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Motivating for behavioral change through smart nudging

Evaluating digital representations of psychological effects

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“There are only two industries that call their customers ‘users’:
illegal drugs and software”
–Edward Tufte

“The bad news is time flies;
The good news is you’re the pilot.”
–Michael Altshuler

Abstract

This thesis aims to study psychological effects and how to represent them digitally within a smart nudging system. A smart nudging system creates personalized digital nudges that are highly relevant to the user's context. How the system presents the nudges and what psychological effects are used is critical to influencing the user towards the nudging goal. The goal of the thesis is to find, implement and evaluate what effects can be used with a smart nudging system and if some of the effects are better suited for digital nudging. A design for applying effects towards a goal of being more physical active is provided, and a subset of the effects are implemented from this design. An evaluation of the implementation and the experiences showed that most of the effects are helpful for a smart nudging system. However, some of the effects are both difficult to solve and less useful. Difficulty refers to how hard it is to create and use the effect in a nudge, and usefulness refers to how well it can be combined with other effects and if it can be used individually as part of a nudge.

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Introduction

Nudging was first introduced by Thaler & Sunstein [1] as a concept from economic and behavioural science that uses positive reinforcements, suggestions and other non-forcible actions to influence peoples decisions. They defined nudging as:

> *...any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives[1].*

A choice architecture is what they refer to as: "...the context in which people make decisions" and is organized by a choice architect. Many people turn out to be choice architects without being aware of it, parents describing the education choices to their children, people creating forms for their employees, and people creating voting ballots for elections. Knowing this in combination with their statement saying: "...there is no such thing as a "neutral" design."[1], is a strong argument for increasing the knowledge of the implications of being a choice architect.

Going into detail about nudges, an important restriction is made clear from this description of nudges:

> *To count as a mere nudge, the intervention must be easy and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not [2]*

In order to be within the ethical boundaries of the people being nudged this restriction must be withheld. Thaler & Sunstein suggested nudges for influencing decisions that was beneficial for society but also in the interests of the person himself. Nudging for physical activity and environmental choices is examples of such decisions. The nudges should make individuals more informed and can motivate them for these choices, but in line with the nudging definition they must be easy and cheap to avoid.

As people transitions into making more and more decisions in digital environments, it is only natural that nudging finds its way to a digital context. Digital nudging is described as:

> *...the use of user-interface design elements to guide people's behavior in digital choice environments[3]*

Even small modifications to the choice environment can have an impact and nudge people in a particular way [4]. Smart nudging is a form of digital nudging that focus on tailoring the nudges to be relevant to the current situation of the user[5, 6].

1.1 Problem definition

The importance of being able to alter the choice environment in a way that nudges people towards the indented action is crucial for a smart nudging system. The statement that "*...there is no neutral way to present choices[3].*" emphasizes that the knowledge of how to present choices must be established in order to succeed, and to not cause unwanted outcomes.

Using psychological effects for designing choice environments to nudge people towards certain behaviours was presented with the introduction to the term nudging by Thaler & Sunstein [1]. But using the same effects in a digital environment might not be a possible or obvious task. So establishing what effects that are useful and exactly how they can be applied is vital to a smart nudging system.

Once the effects that is suitable for a digital context is found, they need to be customized towards the purpose or goal they aim to achieve. Seeing how it might look in an actual digital nudge can be hard just from an explanation of the effect, so providing implementations of the effects will be valuable.

1.2 Goal

The main goal of this thesis is to study psychological effects and how to represent them digitally within a smart nudging system. The research questions answered in this theses are:

- How psychological effects for behavioral change can be represented digitally and used in smart nudges?

This research question leads to two sub questions which will be answered as well:

- How can all of the effects we find be used in a digital smart nudging system?

- Can some of the effects be better suited for digital nudging, and if so, how?

The term "Better suited" is based on two factors; difficulty and usefulness. Difficulty refers to how complex it is to create a nudge with a specific effect, and usefulness refers to how well an effect can be combined with other effects and how well it can be used individually as part of a nudge.

Taking the psychological effects from theory to implementation is a non-trivial task and can present challenges that we need to solve. Finding the appropriate digital components and combining them to target a specific psychological effect in the human brain is something that needs to be look at. The thesis will establish a foundation for application designers to understand how their design can affect the users, either deliberately or accidentally.

1.3 Method

There is two main categories of research methods called *Quantitative research method* and *Qualitative research method*. The Quantitative method is concerned with experiments and testing which wants to evaluate theories, hypothesis or functionalities through measuring of variables[7]. The method requires large datasets and through evaluation of data from this dataset the hypothesis is tested.

The *qualitative method* is a more descriptive approach and involves collecting, analyzing and understanding non-numerical data [8]. This is used to reach theories, tentative hypothesis or develop computer systems. In this thesis the

qualitative method is used because the evaluation is not based on measuring of numerical data, but rather through interpretation of former research and textual data.

This thesis uses the *applied research* method which is about answering questions or solving known practical problems. This thesis looks at solving a practical problem in finding and implementing the psychological effects that can be used in smart nudging. Research done in the applied research method often builds on existing research and applies it to develop practical applications or inventions. This is true for this thesis as well as the thesis builds upon existing research from Dalecke & Karlsen [9].

This thesis aims to study psychological effects and how they can be applied in a smart nudging system. A thorough explanation is given first on their general usage followed by a digital nudging specific explanation. Further the thesis provides implementations of a subset of these effects and provide a conclusion based on the experience gained from working with the effects in a digital nudging system.

1.4 Contribution

The thesis makes the following contributions:

- Establishes a set of psychological effects that are applicable to digital nudging and describes in detail how they can be used to create digital nudges.

- Evaluates the usefulness and difficulty of the effects based on practical experience working with the effects.

- Implementations of a subset of the psychological effects to show how they can be used and prove that they are possible to use in digital nudging. Discusses how they can be altered while still staying within the boundaries of the effect.

1.5 Context

The context of this thesis is the Open Distributed System[1] (ODS) group at the Arctic University of Tromsø (UiT). The group focuses on supporting, among others, next-generation applications, information exchange, data analysis, and real-time collaboration. This thesis is a part of a more comprehensive Nudge project focusing on smart nudging towards green transportation and physical activity.

1.6 Outline

The rest of the thesis is structured as follows:

Chapter 2 - Technical background Presents theoretical information about nudging and smart nudging in general, in addition to the psychological effects and their workings in the human brain system.

Chapter 3 - Method Describes the research methods used in this thesis.

Chapter 4 - Design Presents the psychological effects and how they will be applied to nudging, along with proposed strategies for giving nudges.

Chapter 5 - Implementation Presents implementations of a subset of the psychological effects, showing how nudges will be seen by the end user.

Chapter 6 - Discussion Discusses the positive and negative findings from the thesis and evaluates what have been done.

Chapter 7 - Conclusion Concludes the thesis and presents future work.

1. https://site.uit.no/ods/

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Technical Background

This chapter will provide a theoretical explanation of the concepts and theories relevant for understanding the psychological effects used in nudging and using them in a smart nudging system. Section 2.1 provides a general overview of what nudging is and wants to achieve. Section 2.1.2 continues to explain what goes into digital nudging, before Section 2.1.3 outlines the key features of a smart nudging system. Further, Section 2.2 and Section 2.3 explain ethics and privacy in nudging which is central terms in nudging. Section 2.4 explains how the human brain systems makes decisions and the psychological effects that are proved to influence how people make decisions. Lastly, in Section 2.5 we look at related work.

2.1 Nudging

Nudging is about influencing people's behavior and decisions without limiting their options. The term nudge was first used in a book by Thaler & Sunstein[1], where they define it as "... *any aspect of the choice architecture that alters peoples behavior predictably without forbidding any options or significantly changing their economic incentives.*" The authors place nudging under Libertarian paternalism, which is a liberty-preserving form of paternalism. According to *The Stanford Encyclopedia of Philosophy*[10], paternalism is defined as " ... *the interference of a state or an individual with another person, against their will, and defended or motivated by a claim that the person interfered with will be better off or protected*

from harm." When talking about Libertarian paternalism, more often than not nudges are brought up, and *The Stanford Encyclopedia of Philosophy*[10] describe nudges in the form of Libertarian paternalism as:

> " ... nudges simply change the presentation of the choices in such a way that people were more likely to choose options that are best for them."

This is all rooted in peoples tendency to make bad decisions, which they would not have made "*if they had paid full attention, and possessed complete information, unlimited cognitive abilities, and complete self control.*"[1] The choices we make are often based on the presentation of the choices available because humans are not entirely rational when making decisions. We tend to rely on some simplified heuristics and biases, which can lead to bad decisions.

2.1.1 Choice Architecture

Choice architecture is the environmental architecture that influences the choices people make. As Thaler & Sunstein said in [1] "*A choice architect designs the environment in which people make decisions.*" This change in choice architecture which Thaler & Sunstein call a nudge, steers people to a specific behavior. This means that the information in the environment is structured and presented in a specific manner to try to change behaviors predictably. When the change is intended, it is a nudge, not if it is unintended. An example is going inside a building and quickly seeing the stairs, placing the elevator out of sight. This intended change of environment nudges the use of stairs instead of the elevator. When moving into the digital environment, such architectural changes is not as costly as our example, making them more adaptable to changing the presentation of information.

2.1.2 Digital Nudging

With the emergence of digital environments and the growing possibilities of making choices in digital environments, there has been made way for a new form of nudging called digital nudging. As said by Weinmann et al. [3], "*Digital nudges is the use of user-interface design elements to guide people's behavior in digital choice environments.*" They enlighten the importance for designers of digital choice environments to be aware of their design effects on people's choices. Digital nudges follow the same core concepts as nudges but are employed in a digital context. The availability of user data in digital environments empowers a nudge by incorporating personalization[6]. This addition can increase the nudge effectiveness further than a traditional nudge

was able to. Considering this, it is essential that, as Weinmann et al. [4] states, the designers understand the effects they are in control of so that they can nudge users deliberately or maintain the free will of the user.

The way digital nudging works is by changing what is presented or how it is presented, counting for the content and the visualization of a digital nudge[11].

2.1.3 Smart nudging

Smart nudging is a new branch of digital nudging. Karlsen & Andersen[6] define it as "*digital nudging, where the guidance of user behavior is tailored to be relevant to the current situation of each individual user.*" The focus of a smart nudge is to use information about users and the context surrounding the decision to increase the likelihood of the user following the nudge. The user will consent to be nudged, knowing that the nudging goal will be in the user's best interest. The smart nudging system will use various sources of information such as weather, traffic, bus times, appointments in the user's calendar, the user profile, and many more. After the nudge is presented, the system will evaluate the success of the nudge and use the knowledge when choosing the subsequent nudges.

2.2 Ethics

Ethics is an important topic in digital smart nudges since nudges can be powerful tools to change people's behavior and thinking. The arguments of the ethical discussion around nudges will in this section be split into three parts, 2.2.1 Structure, 2.2.2 Transparency and 2.2.3 Persuasion and Coercion. It will be presented arguments from both sides to clearly give a view of the different meanings on the specific topics.

2.2.1 Structure

The ethics of nudging is closely related to the principle of libertarian paternalism mentioned earlier in this chapter. An essential feature of libertarian paternalism is to preserve the freedom of choice, and it is clear that removing choices is not allowed. This is where choice architecture comes in, and it concerns itself with altering the structure and order of choices. In the context of nudging through choice architecture, Thaler & Sunstein argue that there is no "neutral" design, and it is then better to purposely design towards some greater

good than to leave it to chance[1]. Presented information can not be without some form of structure to it, and this is what Thaler and Sunstein use to argue for deliberate choice architecture design.

Bovens argue in [12] that when under the influence of nudges, we act as "fragmented" self's, making other decisions than when not nudged. The main issue with this, according to Bovens, is the development of moral character. He argues that if individuals do not learn to make good decisions in any context, they will rely on nudges and nudgers to guide them away from bad decisions.

