. In addition, the indicated prices are calculated for the entire trip. The cheapest economy fare has been chosen for all modes of transport, including special discounts such as early booking deals.

After choosing the mode of transport. the experiment participants are asked to select their accommodation. Data of a Booking.com search from 16 July, 2022 is used with 4 different hotel options which users can choose from. The indicated price per person and night was calculated by using the lowest available rate for the cheapest room of the hotel on the booking platform. There is no data on which hotel has the lowest greenhouse gas emissions per person. The assumption to test the effectiveness of nudging one specific hotel is that Westin Palace is the most sustainable accommodation with the lowest CO2 output per person.

Another transport decision relates to the selection of mobility options at the destination. Users can choose between (1) public transport, (2) taxi / ride hailing or (3) taking a rental car. As this question is a general one, there are no price indications for the different options. If participants want to take the most sustainable choice, they would select the public transport option.

The last step of the booking process is the selection of food options that users plan to consume during their stay in Milano. Scarborough et al. (2014) estimated the difference in greenhouse gases of different dietary options. Users in the experiment can decide between a (1) vegan, (2) vegetarian, (3) high-meat based and (4) medium meat-based diet. The vegan diet is the most environmentally sustainable one. Guests who choose this option have mean greenhouse gas emissions of 2,890 grams of CO2 equivalents per day based on a 2,000 kcal diet.

Following the definition of decision areas and choice options, the regular booking process can be designed. The user interface design for the experiment was created with the web-based design tool Figma. It is a free, intuitive and user-friendly tool to create designs.

3.2.2. Development and elaboration of Digital Nudging Ideas

In the second phase, Mirsch et al. (2018) describe the importance of dealing intensively with the effects and implementation opportunities of Digital Nudging. The aim of the approach is to gain an in-depth understanding of which nudges could be used to achieve the goal of the interventions. Subsequent prioritization makes sense in order to further specify the most promising Nudges. The specification can be made by prototyping the different nudging ideas.

As described in the theoretical background, there are various ways to categorize different nudging tools. This thesis uses the framework by Sunstein (2019). The same categories were also used in the literature meta-analysis by Hummel and Maedche (2019).

The overall goal is to test every nudging tool out of our toolbox. This enables us to identify the most promising nudging ideas, which will be tested for effectiveness. For this pur-

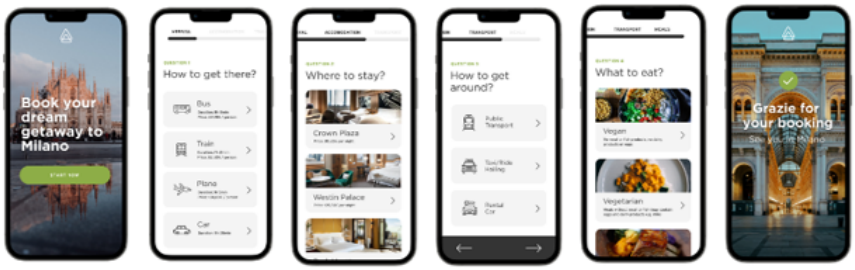

Figure 13: *The regular booking process (G1)*

Table 6: *Modes of transport – Sources (Deutsche Bahn, 2022; Flixbus, 2022; Google Flights, 2022; Google Maps, 2022; Umweltbundesamt, 2021)*

Mode of transport	*Distance*	*Average Emission*	*Total Emission*	*Duration*	*Prices*
Bus	505 km	27 g/Pkm	**13.635 g**	8h 5min	69.98 EUR
Train	388 km	50 g/Pkm	19.400 g	7h 21min	82.80 EUR
Car	495 km	152 g/Pkm	75.249 g	6h 20min	
Plane	348 km	284 g/Pkm	98.832 g	1h 5min	180.00 EUR

Table 7: *Accommodation Options - Source* (Booking.com, n.d.)

Accommodation / Hotel		*Price per person / night*
Crown Plaza	https://www.booking.com/hotel/it/milan-city.de.html	80.25 EUR
Westin Palace	https://www.booking.com/hotel/it/westinpalacemilano.de.html	139.50 EUR
Park Hyatt	https://www.booking.com/hotel/it/park-hyatt-milano.de.html	423.00 EUR
Mandarin Oriental	https://www.booking.com/hotel/it/mandarin-oriental-milan.de.html	747.50 EUR

Table 8: *Dietary Options and emissions - Source (Scarborough et al., 2014)*

Dietary Option	*Mean Emissions per 2,000 kcal diet*
(1) Vegan	2,890 g
(2) Vegetarian	3,810 g
(3) Meat Lover	5,630 g
(4) Standard Diet	7,190 g

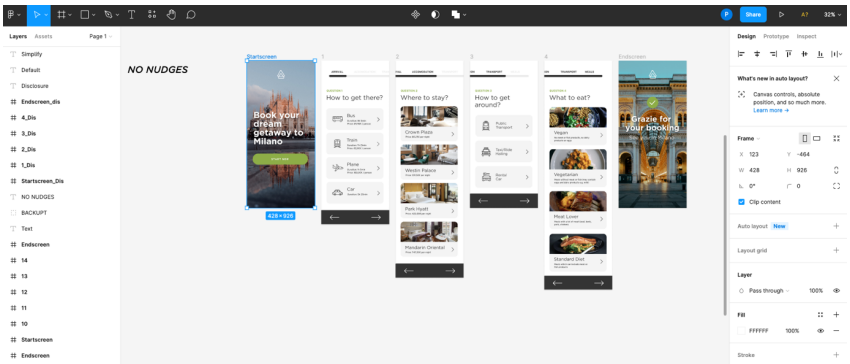

Figure 14: *Designing the booking process in Figma (Screenshot)*

Table 9: *Overview of different (Digital) Nudges – Adapted from* Sunstein (2019)

(Digital) Nudges	*Intervention implementation*
Default rules	Preselecting a choice option
Simplification	Reducing complexity of a topic
Use of social norms	Providing information about the decisions that others made
Increase in ease and convenience	Reducing barriers of a choice
Disclosure	Providing relevant, comprehensive information
Warnings, graphic or otherwise	Alert people about serious risks
Precommitment strategies	Commitment to a certain course of action
Reminders	Sending reminders (for example, by e-mail)
Elicitation implementation intentions	Asking persons for intended actions
Informing people of the nature and consequences of their own past choices	Disclosing previous personal choices

pose, the general booking process version without Nudges will be modified. In Figma the general version is duplicated and adapted with one specific Digital nudge. Based on the hypothesis, this Digital nudge will cause more users to choose the most sustainable option.

