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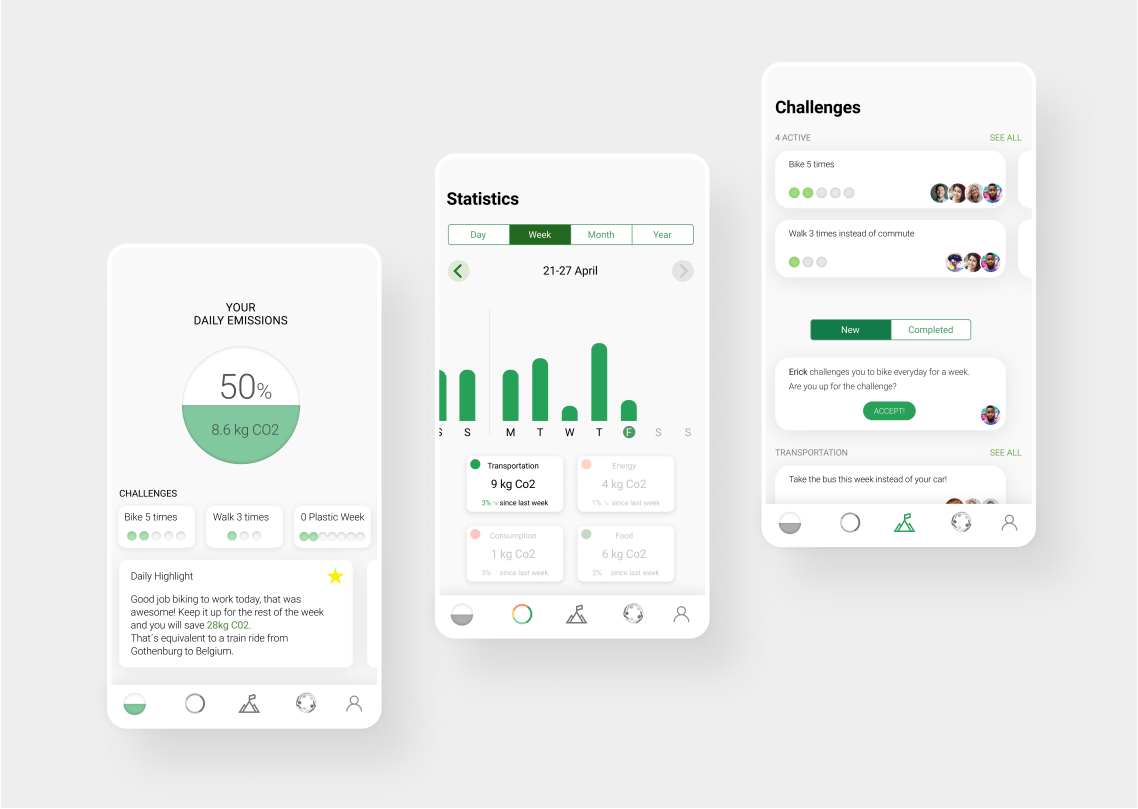

Behavioral Change through Interaction Design

Minimizing individuals' environmental impact in their daily life

Master's Thesis in Interaction Design and Technologies

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CHALMERS UNIVERSITY OF TECHNOLOGY
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Master's thesis 2019

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Cover: Final screens of EcoHero, see chapter 7.2 The Final Prototype.

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Abstract

Living an environmentally sustainable lifestyle is an important factor for the well-being and future of the planet. Making a change towards a lifestyle more beneficial to the environment is critical in order to slow down the consequences of the negative trend. Making a drastic change in one's daily life can be difficult. Motivational systems, such as persuasive user interfaces, supporting communities, and helping relationships, could engage and support people in making lifestyle changes. This could lead to a behavior change that favours the environment. The use of computers as persuasive technologies to change behaviors and attitudes was coined by B. J Fogg as Captology. This thesis explores how persuasive design principles can be used to motivate, support and raise awareness of individuals' environmental footprint in the design of an eco-feedback carbon footprint calculator.

Several areas were researched, and behavior change theories and persuasive design principles were proven to be valuable for the project aim. A preliminary study was carried out to explore existing research and solutions in the context, and an expert within the field of sustainability was consulted to provide guidance and support in the project. To understand the needs of potential users in the context, a questionnaire was distributed and answered by respondents. As part of an iterative design process, theoretical knowledge and user insights were transformed into prototypes and were thereafter validated in a realistic setting.

The final result of this master's thesis is a concept and prototype of a smartphone application called EcoHero. EcoHero utilizes principles of persuasive design, persuasion guidelines and behavior change theories and provides users with their daily carbon footprint summary, through calculations of their purchases and transportation routines. Together with EcoHero, 5 suggested features for designing persuasive technology related to behavior change were identified.

The result of this project can be seen as an example of how to implement persuasive design principles in parallel with behavior change theories when designing eco-feedback applications. To fully understand the impact of the identified insights, the long term use aspect should be explored in future work.

Keywords: interaction design, behavioral change, sustainability, self-tracking, carbon footprint, persuasive design, persuasive technology

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List of Definitions

Sustainability, Self-knowledge, Eco-feedback, Interaction design, carbon footprint, individual carbon footprint, EcoHero

List of abbreviations and acronyms

HCI - Human-Computer Interaction
SHCI - Sustainable Human-Computer Interaction
GHG - Greenhouse Gas
GWP - Global warming potential

1 Introduction

This section gives an introduction to this Master's Thesis. It begins with an introduction to current environmental challenges, followed by a description of how these challenges can be approached through the field of interaction design in the context of behavioral change. Thereafter, the research problem is presented, as well as the research questions, followed by the aim of the project and its limitations.

1.1 Environment and Sustainability

Today we face several environmental challenges, where a critical one is Greenhouse Gas (GHG) emissions, due to rapid climate changes (Ericsson 2018; Pittock 2005). Climate changes are a threat to the ecosystem, thus affect our present and future well-being (Schanes, Giljum, and Hertwich 2016). Ongoing debates urge people to make informed decisions to change behaviors and living conditions, expressed with the implication of non-reversible effects on the planet (Team 2019).

The threatened climate and the need for change are not groundbreaking news and have not been for a substantial amount of time. Still, people remain passive and reluctant to make changes in their daily life, due to various reasons or conflicting motivations (Manning 2009). To make a positive impact on the environment, a variety of activities can be carried out on both individual and communal levels. It is becoming vital that more stakeholders and people are included in making environmentally conscious decisions (Ericsson 2018; Team 2019). But engaging individuals in making drastic behavioral changes where living standards might need to be altered is not considered an easy task, especially if a lasting behavior change is a goal.

1.2 Interaction Design for Behavioral Change

A lot of research has been conducted on the wide topic of behavioral change, particularly within areas such as health, fitness and psychology (Davis et al. 2015). While this is paralleled by a growing market and interest in mobile applications supporting behavioral change, there is still a lack of research regarding the perception and use of such applications, according to (Dennison et al. 2013). The area of using interaction design for behavioral change is still quite novel and has yet not been studied in greater depth, even though some studies have shown positive outcomes regarding physical activity (Gal et al. 2018; Eckerstorfer et al. 2018; Flores-Mateo et al. 2015).

Within the field of Human-Computer Interaction (HCI), it already exist applications with the goal of supporting or nudging (Thaler and Sunstein 2009) users to act more environmentally aware, although many of these applications require considerable amounts of manual input from the user, and they often tackle merely one problem at the time, such as transportation awareness (Sullivan et al. 2016). There is also a growing interest in self-quantification applications (Sjöklint 2014),

however, the purpose of most of them is to improve behaviors connected to individual health.

While behavioral change related to sustainability is a growing field, research using principles of persuasive design is relatively unexplored. Within this Master's Thesis project, we will explore different principles and frameworks for designing for behavioral change, such as the *Transtheoretical Model of Change* (Prochaska and Velicer 1997) and *Persuasive Design* (Grasso, Ham, and Masthoff 2011), to create a concept for the context.

1.3 Problem Description

Today's environmental situation, with high levels of GHG emissions and rapid climate change, is a multifaceted and global problem area concerning large populations throughout all societies. Various actions have been taken to lessen the impact human behavior has on the environment, but climate changes seem to be inevitable. A lot of studies have been conducted on how to reduce GHG emissions, but a lot of focus has been put on high-level changes, while less focus has been on how behavior changes among individuals can lessen the impacts on GHG emissions. The individual impact might be seen as relatively small and not equally important compared to bigger establishments, but behavioral change for people within larger groups of the population could have a substantial positive impact on the environment (Sullivan et al. 2016).

According to Sullivan et al. (ibid.) there is a need for more effective intervention strategies that aim to motivate individuals to change their lifestyles and behaviors, focusing on smaller steps. Although there have been many attempts within the technology sector to contribute and studies show that the possibility of simpler applications such as GHG calculators and applications could make a change, applications in the context fall short since they require too much navigation and manual user input, resulting in being ineffective in supporting behavioral change in a long-term sustainable way. Nkwo, Orji, and Ugah (2018) states that technology can be designed in a way that promotes a sustainable environment through empowerment or discouragement of certain human behaviors. They also note that the field of HCI is making further advances towards capitalizing on the influential role technology possesses when it comes to designing interactive systems for people to use in their daily life (ibid.).

More research is needed for potential applications that evoke behavior change for climate benefits (Sullivan et al. 2016). It is acknowledged by the European Union that greater behavioral changes at an individual level might be needed - it might even be a critically important solution for reaching the target numbers for the GHG emissions on earth (Schanes, Giljum, and Hertwich 2016). Therefore, we see that there is a need to further explore the possibilities within the chosen research area of this Master's Thesis.