2.2.2 Transparency

A common accusation of nudges is that they are manipulative by changing people's behavior without their knowledge and are in that sense considered unethical [13]. Because of this, a nudging system wants to incorporates transparency. Transparency is the act of being open and informative about the motives of something. In nudging, it is concerned with informing about its effects, how they affect people, and how the choice architectures are altered. Sunstein [14] mentions transparency as a safeguard against the argument that nudging is unethical. There are studies on how transparency impacts the effectiveness of the nudges, and the result shows that they can be both transparent and effective[15]. Although this study[15] mainly focuses its experiments on nudging with defaults and status quo, it seems that the majority sees transparency as the correct way to ensure the ethical aspects are as transparent as possible.

The way Dalecke & Karlsen [9] has proposed this is with an application that clearly states that it will use psychological effects to nudge the user. By being transparent in describing how the applications work, users consent to be nudged when installing the application.

2.2.3 Persuasion and coercion

An essential part of the ethics discussion behind nudging is how nudges differ from persuasiveness and even coercion. Coercion is the most extreme of the two, and it is the act of forcing or threatening a person to act in any way wanted. However, nudging is sometimes thought to be related to persuasion, which is more loosely defined. Nudges is, from the beginning, concerned with preserving the liberty of the person it nudges, and persuasion does not explicitly say what is allowed or not. Nudging would not present something as better than it is to make a user choose that particular thing. On the other hand,

persuasion would not be concerned with this as long as the user chose the suggestion. The means of getting the user to do so is not explicitly regulated. There are essential differences between the two which is vital in order to be classified as nudging and not persuasion[1].

2.3 Privacy

Smart nudging is highly reliant on data from the user it intends to nudge, which can come from a user profile[9], but handling the user data brings many privacy issues which are essential to address. The data is vital to increase the likelihood of success through dynamic, personalized nudges, so the user will have to give up some private information about themselves to gain the full benefit of smart nudging. The users' privacy is protected by the *General Data Protection Regulation* (GDPR), which services have to follow. Considering the nudging goal is to help people achieve what is best for them, it would be a direct contradiction if the system were to violate the GDPR and privacy of its users.

2.4 Psychology

To understand how nudges influence people, it is important to know how it affects people and what mechanisms in our psychology are being targeted. This section will go through the processes that play a role in our decision-making, and why it is flawed. It is divided into four sections, Section 2.4.1 describing systems in our brains, Section 2.4.2 and, Section 2.4.3 describing the heuristics the brain systems uses and the biases it can lead to, before Section 2.4.4 presents other psychological effects. They will introduce the workings of the effects that will be used later in the thesis, explaining how and why they work.

2.4.1 The brain systems

There are mainly two systems at play when humans make decisions, and these are not actual systems separated in our brain but instead processes that we go through to make a decision. These are called the automatic system and the reflective system, or just system one and system two for easy recollection [1, 16]. These systems are also referred to as the fast and the slow system, the automatic system being the fast one and the reflective system the slow one. The amount of decisions people have to make in this busy and complex

world makes it so that it cannot be afforded to think thoroughly about every decision made. This has led us to support the decisions on heuristics and biases. Our automatic system, which is the first system that we use, relies on their support to make fast decisions, but they are a big part of why people make bad decisions.

Secondly is the reflective system accounting for peoples conscious thought. This system breaks down the decisions and sets the outcomes up against each other to make the best possible decision with the current knowledge. Because people make most of the decisions with the automatic system, and it also being most acceptable to errors, this is a system that nudges will target.

Looking at metacognitive influences explained by Holyoak & Morrison[17], our decisions can even be changed by our metacognitive experience when processing information. This means that the difficulty people have when processing information can influence the decision they make. An example of this, as given by Holyoak & Morrison[17], is that stocks with more pronounceable names and ticker logos are traded more heavily than stocks with less pronounceable names and logos on their first day of trading.

2.4.2 Heuristic thinking

Heuristics is a mechanism that people use to make it easier for their automatic system to make decisions fast and efficiently and can be thought of as a mental shortcut. They reduce the complexity of tasks which in most cases is useful for us, but it can also lead to critical systemic errors. A common example of a heuristic is the determination of distance to an object. People tend to rely on the clarity of an object to determine how far away it is. The clearer an object appears, the closer we think it is, which is generally correct, but using this rule to determine distances can lead to errors. In foggy weather, when vision is blurred, people tend to overestimate the distance towards an object, and the other way around, underestimating the distance when vision is clear. This becomes what is called a bias. Heuristics are also used in our intuition, meaning that biases will occur also when making cognitive judgments. [18]

Anchoring

The anchoring effect is a heuristic that makes people estimate values based on some initial value and adjust from that value. This known initial value is the anchor and can be influenced by subtly suggesting this starting point in the same context. It is known as "*anchor and adjustment*" and is best exemplified in a salary negotiation where high initial demands, the anchor, will typically

lead to a higher agreed-upon values.

Availability

The availability heuristic suggests that people tend to predict the likelihood of an event based on how quickly it comes to mind. This is essentially making events that have occurred closest to a person or most recently to appear more likely because they come to mind faster. The availability heuristic can lead to known biases, which we will look at in the next section.

Representativeness

Representativeness is a heuristic that makes people classify things based on how well they feel it represents something, how well does A fit into their image of stereotype B. A much-used example of this is a description of a person like this "*Steve is very shy and withdrawn, invariably helpful, but with little interest in people, or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail.*" [19] Is this person more likely to be a librarian or a salesman? We assess the likelihood of him having any of the occupations through how representative he is to the stereotype of an occupation. However, this method of determining probability can cause errors because the judgment is based on limited information.

2.4.3 Biases

Biases result from the heuristics we use to ease the many situations we go through every day and are a deviation from what would have been called rational. Some argue that humans possess unlimited cognitive abilities and always act rationally and make unbiased decisions, meaning that they can be wrong from time to time but never systematically wrong. This is mentioned by Thaler & Sunstein[1] and called *Homo Economicus* or just Econ for short. However, experience shows that humans do indeed make bad choices and systematically so, examples being the increasing problem of obesity, smokers, and drinkers, to mention some. These examples is used as arguments to promote nudges. Peoples systematic biases causing them to make bad choices which nudges can help prevent in many cases. People possess numerous biases, but some are more general and are likely to be biases most of us have.

Loss aversion

Studies have shown that people are loss averse, meaning that losing something makes people sadder than gaining that same thing makes them happy[20]. This means that changes for the worse have greater significance than changes that improve. Loss aversion behaves as a mental nudge to not make changes, even though they might be in our favor [1].

Status quo bias

Status quo bias is the tendency for people to prefer to stick with the same decision or choice as before[21], e.g., people often choose the same thing on food menus because they know it is good. When presented with a default choice, the status quo also comes in, resulting in many people staying with the default. Sellers often use this by giving people the first month free with an automatic renewal when the month has passed, relying on the status quo bias to keep them on the subscription plan.

Middle option bias

Middle option bias shows that people tend to favor a middle option when presented with three or more choices ordered sequentially. Research has shown that this is the case in various settings [22], and now also in a digital environment [11]. A study conducted in a digital environment[11] gives crowdfunding options to its subjects, asking for money in support from all options. They conduct three studies where they increased the prices of all options before repeating the study. All three of the studies showing that the middle option is the most popular regardless of the amount they have to give.

2.4.4 Other effects

This section will go through more techniques proven to be effective when trying to influence people's decisions.

Framing

Framing is the act of presenting something such that it can change the perception of things without altering or twisting facts. Thaler & Sunstein[1] describes it with an example about a doctor presenting the odds of an operation you might need. The doctor can present it in two different ways with outcomes

that are likely to be different. In the first one, the doctor says, "*of one hundred patients who have this operation, ninety are alive after five years.*" When presenting it this way the chances are good that this will end up with the patient taking the operation[23]. The second way of presenting it is: "*of one hundred patients who have this operation, ten are dead after five years.*" This presentation will likely come off as more troubling than the latter example and can have the opposite outcome. Both of the statements are based on the same fact but it is framed differently. Framing is proven to be an effective way of influencing people's choices[16].

Simplification

People are less likely to enroll in a task the more "friction" there is to start, this is what simplification solves[24]. Laying out clothes, shoes, and other gear needed for a workout the day before makes it easier to embark on because the process of getting ready is simplified. Having created a plan for where to go in advance further simplifies it.

Bringing this to nudging, simplification aims to reduce the friction of the goal you wish to nudge towards. This is usually done by providing supportive information with the nudge, making sure the people being nudged must do as little as possible to achieve or get started with the nudging goal.

Priming

Priming is small and often subtle cues that aim to influence a subsequent action or response unknowingly. It aims to "*stimulate peoples mental representations of events or situations, that then influences subsequent judgments and actions*" [25]. The effect of the prime is assumed to work best when people do not recognize its potential effects on their following responses or, if recognized, does not intend to use this when making the response [26]. The priming itself can be words, sounds, pictures, colors, and videos, and outside of the digital context, taste and smell. To give an example, when primed with the word doctor, people will respond quickly to words associated with doctor compared to other non-related words. The same outcomes can be achieved with emotions and actions, priming towards feeling a specific way or making a particular action.

Social norms

Social norms are described as "*... rules and standards that are understood by members of a group, and that guide and/or constrain social behavior without the force of laws*"[27]. The sanctions for breaking these norms are solely from social interactions, which can be as strong as the legal system on some occasions. People often seek approval for their actions to determine if they have made a good decision or not, essentially making them steer towards the actions of others. Many online stores have implemented this by adding sections under products containing products that other people bought. Alternatively, providing product reviews alongside products because people tend to trust the opinions of others.

Decoy effect

The decoy effect aims to change people's preferred choice when presented with two options by including a third option that attracts people's attention towards the more expensive one. It essentially makes the expensive choice appear like a more attractive choice. The goal of the decoy choice is not to be chosen but to increase the perceived cost-benefit of the more expensive choice.

It is best described from a consumer perspective when choosing between two sizes of popcorn. The ones that originally choose the small bucket are the ones that are targeted with the decoy effect. Adding a third bucket of popcorn slightly lower in price to the largest of them but is increasing more in size compared to price will make the most expensive one seem like a better deal.

2.5 Related Work

This section presents an overview of related work.

Schneider, Weinmann and Vom Broecke [11] conducted experiments on three different types of nudges applied in a digital context. These nudges was based on three different psychological effects, decoy effect, scarcity effect and middle option bias. All these effects are applied to experiments where users are given options to support a reward-based crowdfunding project. They conclude that the results of the applied nudges have a noticeable effect on all of the experiments, and that "designers can create digital nudges on the basis of psychological principles of human decision making to influence people's online behavior"[11].

The work by Schneider et al. [11] also provide a three step process for deciding what type of nudge to use based on the type of choice that is to be made (Table 2.1), with examples of how the corresponding nudge could be presented. This is an interesting and new way of looking at how to decide which psychological effects to use.

Compared to the work done by Schneider et al.[11] this thesis looks at several additional effects, and is also applying the effects towards a different nudging goal. Where they focus on crowdfunding and what the effects result on how much people give, this thesis look at using similar measures to increase peoples investment in their own goals, and specifically living a more active lifestyle.

Dalecke and Karlsen [9] creates a set of nudge types based on a set of psychological effects. This will partly be done in this thesis as well, but we will go further by supplementing to that set and focus more on the psychological effects in addition to giving an evaluation of the effects. This paper is different from Dalecke and Karlsens[9] in the main focus, where they look at the system in a broader scope we focus particularly on the psychological effects and how they can be best utilized, and providing implementations of them.

Andersen and Karlsen [6] introduces smart nudging in this work, describing the design process, ethics, and architecture of the smart nudging system. They identify critical features needed to create the best possible personalized smart nudge system and describe a nudgy recommendation system. Recommender systems are software tools and techniques that provide suggestions for items that are more likely of interest to a particular user [28]. Such a system is often based on historical actions made by the user, but they alter this by using the same system to chose a nudging goal in replacement of the historical action. The paper by Andersen & Karlsen [6] focuses on the design and architecture of the smart nudging system and what its goals are, where this paper focuses on describing how nudges should be implemented and the effects used.