3.2.3. Default nudge (G2-1)

The first Digital nudge implemented is a default nudge. It is a very simple adaptation of the general booking process. When users choose their preferred mode of transport from Munich to Milano, the nudged option would already be preselected. If users do not proactively opt for another choice, they would be choosing to go by bus by default, which causes the least greenhouse gas emissions.

3.2.4. Simplification nudge (G2-2)

Even if users want to choose a sustainable option, it is difficult to find out which decision will have the lowest emissions. Furthermore, most of us cannot relate to a certain specification of CO2 equivalents. With the simplification nudge, users can easily see which decision can help to protect the environment. In the digital experiment, the green hotel label flags accommodations that are taking significant steps to reduce greenhouse-gas emissions and make the guests' stay more sustainable. To test the Nudge, the assumption made is that the Westin Palace Hotel is part of this program and the most sustainable option for the participant.

3.2.5. Increase in ease and convenience nudge (G2-3)

For the next nudging tool, the user interface is redesigned in a way that makes it easier for users to choose the most sustainable option. When asking users to book their local transport option in Milano, the regular booking process has the 3 options presented in the same way. To increase ease and convenience of choosing the most sustainable option, public transport is highlighted and complemented with a picture, while the alternative two options are less conspicuous.

Furthermore, the increase in ease and convenience nudge is not limited to the design of user interfaces in a simulated booking process. These Nudges can be about more than just making the most sustainable option more attractive visually. What (Thaler, 2011) described with "Make it easy" can be achieved by making the actual travel service more convenient and better for consumers. This means improving prices, quality and convenience of the most sustainable travel offer. For example, the train connections from Munich to Milano could be made less costly, faster and more punctual which makes the choice easier and more convenient for guests.

3.2.6. Social norm nudge (G2-4)

It is expected that most users will choose their usual diet in the regular booking process. Based on the influence of others, a social norm intervention could nudge more users to choose a vegan diet during their holidays. The design of the nudged version would indicates that 64% of other guests choose to eat vegan dishes during their stay. A it's popular sign design intervention is implemented at the vegan diet option with additional information on the bottom of the interface.

3.2.7. Disclosure nudge (G2-5)

Another nudge to choose the most sustainable option to travel from Munich to Milano discloses the weight of CO2 equivalent greenhouse gas emissions for the different transport options. It transparently and objectively communicates the environmental impacts of the different options. As an additional visual element, the different CO2 outputs are indicated with green, grey and red. The green option of travelling by bus is the nudged element with 13.635 g of emissions.

3.2.8. Warning nudge (G2-6)

The disclosure of CO2 equivalent emissions is used for the next nudge. As stated in the theoretical background, warnings can be addressed in a positive or negative way. The nudge used in this experiment is a positive example of mobilizing people towards a common goal of fighting the current climate crisis and addressing the individual power of the chooser. The G2-5 version also uses the developed G2-4 nudge, as users may not be familiar with which option actually is the most sustainable one. As in the previous option,

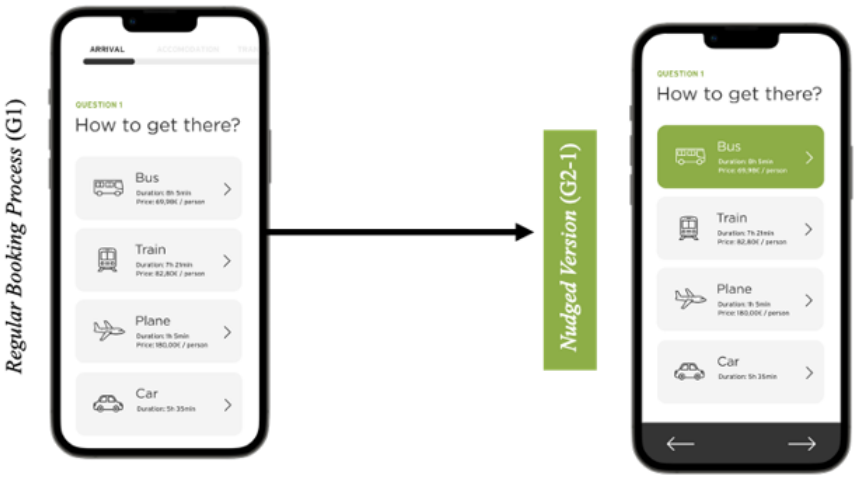

Figure 15: *Default rule nudge G2-1*

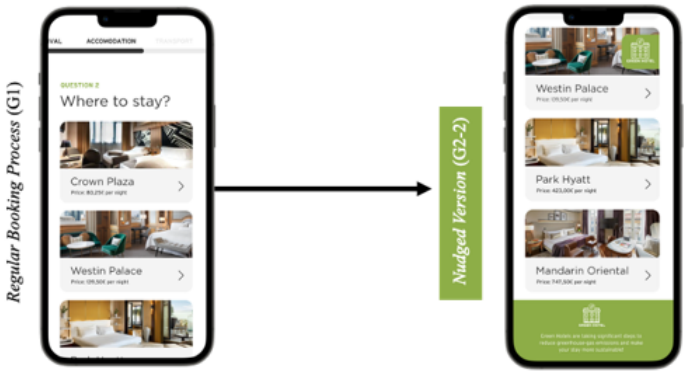

Figure 16: *Simplification nudge G2-2*

Figure 17: *Social norm nudge*

the effectiveness is measured by how many people choose the most sustainable option in comparison with the regular booking process.