1.4 Research Question

> *How can individual carbon footprint be decreased through interaction design incorporating methods for behavioral change in the design of smart phone applications?*

Assuming the answer to the first research question is positive, the aim is to answer an additional research question, which is the following:

> *Which key features should be considered when designing mobile applications aiming to decrease the carbon footprint of their users?*

1.5 Aim

This project is in the form of a thesis, and it aims to explore how to design applications through the field of behavioral change related to sustainability concentrating on the user's daily life. The result will be applicable for when designing future interactive products that aim to address user behavior regarding environmental sustainability, and what principles can be used to motivate and engage users in making a long-term behavior change. The final result of this project is a concept, consisting of a prototype and design features that should be considered when designing for behavioral change concerning sustainability.

1.6 Limitations

The end result of this thesis is primarily insights in how to change behavior through interaction design as well as a conceptual design, including prototypes that follow and include these design features. The final prototype is not intended to be a functional and completed product, and it is limited in this thesis to a smartphone application and not anything else. The aim of developing prototypes as a part of this thesis is to display the concept that is being researched and to enable efficient evaluations of the concept and the methods and principles used through user testing of the prototypes. The level of fidelity of the prototype should be interactive enough for this cause. Another limitation is not being able to test the concept for a longer period of time with potential users, such as conducting observations on users or catching their behaviors and attitudes during a number of days to fully test the prototype and concept and be provides with their feedback, which would have been tremendously valuable in designing applications for maintaining a sustainable lifestyle. To identify features supporting a lasting behavior change is the end goal of the project and it is addressed throughout the project, although it is not evaluated fully in this project.

Together with the research question, the thesis is based on a couple of assumptions, to steer and base the project on. One assumption is that it is possible to influence and change the behavior of humans through design, and more specifically: that it is possible to influence and change the behavior of humans through the design of mobile applications.

2 Background

In this chapter, background information about the different topics and theoretical frameworks that are discussed within this Master's Thesis will be described. Firstly, there will be an introduction to sustainability and the concept related to behavior. Secondly, an introduction will be given to the concept of carbon footprint to fully give an understanding of the importance of the individual carbon footprint. Lastly, present research on carbon calculators will be stated, since it is a fundamental part of this thesis.

The background section closes with a description of sustainability in relation to HCI, and a presentation of related work within the research area, where three systems will be portrayed.

2.1 Sustainability

The term sustainability is a quite simple idea but yet so complicated. A straightforward definition of the term might be "a sustainable system is one which survives or persists" (Costanza and Patten 1995). Another definition made by J. Brown et al. (1987) is "a sustainable world as one in which humans can survive without jeopardizing the continued survival of future generations of humans in a healthy environment".The definition of sustainability is broad and acts as an umbrella term, including various aspects with different meanings.

In this chapter, we define and limit the scope of sustainability related to the context and discipline of HCI, which is the main focus of this thesis. Sustainability can be divided into different overarching interaction levels, where the individual level is located in the center, and included in the organizational, political, social-cultural and ecological levels. It is at the individual level where decisions are initiated and taken place, which thereafter stems out in the outer levels where changes occur (Chung and Sundaram 2014). Consequently, the inner individual level, which is the main focus within this thesis, can make a substantial difference to the levels above.

2.1.1 Sustainability and Behavior

Citizens in today's society acquire more awareness about the environmental impact our daily habits have on the planet. Contrary to our increased knowledge about the environment and our impact on it, our actions seldom correspond with how the research says we should act to make a positive change (Arnold et al. 2018).

According to Preece, Rogers, and Sharp (2015) comprehensive research has been conducted that shows how continuous feedback provided to people regarding their energy usage decreases their energy consumption, as shown by Froehlich, Findlater, and Landay (2010). There are several aspects in play when deciding the efficiency of these mechanics, where the most prominent ones are the frequency of feedback, the type of representation used and social norms (Preece,

Rogers, and Sharp 2015, p. 151). Similar parameters could potentially be utilized to support people in changing more behaviors, such as making food and shopping choices more beneficial to the environment.

2.1.2 The concept of Carbon Footprint

Carbon footprint is a term that describes the total amount of Greenhouse Gas (GHG) emissions that are caused by an individual, an organization, an event or a product. The carbon footprint can be both indirect and direct actions caused by the subject. The emissions are calculated from every step of the product's or service's life cycle. Pertsova (2007) defines it as "... a measure of the exclusive total amount of carbon dioxide emissions that are directly and indirectly caused by an activity or is accumulated over the life stages of a product". The emitted gases are often gases such as methane or nitrous oxide, which have different effects related to global warming due to their different abilities to trap the heat inside the atmosphere, which is the cause of global warming. The Global Warming Potential (GWP) is used to transform the numbers of the different emissions to CO_2e so that they can be compared (*Carbon Footprint Factsheet* 2018).

2.1.3 Individual Carbon Footprint

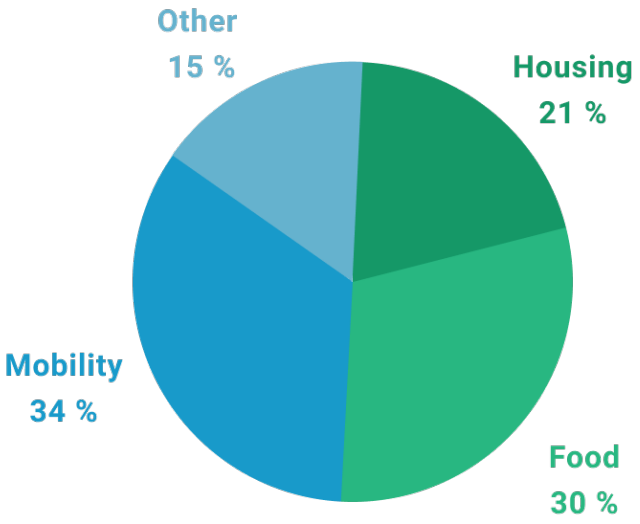

Figure 1: Graph showing the initial median carbon footprint(kg CO_2e per consumption unit per year) for households included in the HOPE study (Dubois et al. 2019).

The individual carbon footprint is the result of all of the GHG emissions of one person. On an individual level, there are many opportunities for change to happen in order to decrease one's carbon

footprint (Schanes, Giljum, and Hertwich 2016). Many include making changes to, or decreasing, living standards and habits, which might be challenging to fully complete. The awareness of the individual carbon footprint is growing, this is most likely in connection to new technologies such as carbon calculators (Pertsova 2007). When making several adjustments to improve the individual carbon footprint, regardless of how insignificant or grand they might feel like, it can initially feel overwhelming. Although it is important to remember that perfection is not a must in order to make major improvements (Manning 2009). Even if there is extensive research suggesting what individuals should do to decrease their carbon footprint, individuals might not want to compromise their living standards, even if they have the knowledge to do it (Bohr 2014). The biggest contributing categories to the individual footprint is food, transportation, housing/energy, and consumption (Malis 2014).

Application area 1: Food Consumption

Emissions connected to food consumption is one of the biggest problems and a serious threat when it comes to climate change and global GHG emissions (Hallström, Carlsson-Kanyama, and Börjesson 2015; Sullivan et al. 2016). Estimates show that around 83 % of the emissions come from the production of food (*Carbon Footprint Factsheet* 2018) and 14 % of the global greenhouse gas emissions come from livestock and dairy. That is the equivalent to 7.1 gigatonnes CO_2e per year (Gerber et al. 2013). Meat from cattle is the biggest contributor, and the methane emissions from the production of cattle meat have a much higher effect on the global warming, in total up to around 21 % more than CO_2 (Malis 2014). This problem is strongly connected to consumer demands.

Research shows that dietary change of individuals could have a huge impact and decrease the emissions from the food sector by 50 % (Hallström, Carlsson-Kanyama, and Börjesson 2015). By switching from a total meat-based diet to eating one vegetarian meal every week for a year, one person could save the equivalent emissions from driving 1000 miles (*Carbon Footprint Factsheet* 2018). Factors such as eating locally produced have also gotten a lot of attention when It comes to sustainability, although this is most often not a good measurement. The emissions from the production of tomatoes in colder countries might, for example, be much higher than from tomatoes grown in warmer countries due to the need for heating and such. It is therefore important to consider all contributing factors (Engelhaupt 2008).

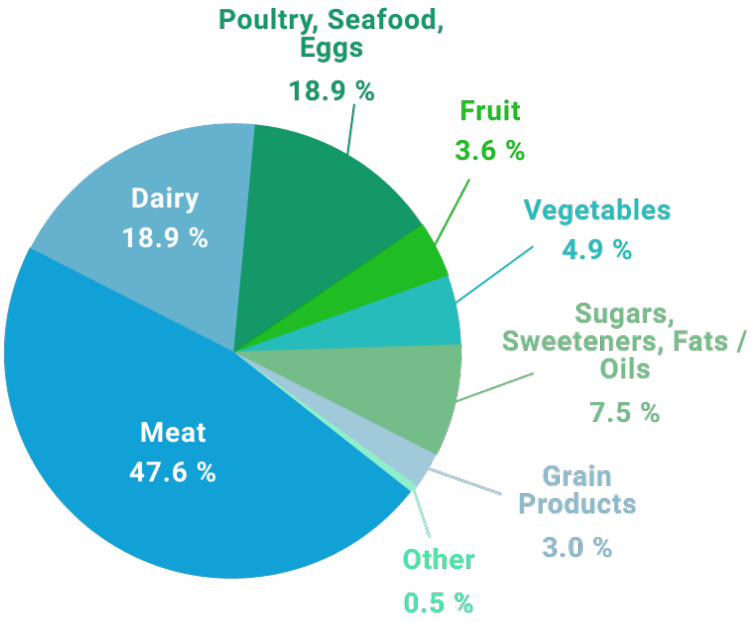

Figure 2: Graph presenting greenhouse gases from average food consumption. Pounds of CO_2e per serving (4oz. meat, 1/2 c.asparagus and carrots, 8 OZ. liquids) (*Carbon Footprint Factsheet* 2018).