Step 1	**Step 2**	**Step 3**
Type of choice to be influenced	**Heuristics/Bias**	**Example design elements and user-interface patterns and possible nudges and mechanisms**
Binary (yes/no)	Status quo bias (defaults)	Radio buttons (with default choice)
Discrete choice (such as two products)	Status quo bias (defaults)	Use of defaults in - Radio buttons - Check boxes - Dropdown menus
	Decoy effect	Presentation of decoy option(s) in - Radio buttons - Check boxes - Dropdown menus
	Primacy and recency effect	Positioning of presentation of desired option(s) Earlier (primacy) Later (recency)
	Middle-option bias	Addition of higher- and lower-price alternatives around preferred option Ordering of alternatives Modification of the option scale
Continuous	Anchoring and adjustment	Variation of slider endpoints Use of default slider position Predefined values in text boxes for quantities
	Status quo bias (defaults)	Use of default slider position
Any type of choice	Norms	Display of popularity (social norms) Display of honesty codes (moral norms)
	Scarcity effect (loss aversion)	Use of default slider position

Table 2.1: Applied nudging design cycle from [11]

3

Method

As mentioned in Section 1.3 this thesis uses a *qualitative research* approach because textual data in the form of other relevant research in the same field is used to answer research questions and develop a computer system. The research method of the thesis is *applied research*[7] as the thesis rely on existing research not only to solve the research questions but to provide a context in which the problem can be understood.

The research approach used in this thesis is an *inductive approach*[7] which looks at formulating theories and alternative explanations based on observations, opinions and experience. The thesis uses former research to evaluate effects that can be used and finds ways to apply them based on experiences of other researchers and opinions. When researching for how to represent the effects digitally the same approach was used, locating and using experiences other researchers and practitioners has made to propose solutions in this thesis.

The thesis uses a combination of two research strategies, *exploratory* and *case study*. The *exploratory research* method[7] is about investigating a problem that is not clearly defined and is used to understand and identify issues that can be used for future research. The *case study* method[7] is concerned with an in-depth investigating of particular cases in a real-world context. It is exploratory because it aims to find and test what psychological effects can be used in a smart nudging system and suggest solutions or possible approaches for solving nudging. Uncovering challenges and gaining experience working with the

effects to evaluate them makes part of this thesis an exploratory one. Further, it is argued that it is a case study because the effects that the thesis describes and implement are targeting a specific nudging goal. So while it is a study of what effects are beneficial for smart nudging in general, it is also a study of how the effects can be applied more specifically.

This work started by collecting and studying literature about nudging, psychological effects, and experiments made in digital nudging. An evaluation of the psychological effects was done to assess their use in nudging before discussing their use in digital smart nudging. It is created a design for applying the effects when nudging for a specific goal, describing methods for using them in smart nudging. Further, the thesis creates implementations of a subset of the effects to show that they can be implemented and gain experience using them. Lastly, the thesis provides a discussion and an evaluation of experiences made during implementation. The usefulness and difficulty of the effects are evaluated to determine if any effects are better suited.

4

Design

This chapter explains the design of different smart nudges and the theories behind the different design choices. Section 4.1 establishes why nudges are needed and for whom, in what situations the nudges will come to use. Further, section 4.2 outlines the setting that surrounds the nudging that we are to design in this chapter and the assumptions made when going further into the chapter. Section 4.3 describes and exemplify the foundation of the nudges, the tools described in this section are the building blocks of the nudge design. Section 4.4 elaborates on how the effects be combined to form strategies that can increase the effectiveness of the nudges, before a summary is given in Section 4.5.

4.1 The need for nudges

A well-established fact is that humans are prone to making bad decisions, and we can blame our brains for many of them [1]. Our automatic system makes so many decisions in a day that not all of them can be good choices. Some of these bad decisions can harm us in the long run and might not be what we want. The choices can be of such importance, either for ourselves or the society, that there is a need for an external resource to help us avoid or at least enlighten these bad choices. Such situations are where nudges come in, helping us make better decisions without removing any choices and preserve freedom of choice. The central concept of smart nudging is to help people reach a goal they would

otherwise not have reached.

4.2 User setting

To better understand the sections that follow, there is a need to explain the setting in which such nudges would emerge. Thaler and Sunstein first introduced the term nudge [1] and proposed it to be used by governments to influence people to make decisions in their own best interests as well as the governments.

This thesis relies on the user actively seeking help from nudges. The nudging can be an application that the user has to install, which nudges towards a chosen goal. This way, the user has given his consent to being nudged when installing the application since consent is an essential part of what nudging relies on.

Examples and explanations provided throughout the rest of the thesis assumes that the goal is to be more physically active. Examples given will measure activities in different ways such as length, intensity, difficulty, duration, and type. The types of activities that will be given in the examples are for the most part hiking and jogging but can be used with any kinds of activities. And the concepts will be able to translate to other nudging goals as well.

For some examples there will be proposed to use an additional resource containing detailed descriptions of specific activities. This resource is named Ut.no and contains suggestions for routes and relevant information such as busses to get there, weather, pictures, best season to visit and more.

4.3 Nudging tools

To make nudging as effective as possible, the application designer must make design choices based on psychological effects and possibly a combination of them. This section begins by revisiting the psychological effects from section 2.4 and provides examples of how they can come to use in a nudge. Further, section 4.3.2 describes how some of these effects can be combined to create a better nudge. Lastly, section 4.3.3 focus on how choice types can determine the effects used in a nudge.

4.3.1 Effect overview

This section will explain the psychological effects that will be the basis of the nudge design and provide examples of how they can be implemented in a nudge. Table 4.1 shows an overview of the effects presented in this section with a short explanation on what the effect does and how it can be used.

Status quo

Status quo is a bias that makes people stay with default options or choices they have made in the past instead of changing to another option. Since the goal of nudging often will be to improve or change the behaviour of the user, it can be argued that status quo is irrelevant. But a too sharp increase in length, intensity, or repetition would work against the goal and increases chances of injuries and the loss of motivation. The need for periods with the same intensities as before will be needed, and that is where status quo will be used. Here are some examples:

- Nudging for an activity that the user has done before.
- Presenting the user with several options can always be accompanied by this effect. E.g., when nudging for physical activity, the default choice can be the length of a trip.
- If a new activity is presented, there can be an option to choose another activity that the user has done before.

Loss aversion

Loss aversion is a bias that makes people feel worse about losing something compared to the joy of acquiring the same thing. A nudge that enlightens the risk of losing something shows better results than nudging towards gaining the same thing [1]. This does not imply that the application designer should avoid nudges about gaining something in favor of highlighting what the user might lose. Variation is also important as will be discussed later. Here are some examples:

- A nudge highlighting that the user is about to lose the training streak he is currently on.
- Accompany the text in the nudge with a warning that the user will not reach his weekly or monthly goal if he skips this activity.

- Stating that many people have taken a specific trip lately and say that the user cannot miss out on this beautiful trip.

- Informing the user that the weather turns for the worse tomorrow and advice to do this activity on the last day with good weather. (This is also called the scarcity effect.)

Anchoring

Anchoring is a heuristic that makes people estimate values or outcomes they are influenced by and suggests that people favor the first bit of information they learn [18]. Presenting this information with the nudge will make it the latest available information the user has before making a subsequent choice. The user then evaluates the following choices with the use of the information given as the anchor. Its application area in nudges will be in play when providing values and information regarding the suggested activity. Here is an example:

- "Wednesday you ran 10km, how long would you like to run today?". This will make the user adjust the distance of today's activity from the one mentioned.

Framing

The framing effect is about presenting information differently depending on what outcome is wanted, making users change their perception of the choices without altering the information. Framing is a versatile effect that can be used in almost all nudges because we can present the nudging goal in a better fashion, or if needed, the downside of not following the nudge. Here are some examples:

- Present the benefits of choosing to take the run or hike that the nudge suggests, or on the contrary, present the bad things about not choosing it. Here we can bring in weather, health benefits, records, streak, and completing goals.

- Highlighting the positive sides of the activity, such as what the user would gain from it, mentioning the weather if it is good, and the streak the user would get for completing it.

- In the case of nudging for a hike, the application designer can use images from the top showing the view, which can be taken on a day with better weather than today.

Simplification

Simplification is an effect that makes us more likely to go through with something when there are fewer preparations, both mentally and physically, in order to complete the task [24]. This effect is about making the task at hand more manageable by providing the necessary information needed to get started or complete the task. Gathering relevant information is something that a digital environment can solve better than offline contexts because of the availability of real-time information. Additionally, when working in a digital environment, the availability of personal information makes an application like this able to tailor nudges based on the application's user. However, simplification can also remove redundant information that provides little to no value when making a choice. The effect is best implemented as a combination of the two variants, providing the most critical information but leaving out the ones that are not critical. Here are some examples:

- When nudging for specific hikes, the nudge can describe the trip and how to get there, either with a map for the drive or timetables for busses to take.

- Nudging for an activity of a specific length in time because the application has checked the user's calendar and estimates that the user will have time to finish this activity before the next appointment or because the calendar is empty.

- If the activity being nudged for is one the user knows well and has completed many times, some information such as how to get there can be left out.

Priming

Priming is an effect that people are often unaware that they are exposed to, and this is why some describe it as a subtle form of influence towards actions that we are about to make. It can come in any form that triggers our senses, such as pictures, video, sound, and other visual cues. They are known from commercials trying to persuade people into buying their product or service. Using visual cues and sound, they want to create a certain feeling so that when people see the actual product or service, they unknowingly get this same feeling and want to buy it. As mentioned in chapter 2, they work best when they are either not recognized to influence the user or when the recipient does not intend to use this towards subsequent actions. In the nudging setting, the application designer can use this effect to increase users' likelihood of accepting a subsequent proposal by priming them to feel better or about the benefits the

user gets by following the nudge. Here are some examples:

- When nudging for a mountain hike, the nudge can contain a picture of the user on a mountain top, giving positive cues from when he reached the top at that picture.

- Highlighting specific words in the nudging text, giving them more weight and attention. E.g., "beautiful view", "great health benefit", "new record", and "amazing", which can be written in bold text, different font, color, or a combination of these.

- Make use of repetition priming, which says that when a stimulus and a response are repeatedly paired, the user is more likely to respond in a certain way more quickly each time the stimulus appears. This can be specific words, a combination of words or images that they have responded positively to before.

Social norms

The social norm is a strong effect taking two different forms according to Thaler & Sunstein [1], "*If many people do something or think something, their actions and their thoughts convey information about what might be best for you to do or think*"[1]. This version builds on our trust in other people or that the majority often is correct. The second one builds upon us caring about what others think about us and what we do. Thaler & Sunstein [1] addresses the importance for choice architects to know and use this effect in nudging. It is so deeply rooted in our nature that it has proved to be one of the most essential effects [29]. Here are some examples:

- Suggest an activity that the users' friends have done recently or is popular with people in general lately.

- Suggest inviting friends to the same activity as the user is going to do.

- Invite friends to challenges that make them see each other progress in the challenge. This challenge can, e.g., be to complete three hikes in a week or run 10 km in a week.

Availability

The availability heuristic makes us evaluate events, topics, and decisions based on how quickly something comes to mind, meaning that it must be important

if something is easily recalled. Nudging can use this heuristic to increase the importance of a person's goals by making sure they are quickly recalled. Here are some examples:

- Giving reminders of why the user wanted to achieve the goals that he set and what those goals were.
- Show pictures of a beautiful trip, so when the trip is proposed in a nudge, the user will remember the photos.
- Reminding the user of the precommitments he has made to ensure that other plans are not appointed at these times.

Representativeness

The representativeness heuristic makes us classify things based on how well we feel they represent something, which for the most part, is helpful to us. It is sometimes referred to as the similarity heuristic, coming from an explanation of representativeness being how similar a person thinks two events are. What nudges can use from this effect is to make the user represent the activities with something positive. If the user does not represent an activity with something positive, it will be harder to choose, stating the importance of helping the user with the representativeness.

Another use case for this effect is stated by Clear [24] who writes that you must make it who you are to form a habit that lasts. Clear elaborates that this occurs when the user represents this habit or goal with himself, so thinking about himself makes him think of that habit or goal. Making the habit be who the user is will be the goal of this use case and can be achieved by giving positive reinforcement when following the nudge. Here are some examples:

- Reminding the user of the good things about completed activities, such as the feeling of having completed, the view at the top, or the health benefits gained by completing. This way, the activity represents something positive when similar activities are suggested.
- If the user has an activity that he often chooses, the nudge can make a new activity proposal where the activity appears similar to his favorite activity.
- Calling out the user's identity "You are active, as your habits suggest" is a way of using the representativeness heuristic in a positive way [30].