3.2.9. Precommitment nudge (G2-7)

The precommitment nudge is implemented before the start of the actual booking process. Choosers can commit or not commit to being a sustainable traveler. A commitment is a pledge to act responsibly by choosing offers that emit less greenhouse gases into the atmosphere. Similar to

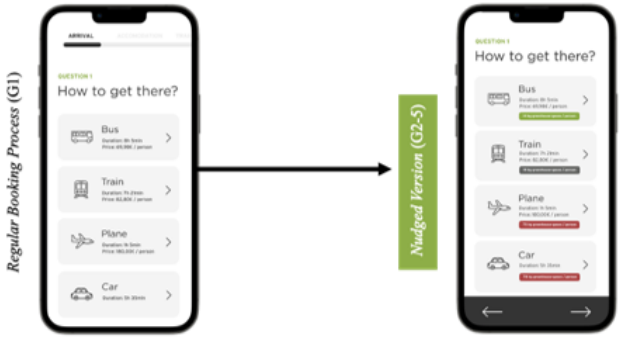

Figure 18: *Disclosure Nudge*

Figure 19: *Warning nudge*

the warning nudge, another nudged version is used to guide users about which option is the most sustainable choice. Both cases can be defined as a hybrid nudging technique.

3.2.10. Reminder nudge (G2-8)

As our regular process design is simulated, it is not feasible to set reminders automatically after the completion of the booking. However, to explore the capabilities of reminders to nudge users towards more sustainable products, an e-mail reminder is used. As the journey is planned to start on Friday, 12th August 2022, users will receive an e-mail which provides them with the option to change their decision three days prior to their departure. Users who did not choose the climate-friendly vegan food option will be nudged to click a link.

3.2.11. Informing people of the nature and consequences of their own past choices

This nudging tool uses the past behavior of people as a baseline. This personal information is not available in our experiment and therefore the nudge cannot be tested for effectiveness in a travel context. For future research in this realm, an existing booking platform could use the past behavior of users obtained from customer relationship management tools. One practical instance of this Nudge would be by indicating if the person's CO2 output is higher than the average user.

3.2.12. Elicitation implementation intentions nudge (G2-9)

The last Nudge tested in the experiment elicits user intentions to choose the most sustainable option. Experiment participants are asked if protecting the environment is important to them before the actual start of the booking process. Similar to the warning nudge, this idea builds up from the G2-4 nudge. This is important as users have to be aware of which is the most sustainable option after they agree to act sustainably. The effectiveness of this hybrid nudge will be measured by how many people choose the low-emission bus option.

3.3. Implementation of the Digital nudge

The third phase of the systemic digital nudging approach by Mirsch et al. (2018) is implementation. Following the careful definition of the goals, understanding the users and their environment, and the development of nudging ideas, this is the last step before testing.

In the implementation phase, Digital nudges are transferred to the corresponding decision-making environment or the user interface. For this research project, the Figma designs are directly used for user interface testing. These designs are imported to an A/B testing tool, which is the decision-making environment of all participants. Maze is used to conduct the A/B testing as it has a seamless functionality to import Figma links. Every nudge is set up as

Figure 20: *Precommitment nudge*

Figure 21: *Elicitation implementation intentions nudge*

one experiment in Maze. Wiggers (2022) describes Maze as a product research platform that facilitates tests and surveys. The tool enables digital marketers to observe how users interact with a product and generate reports. Maze can generate sharable links with instructions which are used to enroll participants to the testing process. It also includes a feature that enables researchers to capture video and screen recordings of people testing the products. In addition, Maze also offers mobile testing on desktop devices or tablets. This provides the experiment with the opportunity to test on all devices for a smartphone user interface.

The following overview shows the experiments created in Maze. The nudged decision is the part of the booking process with an intervention. The results will be analyzed whether a user chose the most sustainable option (1) or chose an alternative (0). The nudged versions will later be compared against the regular booking process.

In addition to the A/B testing, Maze is also used to obtain personal information of users to analyze the sample of the experiment. Experiment participants are asked for their:

- ***Age –*** *What is your age?*
- ***Gender –*** *What is your gender?*
- ***Country of Residence –*** *What is your country of residence?*
- ***Importance of Climate Change –*** *How important is the issue of climate change to you?*
- ***and E-Mail Address*** *(for the reminder nudge) – What is your e-mail address?*

To test the research design, a pretest was carried out with 20 participants. The pretest asked participants for qualitative feedback on the process and also used the screen recording function of Maze to identify barriers in the simulated booking processes. Minor adjustments to the experiment were made before the actual sample and data collection.

3.4. Sample & Data Collection

According to a publication by Allen (2017) true experimental designs are characterized by the random assignment of participants to experimental conditions. This provides researchers with the advantage that causal relationships can be clearly demonstrated. Creswell (2009) also specifies that if one of the groups receive a treatment and the other group does not, researchers can observe whether it is the treatment and not other factors that influence the outcome. Ideally, each individual in the general population has an equal probability of being selected for the experiment. On its Experimental Design Website, Yale (2022) mentions randomization in experiments as a common practice for researchers as it is