Application area 2: Transportation

Transportation is one of the biggest problem areas when it comes to emissions, where about 22 % of emissions related to energy depend on the increasing use of motorized vehicles (Sullivan et al. 2016). Traveling by car and airplanes are massive negative contributors to the global effects on the environment, but in a society that is shaped for using motorized vehicles, making changes into other transportation methods can be difficult, despite the fact there being well-developed infrastructure, such as trains and other public transport.

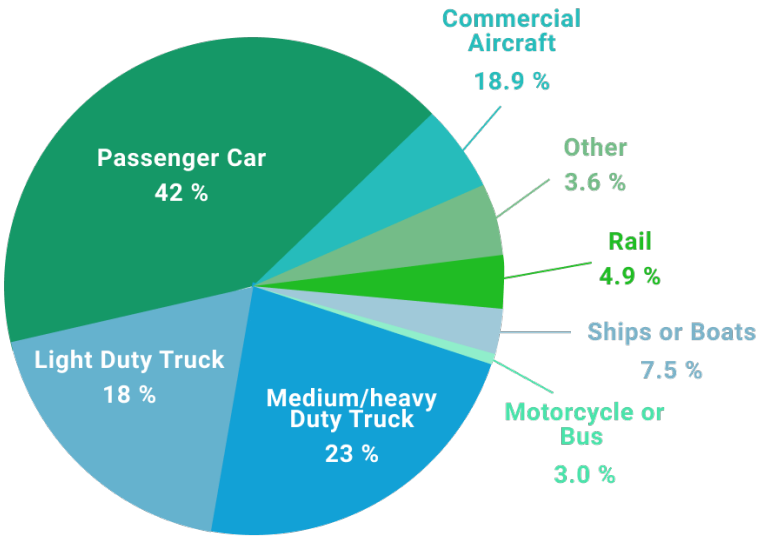

Figure 3: Graph showing the distribution of greenhouse gases emitted by the different sectors of transportation, 2016 (*Carbon Footprint Factsheet* 2018).

Application area 3: Household Energy use

According to *Carbon Footprint Factsheet* (2018), 10.3 % of all U.S emissions come from household electricity, of which about 53 % come from heating and cooling. A lot of focus within households have been connected to using more energy-efficient appliances. Despite the fact that using energy-efficient appliances is a good start and an important change to make, we also need to change the way in which we use them (Gram-Hanssen 2011). A quick but effective change to make in the context is to decrease unnecessary electricity use, specifically during nighttime and when no one is located in the household (*How much electricity does a home use?* N.d.).

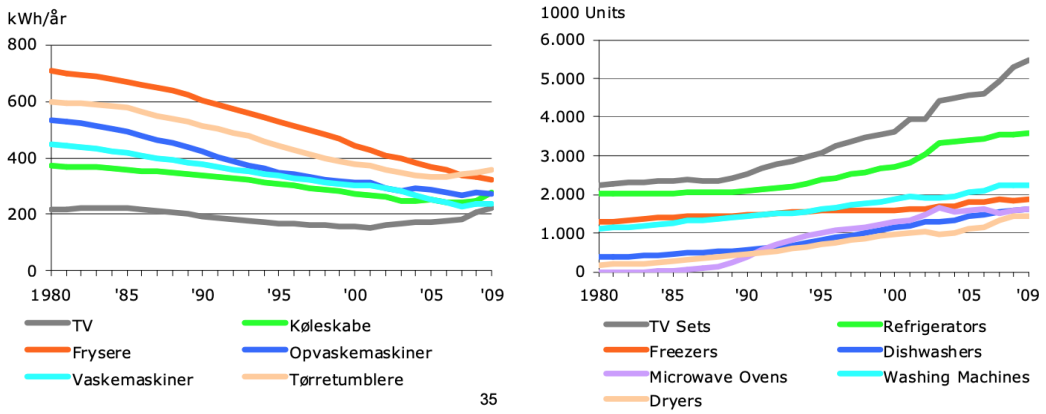

Figure 4: Graphs showing data for household appliances (color coded graphs) and energy use (y-axis), from a study made with danish homes (for 1980 to 2009; x-axis). Left: energy efficiency of household appliances 1980-2004, (KWh/year), right: number of units off appliances 1980-2008, (1000 pcs) (*Energy Statistics 2009* 2010).

Application area 4: Consumption

The fourth most contributing factor to the individual carbon footprint is consumption. As Assadourian (2010) state, consumption is natural in a human's life, but not to the extent we are living today. Although buying less is an important factor it is not as simple as that. To decrease consumption factors like quantity, quality, production, material, use, and end-of-life of the products and services needs to be considered. There are also possibilities of making progress by borrowing and buying vintage (Schanes, Giljum, and Hertwich 2016). Consumer demands have a huge role in what is produced and because of that, making sustainable choices can have a major impact (Malis 2014).

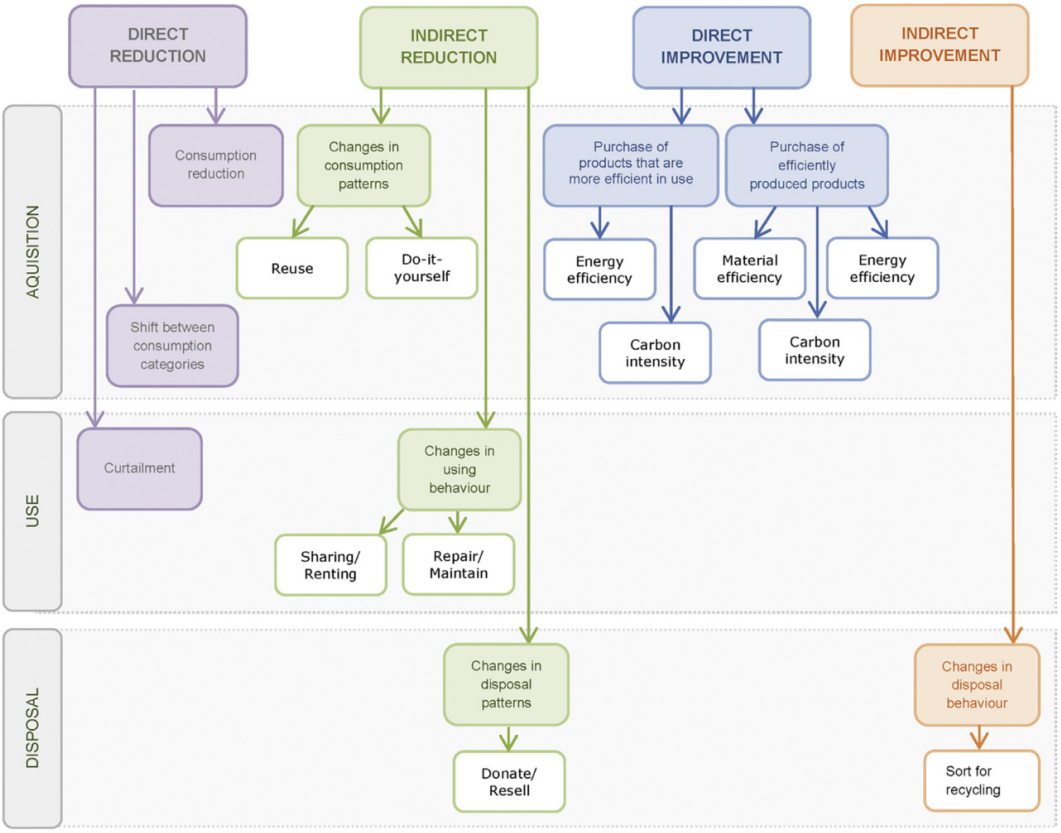

Figure 5: The flowchart explains the Framework for mitigation strategies and options for consumers to create better consumption patterns (Schanes, Giljum, and Hertwich 2016)

2.1.4 Carbon Calculators and Eco-Feedback

New technologies and services have emerged within the last years with the purpose of calculating people's individual carbon footprint. These technologies are often based on data people are filling in regarding their habits with food, transportation, travel, energy use and similar areas in the context. Although efficient, these carbon calculators often lack in consistency and transparency of methods and calculations (Padgett et al. 2008).

Carbon calculators can be related to the popular research field of sustainable HCI called *Eco-Feedback Technology*, which Froehlich, Findlater, and Landay (2010) define as technology that provides feedback on individual or group behavior related to sustainability with the goal of decreasing the environmental impact, while others see eco-feedback technology closer related to research within persuasive technologies (Brian J Fogg 2002).