Middle option bias

The middle option bias makes people favor a middle option when presented with three or more options in sorted order. As mentioned in chapter 2, several studies have demonstrated this effect through experiments both digitally and in other settings[11]. In a nudging application, this effect will be well suited since it is often given several options for the user to choose between in a nudge. Here is an example:

- Suggesting three or more activities with increasingly longer distances, having the user choose between them. The same can be done but replacing distances with activity duration, the complexity of the activity, or health benefits of the activity.

Decoy effect

The decoy effect tries to steer people away from one of two original choices by introducing a decoy choice that makes the more expensive choice seem more attractive. The decoy choice is not intended to be chosen and is solely added for increasing the attractiveness of the expensive choice. The effect is most used in sales of items with variable size such as cups of soda, which targets people's tendency to look for value for money. A nudging application must establish the specific user's cost-benefit to know what the decoy wants to target, and this will vary between each nudging goal. Here are some examples:

- One approach for using the decoy effect focuses on how beautiful the proposed activities are, saying the activities are of equal lengths or difficulty, then the decoy could be another activity with better views. The activity that the decoy wants the user to choose can be an activity with similar views and length but greater health benefits.

- If the user wants maximum health benefit and using the minimum amount of time, it can be translated to time being the cost and health benefit being what that cost gives the user. The decoy choice will then be an activity that gives more benefit from additional 30 minutes compared to the original choice. The next choice will then be an activity that gives an equal increase in benefit but with just an additional 15 minutes.

4.3.2 Combination of effects

To maximize the probability of a successful nudge, it can prove beneficial to use a combination of psychological effects with nudges. Many of the effects

Effect	Description	Example
Loss aversion	Makes people feel worse about losing something compared to the joy of acquiring the same thing.	Last day of good weather, last chance to do this activity.
Status Quo	Using default options or choices the user has made in the past.	Nudging for a favorite activity, possibly set as default.
Anchoring	Makes people favor the first bit of information that they learn about something.	Mention the length of another trip before prompting the user to choose the length of today's activity.
Framing	How information is organized and presented to the user.	Present the benefits of choosing this activity.
Simplification	Making complex information easier.	Only present the strictly necessary information about an activity.
Priming	Subtle form of influence towards actions made subsequently.	Highlighting specific words in a text giving them more attention.
Social Norms	Informal rules that govern behavior in groups and societies.	Suggest an activity that is popular among friends.
Availability	Evaluate events, topics, and decisions based on how quickly something comes to mind.	Giving reminders of the goals that is set.
Representativeness	Estimating the likelihood of an event by comparing it to an existing one in our mind.	Reminding about the good things of the activities, making them represent something good.
Decoy	Steer people from a low choice towards a higher choice by introducing a more attractive decoy.	The decoy suggest a more beautiful trip which is a bit longer, but the longest trip is closer in length but even more beautiful.
Middle Option Bias	Favor a middle option when presented with three or more options in increasing order.	Presenting three activities with increasing length or difficulty.

Table 4.1: Psychological effects with description and examples.

mentioned above can work well alone, but some are also suited for combining other effects. This section will go through these combinations and explain what makes them suitable for pairing and how they can increase the chance of success.

Priming combination

Priming is an effect that will work well in combination with other effects, mainly because it can be used before the actual decision itself and can supplement the effects used in the moment of decision. However, priming might also be incorporated at the moment of decision using pictures, sounds, videos, fonts, or colors. The goal of priming alongside the other effects will be to empower the feeling needed for them to choose the nudging goal, and by that, increasing the likelihood of a positive response. Here are some examples:

- Highlight important words in the text to give them more attention from the user. This can be done by making words bold or giving them a strong color that makes them stand out. "The weather is **beautiful** today and this **amazing** hike will fit **perfectly** into your schedule"

- Displaying pictures with the nudge that can either be of the activity that the nudge is suggesting or an image that is motivational for the user.

Social norms and status quo

The combination of social norms and the status quo is a useful nudge as it is easy to implement and combines two individually strong effects. Having the default option be a choice the user had taken before and highlighted that this is a popular choice amongst other people around him. This way, we can use both of them in the same context, possibly gaining from both of them simultaneously. However, the status quo is not only about past choices. It is also about keeping things the way they are, which we can target by giving defaults. So it can be used although there is no past choice or where a past choice would not be appropriate. Here are some examples:

- The nudge explains that this activity is popular among the users' friends or people in his area, and set as the default choice.

- Telling that none of the users' friends have done this activity more than him, either in length or times completed. This activity will be set as default.

- Telling that completing this activity, set as default, will make the user the most active among his friends, either in activity days, total length, or intensity.

Framing and loss aversion

One of the best ways to target the loss aversion effect is with the use of framing. By framing something such that the things the user is at risk of losing are highlighted, we can target the loss aversion effect. Here are some examples:

- Providing information that the weather is turning to the worse tomorrow highlighting that the user would not want to miss out on this activity before it is too late.

- Framing the health benefits the user is missing if not choosing to do this activity today.

Anchoring combination

Anchoring is an effect that can work with almost all of the other effects. It is a bias that makes a person depend heavily on an initial piece of information, the anchor, to make subsequent decisions. A nudge will often come with a text leading up to the decision, and this initial piece of information can be provided along with that text. Anchoring works well on numbers as well, e.g., by mentioning a trip of a certain length in the description, the anchoring effect says that the person will adjust from that number when choosing the length of a trip for himself. Here are some examples:

- Presenting a trip that many people have visited lately will create an anchor that everyone but the user has been there. This makes the user more likely to go since he is "the only one" that has not been there.

- If the nudge lets the user choose the length of the trip himself, it can be mentioned a former trip of a given distance before, making that distance become the anchor.

Simplification combination

Simplification is a vital heuristic that can and should be used whenever it is suitable. Clear describes it well when saying "*the more friction there is before*

engaging in a task, the less likely a person is to go through with it."[24] This effect can be targeted by providing essential information with the nudges, saving the user from subsequently looking it up. The simplification heuristic can be combined with all the other effects since the additional information will not intervene with the effects used in the nudge. Here are some examples:

- Include a link to, e.g., Ut.no, which has detailed descriptions of hikes when nudging for such an activity.

- Suggest a time frame that would be best for an activity based on when the weather is best or when it would fit into the user's calendar.

4.3.3 Choice types

Choice types are an alternative way of looking at the choices the nudges presents to the user. Can the type of choice we make better guide us towards what effect is favorable. Schneider [11] wrote about this, separating between four different choice options, binary, continues, discrete, or other.

- Binary choices are yes or no answers and can be a precommitment nudge asking if he plans to train this week.

- Continues choices are choices with many options, e.g., a slider for the length of a run the application is nudging him to take.

- A discrete choice is when selecting between different items or a predefined set of available options.

- The type called other is meant for the effects presented either as support effects or in a context leading up to making a choice. Examples of this are notifications or widgets, which are not where the user makes a choice but can be utilized to support the choice to come.

In Table 4.2 the effects presented in this thesis is put alongside the choice types to show what choice types they can be used in. Each choice type can exclude at least one effect making it easier for the nudging system to select an effect with the nudge. Table 4.2 is based on Table 2.1 which shows the choice types and what effects can be used with them in addition to examples of how that effect will be implemented. Table 4.2 presented in this thesis brings all the effects from section 4.3.1 into this table to show how the choice types can categorize the new effects.

To explain how the effects are evaluated for each choice type, the middle

Effects / Choice Type	Binary	Discrete	Continuous	Other
Loss aversion	X	X		X
Status Quo	X	X	X	
Anchoring	X	X	X	X
Framing	X	X	X	X
Simplification	X	X	X	X
Priming	X	X	X	X
Social Norms	X	X	X	X
Availability	X	X	X	X
Representativeness	X	X	X	X
Decoy		X		
Middle Option Bias		X		

Table 4.2: Eligible effects per choice type

option bias can be used. Middle option bias is reliant on there being at least three choices which means that it can not be applied with the binary choice type. Further, because the cost, length, or difficulty for an activity must be in increasing order, it will not work with the continuous choice. It allows for interactions that often will alter the difficulty or length of the activity.

Similarities

The implementations of effects within a choice type category can have similarities, what those are and why will be looked at here.

Binary Binary choices require yes or no answers, and because of that, there will only be nudged for one choice in this type. As seen from Table 4.2, this one choice can be implemented with a variety of effects.

Discrete Discrete choices are when selecting between different choices, which implies that there will be at least two choices given with this type. When working with two or more choices, there can be used individual effects in each of the choices and effects that change the order of choices, such as middle option bias. As seen in Table 4.2 all of the effects are possible to use with this choice type, although some of the effects require it to be three choices and would not be applicable with only two.

Continuous Continuous choices in nudging are choices that demand more involvement from the user, e.g., by a slider for selecting the length of an activity. Typically this will be used when nudging for just one activity, but there is possible to present two continuous choices, although this can

create unwanted complexity in making a choice. So this type will have more interactive components than the other types and have one or two choices presented.

Other The choice type other is the only type that does not have any similarities across the effects used. This is because they can be used to support other nudges either before nudging with the use of either notifications, widgets, or a strategy.

Another benefit of using this categorizing of effects with choice types comes from the difference in the presentation of each choice type. Meaning that binary choices will have two options, discrete choices will have more diversity in the choices presented, and continuous choices can demand more involvement from the user. All of this makes it favorable to evaluate each effect based on the choice type it was used with. The same effect used in two different choice types will be implemented differently, so evaluating them by category can be more accurate. With this way of evaluating effects, each choice type can have its own most effective effect. If an effect works well in many of the choice types, this effect can be effective in general for this user.

4.4 Nudge strategies

This section describes how the effects can be used towards a specific purpose and how they work together to create strategies for reaching goals. The strategies are psychological effects put into a system and can consist of giving several nudges in a period of time. Some nudge strategies are inspired by Sunstein's paper [30] about nudging.

4.4.1 Eliciting user intentions

Eliciting user intentions is creating a plan or making the user create a plan for completing a goal, e.g., setting a time and date for when he plans to exercise this week. A study conducted by a group of researchers [31] aimed to try different methods of helping people building better exercise habits. They were divided into two different groups, each given different methods of help. One group was given motivation to build better habits, and the second group was asked to create a plan for when they would train for the two weeks the study lasted. The results show that the group of people asked to create an implementation intention, as it is called in[31, 30], is more than twice as likely to go through with the training compared to the group that they only gave motivation. The results also showed that "*Motivation ... had no significant effects*

on exercise behavior."[31]. The results from this study[31] makes the "*eliciting user intentions*" strategy a valuable one for use in nudging.

This strategy's target will be to nudge the user towards planning when and where to complete the different activities and even plan to complete a nudging goal or sub-goals. James Clear describes this as an essential part of forming a good habit [24]. The specific nudge used for this can be in the form of a question, "do you plan to work out this week?" followed by having the user setting the time and date for this. This way, it becomes harder to delay or postpone the activities since they are appointed to a time slot. The strategy will also make it easy for the application to remind of the user's commitments before they occur to increase the likelihood of completion even further.

Examples of this strategy in use can be:

- Running X kilometers during a week, preferably setting which days the user should run and how many kilometers each specific day.

- Committing to be active for 6 hours during the week, specifying the amount of time each day.

4.4.2 Precommitment strategies

Precommitment was first introduced by a Nobel-prize-winning economist named Thomas Schelling in a paper called "*Egonomics, the art of self-management*" [32]. This paper's core concept was that there exist two selves, a future and a past self within each of us. He argues that these two selves are in natural conflict and are active at different times, making an internal fluctuation between long-term goals and instant desire.

This problem is what the precommitment strategy aims to solve by making things more complicated or impossible for a person to deviate from future goals. In terms of nudging, the application will push the user towards, e.g., having the user sign up for a class or group that goes hiking two times a week. Alternatively, the user could arrange to meet someone in advance so that the users' accountability makes it harder not to attend. To put the strategy to the extreme, a military leader burning the ships of his troops so that they could not even consider retreating home is a much-used example.