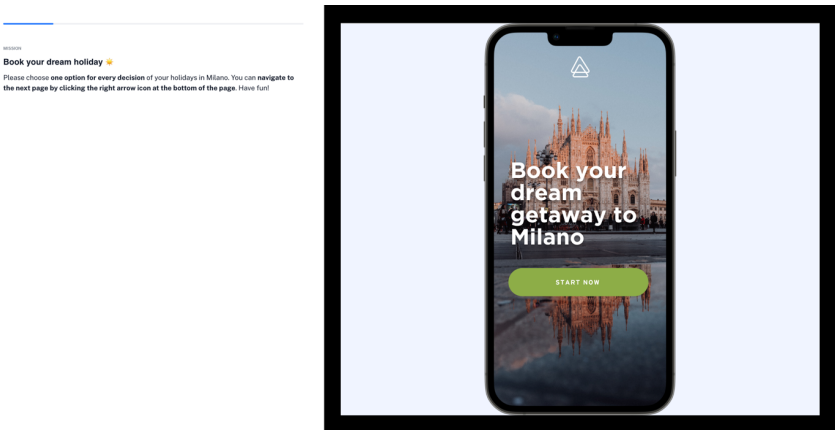

Figure 22: *The Maze experiment conducted on a desktop PC (Screenshot)*

Table 10: *Overview of Maze Experiments / Nudges*

Experiment / Nudge		*Nudged Decision*	*Nudged Item*
G1	Regular Booking Process	-	-
G2-1	Default nudge	Arrival	Bus
G2-2	Simplification nudge	Accommodation	Westin Palace
G2-3	Increase in ease and convenience nudge	Transport	Public Transport
G2-4	Social norm nudge	Meals	Vegan
G2-5	Disclosure nudge	Arrival	Bus
G2-6	Warning nudge	Arrival	Bus
G2-7	Precommitment nudge	Accommodation	Westin Palace
G2-8	Reminder nudge	Meals	Vegan
G2-9	Elicitation implementation intentions nudge	Arrival	Bus

the most reliable method of creating homogeneous treatment groups without involving any potential biases or judgments.

Overall, this research project tests 9 different nudges for effectiveness. 8 nudges are directly applied in the booking process. The reminder nudge is the only intervention that is applied afterwards on a different channel. Additionally, there is the regular booking process which is used to test the hypothesis. This means our experiment has 9 different Maze sharing links.

To randomize our sample test, participants will receive one link which evenly distributes the traffic to the 9 Maze experiments. This process is done automatically by using the online tool Linkly. In addition to splitting, the links can also be analyzed constantly while the experiment is running. This enables traffic monitoring on the link and the analysis of which sources are the most promising ones, which users are clicking the link, etc.

The nudged versions will receive 11% of the traffic and the regular booking process 12% of the volume. By virtue of this procedure, the sample is randomized and as traffic is split equally, it can be inferred that the number of participants is also evenly distributed. Upon completion of the experiment, the reminder nudge will be tested by e-mail. Users that have not chosen the most sustainable option in G1 will receive this specific intervention.

As part of an online experiment, Budiu and Moran (2021) from the renowned user interface and user experience consulting firm Nielsen Norman Group, defined 40 participants as an appropriate number for most quantitative studies. This sample size will typically lead to a trustworthy prediction for the behavior of your overall population if researchers try to measure binary metrics such as success rates or conversion rates. Experiments with 40 or more participants will produce results with a small margin of error and a high confidence level.

The goal of this research project is to attract 50 participants for every experiment. This should reduce the risks of the findings not representing the behavior of the user population. For the reminder nudge, users who did not choose the option with the least CO2 emissions, will take part in two experiments. A 300 EUR Amazon voucher was used to increase participation rates for the online experiment by incentivizing users to take part in the experiment.

4. Analysis

Overall, 456 participants completed the entire booking process of the nudging experiment. The test persons were recruited via social media networks with Instagram being the most important one (38%). The link to the experiment's random link rotator was shared along with social media creatives with personal contacts and travel influencers. The strategy

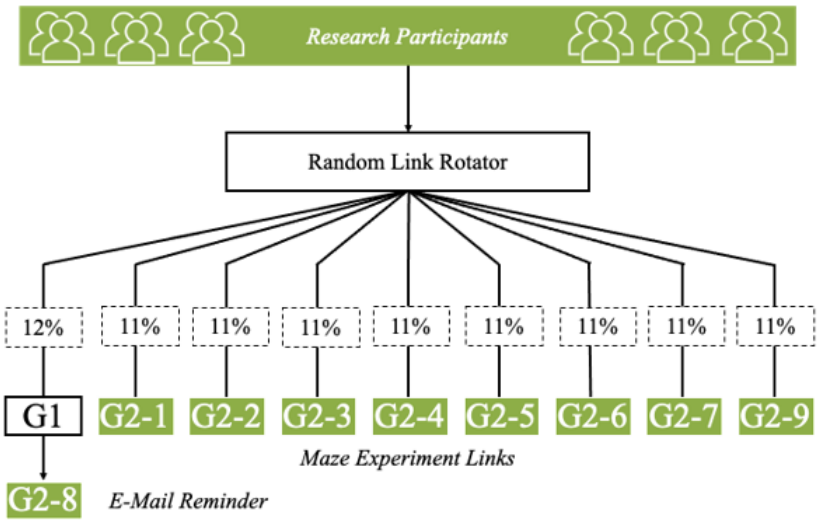

Figure 23: *Randomization in the experiment*

to activate diverse networks at the same time proved to be very successful. After major social media influencer accounts such as @manueldietrich or @evolumia posted the experiment, a major increase in experiment participants was observed. Furthermore, personal social media accounts were used to call attention to simulated booking process. The social media postings attracted 356 participants for the research project. To complete the sample, 100 more testers were acquired from the integrated panel function in Maze. The experiment started with the first testers on 29th July 2022 and ended on 11th August 2022. The dataset was exported from Maze and cleaned in Excel. The following analysis has been performed using SPSS.

The median age of experiment participants was 28 years with the sample reaching an average of 30.17 years. The sample consisted of participants identifying themselves as 226 female, 219 as male and 1 as non-binary. Looking at the countries of residence, the online booking process was completed by users from 29 nations, with the 5 main ones being:

- **Austria** – 175 participants ***(38.38%)***
- **Germany** – 124 participants ***(27.19%)***
- **United Kingdom** – 31 participants ***(6.80%)***
- **United States** – 30 participants ***(6.58%)***
- **Italy** – 30 participants ***(6.58%)***.