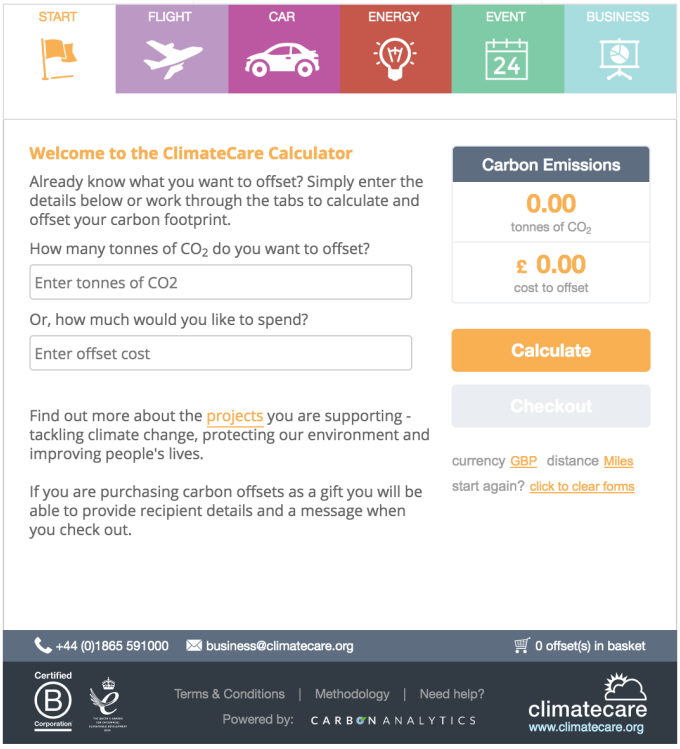

Figure 6: A carbon calculator from climatecare.org, where users can choose to calculate their various carbon emissions.

2.2 Sustainability meets Human-Computer Interaction

As a response to sustainability issues related to the four application areas mentioned earlier, together with the wide use of mobile technology, new opportunities have opened up for tools aiming to help users change behavior regarding sustainability, which is a part of the research field called Sustainable Human-Computer Interaction (HCI) (Chung and Sundaram 2014; Dourish 2010; Preece, Rogers, and Sharp 2015). Sustainable HCI includes, among other things, research related to environmental sustainability and ecological responsibilities connected to pursuing a technology-centered lifestyle. Within sustainable HCI, there is a focus on making people understand and change their behavior related to their environmental footprint, both on an individual and communal level (Preece, Rogers, and Sharp 2015). Due to the worldwide concern of the environment, with rising climate changes and GHG emissions, many researchers within HCI aim to develop new solutions that can sense energy consumption and deliver real-time data to people, to help them decrease their energy consumption (ibid.).

Sustainable HCI is closely connected to Sustainable Interaction Design (SID). As a designer, several aspects are critical to the development of interactive products related to sustainability. The discipline SID is used when the interaction design has sustainability in the focus of the design and the development of products and services (Blevis 2007). Cooper et al. (2014) claims that there should be a more cohesive consideration regarding sustainability and that it is important

that designers consider the total life cycle of their designs and what the consequences might be on the environment when users use their products. For instance, innovation can have negative consequences from a sustainable perspective where the use of digital material can lead to more use of physical material, which can affect behavior and the environment in total (Blevis 2007). According to Dourish (2010) it is also necessary to take potential contradictions that might stand in the way of the goal when designing for sustainable HCI with environmental aspects.

In a study by DiSalvo, Sengers, and Brynjarsdóttir (2010), a mapping was made of the area of sustainable HCI in an attempt to define the field. Sustainable HCI can be divided into two different directions: sustainability in design and sustainability through design, where the former includes material effects of the product (e.g. minimizing the electricity usage of a product) and the latter includes lifestyle or decision making. These two categories are often overlapping (ibid.). In this thesis, we are focusing on sustainability through design.

2.3 Related Work

As a reaction to the sustainability dilemma, together with the rise of new technologies, several closely related applications and systems have been proposed to give their users opportunities to make changes related to sustainability. Also, through media, we are often told to be more sustainable and "go green" regarding many aspects of our lives. Some of the most prominent areas discussed through media are how and what we eat, how we get to places, how we recycle and our consumption habits. Overall, it is often about changing our mindsets and routines to reach a desirable behavior that favors the environment. There are various applications and systems on the market today that provide users with the self-knowledge of their behavior, which lets them monitor their behavior accordingly (Preece, Rogers, and Sharp 2015), with the basis of interaction design respectively behavioral change. In this related works section, three applications in this context are described.

An application that falls within the research context is *Worldbeing*. *Worldbeing* is a project idea of a wearable that is designed to track the user's daily carbon footprint. The aim is to help the user make behavioral changes that support the well being of the earth. One goal with the project is to make it meaningful and engaging to monitor one's carbon footprint and get insights into how one's behavior affects the planet. The system relies on exciting technologies in wearables such as Google Maps and various payment services to track the carbon footprint of the user. The creators of *Worldbeing* want the user to see the connection between habits and carbon footprint, to enable the user to make better and informed choices (*Sustainable System, LAYER* n.d.).

WaterBot is a system aiming to decrease water use in a household setting by focusing on the daily interaction with the sink, since it is one of the places where the most waste of water occurs (Bonanni et al. 2005). *WaterBot* uses a combination of positive feedback and reminders when people use the faucets, to influence them to turn off the tap. *WaterBot* provides the user with continuous feedback together with social validation, enabling the users to compare their behaviors with other members of the household. One goal of the system is for the participants to see

the faucet as a utilitarian object and the water resource as something highly valuable (Bonanni et al. 2005).

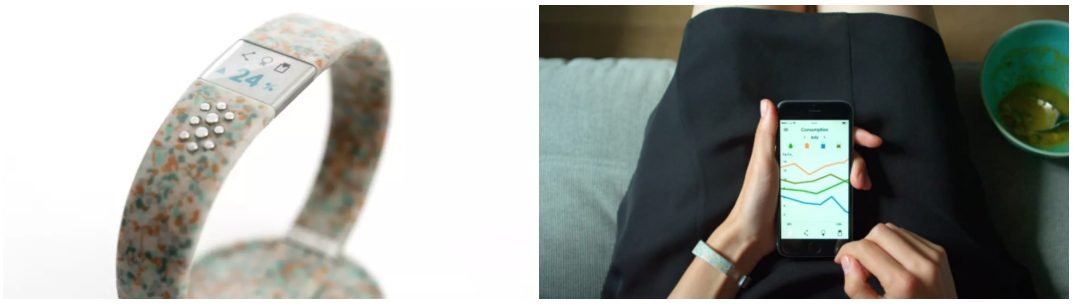

Figure 7: A picture of the product WorldBeing that consists of a wearable bracelet that is connected to an smartphone application (*Sustainable System, LAYER* n.d.).

Svalna is a Swedish developed application just released this year (2019) with the aim of providing the user with knowledge of their carbon footprint, where the user can calculate their carbon emissions. The application focus on displaying the user's carbon emissions based on consumed products and services, and users are able to join groups and set goals related to sustainability.

Figure 8: A screen from the application Svalna, showing the total carbon emissions for a user.

3 Theoretical background

To fully understand the area of behavioral change through interaction design, an extensive research phase was executed. This theory section describes the theory, concepts, and frameworks that were used as the base for the thesis work. Firstly the design approach taken will be described, followed by an explanation of the discipline of Interaction Design. Thereafter the theories on behavioral change, there among the Transtheoretical Model of Change, and persuasive design will be introduced.

3.1 Design Approach

Research design is a concept describing the approach of how to get answers to a research problem and get a desirable outcome of evidence. Critical within this approach is to not only focus on literature and research that is coherent with the researchers' own hypothesis or attitudes but include the literature that is critical of a studied phenomenon. This will ensure the outcome to be valid and trustworthy, and not be skewed to certain hypotheses of the researchers themselves.

Gaver (2012) argues that research through design can result in theories being temporary and circumstantial. Research within design could be more valuable if we value its exploratory aspect and power of developing new rich artifacts from results, instead of developing increasingly substantial design theories. A criterion for a good research design is also, according to Wadsworth (2016), to focus on the research question throughout the process, and that the research has a clear purpose and context. Important is also the part of us researchers being critical and challenge the evidence and insights, and how our part as researchers potentially might influence the results, and instead focusing on the user and their needs, thoughts and perspective.

Considering the aspects above, the aim of the project is to create a concept-centered research result as a final outcome in the form of a prototype. The prototype will be designed through guidelines received from the research phase, and be presented along with insights and findings. The project will aim for a planned *Research Design approach* according to Wadsworth (ibid.), with a continuous focus on the research question.

3.2 Interaction Design

Interaction Design is the umbrella term for the design of various interactive systems, products and services, where there is an increased focus on the user, and how the user will interact with the artefact in context (Preece, Rogers, and Sharp 2015). Within interaction design, there are several different areas that focus on certain aspects or technologies, among other web design, product design, software design, user-centered design and experience design (ibid.). Interaction design is involved in all fields and areas where computer-based systems are designed and developed, and the principles of interaction design are valuable in all of these areas.

The principles of interaction design are guidelines to help design interactive products according to users' goals and needs and provide positive experiences thereby. These guidelines often approach ways of designing products related to form, behavior and the content itself, with the purpose of designing products for human intellect and needs instead of a system-based focus (Cooper et al. 2014). There is often a big difference between systems and services that are designed with the user foremost in mind or with the system-centered design approach. Designs with the incorrect approach can lead to feelings of annoyance or frustration for the user. The user experience of interactive products is, therefore, according to Preece, Rogers, and Sharp (2015), fundamental within interaction design and something that should always be aimed for.

3.3 Transtheoretical Model of Change

The Transtheoretical Model of Change is a framework created to address different aspects of behavioral change. The framework was created to address behavioral issues regarding individual health and habits, such as quitting smoking or exercising more (Faklaris, Dabbish, and Hong 2018a), although the framework has been used in a wide range of fields. Within the field of interaction design, it has been used in a study where user behavior regarding internet security was addressed (ibid.), and in another study where sustainable behavior connected to energy feedback was in focus (He, Greenberg, and Huang 2010). The framework identifies six stages of change which are the following; pre-contemplation, contemplation, preparation, action, maintenance and termination. The framework aims to create progress, as well as a balance in decision-making, self-efficacy and temptations. Making use of this framework, studies have shown positive results with computer-based interactive interventions that are individualized for the user (Prochaska and Velicer 1997).