4.4.3 Historical data

This strategy will focus on using the activities that the user has done in the past to motivate the user's goal further. An example could be when nudging for a specific activity, the application could mention the longest distance the user has jogged and propose to try to set a new record. This strategy can be done for individual activities or periods like weeks or months, pushing the user to set new records bringing them closer to their goal. Both the positive historical data but just as much the negative historical data can come to use. The negative data can drive the user towards making a positive change, e.g., if he did not do as many activities as planned or fell short of his average activity amount. The application designer can use the negative history as a motivation to outperform that trend and suggest this accordingly in a nudge.

4.4.4 Gamification

Gamification is by some described as implementing game principles and game design into non-game contexts[33]. Humans need rewards, status, and achievements, and that is some of the driving factors of why games can be so addictive[33]. Achievements and rewards will appear in most games, and this is what a nudging application can translate to its context.

The strategy will use the driving factors, such as rewards, status, and achievements, to give a more emotional connection to the users' goals. Achievements can come in the form of virtual badges that the user gets to its profile for completing activities. It can also give achievements for setting new records on a particular activity or following the application suggestions for a week or a month, or setting a record for most activities during a week or month. This example incorporates both the achievement and reward aspect of gamification and brings a motivational side to rewarding the user when he competes with himself and wins. These achievements are also an excellent way to engage in social activities, enabling users to challenge friends to get such achievements or cooperate to get them.

4.5 Summary

This section demonstrates through examples and explanations that each of the psychological effects is possible to use in a digital nudging system. The first research question asked how all the effects that were found could be used in a smart nudging system. The explanations and examples from Section 4.3.1 indicate how this is done.

This section also describes combination of effects, arguing that it would be possible and beneficial to utilize a combination of effects more often than not.

Psychological effects are in section 4.3.3 described in relation to choice types. The relation between effects and choice type will be further discussed when implementing the effects and evaluate its use in nudging.

The strategies presented in Section 4.4 results in alternative ways of giving nudges that can be valuable to a smart nudging system. Strategies such as «eliciting user intentions» and «precommitment» are used in studies[31, 32] and found to increase the completion of goals. Using them in a smart nudging system will then be essential. Because the psychological effects create a foundation for these strategies, the strategies will not be prioritized for implementation. However, implementing the strategies will be added to the future work section.

The psychological effects and combination of psychological effects will be focused on when proceeding to the implementations because the main focus of the thesis is evaluating the effects. The choice types will also be used with the implementations to experience what they can contribute to a digital nudging system.

5

Implementation

This chapter will go through the implementations made in the thesis and describe the different parts of each implementation. It also discusses variations of the implementations to show how they can be altered and still be within the boundaries of the effect they represent. Section 5.1 explains general concepts used when implementing and the architecture where an application would present nudges to a user. Section 5.2 presents the implementations of a subset of the effects from Chapter 4. Section 5.3 presents the concepts that can be used to apply the effects towards different nudging goals. Lastly, Section 5.4 evaluates the lessons learned from implementing and key takeaways from the experiences developing them.

5.1 Implementation overview

Section 5.1.1 starts by giving a general description of concepts used when implementing nudges and what these concepts refer to. Section 5.1.2 describes how components are created, what they consist of, and how they are used in the implementations. Lastly Section 5.1.3 presents the architecture which the nudges present information in.

5.1.1 General

In this thesis, implementation refers to creating and combining components to form a screen on a mobile phone. This will be how the user sees the nudges. Precisely what these components are and what they consist of will be presented in detail in Section 5.1.2.

One nudge must have at least one activity for the user to choose from, but it can consist of more than one. Because of the lack of space on a mobile screen, it is presented between one and four activities in a single nudge. Presenting more can also be done, but this would fill the screen with many choices, making it harder for the user to choose just one activity.

5.1.2 Components

A component is everything that goes into creating one piece of information, and bigger components are built by several smaller components. E.g., a simple text can be one component, and combining this with a title component and a picture becomes a bigger compound component. One choice will typically be one component, and a nudge can consist of several choices.

Designing these components and deciding what smaller components they should consist of is a task that can be difficult. There is always a way to make slight alterations while still supporting the overall goal.

The implementations are created with a digital design and prototyping tool called Figma[1]. Its use is mainly for creating designs for web or mobile application interfaces, prototypes, and other forms of graphic design work.
This tool was chosen because the goal of the implementations is to demonstrate how a nudge can be presented to a user and how a psychological effect can be targeted in a digital context. Figma enables creating designs and prototypes for applications fast and efficiently, and the ability to reuse and alter components easily speeds up the process. Once the overhead of creating the first implementations or components is done, many of the components can be reused and altered to fit a new implementation variant.

5.1.3 Architecture

To understand how nudges are presented and how implementations are intended to be used, there is a need to explain the system's architecture. The

1. Figma.com

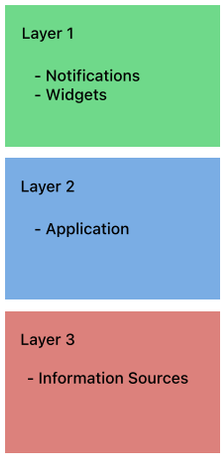


Figure 5.1: The three layers of information in a nudging application

architecture is divided into three separate layers as shown in Figure 5.1. Layer 1 resides on the locked screen or the home screen of the users' phone. This is where notifications and widgets are used. Notifications are used to either notify that today's suggested activity is ready or as a way of presenting support effects. Widgets can serve the same purpose as notifications but will only be found on the user's home screen. Examples of how widgets can be used and implemented are presented in Section 5.2.6.

The second layer is where the application itself resides, which is what the implementations presented in this chapter shows. Following a notification from the first layer will take the user to this second layer. Here the user will be presented with the choices the system has picked for him using an implementation exemplified in Section 5.2.

The third layer is any external resources the system uses, either directly displayed in the application or through a link that redirects the user to the resource. These external resources can be weather data, timetables for public transport, or detailed information regarding activities.

5.2 Effect implementation

This section will present the implementations of the effects and explain how the components are used to target the specific effect. Some of the components from section 5.2.1 will be found in all of the implementations, and will only be described in the section it originates from.

Figure 5.2: Implementation of the simplification effect

5.2.1 Simplification

The implementation of the simplification effect aims to answer as many questions the user may have without flooding with too much information. This means that the most significant things the user needs to get started must be answered without complicating it. This is why only one activity is presented to the user seen in figure 5.2. If there is only one suggested activity, there are fewer choices to confuse the user with and results in the design being tidier and using the space for essential information. Because there is only one choice, this implementation falls under the binary choice, which is possible for the simplification effect seen from Table 4.2.

Further, there is a visual representation of difficulty and length, which is essential to know before starting the activity. The visual representation is chosen

because numbers can be hard to remember compared to the color representation of the same thing. This visual representation also simplifies the comparison between other activities. Choosing a colored bar was done because many factors making activities difficult, and listing those would create unwanted complications. There is a symbol describing the weather as well, which gives a quick visual expectation of the weather that can be expected.

The time frame of the activity is highlighted since finding the time often can be a complicated part of starting an activity. This time period can be taken from the user's calendar to minimize the chances of rescheduling or cancellation. The text that comes with the nudge is meant to give a quick understanding of the suggested activity to set the expectations and, importantly, not flood the user with irrelevant information. A link to Ut.no is provided for easy access to information surrounding the activity. This can be how to get there, where the path is, weather details, the height and length of the trip, and several pictures. It provides a complimentary resource for simplifying the activity.

Simplification is about removing complexity from choices, and it can be done in two ways. The first one is solving the complex collection of information in advance, limiting what the user has to do subsequently. The other way it can be solved is by removing unnecessary information that brings complexity, e.g., by removing details about a trip that the user knows already or information that is not relevant before beginning.

5.2.2 Middle option bias

Middle option bias is the tendency for people to choose a middle option when presented with three or more choices sorted by some factor, in this case, the difficulty and length of an activity. The colored bars introduced in section 5.2.1 representing the difficulty and length of the activity, is used in this implementation as well, seen in figure 5.3. The most important part of this implementation is the sorted increase in the difficulty of the user's choices, ranging from the easiest to the hardest. As long as activities are sorted and the user can see this, the effect is successfully targeted. There are three choices to choose from in this implementation which places this under the discrete choice type, and from Table 4.2 this is the only suitable type for the middle option bias effect.

In this implementation, there are two factors that the choices are sorted by, but just sorting on one of them would be valid as well. As long as the costs of choices decide their order, then the effect is still targeted.

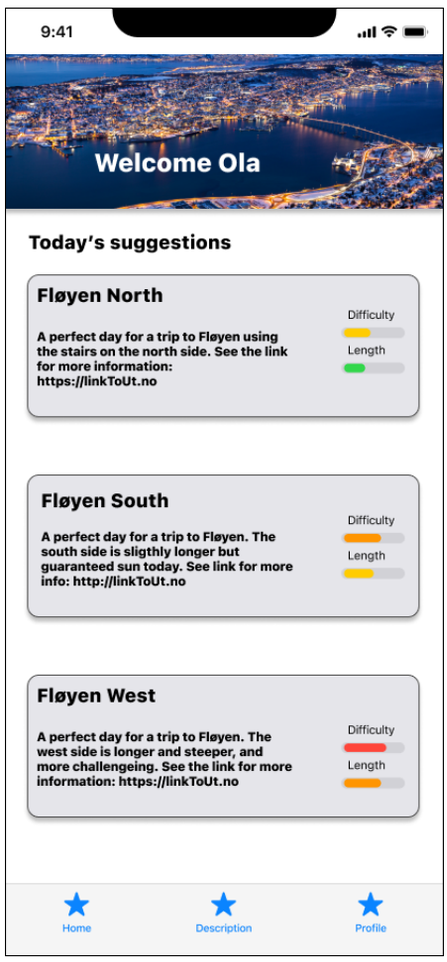
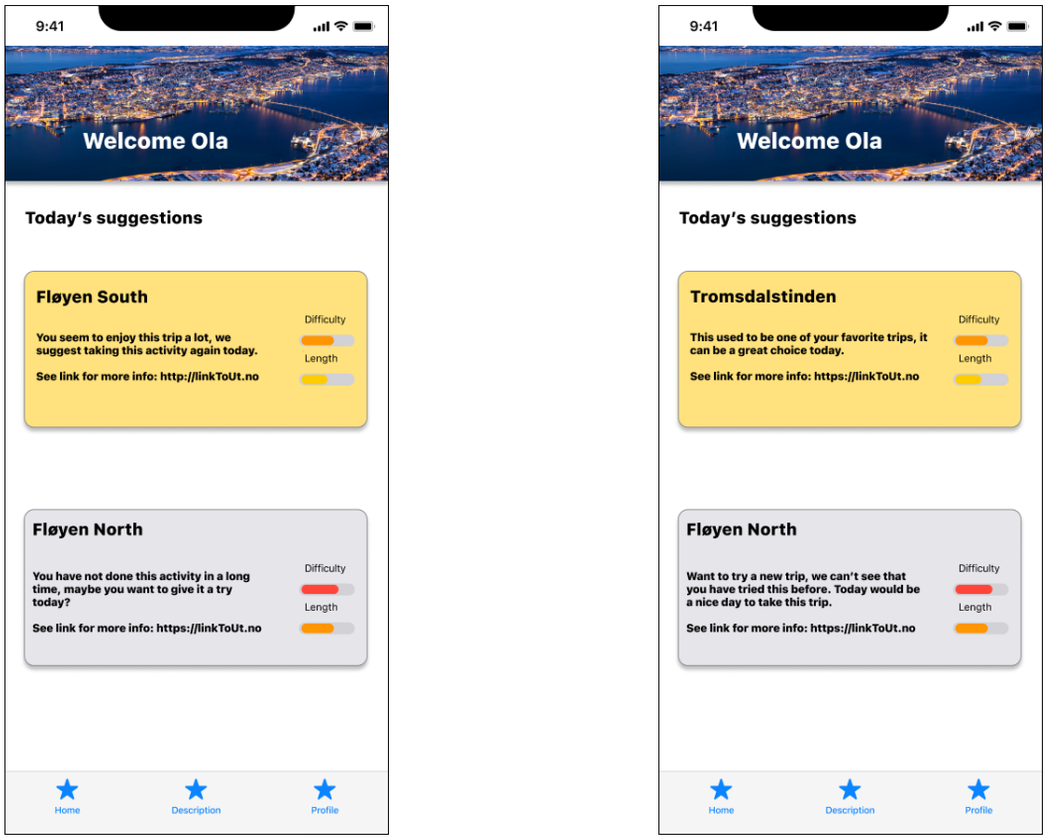


Figure 5.3: Implementation of the middle option bias



(a) Status Quo effect version 1

(b) Status Quo effect version 2

Figure 5.4: Implementation of the status quo effect

5.2.3 Status quo

Implementing the status quo effect is about pre-selecting a choice that the user has made before, as illustrated in figure 5.4a. The activity should be one the user has completed more frequently than others in the last week or month. It is paired with another activity in case the user wants to try something new. In Figure 5.4b there is an alternative way of implementing the status quo effect. If the user does not have a favorite standout activity, an activity that used to be the favorite can be used. These implementations contain two choices and do not have any user involvement besides choosing the activity, meaning this falls under the discrete choice type.