Participants were also asked to state how important the issue of climate change was for them on a scale from 1-10. 1 was defined as not important and 10 as very important. As demonstrated from the results, the sample was very aware of global climate challenges with 76% of surveyed participants rating the issue between 8 to 10.

Testers mainly used iOS devices (207) to perform the simulated booking process. Other operating systems which we identified in the sample by using Maze were Android (106), Windows (104), Mac OS (37), Chromium OS (1) and Linux (1).

4.1. Binary Logistic Regression

To analyze the effectiveness of Nudges, this research project uses Binary Logistic Regression. The goal for any regression model is to find the best fitting, simplest model to understand the relationship between the Ys and the Xs, and to be able to determine appropriate statistical conclusions from data (Fritz & Berger, 2015). According to the method consulting at the University of Zürich (2022) Binary Logistic Regression examines the relationship between the probability of a dependent binary variable taking the value of 1 and one or more independent variables. This means that it is not the value of the dependent variable that is predicted, but rather the probability that the dependent variable will have the value 1. To use this regression model, the dataset must fulfill the following prerequisites:

- The dependent variable is binary (0-1);
- The independent variables are coded scale or, in the case of categorical variables, as dummy variables;
- For each group formed by categorical predictors,
- The independent variables are not highly correlated with each other.

In short, the Binary Logistic Regression examines if the independent variables have an influence on the probability that the dependent variable takes the value 1 and how strong the influence of the dependent variable is. In our case, the effectiveness of a certain Nudge.

The independent variable of our data set is called 'sustainable item selected'. (1) stands for when the user has chosen the

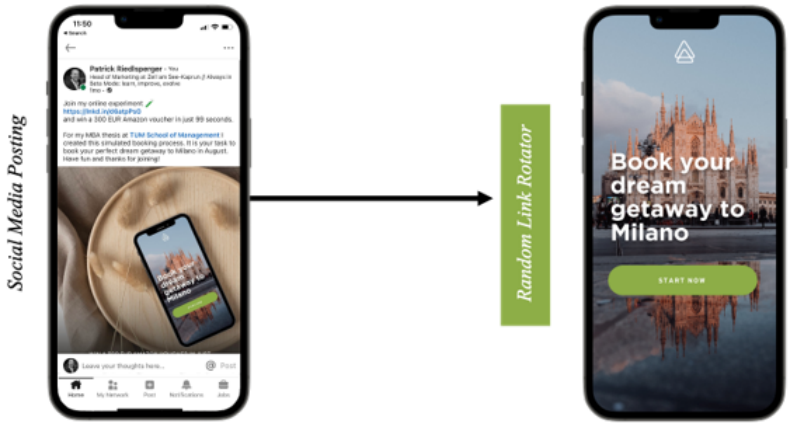

Figure 24: *Generic Social Media Posting on LinkedIn*

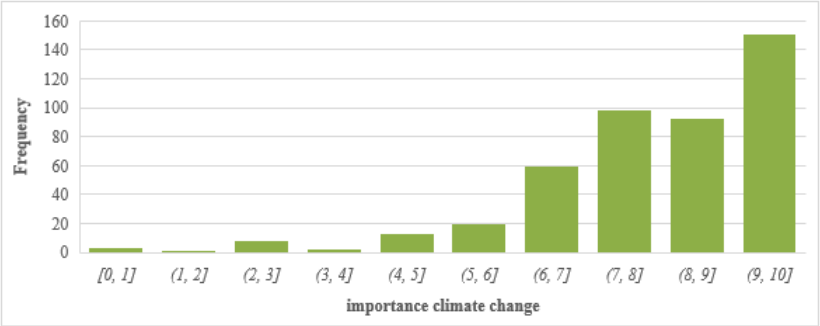

Figure 25: *Frequency of 'importance climate change'*

most sustainable option or positive result, and the (0) stands if the user opted for an alternative choice, or negative result. The dependent variables are different forms of nudging interventions. Therefore, they are categorical and coded as dummy variables for the analysis. For the dependent variables, the "No Nudge" category was set as a reference group. According to Alber (2021) a reference group is a group that we choose to be the reference so that all odds ratios will be a compared to. Therefore, nudging category intervention in the analysis will be compared against the simulated booking process, which did not include any of the interventions. This enables us to measure the effectiveness of Nudges.

The logistic regression analysis is based on Maximum Likelihood Estimation. Similar to a linear regression, an attempt is made to find a function curve that fits the data best. However, in contrast to linear regression analysis, this function is not a straight line but a logistic function. It is "S-shaped", symmetrical and runs asymptotically towards y = 0 and y = 1 – namely positive or negative results of the sample. The model is based on the following formula. $P(y = 1)$ defines the probability that y = 1, e the base of the natural logarithm and z the Logit, which represents a linear regression model of the independent variables (University of Zürich, 2022).

$$P(y = 1) = \frac{1}{1 + e^{-z}}$$

A logistic regression function is not linear and therefore more complex than a linear regression. However, what still applies is if the sign of a regression coefficient is positive, an increase in the relevant independent variable causes an increase in the probability that y = 1. If the sign is negative, this means a decrease in the probability. The connection between an independent variable and the dependent variable can also be interpreted using so-called "odds" in a logistic regression. To calculate the odds, the probability that the event will occur is placed in relation to the non-occurrence of the event. The **Exp(B)** or odds ratios of an independent variable give the change in the relative probability of y = 1. If Exp(B) is one, this results in a multiplication of the relative probability by 1 and thus no change. If the odds ratio > 1, this means an increase in the odds, while an odds ratio < 1 means a decrease in odds (University of Zürich, 2022).