In the first stage, *Precontemplation*, the user does not yet have the intention of making a change in the future, but in about a 6 months range. The lack of intention to change might be because of the fact that they do not have enough information or are simply misinformed of the consequences that their behavior might result in. Another cause can be because of discouragement after failing previous behavior change attempts. Users in the precontemplation stage do most likely not want to talk or think about their behavior or the risks that come with it (ibid.).

The second stage *Contemplation* takes place when the user, contrary to the former stage, has the intention of making a change within about 6 months of time, and have understood the value of the change as well as the negative sides that will come with. If the user identifies the negative aspects to be too hard to tackle, there is a risk that the user gets stuck in this stage. The user will then most likely procrastinate instead of making the changes. (ibid.).

The third stage, *Preparation*, takes place when the user has decided to start the change within about a month. These users might already have a plan or have taken small steps towards starting their journey of change, such as joining a group or buying a book related to the specific purpose. (ibid.).

The fourth stage, *Action*, occurs when the user has made changes connected to the behavioral problem situation within the six months that have passed. To be labeled as an action within this stage the user must achieve a certain level of change that has been set in advance. For example, a person who is a heavy smoker could have decided to lower their usage of cigarettes and smoke a certain number of times a week as a behavioral change step. (Prochaska and Velicer 1997).

The fifth step, *Maintenance*, occurs when changes in the behavior have been made and continuous work with relapse prevention is needed. This stage can span from 6 months to 5 years, with the relapse risk decreasing with time. If relapsing occurs, the user will fall back in the change process and reverse to a previous stages.(ibid.).

The sixth and last stage, *Termination*, is when the user has gone through with the change and does not have any temptations or wishes to go back. The behavior change process that has been carried through will be sustainable even if the user goes through challenges like loneliness or stress. This stage is not attained by all users, far from. Most users will have to work on maintaining the changes for the rest of their lives, with more or less temptation of relapsing (ibid.).

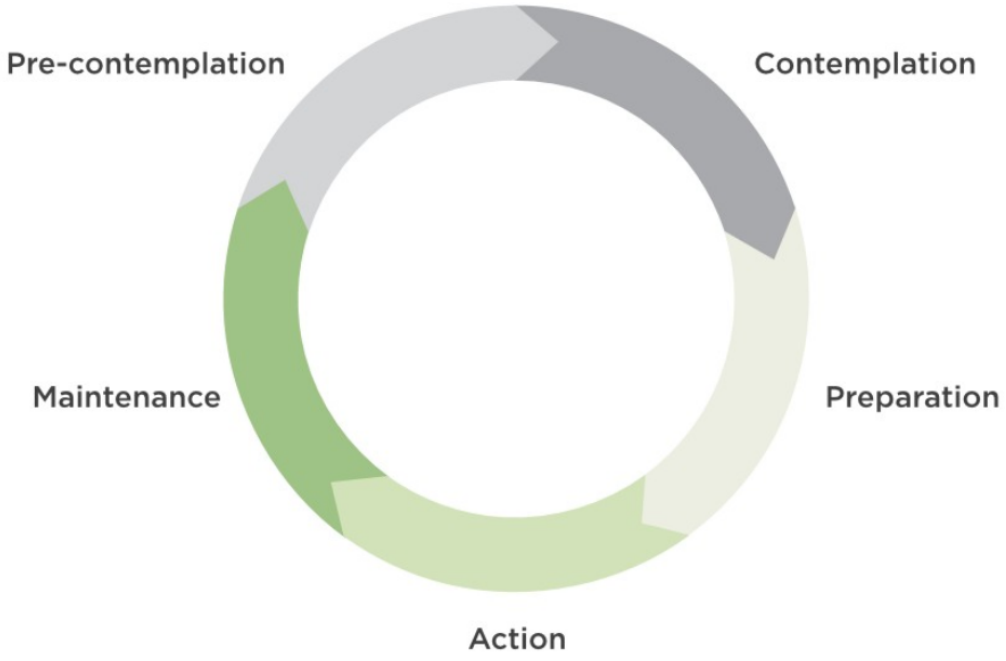

Figure 9: Five of the six stages of change from the Transtheoretical Model of Change (Prochaska and Velicer 1997). The last stage not shown, Termination, is when the user has carried through the change and will not fall back into the previous behavior.

The Transtheoretical Model of Change also defines 10 processes of change as independent variables and guidelines that are used to achieve progress throughout the stages (ibid.).

1. *Consciousness Raising* is about raising the user's awareness about the causes, consequences and solutions of the behavioral problem. In this stage can informational education, feedback and confrontation be used to raise the user's consciousness about a specific situation.

2. *Dramatic Relief* aims to create one or multiple emotional experiences for the user.

3. *Self-Reevaluation* lets the user asses the self-image both with and without the behavior that is addressed. To help the user self-asses their own behavior, role models or imagery techniques can be used.

4. *Environmental Reevaluation* aims to make the user asses how the individual behavior affects the social environment, and how the user acts as a role model in their environment. Helping the user asses these techniques can be used to inform the user about empathy.

5. *Self-Liberation*. In the stage self-liberation, the user has come to the conclusion that the change is possible, and is willing to commit to making the change as well as acting to fulfill it. To increase the willpower, the user can share the commitment publicly, among other things. It is also good for the user to have more than one way to success, and up to four choices enhance the success rate, according to studies.

6. *Social Liberation* is about finding support in the social and environmental surroundings of the user. It aims to highlight opportunities for the good behavior in the environment to make it easier for the user. Smoke-free zones for people trying to quit smoking are clear examples of the social liberation principle.

7. *Counter-Conditioning* aims to make the user find a good behavioral pattern to trade for the previous bad behavior.

8. *Stimulus Control* aims to remove the triggers of the bad behavior from the surroundings of the user. It also aims to add triggers for supporting a desirable behavior.

9. *Contingency Management* is about using rewards and punishments as consequences of the actions taken by the user. Studies show that rewards are often more successful than the use of punishments. Public recognition can also be a tool to use to make sure that positive behavior is continued.

10. *Helping Relationships* aims to make sure that the user has social support that can help them in making the change. Important factors in these relationships are trust, care, openness and acceptance.

3.4 Persuasion

Persuasion is a term that is not entirely agreed upon, regardless of years of research (Brian J Fogg 2002). Brian J Fogg (ibid.) defines persuasion broadly as *"an attempt to change attitudes or behaviors or both (without using coercion or deception)"*, and states that many professions within the research area would agree upon this definition.

There are various persuasive techniques that can be used to influence people, including both social influence strategies and psychology strategies (Goldstein, S. Martin, and R. B. Cialdini 2017). Even by using persuasive strategies in communication situations can result in influencing people. A single word that can strengthen a persuasion attempt, according to Goldstein, S. Martin, and R. B. Cialdini (ibid.), is *Because*. Studies show that by adding a valid reason to *Because*, persuasion attempts are much more likely to be successful compared to attempts without them (ibid.). Another way of persuading people to make a change is to use the *Fresh Start effect* (Janson and Laninge 2017). We are more likely to start something or make a change when we experience reaching a milestone. We begin reflecting on our lives and routines, which result in us setting new goals. New Year's Eve is an unmistakable example of this principle (ibid.), which motivates people with the beginning of a new year.

In the book *Influence: Science and Practice* R. Cialdini (1993) explains six principles of social influence as ways of persuasion. These principles are Reciprocation, Authority, Commitment and Consistency, Scarcity, Liking and Social Proof. *Reciprocation* means that we feel bound to return favors given to us, while *Authority* makes us look to authoritarian figures and leaders to show us the correct path. *Commitment/Consistency* is about us wanting to act according to our values and commitments, and *Scarcity* as a principle makes us think that the less available a product is the more value it has, which makes us want it more since we do not want to miss the opportunity, stated similarly in Janson and Laninge (2017). *Liking* in the context is about us being more likely to agree and say yes to people who we like, whereas *Social Proof* is when we look to other people's behavior when deciding how to behave ourselves.

3.4.1 Persuasive Design

Systems aiming to influence and motivate people are often called *Motivational Systems*. Grasso, Ham, and Masthoff (2011) identify three prominent research fields investigating Motivational Systems, being *Affective Computing*, *Argument and Computation* and *Persuasive Technology*. Persuasive Technology is a broad definition of interactive technology that aims to influence, motivate or change users' behaviors and attitudes towards a specific phenomenon (Grasso, Ham, and Masthoff 2011; Brian J Fogg 2002), and it is widely used as a motivational system. Today, technology is increasingly more persuasive, since becoming a natural part of everyday life, and it can therefore possesses various roles of persuasive characters. Examples of designs of persuasive technologies related to computer screens are pop-up ads, reminders, prompts and personalized content provided to users, in order to catch the attention of users or direct them into certain actions (Preece, Rogers, and Sharp 2015). Persuasive technology is researched by various disciplines ranging from psychology to computer science, and this is not surprising due to the difficulty of designing effective persuasive technologies. The research area of persuasive design is a part of the field sustainable HCI, according to DiSalvo, Sengers, and Brynjarsdóttir (2010). Brian J Fogg (2002) coined the term *Captology* to describe the use of computers as persuasive technologies. Brian J Fogg (ibid.) describes Captology as a focus on *"design, research and analysis of interactive computing products created for the purpose of changing people's attitudes or behaviors"*. Captol-

ogy is where persuasion and technology overlap.