5.2.4 Priming

Priming is an effect with many possible implementation variations, and some of them are shown in figure 5.5. First of all, there are pictures which can be used in different ways. The first suggestion is to create an expectation of how it will be when reaching the top of the mountain. For people to imagine how it might look at the end of an activity is not easy, so providing it to them can motivate them to complete the activity. The second picture is another example of priming with pictures, now wanting to invoke a feeling from the user. In this example, the picture aspires to bring a feeling of power and self-esteem, which further increases the chances of the user choosing and completing the activity. Using pictures of the user himself or taken by the user himself is a better choice because there are often feelings connected to the situation the picture was taken in, which can be brought back when seeing the same picture again. Using pictures taken by the user makes use of the availability effect and makes the feeling or memories with that picture more available.

Further, specific words have been highlighted by changing the color to get more attention and stand out from the rest. Those words will, in essence, have more impact than the rest of the text and will be what the user remembers most after reading it. The goal here is to highlight the key factors that make the user want to choose this activity, and in figure 5.5 there are two examples of this. The first one highlights something that makes this activity unique or beautiful such as the northern lights in this example. Secondly, there is highlighted that this activity will have significant health benefits for the user, targeting the users' goals. The implementation presents two choices making figure 5.5 a discrete choice type. However, the two choices are different examples of the priming effect and can be given as a binary choice type. Both these are possible as seen from table 4.2.

5.2.5 Social norms

Implementing social norms is about either nudging towards bringing friends, challenging friends, or suggesting popular activities among friends or social groups. In Figure 5.6 there is an example of how this can be implemented. The first one tells the user that his friends chose this activity, suggesting the user do the same.

Secondly, there is implemented a choice of challenging friends to complete three hikes during this week, leveraging the effect either in bringing friends or knowing the user's friends can see his progress. From the last choice presented in figure 5.6, the user can interact with the nudge, making the choice type a continuous one. The continuous choice type does not say anything about

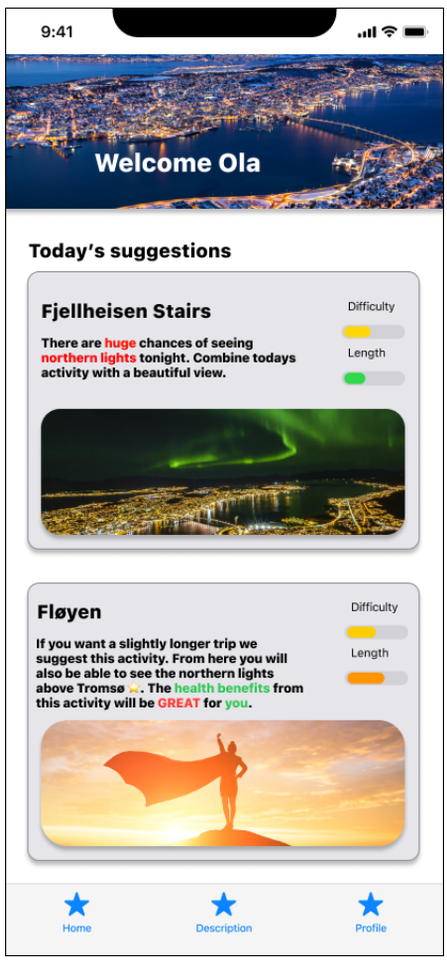


Figure 5.5: Implementation of the priming effect

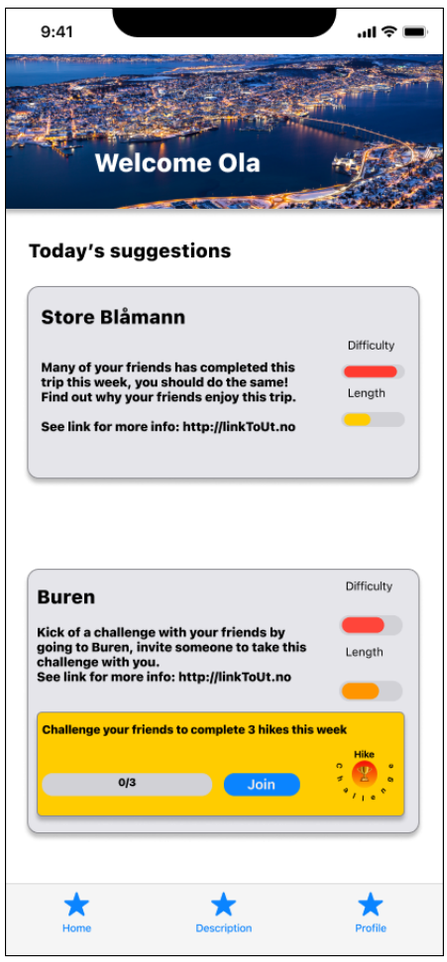


Figure 5.6: Implementation of the social norms effect

Figure 5.7: Implementation of the availability effect

the number of choices presented, so nudging for just the last choice would still keep this implementation in the continuous type. However, replacing the nudge containing the interaction would no longer qualify for a continuous choice but rather a discrete one.

The activities suggested with the social norms effect can also be what famous people have done lately, someone the user has a special interest in. It is all about social connections, so famous people the user pays special attention to can work just as well as friends and close contacts.

5.2.6 Availability

The availability effect is all about recollection and remembering the goals or precommitments made. For this, it has been implemented two examples of widgets seen in Figure 5.7. Widgets are small applications on the home

screen of a smartphone that is meant to be more available than the rest of the application. Since the widgets reside on the home screen, they are seen every time a user uses the phone, regardless of the purpose. In Figure 5.7 this is leveraged by displaying the activities planned. The widget contents could be the user's goals or an image reminding the user of the goals, as this is the most important thing to remember. Figure 5.7 shows an example of how a small and a large widget can be implemented. This implementation qualifies for the choice type "other" because the effect is used outside the actual choice making. As seen from Table 4.2 the availability effect can be used with the choice type other.

The contents of a widget can vary as the primary purpose of the widget is to make the goals and commitments of the user quickly come to mind. Alternatively, it can display a picture the user has chosen, a text, progress of challenges, or, e.g., progress of a monthly goal the user was nudged to choose.

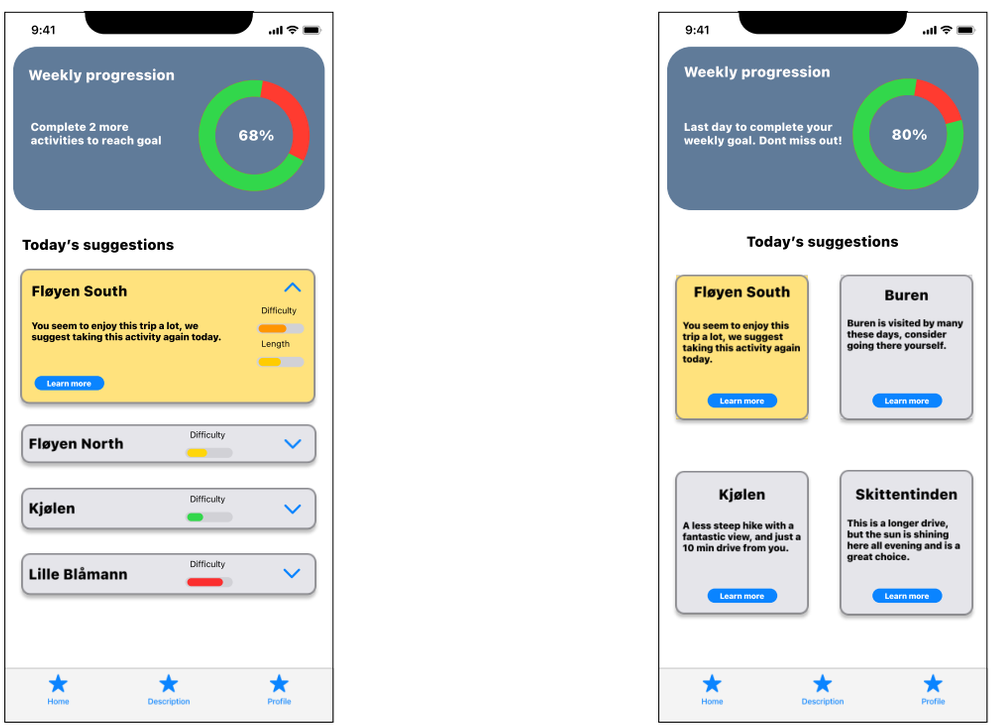
5.2.7 Alternative implementations

Figure 5.8a displays an implementation with a weekly progression box at the top of the screen and four choices where one of them is selected in yellow. The three other choices presented only show the title of the choice to save space.

Figure 5.8a show an implementation that has taken into account the lack of space available on a mobile screen. Instead of presenting texts or pictures of all the choices simultaneously, the choices that are not selected are collapsed. Collapsed refers to hiding the information that the choice contains temporarily until the user selects the choice by clicking it. The choice uses less space, exemplified here by only showing the name of the activity and the difficulty bar. Status quo is ideal for this example as it sets a default choice it wants the user to choose, and by hiding the information that the other choices contain, the default gets more attention. A selected choice is shown with yellow color in Figure 5.8a.

The simplification effect is used with the progress circle at the top of the screen. It is used to visualize and simplify the progress the user has made. The availability effect is also used by displaying the progression box, reminding the user how much is left to reach the goal.

Figure 5.8b has the same weekly progression box at the top with a different text saying that it is the last day to reach the goal. The ordering of the choices presented are different, now showing the four choices in two rows with two



(a) Alternative implementation 1

(b) Alternative implementation 2

Figure 5.8: Alternative Implementation 1 and 2

Figure 5.9: Alternative implementation 3

choices each. A short description of each choice is given in text and a button for learning more about the trip is added to all the choices.

Similarly Figure 5.8b has arranged the choices in a different manner and does not include the difficulty bar that Figure 5.8a has. In the weekly progression box on the top of Figure 5.8b, the text uses the loss aversion effect by informing that this is the last day to complete the weekly goal. Figure 5.8b uses a combination of loss aversion and status quo to nudge the user.

Figure 5.9 displays two boxes at the top of the screen showing the weekly goal progression and the monthly goal progression. The three choices in this implementation are ordered with two small choices at the top and a larger box at the bottom, allowing more text to be added.

In Figure 5.9 it has been added both a weekly and monthly goal progression that utilizes the availability effect in addition to the simplification effect with the progress bars. The bigger box presenting the choice of swimming allows for more information and is valuable if additional information is needed.