From Exp(B), a relationship can derived, which is very useful for the interpretation of our result:

$$Odds_{after} = Exp(B)\ x\ Odds_{before}$$

$Odds_{before}$ represents the sample of the simulated booking process without choice interventions – our reference group.

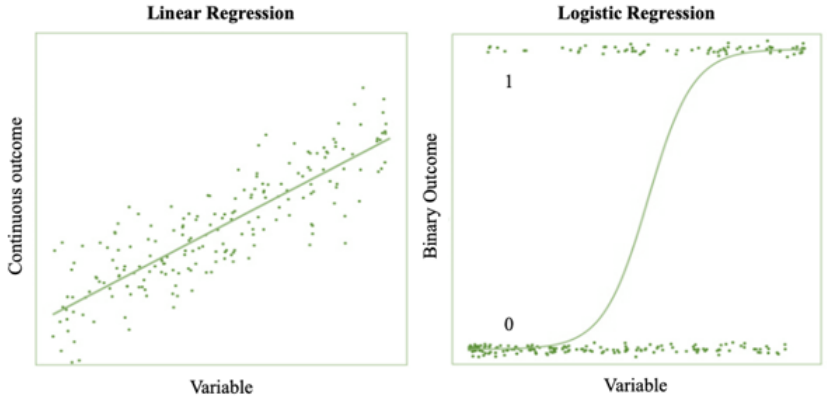

Figure 26: *Linear vs. Logistic regression – Adapted from* Kubben et al. (2019)

Table 11: *Interpretation for regression coefficients and odds ratios. Adapted from University of Zürich (2022)*

B	Exp(B)		P(y=1)
Regression coefficient	Odds ration		
$B > 0$	> 1	increases by the factor Exp (B)	Ascend
$B = 0$	$= 1$	remains the same	Steady
$B > 0$	> 1	decreases by the factor	Decline

$Odds_{after}$ represents the regression coefficient (B) after a nudging intervention has been applied. The higher Exp(B) is the more efficient the form of Nudge. If Exp(B) is > 1, the hypothesis of this research project is confirmed.

The level of statistical significance or probability value is a number describing how likely it is that research data occurred by random chance. A value of ≤ 0.05 is typically defined as statistically significant (McLeod, 2019). For this research project, the significance threshold is also defined in this 0.05 significance threshold. If a value of > 0.05 is obtained for an experiment/nudging test, the result of the Binary Logistic regression is defined as not significant. If the significance value is ≤ 0.05 and the regression coefficient B is > 0, our alternative hypothesis can be confirmed. Based on the significance level, there is a 95% chance that the relationship between the dependent and independent variable is not coincidental.

5. Results

For comparing the different Nudges objectively, the same decision environments have to be evaluated before and after the application of the intervention. Therefore, the 4 different booking questions in the realm of transport, accommodation and restaurants are analyzed individually to gain insights on the effectiveness of nudging people towards the most sustainable travel options. The results are presented in cross-tabs and the described Binary Logistic Regression.

5.1. Arrival

Analyzing the first decision on arrival/mode of transport, the crosstabulation shows that the nudged versions of the simulated booking process had an increased number of decisions towards the most sustainable option (1). The binary logistic regression provided evidence for the effectiveness of nudges as all regression coefficients **(B)** had positive values. When comparing the nudges against each other, it has to be taken into consideration that the G2-6 and the G2-9 experiment uses the disclosure nudge, and the indicated warning and elicitation implementation intentions nudge. The disclosure nudge had an Exp(B) value of 2.068. However, the values for the binary logical regression were not statistically significant. Therefore, no relationship can be inferred based on the regression model.

When the warning or elicitation implementation intentions nudge was placed before the disclosure nudge in experiments (G2-6, G2-9), the Exp(B) values increased. The highest odds for users choosing the most sustainable option were calculated for the G2-6 experiment – the warning nudge. The default nudge G2-1 also increased the odds of choosing the option which emits the least greenhouse gases by a factor auf 2.825. Beyond the experiment G2-5, all results were statistically significant. The first decision of the simulated booking process provided evidence that confirmed our hypothesis. There is evidence that 3 of the 4 Digital nudges lead users towards more sustainable choices.

5.2. Accommodation

For the accommodation decision in the simulated booking process, two Nudges were tested for effectiveness. These were the simplification nudge (G2-2), which used the green hotel label, and the precommitment nudge (G2-7), which used the same label and where participants were additionally asked if protecting the environment was important to

Table 12: *Sustainable Item Selected * Arrival Nudge Crosstabulation*

		Sustainable Item Selected		
	Nudge	***0***	***1***	***Total***
G1	Regular Booking Process	44	6	50
G2-1	Default nudge	35	15	50
G2-5	Disclosure nudge	39	11	50
G2-6	Warning nudge	35	15	50
G2-9	Elicitation implementation intentions nudge	32	18	50

Table 13: *Results Arrival - Binary Logistic Regression*

	B	***S.E.***	***Wald***	***df***	***Sig.***	***Exp(B)***
G1			8.154	4	0.086	
G2-1	1.048	0.537	3.805	1	0.051	**2.852**
G2-5	0.727	0.553	1.726	1	0.189	**2.068**
G2-6	1.417	0.526	7.270	1	0.007	**4.125**
G2-9	1.145	0.534	4.607	1	0.032	**3.143**
Constant	-1.992	0.435	20.960	1	0.000	0.136

them before starting the booking process. The two options were compared against how many users chose the same hotel without intervention.

Out of the 50 respondents for G2-7, 44 testers selected that protecting the environment is important to them. 28 of the testers took the most sustainable accommodation option in the booking process afterwards. Comparatively in the regular booking process, only 17 users chose the same hotel offer and only 20 users selected that option in the version with the simplification intervention.

For our G2-2 experiment – the simplification nudge - the binary logistic regression calculated only a slight increase of odds Exp(B) of 1.078. These results were not statistically significant. However, when users pre-committed to protect our environment and were offered the sustainable option afterward, Exp(B) increased to 2.471 with statistically significant results.