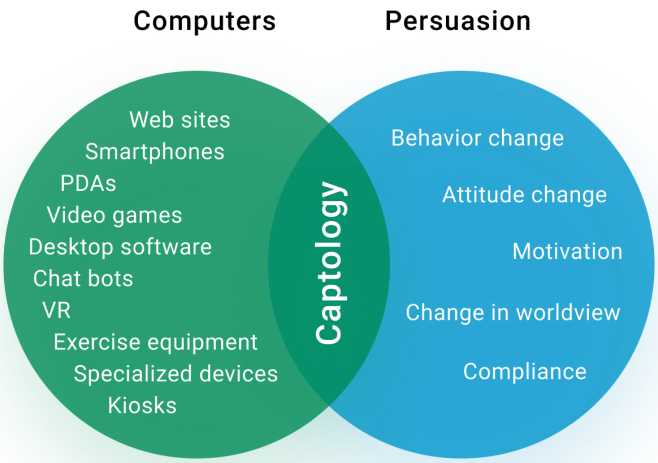

Figure 10: Showing how Captology is where persuasion and technology overlap. Figure from (Brian J Fogg 2002)

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Persuasive technology is not only used for commercial purposes but is also increasingly used for areas such as safety, health care and energy consumption, according to Preece, Rogers, and Sharp (2015). Persuasive technology is in the context of behavioral change used for improving people's well being by providing them with feedback of their behavior through self-monitoring tools. Examples of application areas for self-monitoring tools are fitness, sleep and weight trackers and devices. These often provide users with statistics and graphs to make comparisons for their behavior for different time ranges. Preece, Rogers, and Sharp (ibid.) even state that these tools can also have a layer of social interaction, such as leader boards showcasing their results in comparison to others, to motivate people further.

The approach of persuasive technology is increasingly being used to influence, motivate and persuade people to reach target behaviors by improving their feelings and behaviors (Nkwo, Orji, and Ugah 2018). Still, according to Grasso, Ham, and Masthoff (2011), the field of persuasive technology needs a more focused user-centered approach, together with extensive evaluations to reach a desirable outcome and understanding of the use. It is also fundamental to consider the backside of using persuasive technology in a harmful way. One example is that an issue can be addressed through persuasive technology with or without the user being aware of the intended persuasion (DiSalvo, Sengers, and Brynjarsdóttir 2010). Criticism of the technique will be described further in the later part of this section.

3.4.2 Features of Persuasive Design

Techniques of Persuasive Design and Technologies are many. Among some of the most prominent concepts when aiming for persuasive design are the design of goals, encouragement, motivation, customization and triggers.

One of the main purposes of persuasive technology is for the user to achieve a high-level goal, and the user should easily be able to start a process with the support of persuasive design. Heyman (2013) calls attention to the importance of appropriately designed goals in persuasive technology, and to provide smaller goals as their model proposes. It is also critical to provide the user with more than one starting goal in a persuasion process since the user should get the impression that there is more than one possible path to take. The model includes guidelines for making the user a part of the decision process and makes it possible for the user to select goals themselves. This way, the users' motivation and commitment can be increased. Related but contrary to this, Brian J Fogg (2009) states that goals too large and vague should be replaced by one small and fundamental starting goal and that whenever that goal is fulfilled, new ones should be provided. Instead, Heyman (2013) states that by using this model, we can decrease the risk of the user interpreting the design as giving too much advice or straight out telling them what to do.

Another principle of persuasive design is to encourage users and provide them with helpful tips, in order for them to improve a certain behavior (ibid.). Other aspects that can be effective in encouraging users are to provide them with customized choices and messages (Rezai and Burns 2014), as well as reminders, points systems and communities to support each other during behavior changes (Rezai, Torenvliet, and Burns 2014).

Brian J Fogg (2009) presents three key factors of behavioral change that needs to happen in the same time, for the success of persuasive technology, in the model Fogg Behavioral Model (FBM). The first factor *Motivation* states that the user needs to *"be sufficiently motivated"*. Within the FBM model motivation is divided into three opposites; Pleasure/Pain, Hope/Fear and Social acceptance/Rejection. The second factor that the user needs is *Ability*: *"to have the ability to perform the behavior"*. These abilities could be things such as money, time, physical effort, etc. The third factor that the user needs is *Triggers*: *"be triggered to perform the behavior"*. These triggers can be divided into three categories; Sparks, Facilitators and Signals. Sparks motivates a certain behavior by triggers, while Facilitators help the user by making the behavior easier and Signals are used as reminders or indicators. Although all off these factors are important, Brian J Fogg (ibid.) argues that the factor "ability" is often the most important to focus on, since a user who does not have the ability to perform the task or change will not be able to do it - no matter of how high the motivation is. The FBM model can be used both in the design stage and the evaluation stage of designing persuasive technologies.

3.4.3 Typical uses of Persuasive Technology

Fogg introduces seven strategies used by technology tools in B. J. Fogg (2003). These strategies to influence behavior are Reduction, Tunneling, Tailoring, Suggestion, Self-monitoring, Surveillance and Conditioning.

Reduction aims to make complex tasks and interactions simple. This supports the user's motivation in making the behavioral change, while complex tasks would instead decrease the motivation. This can increase the user's attitudes towards being more positive towards the behavioral change.

Tunneling is used to guide the user through sequences of interactions or a process. By guiding the user, the designer has more control in influencing the behavior of the user. This can lead the user to engage with things that normally would have been ignored, according to B. J. Fogg (ibid.).

Tailoring is used to tailor information or actions based on the user. This could, for instance, be carried out by determining the user's level of knowledge, or gather data such as the user's physical state or geographical location. It could also mean that information is based upon the user's attitude or behavior.

Suggestion is a strategy of persuasion where the goal is to present the information at the right time or place, for it to be as effective as possible. It can be utilized when making suggestions to the user, while the user is motivated.

Self-monitoring is valuable when making the user aware of their state or progress, and to allow them to change their attitudes or behavior to reach the behavioral goal. One of the goals for using this strategy is to remove the effort of tracking and putting in data. The data should preferably be provided to the user in real-time.

Surveillance is, in difference to self-monitoring, used to learn about others and for others to learn about you. According to B. J. Fogg (ibid.) surveillance techniques are only effective for behavioral change when the user is aware of that they are being observed and in that way reflects on their behavior. It should also be used with respect for privacy concerns and awareness of ethical considerations.

Conditioning is used as encouragement for the user. By using strategies such as rewards, the user behavior can be effectively improved.

3.4.4 Criticism of Persuasive Design

Although the concept of persuasive design is well-known and frequently practiced (DiSalvo, Sengers, and Brynjarsdóttir 2010; Nkwo, Orji, and Ugah 2018), the area has been criticized. There

are ethical aspects questioning the purpose of using computer-aided persuasion as a means of changing attitudes and behaviors of people, especially if it occurs without people knowing about it (Atkinson 2006). If people are not aware of the intention of being persuaded when participating in an occurrence, there might be questions of manipulation (ibid.). Even if the intention of persuasive systems is carried out with the well-being and care in mind regarding someone or something, or is motivated by wisdom, there are still ethical aspects to consider. Atkinson (ibid.) states that persuasion done correctly occurs when a user is aware of the intention early on when using a system, and that the user itself can determine the value and accuracy of a system, and if it is deemed useful for them.

4 Methodology

In this methodology chapter, the methods used during this project will be described. The methods that have been chosen for the thesis lay the foundation for the whole project and is the key for a successful outcome. The design process of the project contained five phases being Emphasize, Define, Ideate, Prototype and Evaluate. The design process followed an iterative manner, with three iterations building prototypes that were later evaluated with users. In order to get a good research design according to Wadsworth (2016), it is important that the project aims for the most valuable, relevant and valid evidence so that the research and insights become authentic. To meet this criteria, an extensive literature research was conducted initially in the preliminary phase of the project to lay a trustworthy foundation for the coming stages and results of the process.

This project was carried out through a Concept-Driven Interaction Design approach. Within HCI, concept development can be used to present future designs, find out new technologies and challenge theoretical frameworks and already existing conceptual foundations. It can also be used as a tool for evaluating how users will react to the newly developed concept. By using concept-driven design it can be possible to explore knowledge that are difficult, or even slightly impossible to express in traditional ways, such as in text. The result of the concept can act as a carrier of the earned knowledge and the used conceptual framework. Concept designs are effective ways of communicating concepts to anyone, no matter the previous knowledge of these people. While a prototype design can present a design solution, a concept design is used to explore ideas and challenge existing frameworks and concepts (Stolterman and Wiberg 2010).

When designing interactive products that enable communication and interaction for users, there must be some understanding and knowledge of how to conduct this appropriately, according to Preece, Rogers, and Sharp (2015). User-Centered Design (UCD) is one approach within interaction design that follows a user-centered cycle where the user is the main focus and is involved in several phases throughout the design process. The project has aimed for a User-Centered approach and included users during research and evaluation phases, and followed the needs of the users throughout the project by continuously evaluating ideas and functionality against user insights (ibid.). UCD is a design approach containing multidisciplinary aspects and is considered by many as fundamental for achieving usable and effective products (Mao et al. 2005).

4.1 Preliminary Study

The preliminary study for this thesis consisted of three parts, the first focusing on literature research of the field, the second focusing on product research of similar projects, and the third on the research of potential users.