Figure 5.10 displays the users name with a "welcome" at the top of the screen,

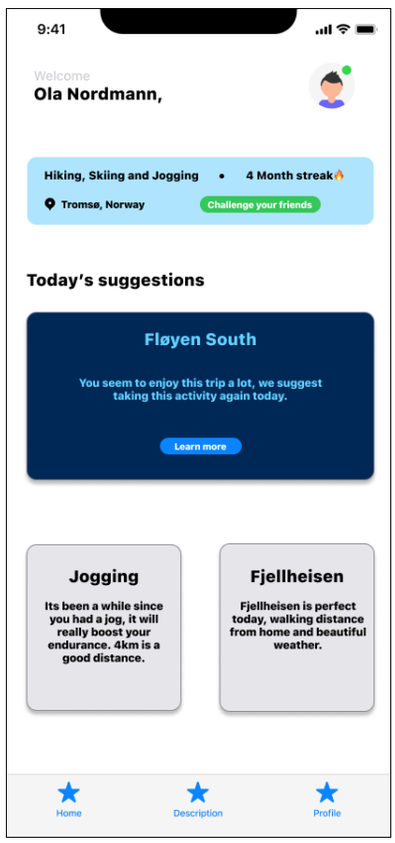


Figure 5.10: Alternative implementation 4

alongside the users profile picture. Then a small section with the activities of this user, his current streak and where he lives is shown. A button for challenging friends is also found there. The choices are ordered with the biggest choice box at the top and two smaller ones beneath.

Figure 5.10 displays a slightly different design with a personalized section at the top. It also adds a button in the personalized section that uses the social norm effect, allowing the user to challenge friends.

5.3 Generalization

Generalization is about being able to apply the concepts and decisions made in this thesis when designing an application that nudges towards a different goal. This section will describe and exemplify the use of specific concepts for different nudging goals.

The takeaway from the implementations when wanting to use it for a different goal is how the components are constructed. Constructed in this context refers to combining components and how an implementation presents choices together. Additionally, which components are used with several of the choices presented, e.g., the simplification components. With the help of simplification, we have created a component for making it easier to assert the difficulty of activities using a combination of colors and progress bars. An alternative nudging goal can be to make more environmentally friendlier choices. The difficulty used in this thesis can be replaced with the environmental impact of a transportation choice and use with the new nudging goal.

5.3.1 Cost-benefit

Being able to identify the cost and benefit that the nudging goal introduces is an important thing. With increasing physical activity, which is the nudging goal in this thesis, the cost is the difficulty of activities or how much energy it will demand. The benefit will be what the user gains in terms of health benefits. For a nudging goal such as making better environmental choices, the benefit will be how much more environmentally friendlier a choice is, and the cost can be in terms of an increase in spending or an increase in time used.

The cost-benefit relationship is the basis for several effects, and users will typically want to maximize the benefits per cost. Middle option bias sorts the choices presented based on cost-benefit, and the decoy effect tries to convince the user that a more costly choice gives more significant benefit per cost.

Framing can focus on the benefits of the choice nudged for, and with this give the benefits more attention than the costs. Simplification can present the cost and benefit visually, as done with colors and a progress bar in this thesis. This visual presentation can simplify the user's understanding of the cost or benefit, especially if it is difficult to represent as a value. This was the case with the difficulty of activities nudged for, as the difficulty was based on several factors such as how steep an activity is, the terrain, and the time needed, which would have been hard to present in full detail.

5.4 Evaluation

Looking back at the implementation experience, choosing Figma to create the implementations allowed for experimentation with different solutions. Implementing has been an incremental process. Creating multiple versions of implementations and only using the best versions for further implementation has been important.

The implementations present nudges containing different combinations of components, such as the simplification effect that creates visual representations of, e.g., difficulty and progress. A nudge can also consist of mainly text, and some effects are primarily targeted with the use of text, such as the framing and anchoring effect. Since textual representation has fewer visual variations, they were not prioritized in this section. Additionally, each choice type is represented among the implementations to show how they differ and what components they can reuse. The simplification component with the colored representation of difficulty is an example of a component that the implementations reuse across many nudges.

The general conclusion from digitally presenting psychological effects is that some effects are easier to implement than others, and some effects are possible and beneficial to use at most times. Simplification is the best example. Finding and evaluating what information is redundant and what information can be simplified by, e.g., representing it visually, turned out not to be a too challenging task. The evaluation of all effects is done in Section 6.2.6, evaluating the usefulness and difficulty of implementation.

Further, presenting nudges on a mobile device demands that we use as little space as possible. When including information, it quickly takes all the available space. This results in developing alternative ways of presenting choices while using as little space as possible, e.g., as presented in Figure 5.8a where the choices presented in the nudge are collapsed to only show the title, revealing the information when the user clicks them.

6 Discussion

This chapter presents discussions regarding the design and implementation made in this thesis. Section 6.1 highlights some of the design choices and discusses their use. Section 6.2 presents discussions surrounding the implementation and the digital environment before providing reflections from the implementations. Section 6.2 also evaluate the effects based on usefulness and difficulty. Lastly, Section 6.3 summarizes by reiterating the research questions and look at them in the light of the findings in this thesis.

6.1 Design remarks

This section presents evaluations on topics introduced in the design of the thesis. Section 6.1.1 looks at the combinations of effects and discuss how they are used. In Section 6.1.2 and Section 6.1.3 discuss the use of nudging strategies and choice types respectively. Further it is looked at the framing ethics and personalization in Section 6.1.4 and Section 6.1.5. Lastly, it is elaborated on how simplification can be be done alternatively in Section 6.1.6 and the subtle difference between the two strategies, before implementation intentions and precommitment are discussed in Section 6.1.7.

6.1.1 Combination of effects

Many of the effects are possible to combine as presented in section 4.3.2, and can bring significant benefits by doing so. Simplification is an effect that application designers should consider using in all of the nudges. It is an effect that focuses on not presenting too much information, presenting only the most relevant information for that activity. E.g., in this thesis, we made a component that simplifies how the difficulty of activities is presented. All of the components with different effects can use this without interfering with the critical factors of that effect.

Introducing priming in notifications is also a combination of effects that can be used with all of the effects, leveraging the layers to use different effects. When combining effects, the most important thing is not to interfere with what makes the effect work and not use an effect that contradicts any information the nudge is presenting. It was experienced that more often than not, it would be natural to combine effects when giving nudges, mainly because the effects make use of different components or techniques. Components in this sense are a specific thing on a mobile screen, such as a picture, text, figure or illustration, and techniques refers to the structure, order, and orientation.

6.1.2 Nudge Strategies

Incorporating the psychological effects in strategies is a way of increasing the effectiveness of nudges. Using several nudges together and not only for the single activity it wants the user to choose is a unique contribution some of the strategies make. E.g., eliciting user intentions, it can be planned when the user wants to do activities. This plan means that the nudging system does not need to nudge for choosing an activity but rather nudge the user to remember the intentions that are set. The nudges that remind of the intentions result from the strategy and are said to be together. The nudges that give reminders use the availability effect. With some of the strategies, it incorporates more involvement from the user, such as the precommitment strategy or the eliciting user intention strategy. Nevertheless, the strategies are an excellent supplement to just giving single nudges that can sometimes seem mindless in the long term.

6.1.3 Choice types

Determining the type of choice the user has to make can simplify choosing an effect that can be used in a nudge. When the choice type is found from the activities wanted to nudge for, Table 4.2 can be used to find the effects suitable for that specific choice type. In addition to simplifying the process of choosing

an effect, categorizing effects by choice type can be used when evaluating the historical decisions a user has made. Effects can be sorted by effectiveness within each choice type to simplify choosing an effect and increase success chances.

The limitation of categorizing effects by choice types is that each choice type cannot exclude many effects and only removed two to three effects. This means that there would still be many effects to choose from in each category, which is favorable for avoiding repeated effects but still some complexity of choosing the effects.

6.1.4 Framing ethics

When working with the framing effect, it is essential not to fall into the temptation of altering the facts to make it appear better than reality. The whole concept of nudging is to present things as they are and make sure people see the positive side. The goal is not to trick the user into choosing something but to highlight the positive sides.

6.1.5 Personalization

Personalization is a big part of the potential that digital nudging has. The ability to tailor nudges to a specific person instead of a general audience is a new aspect of nudging. The concept is briefly visited in Chapter 2 when introducing the nudging terminology but is not the main focus when designing the nudges in Chapter 4. Although, when greeting the user in the implementations in Section **??** with "Welcome Ola" it is included some degree of personalization. Personalization should be used extensively in digital nudging, creating a personal connection when the nudges are meant for just this user and not a general group of people.

6.1.6 Simplification without obfuscation

Simplification is originally about simplifying complicated things by removing unnecessary information and turning complex descriptions into more understandable information. In addition to this original use, this thesis uses another form of simplification, which tries to decrease or simplify the user's need for information collection after the nudge, in essence, to answer essential questions the user can have before making a particular choice.

The two simplification methods can seem to be opposites of each other, one

of them removing information and the other adding more information. However, the original choice is not necessarily removing information but instead making the same information more understandable. Nevertheless, adding information to increase simplification can be thought of as the opposite of what simplification is.

6.1.7 Implementation intentions and precommitment

The difference between eliciting user intentions and precommitment can be challenging to see, but we will emphasize the difference here. Precommitment focuses on making it hard for a person's future self to deviate from a goal or activity set in advance. Achieving this can be done by paying for a training course or other activities such that the motivation to go is more significant because the money would go to waste if the user chose not to go.

Eliciting user intentions do not go that far. It can be as simple as asking the user if he plans to train this week. The question alone shows an increase in the likelihood of doing so [30]. Further, it can nudge the user into scheduling a plan for when to complete activities for some proposed time.

The difference is that precommitment strategies will nudge to commit to activities, making people accountable or having materialistic things at stake. Eliciting user intentions is focused on making plans for the person and being accountable to himself.

6.2 Implementation discussion

This section presents implementation-specific discussions looking at limitations and positive sides of digital nudging and mobile devices before providing reflections on the implementation done in this thesis. Further, Section 6.2.5 looks at how nudges can be evaluated in order to learn from historical nudges. Lastly, Section 6.2.6 evaluates the effects presented in the thesis on difficulty and usefulness, based on the experience working with them.

6.2.1 Digital representation of effects

Representing psychological effects in digital environments has some drawbacks but many more upsides. The ability to tailor the nudges to the specific user is possibly the most significant upsides of them all. It is called personalization and is a unique ability that the digital environment can use compared to

nudging in an offline context where the creation of nudges often is for a general audience.

Further, another positive side is learning from the individual user's interactions and gradually becoming better at knowing what the person wants or not. This feature enables to create a better experience for the user and a bigger chance of assisting the user in reaching his goals.

Considering that the system is constantly evolving, the next positive thing about nudging in digital environments comes into play: the ease of changing the design and setup of a nudging environment. Compared to traditional ways of nudging, such as the layout of a grocery store, the cost, and effort of changing the layout, or just parts of it, are much higher than changing the design in a digital environment. In a digital environment, the system can alter itself as it learns what the individual user prefers.

Digital environments can react to real-time sources of information and apply them in nudges, making the nudges tailored to the user's current situation. Using weather resources, traffic, public transport, and other live information sources is a feature that offline nudge environments could not benefit from. This unique opportunity makes the nudges highly relevant and reliable and is crucial for the long-term use of a nudging application.

Lastly, the availability of mobile devices makes nudging even more powerful, and nudges can be given at almost any time since many people carry their phones with them at all times. Being able to nudge people where they are at almost any time is something offline nudging has not been able to in the scale that digital nudging on mobile devices is.

6.2.2 Limitations on mobile devices

Our mobile devices are great for having information readily available in our pockets at all times and have quickly become the source where people make most decisions. Presenting choices on mobile devices is important because most people carry the device with them and checks it regularly, but it has its challenges which we will discuss here.

First and foremost, the biggest challenge is the size of a mobile device. It is usually relatively small, meaning that the components designers have to use to deliver a nudge can quickly become cluttered and cause more disturbance or confusion than it does good. Keeping the screen tidy is part of the simplification effect presented in section 2.4.4. One of its core concepts is that too much information about a choice can make it appear difficult and decreases

the chances of being chosen. Moreover, since smaller screens require fewer components to become cluttered, this effect is even more important. Taking this effect into consideration implies that mobile devices must balance their use of their components. If there is a need for more text, then pictures or figures may have to be taken away, or the other way around, if a picture is needed, it should use less text.

Another way of solving the problem with lack of space is to use more screens, e.g., when presenting two or more choices, there can be one choice per screen, and the user has to slide back and forth to see the different choices. However, it is also possible to benefit from the different layers proposed in section 5.1.3. Some of the information or necessities for triggering an effect can be introduced in the first layer with notifications and widgets, essentially freeing some space for use in layer 2 (see figure 5.1).