5.3. Transport

Analyzing the decision on users choosing either public transport or an alternative option, there were only minor differences between the nudged version and the regular booking process.

The majority of users (69%) chose to use public transport during their stay in Milano. For the regular booking process (G1), 34 people chose the sustainable option. The G2-3 experiment, where the size of the interaction element was increased, had 35 users choosing public transport.

Running binary logistic regression, the relationship between the dependent variable, sustainable item selected, and the independent nudge was not statistically significant. Therefore, no relationship was proven between the Digital nudge and the selection of the most sustainable item. despite many users choosing the climate-friendly public transport option in the experiment G1 and G2-3. This could be related to the convenience of the actual service as public transport is inexpensive, fast and punctual in many European metropolitan areas.

5.4. Meals

The final analysis of the nudging experiments relates to the selection of meals. Hereby, the experiment measured how many users opted for the most sustainable, vegan meal option.

In the regular booking process, only 3 users opted for the vegan option. When the reminder nudge was used in the experiment G2-8, 7 research participants switched their diet option, which resulted in a total of 10 people selecting the vegan choice. The social norm nudge - which indicated that 64% of other guests chose to eat vegan dishes during their stay - led 11 users to make the same decision and reduce the overall greenhouse gas emission of their stay.

For both options, regression coefficients **(B)** were positive and results were statistically significant. The higher Exp(B) was calculated in the regression for the G2-4 experiment – the social norm nudge. Compared to the regular booking process, odds increased by 4.419. The reminder nudge also led a notable increase in odds Exp(B) of 3.917, based on the effects of the intervention.

Comparing the regular simulated booking process to the nudged versions, this study observed the intervention led more users to choose the most sustainable items (1). Overall, the digital nudges in the observed experiments G2-1 to G2-9 had a positive regression coefficient (B) and thereby odds ratio Exp(B) > 0. Of the 9 experiments which used digital nudging interventions, 6 produced statistically significant results. Their odds ratios were between 2.471 and 4.419. Based on this observation, the alternative hypothesis (H1) can be confirmed.

> ✓ *Digital nudges lead to the booking of the most sustainable travel offer*

Table 14: *Sustainable Item Selected * Accommodation Nudge Crosstabulation*

		Sustainable Item Selected		
	Nudge	***0***	***1***	***Total***
G1	Regular Booking Process	33	17	50
G2-2	Simplification Nudge	36	20	56
G2-7	Precommitment Nudge	22	28	50

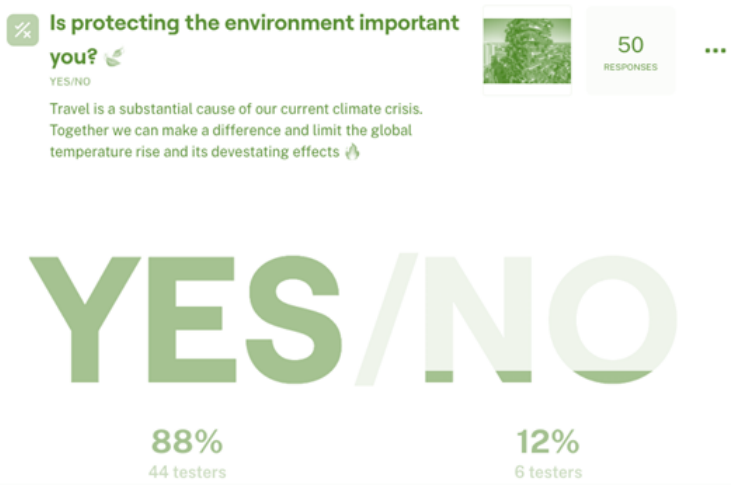

Figure 27: *Precommitment Nudge Results (Screenshot)*

Table 15: *Results Accommodation - Binary Logistic Regression*

		B	***S.E.***	***Wald***	***df***	***Sig.***	***Exp(B)***
	G1			6.120	2	0.047	
	G2-2	0.076	0.409	0.034	1	0.853	**1.078**
	G2-7	0.904	0.413	4.804	1	0.028	**2.471**
	Constant	-0.663	0.299	4.936	1	0.026	0.515

Table 16: *Sustainable Item Selected * Transport Nudge Crosstabulation*

		Sustainable Item Selected		
	Nudge	***0***	***1***	***Total***
G1	Regular Booking Process	16	34	50
G2-3	Increase in ease and convenience nudge	15	35	50

Table 17: *Results Transport - Binary Logistic Regression*

		B	***S.E.***	***Wald***	***df***	***Sig.***	***Exp(B)***
	G2-3	0.094	0.433	0.047	1	0.829	**1.098**
	Constant	-0.663	0.299	4.936	1	0.026	0.515

Table 18: *Sustainable Item Selected * Meals nudge Crosstabulation*

		Sustainable Item Selected		
	Nudge	***0***	***1***	***Total***
G1	Regular Booking Process	47	3	50
G2-4	Social Norm Nudge	39	11	50
G2-8	Reminder Nudge	40	10	50

Table 19: *Results Meals - Binary Logistic Regression*

	B	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
G1			4.973	2	0.083	
G2-4	1.486	0.686	4.686	1	0.030	4.419
G2-8	1.365	0.693	3.886	1	0.049	3.917
Constant	-2.752	0.595	21.350	1	0.000	0.064

The most effective Digital nudge was observed at the G2-4 experiment (4.419) followed by the G2-6 experiment (4.125). Choice architects can increase the odds of users choosing the most sustainable option by more than 4 times. Furthermore, the experiment G2-8 provided evidence that nudging users by reminding them to take a more sustainable choice, nearly quadruples (3.917) the amount of people opting for the decision which emits the least greenhouse gases. Additionally, the elicitation implementation intentions nudge (G2-9) is an effective way to reduce emissions for travel bookings. It provides user interface designers with the ability to more than triple (3.142) the selection of an indicated sustainable product category. The default nudge (G2-1) also nearly tripled (2.852) the chances of users to select the most sustainable arrival option in the experiment. The precommitment nudge was the statistically valid result, with the merest degree of effectiveness – though it increased odds by 2.471.