4.1.1 Literature Research

To get acquainted with the problem domain, an extensive literature review was executed, mainly in the early phases of the thesis project. Additional literature research was carried out whenever there was a specific need to get the project in a certain direction or to further explore new areas of interests. Several literature and article pieces were read throughout the thesis, with a majority of the literature being retrieved from the following databases:

1. *Chalmers Library*
2. *Google Scholar*
3. *HCI Bibliography*
4. *HCI ACM digital library*

4.1.2 Product Research

To get a cohesive understanding of the current market of products and services aiming to change attitudes and behaviors related to a sustainable lifestyle, a product research phase was carried out in the beginning of the thesis. This was done since we wanted to find out whether products on the market existed and what kind of mechanisms they used in order to change human behaviors. Many different products and services were found and explored, both products related to sustainability and other self-assessment tools more aimed towards personal health purposes. A wide selection of applications with a wider scope than the aim of this thesis were investigated, due to the possibility that the motivations and features used in these applications be could be applied for applications leaning towards personal sustainability. This phase was reevaluated during the project due to new findings from research literature and emerging project with a similar aim to the thesis project.

4.2 Research of Potential Users

To understand the users in the essence of a user-centered design process, extensive work was carried out. The goal of the user research phase was to get a comprehensive understanding and synthesize the users including their goals, tasks, needs, attitudes and journeys. During the user research both quantitative and qualitative data was gathered through the use of a questionnaire. Mao et al. (2005) state that ethnography and field studies within user research is critically important in a user-centered design process. In order to fulfill this prerequisite, the user research was conducted in a natural setting so that users where in their natural environment.

4.2.1 Questionnaire

Questionnaires are sets of questions often in printed or digital form and works as a self-reporting survey tool where users respond by choosing options or writing answers. Questionnaires can be both quantitative and qualitative, and gather information about people's feelings, attitudes, actions and characteristics (Hanington and B. Martin 2012, p. 140). In this thesis a questionnaires was used to find out user motivations and attitudes towards an interactive design concept involving monitoring individual sustainability and environmental aspects. By using a questionnaire, we can complement interview result and humanize the collected data from the questionnaires, which is a good practice when conducting research (ibid., p. 140). Other data gathering method could be used within this phase, such as observations. Observations was considered as not suitable in this project, since the extent of the problem situation could be difficult to observe and gain insights from. The aim of the user research is to gain insight from users' experiences, behaviors and attitudes, which was made possible through the chosen methods questionnaires and interviews.

4.2.2 Idea Generation

During the idea generation phase, the problem area can be looked at from different angles. Brainstorming is one method that can be used to come up with new ideas and solutions, and refine and develop suitable ones according to the problem statement (Preece, Rogers, and Sharp 2015). Important during this phase is to come up with as many ideas and solutions as possible, and this is supported through a free space where no ideas are labeled as bad ones but as a launch pad to get into a creative mindset. The chosen brainstorming techniques can be carried out with a varied level of structure, and have the participants talking or remain quiet while conducting the brainstorming (Hanington and B. Martin 2012).

Sketching is the activity of quickly scribbling and sketching down ideas by hand, often on pieces of papers. Sketches are not to be considered as final products of work, but is a way to quickly put down ideas coming from one's mind and make it into something concrete that can act as a model or concept of the idea. Buxton (2010) describes that in order for something to be a sketch, it needs to be consistent with certain attributes that sketches contain. Sketches should be created in a quick and timely manner, and be inexpensive and disposable, together with making plenty of them. This, in order to come up with lots of ideas, but also be able to discard them if necessary. Sketches should contain clear vocabulary, use distinct gestures, have minimal details and still have an appropriate degree of refinement. Sketches should not be too clear and decided, but they should contain a level of ambiguity so that the designers do not limit themselves with boundaries early on in the design process (ibid.).

Sketch-storming is a collaborative method based on brainstorming, used for generating a big quantity of ideas in a short time. Sketch storming can be preformed in different ways, but the main idea is that the participants creates quick sketches during a short limited time (*A guide to*

sketch storming - a design game for ideation 2017). How-Might-We is a method that can be used to find solutions or design opportunities to problems and problem statements. The first step of the method is to rephrase insights to questions starting with "How might we". When the questions have been formed a brainstorming session is preformed where the participants should try to come up with as many possible solutions as possible(designkit n.d.).

4.2.3 Prototyping

Prototyping is the process of creating physical mock-ups to try out concepts and products with people, stakeholders and within design teams, and to investigate if they are appropriate for the intended purpose (Hanington and B. Martin 2012; Preece, Rogers, and Sharp 2015). Prototypes are an important part of the design process and can have different levels of fidelity depending on where in the design process they are created, and for what purpose. Producing quick low-fidelity prototypes early in a design phase is valuable, since ideas can be tested early on by users and clients (Hanington and B. Martin 2012, p. 138).

Low-fidelity conceptual prototypes have been used in the thesis project when involving users with the aim of understanding their attitudes towards the concept, information flow and functions, whereas high-fidelity prototypes were used in the context of usability evaluations and for thoughts on look and feel. Sketches for ideation purposes, used before the creation of each prototype, were developed in accordance with the attributes of a good sketch that Buxton (2010) describes. The prototypes with a higher lever of fidelity were designed to look like a final design solution, being visual designed wire-frames. The design process started from scratch with a new design and not of refining an existing one.

4.2.4 Prototype evaluation

Evaluation is a fundamental part of the design process where the experiences of users with a specific concept, prototype, or application are observed in order to refine and improve designs (Preece, Rogers, and Sharp 2015). During evaluation sessions, both usability and experience aspects with an artifact are gathered, both being important parts of well designed products and services. The choice of evaluation type can be determined by three aspects: the setting, the level of user involvement and the level of control of the session. Preece, Rogers, and Sharp (ibid.) categorize evaluations into three broad types with examples of each type: *controlled settings involving users* where usability testing can be carried out, *natural settings involving users* where field studies are a common practice, and *any settings not involving users*, where heuristics and walkthroughs are popular. When conducting user tests of a concept, various approaches and methods can be utilized. The type of evaluation and methods to be used are determined by several aspects, and specifically where in a design process a project is, and what the goal of the evaluation is.

To receive rich user feedback, observation and interview methods can be used. To make users explore a concept, user tests can be carried out through the use of scenarios (Hanington and

B. Martin 2012, p. 152), which urge users to perform a couple of tasks. The scenarios have to be clear, structured and associated to the target user's goals, according to what Hanington and B. Martin (2012, p. 194) state. Purposes of evaluations involving users can be to observe them throughout a process and to get their valuable feedback for a further refinement of concepts. This can be enabled by using the Think-aloud protocol technique (ibid., p. 180). The Think-aloud protocol is valuable for finding out what is going on in a user's mind (Preece, Rogers, and Sharp 2015), which can be difficult to determine when using only observational methods.

But conducting the Think-aloud protocol related to usability comes with limitations, according to Kahler, Kensing, and Muller (2000). The interaction can be interpreted as limited since a real dialogue is not created due to the different roles of the participant and facilitator. Instead, only the subject's thoughts are expressed, together with the risk of the subject feeling too observed. Another risk is that the result can be skewed if the facilitator is too involved interaction-wise. Instead, Kahler, Kensing, and Muller (ibid.) proposes involving two subjects when conducting usability testing. Instead of when only using one subject, having two subjects in usability testing can lead to a more natural discussion in how to perform certain tasks, and participants are more prone to explain their thought process to one and other. Also, the interaction with the facilitator is minimal. There are various names for these kinds of constructive interactions. Kennedy (1989) refers to them as *Co-Discovery Learning*. Both individual and co-discovery user testing were carried out in the project, when it was deemed suitable one or the other method were chosen for evaluation sessions.

4.2.5 Interviews

Interviews are a common practice of gathering personal information, experiences and attitudes from people (Hanington and B. Martin 2012, p. 102). There are several types of interviews, each with different levels of structures and questions, depending on the research aim. What decides the form of the interview also depends on the level of control the interviewer has of the interview flow and content, and when in a process interviews are held. Fontana and Frey (2005) describe four central kinds of interviews. There are interviews that are open-ended or unstructured, structured, semi-structured or carried out in groups: group interviews, where focus groups (Preece, Rogers, and Sharp 2015) is a common type.

Semi-structured interviews can be carried out for various purposes, and will in this project act as an evaluating instrument after testing prototypes with potential users. Interviews are held in order to catch the user's attitudes, experience and thoughts about the researched area and the concept, while testing a prototype. The more flexible approach of semi-structured interviews can be used for this purpose since the discussion can be steered both by the researchers and the participant's experiences while maintaining a structure that enables more questions to be asked.

4.2.6 Heuristic Evaluation of Persuasive Features

Before letting users test a concept or a prototype, designers should reassure that the quality of the artifact is good enough. In this phase, usability and minor problems can be identified and solved before involving actual users. Heuristic Evaluations are, according to Hanington and B. Martin (2012, p. 98), best practices, "rules of thumbs", to follow when identifying usability issues in designs. It is carried out by following a set of rules when investigating designs, instead of only following their own intuition and experiences (ibid., p. 98). Since the heuristic evaluation method is an expert evaluation, there are some risks of potential biases that need to be kept in mind (Langrial et al. 2012).

Evaluation of Persuasive Features is a method based on Heuristic Evaluations, but where persuasive features are the focus of the evaluation. The method is conducted by experts within persuasive design. The people in charge of conducting the method individually walk through the functionalities of the system, with the persuasive features that have been selected for the evaluation in focus, while taking notes, for instance using an excel sheet. The individual notes are thereafter compared and summarized into a synthesis of findings (ibid.).