6.2.3 Notifications

Notifications are used primarily to draw the user's attention towards the application itself, where the user is presented with choices. This requires that the notification has content that makes the user interested and want to see what it suggests. The notification can hold just one or two short sentences of text, so the little space available must be used well. It can rely on that people's curiosity will make them want to see what the application suggests or use the notification to trigger emotions with emojis or pictures. Alternatively, it can make use of an effect in the choice type "Other" presented in Table 4.2. However, the limitations made by the lack of space available make some of the effects not suitable for notifications. Lastly, as mentioned in section 6.2.2 notifications can provide information such that the application itself, presenting the choices in Layer 2, has less information to present.

6.2.4 Reflections

Taking psychological effects from general description and exemplification to actual implementations as done in this thesis is valuable for seeing how we can display the effects with digital components. Just describing how they affect a person can be difficult, so seeing it go from description to implementation is key to understanding how to translate it to a digital setting. Even if we create implementations with a particular goal in mind, the concepts are the same, so changing the goal only impacts the contents of the implementations. This ensures that the implementations can be understood even when wanting to use them towards another end goal. See Section 5.4 where we give examples and evaluate how they can be altered for use with another goal.

One limitation of the implementation is the textual part because many of the effects rely on how the choice is presented in text or uses text alongside it. The main concern has been implementing the effects that use visual components and alter the structure and order of components. This focus resulted in a lack of work done with the textual nudges, but the included text is considered sufficient for exemplifying the effects.

An important notice is that the implementation design is not the "de facto" way of implementing a nudging application. It is the proposed way in this thesis, and others can use it as inspiration or as it is. Imagining how effects can be implemented is not an easy task, so seeing it done can open up alternative ideas for people. In section 6.2.2 it was proposed an alternative way because of the limitations on screen size on mobile devices. This alternative was to scroll between the presented choices, enabling to utilize the entire width of the screen for just one nudge choice.

6.2.5 Evaluation of nudges

An essential part of a smart nudging system is evaluating the nudges given and specifically the user's reactions, did he follow the nudge or not. If we combine this with our proposed choice types, we can evaluate the effects within one category of choice types because the presentation varies significantly between the categories. One effect can have many positive reactions with binary choice types and fewer positive reactions when presented with a discrete choice type (see Section 4.3.3 for a description of choice types).

As the user continues to use the application, the smart nudging system gains knowledge of the users' reactions and can provide nudges with the most positive reactions. By doing so, the application can more reliably influence the user to reach his goals. Additionally, by keeping track of the nudges and their effects, it can be ensured that the system does not give some effects too often, risking annoying the user with repeated nudges. Setting a threshold number for the weight of an effect related to the total amount of nudges given is one way of ensuring that the system does not use an effect too much.

6.2.6 Evaluation of effects

Based on the experiences made from implementing the psychological effects digitally, their assumed usefulness in digital smart nudging and their implementation difficulty has been evaluated. Usefulness refers to the assumed usefulness for the user and how easily it can combine with other effects and on its own in a nudge. The difficulty is concerned with implementation and

Effect	Usefulness	Difficulty
Simplification	High	Neutral
Social Norms	High	Neutral
Availability	High	Neutral
Framing	Medium	Neutral
Representativeness	Medium	Difficult
Status Quo	Medium	Easy
Loss aversion	Medium	Easy
Middle Option Bias	Medium	Easy
Priming	Medium	Neutral
Decoy	Low	Difficult
Anchoring	Low	Difficult

Table 6.1: Evaluation of the psychological effects in the perspective of Smart Nudging. Sorted by usefulness.

how difficult it is to apply the effect in a nudge. The evaluations are listed in Table 6.1 and will be explained more thoroughly below.

Anchoring is set to the most difficult category because it can be challenging to make sure users depend primarily on the nudge's information. Although it can be argued that making users depend on numbers to influence the length of activities is less complicated and therefore would qualify for a neutral assessment. Considering that influencing the length of activities does not directly influence the user to choose the activity, it is evaluated to low on the usefulness scale.

The decoy effect is also placed in the most difficult category along with representativeness. The reason for this is that the decoy choice is dependant on evaluating the cost-value relationship of the activity being nudged. Deciding what a user sees as cost and value is not trivial and can vary significantly from one user to another. If the effect is successful, the user has chosen the activity that costs the most of the nudged choices but will also benefit more from, referring to the cost-benefit discussed in Section 5.3.1. Because the primary purpose of a nudging system is to help the user regularly make better choices and occasionally try to nudge for longer or more demanding activities, we have placed the effect in the lower bracket of usefulness.

Along with the decoy effect, representativeness is placed as the most challenging effect to implement. First and foremost, it will take time to make users represent themselves with the nudging goal, as presented in Section 4.3.1, or changing what the activities represent for the user. Secondly, finding the features of an activity that a particular user values most and then making the activities

represent this positive value is not a trivial task. If a nudging system succeeds with this effect, it will have a constant positive effect with minimal maintenance. It will make it easier for the user to choose activities because it represents something the user enjoys, and even better, it might have formed habits in the user.

On the top of the usefulness scale, social norms and simplification is placed. Social norms are easy to implement as long as the information is available regarding what friends or social contacts have chosen lately. Gathering information about social contacts is something a digital system can solve better than offline contexts. Providing this is in place, it is just about presenting the choice to the user. That is why social norms are set to neutral on the difficulty scale. It is set to high when it comes to usefulness because the effect is rooted in people's basic need to belong and is, therefore, a powerful effect [34]. Humans are social beings and will naturally seek social approval.

Simplification is placed in the category high in terms of usefulness, mainly because of two things. We are yet to find a nudge where simplification can not be used. Whether it is to simplify information or to change the structure of nudges, it is always helpful. The versatility of the effect, therefore, contributes to why it has been valued at high. Secondly, simplification limits information to only the necessities, making it easier to keep mobile device screens tidy and not appear cluttered. It is set to neutral in terms of difficulty, meaning that it is not overly difficult but not straightforward. Identifying what information is needed or not can be challenging, and making complex information more understandable and compact is not trivial. These factors are the ones considered when placing it in the neutral difficulty.

The effects evaluated as neutral on the usefulness scale are effects that work well by themselves and can be combined with other effects but not all of them. Because they are not applicable in all nudges but work well in a digital context, the effects are assessed as neutral. They are still equally important effects because the need for variation in nudges is essential.

Overall the assessments of the effects show that most of them are useful in a smart nudging system and mostly evaluated to be on the middle of the scale in difficulty.

6.3 Summary

This section gives an overview of the evaluation done in this chapter and ties it into the research goals presented in Section 1.2. This thesis aims to study psy-

chological effects and how to represent them digitally within a smart nudging system. While doing so, we want to answer these research questions:

- How can psychological effects for behavioural change be represented digitally and used in smart nudges?
- How can all of the effects we find be used in a digital smart nudging system?
- Can some of the effects be better suited for digital nudging, and if so, how?

Lastly, the goal was to implement some of the effects found, proving and exemplifying how they will come to use in an actual application.

The thesis can answer how psychological effects for behavioral change can be represented digitally and used in smart nudges through the design and implementation provided in this thesis. With specific examples and descriptions of the different effects in Chapter 4, the thesis proposes how each effect can be applied to a digital smart nudge. Chapter 5 presents implementations for a subset of the effects, and with this, the thesis shows how the effects can be represented digitally. While doing this, the thesis aimed to answer the two sub-questions utilizing the knowledge acquired when working with the effects.

The second question asks how all the effects we found can be useful in a digital smart nudging system. Section 4.3 answers this by describing a design using the psychological effects in digital smart nudging. An explanation of each effect is given in Section 4.3.1 answering the question by describing several examples of how they can be implemented as a digital nudge. Section 4.3.2 and Section 4.4 also contribute to answering the second question by describing how the effects can be combined and how more complex strategies can use the effects.

The third question asks if and how some of the effects can be better suited for digital nudging, and Section 6.2.6 answers this by evaluating the effects based on usefulness and difficulty. With the usefulness and difficulty evaluations, Section 6.2.6 concludes that there are effects that are better suited for digital nudging. Simplification, social norms, and availability are the effects that were evaluated highest in terms of usefulness.

Simplification is an effect that digital nudging is benefiting greatly from because it limits or simplifies the presented information. The problem regarding lack of space on a mobile device is mentioned in Section 6.2.2, and simplification

can help solve this issue. The social norm effect also stands out because of a digital nudging system's ability to collect information that can be used with the social norm nudges.

Social norm is an effect that is deeply rooted in our lives; people constantly seek approval and have a fundamental need to belong [34]. Combining this with a digital context's ability to collect information about social contacts makes social norms highly useful for digital nudging. Considering that the effect is evaluated as neutral in difficulty, the effect is well suited for digital nudging.

Availability is well suited for digital nudging because we can utilize the already highly available mobile devices. Then it is a matter of choosing what is favorable to make available to the user and use it with, e.g., a widget or notification. Continuously reminding the user of the goals that have been set can increase the chances of completing the activities the goal consists of [35].

There are also some general cases that all the psychological effects can benefit from in digital nudging. Providing live data from various sources of information will tailor the nudges for the user's current situation, making them more reliable. The ease of changing how we present the nudges allows the system to react to nudges that do not work as intended. This can be achieved by incremental learning, recording the reactions, and updating the user's nudging preferences. Lastly, the ability to use effects in different layers supporting each other is a unique ability a digital nudging system can use to its advantage.

The last goal was to show how the effects and strategies can be implemented, and Chapter 5 presents these implementations. A subset of the effects is implemented based on the descriptions made in Section 4.3.1, where the effects were described towards the case of physical activity. As mentioned in Section 4.5 the nudge strategies presented in Section 4.4 was decided not to be implemented because the work done in this thesis creates a foundation for the strategies. However, the strategies are suggested as future work.

/7

Conclusion

This thesis aimed to study psychological effects and specifically how psychological effects for behavioral change can be represented digitally and used in smart nudges. After studying literature on nudging and psychological effects, a set of effects is described, and a design applying them for a specific nudging goal is provided. By designing and implementing the psychological effects, the thesis was able to show how the effects can be utilized in digital nudging. With the experience from implementing the effects, an evaluation of each effect's usefulness and difficulty was proposed to establish if some effects were better suited for digital nudging. Usefulness refers to the effect's ability to be combined with other effects and how well it is perceived to work by itself in a nudge. Difficulty refers to the complexity of creating a nudge with a specific effect. The results from the evaluation show that simplification, social norms, and availability stand out as the most suited effects from the ones proposed in this thesis. They utilize the strengths that digital nudging provides, as well as minimizing some of the downsides. Availability benefits from the frequency of mobile phone use, simplification helps solve the lack of space in digital contexts, and social norms can utilize the possibility of activity data from social contacts. Combining this with their ability to be combined or support other effects is why they are better suited for digital nudging.

7.1 Future Work

This thesis has opened up several possible areas for continued research, taking the nudges in a smart nudging system and the components supporting it further. The most interesting topics are listed below.

Implementation Since only a subset of the psychological effects was implemented in this thesis, continuing and implementing all of the effects and strategies would be of great value. This would allow for testing the whole specter of nudges on actual users, collecting valuable feedback about what works and what that does not work.

Changing the goal This thesis provided psychological effects with examples and implementations towards a specific goal. Seeing similar implementations and research towards another goal will answer questions about how well the effects and strategies can be translated to other means.

System for evaluation Evaluating the effects that are presented to the user in order to measure what type of effect that works best is a crucial part of the smart nudging system. If a nudge with an effect is consistently not successful then the system needs to learn this and reduce the times this effect is used. As mentioned in Section 6.1.3, choice types can be used as a way of evaluating effects within each choice type as they can vary in how they are presented.

Nudge choosing component Dynamically choosing the effects for a nudge is essential for an application nudging users towards a goal. Identifying the steps needed to choose all the components necessary to create a nudge is something that must be figured out.

Nudge strategies The nudge strategies presented in Section **??** can be valuable to implement and test to see how the effects work. They can be valuable to a smart nudging system because of the studies on their effectiveness and provide more diversity to how a system can give nudges.

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