6. Conclusion

Individual consumption decisions we make every day have caused our current climate crisis. Too often, we operate on System 1, which leads us to short-sighted and self-centered decisions made at the expense of our climate and planet. This includes our decision-making when we are booking a holiday on digital channels. This thesis has been able to demonstrate that nudges can help us overcome this issue. As Sunstein and Thaler (2021) indicated, the experiments proved that in a travel context, environmentally-friendly nudges can help reduce air pollution and the emission of greenhouse gases. This doesn't mean that they can totally resolve the challenge of global warming and travel-related emissions. Nudges are not the solution, but they can be one of the many small steps we take to reach a net zero emission economy by 2050. Beyond technological innovation, fiscal and regulatory measures, nudges are a simple, cost-effective way to reduce the level of greenhouse gas emissions in the travel industry.

Research participants were very aware of the issue of climate change with 76% rating it in an 8-10 range. However, when analyzing those participants in detail, the study observed only 38% of them chose the most sustainable option in the booking process. The experiments found the same phenomenon that Hornsey et al. (2016), Jacobsen (2011) and Mazar et al. (2020) discovered in their research projects. Our society is not lacking environmentally-friendly attitudes or intentions. It is lacking in transforming those into actions and results. Nudges can help us achieving that. This research did not calculate the overall greenhouse gas emissions which would be saved by implementing our green digital nudges. Although this would be an interesting future experiment, the increase in odds or Exp(B) ratios provides evidence that overall emissions can be drastically lowered by choice interventions. People still want to and should travel in the future. It can increase health, enhance creativity, and exposes us to new cultures and environments. The overall greenhouse emission can be lowered by green nudges along the customer journey.

Regarding the effectiveness of the different nudging interventions, this research confirms the literature by Kosters and van der Heijden (2015) and Sunstein and Thaler (2021) that the virtue of nudges is context-specific. While Hummel and Maedche (2019) tried to generalize results for different nudging research projects, this thesis did not confirm their findings on the effectiveness of nudges. For a travel-specific context, default nudges were not the most efficient form of choice intervention. While the nudge ten folded the purchases of a green energy plan according to Ebeling and Berger (2015), this travel-specific experiment led to a near tripling of sales of the sustainable product (2.852). Based on the results of this thesis, choice architects should use social norm nudges if they aim to only implement one specific intervention. However, hybrid nudges which use two or more interventions have also proven to be successful in the experiments G2-6 to G2-8. They remind users to act sustainably, and received statistically significant results contrary to the implementation of the interventions as a singular digital nudge in the G2-2 and G2-5 experiment.

Discussing the limitations of this research, the simulation of the booking process could have led to the Hawthorne Effect. This effect may have reduced the validity of the results. According to Koch (2011) the effect describes the phenomenon of test subjects changing their output on a test in response to being observed, as some Hawthorne employees did when they knew they were part of the study. Researchers today use randomized control groups in experiments to weed out this bias in studies. Although this control group has been created in the experiment with the regular booking process, the nudged versions could have generated more users to choose the socially desirable behavior i.e., the selection of the most sustainable option. Especially when warning users, or after a precommitment to take climate action, or the elicitation of implementation intentions, some users could have made biased decisions in the booking process. Furthermore, it is unclear for all experiments including the regular booking process if users would have behaved in the exact same way

Table 20: *Experiment Overview - Effectiveness of Digital nudges*

Experiment / Nudge		*Exp(B)*	*Significant*
G1	Regular Booking Process	-	-
G2-4	Social norm nudge	**4.419**	✓
G2-6	Warning nudge	**4.125**	✓
G2-8	Reminder nudge	**3.917**	✓
G2-9	Elicitation implementation intentions nudge	**3.143**	✓
G2-1	Default nudge	**2.852**	✓
G2-7	Precommitment nudge	**2.471**	✓
G2-5	Disclosure nudge	**2.068**	
G2-3	Increase in ease and convenience nudge	**1.098**	
G2-2	Simplification nudge	**1.078**	

in an uncontrolled field experiment.

Future research on the topic could include the application of the designed digital nudges into an actual e-commerce environment to measure their effectiveness on the booking of more sustainable products. In these experiments, researchers could gain larger samples and include other influencing factors such as prices in future studies. As the process of this research project has been a well-designed, but simulated environment, there is uncertainty around whether testers would have behaved the same way if an actual payment follows after the completion of the booking process. It would also be interesting to observe if people are willing to pay higher prices for more sustainable products, if they are nudged for the suitable options. Paying higher prices can also include the offsetting of carbon emissions for services, where fossil fuels are still used. As discussed, one important factor beyond the digital application of nudges is the convenience of the physical travel services and products.

Nudges can guide people in their decision making, but they won't let people choose options for decisions against which people have an aversion based on their prior experience. Therefore, sustainable transfer options have to be convenient and punctual, green hotels have to provide the same excellent services as their competitors, and vegan food has to be tasty. This research project has proven that decarbonizing travel decisions by using nudges is an effective strategy and one of the many steps we can perform to fight our current, global climate crisis. Nudges enable us to enhance the decision-making of every traveler to a more sustainable outcome. The thesis should encourage accommodation and mobility providers, online travel agents, tour operators and other participants across the value chain of travel to implement those nudges in their digital booking solutions. When it comes to the conservation of greenhouse gases, every individual decision counts and adds up to reduce global warming. Choice interventions in a digital travel booking process can make it more than 4 times likely that users take the most sustainable option. Let's nudge together for a better, more sustainable future.

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