4.3 Analysis

Different Analysis methods have been used during the project. The methods have been chosen to be able to extract the important aspects of the gathered data.

4.3.1 Affinity Diagram

Affinity Diagram is a method that can be used to organize and structure ideas, gathered data and observations. It is used to keep the gathered information present when moving between stages of the project. This is done to make sure that, for example, information and insights gathered from user studies follow to the next design stage. When using the method ideas, concerns, requirements, and thoughts are written down on individual sticky notes and are thereafter grouped into emerging themes or categories (Hanington and B. Martin 2012).

4.3.2 Feedback Capture Grid

is a method that can be used in usability testing and to structure and analyze feedback in a design process (Dam and Siang 2018). Feedback Capture Grids are commonly used for structuring feedback from activities such as prototype testing where likes, criticism, questions, and ideas are structured into a grid of four squares. By using a feedback capture grid, you can quickly get an understanding of what quadrant has fewer inputs than others, thus slightly steering discussions to that area, but also get an easy overview of feedback already been given.

4.4 Limitations

The above presented selection of methods has been affected by the limitations of this thesis. The biggest limitation that has affected most of the choices is the time limitation. If this project would have lasted over a greater amount of time other methods of evaluation and prototyping could have been used to get a greater understanding of the use in a real-time setting. This project has also been limited by our knowledge of prototyping and coding.

5 Project Plan

This chapter will present the different parts of how the project was created. First an explanation of how the scope of the thesis was set, followed by a description of the process of the project. Thereafter, the choice of tools will be presented followed by a time-plan that was followed throughout the project. The work of this Master's Thesis Project in the Interaction Design and Technologies master's program at Chalmers University of Technology has spanned over about 20 weeks, beginning in February 2019 and ending in July 2019, with the final presentation carried out in September 2019. The project has been supervised through Chalmers, and with additional support from experts from outside the university, previously engaged in master theses within a similar research context.

5.1 Setting the Scope

Behavioral change related to sustainability is a wide and complex area to research. Many disciplines are researching the context from various perspectives. Initially, setting the project scope proved to be a more difficult task than anticipated, instead the scope was set somewhat after the insights from the early user research phase were retrieved. This was carried out to focus the project on a context that would tie in with the needs of the potential users of a solution in the researched area. Setting the scope beforehand could have meant developing a concept not entirely in line with the attitudes and needs of potential users. Instead, the scope was set according to what potential users responded in the exploratory questionnaire, which resulted in the scope being limited to include the concept for a smartphone application, EcoHero, which measures a couple of parameters related to individuals' carbon footprint. An essential takeaway from the user insights was that EcoHero had to minimize the user's need for manual data input, which steered the project in a suitable direction.

5.2 Project Process

The plan of the project followed an iterative design process where new requirements from potential users were put into the concept, making it more coherent with a user-centered approach and refined. Stages in the process were initiation and planning, background and user research, requirements gathering and analysis, concept and design development and evaluation.

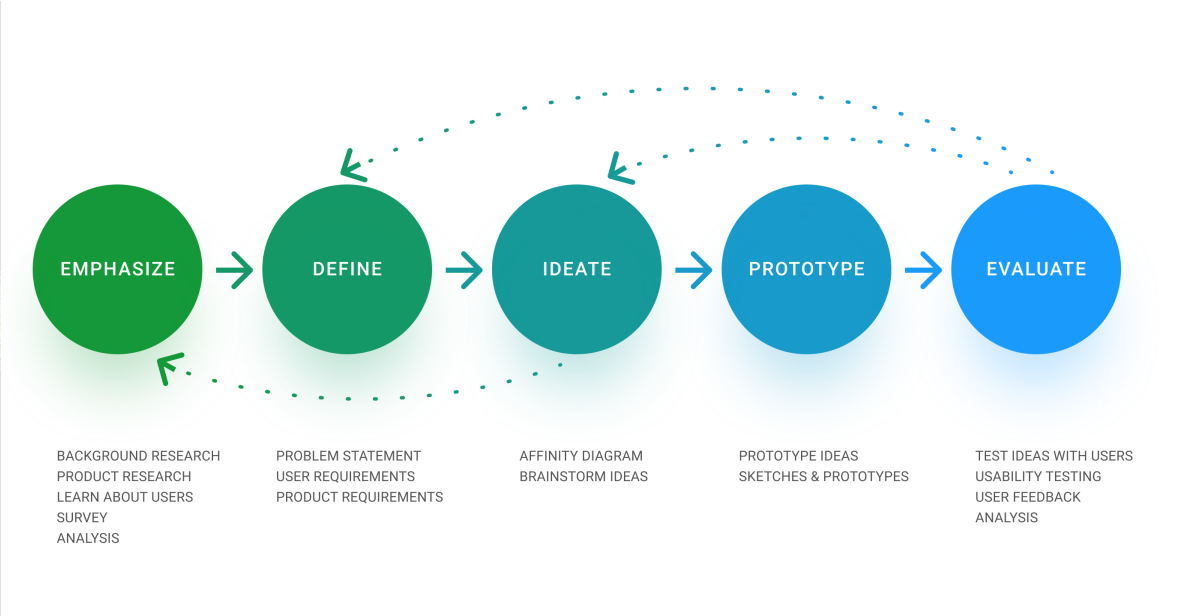

Figure 11: Image showing the design process followed in this thesis

5.3 Selection of Tools

To successfully carry out a Master's Thesis project, the project utilized several tools for various purposes. These tools are divided into three categories: prototyping tools, digital design tools, and project support tools. For making prototypes, the tools POP (POP 2019) and Figma (Figma 2019) were used. For making digital design, once again Figma was used. The project used Google Drive (GoogleDrive 2019) for project support purposes, such as planning, documentation and making transcriptions of meetings and user research sessions.

5.4 Project Time Plan

The project time plan was divided into three phases; Project Initiation, Project Work and submission, and Presentation. The writing of the report spanned over the 20 weeks of the project. Overall, the project had three major iterations. In each iteration a prototype was developed and analyzed with potential users, to be further refined before the upcoming iteration. This finally resulted in the concept of EcoHero, displaying the potential and use of a smartphone application in the context of behavior change related to sustainability, through interaction design.

	Project Initiation				Actual Project work												Handing in & Presentation			
Date	18-22 feb	25-3 march	4-8 march	11-15 march	18-24 march	25-31 march	1-5 april	8-12 april	15-19 april	22-26 april	29-3 may	6-10 may	13-17 may	20-24 may	27-31 may	3-9 june	10-14 june	17-21 june	24-28 june	27-30 aug
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	35
Concept and thesis ideation																				
Proposoal witing																				
Reaserch Methodology																				
Reaserch Target group																				
Reaserch Related work																				
Planning user studies																				
Executing user studies																				
Analyse and evaluate																				
Planning continuation																				
Develop concept, prototype																				
User evaluation																				
Evaluate results																				
Create prototype 2																				
Evaluate results																				
Finalize concept																				
Finnishing report																				
Handing in draft of report																				
Presentation and opposition																				
Report writing																				
Documentation																				

Figure 12: Showing the Project Time plan that was followed in this work

6 Execution

In this chapter, the execution of the project will be presented in chronological order. The project was initiated with a background analysis of current research, frameworks, and applications in the research context, together with the making of a project process plan. When the background analysis and research were executed, a questionnaire was sent out to respondents, in order to gather insights of attitudes and behavioral patterns from potential users. The questionnaire result was thereafter analyzed, potential user groups and their requirements and goals were retrieved. Three prototyping iterations were then executed, resulting in a final prototype design, EcoHero.

6.1 Background Analysis

The background analysis began with an initial literature study to get a better understanding of the area to be researched, and to see what the latest literature stated. An online questionnaire was carried out where requirements and user attitudes were analyzed from the results.

6.1.1 Literature Research

To be able to go into the design phase with more knowledge in the area and to design according to best practice, a literature pre-study was carried out early on in the project. The search for suitable literature to the context covered research papers and articles, books, websites, and related work. The research was primarily found on search engines containing scholarly literature, such as Chalmers Library, Google Scholar and HCI Bibliography. To find appropriate literature certain search terms were used, such as behavior change, sustainable HCI, Eco Feedback, persuasive design, change through design, among other terms. The literature research was also continued throughout the project when there was a need for more knowledge or to steer the project in a certain direction.

6.1.2 User Research

It was seen as challenging to get an accurate understanding of people's relation to the area of sustainability at the beginning of the user research phase since there can be contradictions between people's thoughts and the corresponding behavior for a specific topic or situation. To understand what motivate people when it comes to sustainability in relation to their own behavior and attitudes, a questionnaire was sent out, as described previously.

Before sending out the questionnaire, a quality reassurance was conducted. The quality was assured by sending an initial pilot test questionnaire to three people, all having experience in both designing and responding to questionnaires. After receiving their feedback, appropriate adjustments were made and the questionnaire was sent out. No major changes were made to the

first draft of the questionnaire. Demographic questions were added, along with a couple of adjustments, such as more options for certain questions. The usability of the questionnaire was increased by removing all the *required** elements from questions, since the questionnaire was quite long and could be interpreted as to demanding of the respondents. This was conveyed from the feedback of the pilot test, which was implemented. The questionnaire was distributed through social media to friends, relatives and classmates, along with being posted on both of the researchers' Facebook accounts to get a broader distribution.

The questionnaire was divided into three major categories, excluding the shorter introductory demographic part. The categories were "Attitudes related to sustainability", "Behaviors related to sustainability" and "Quantified self / self-tracking applications". These three categories were needed to get a richer picture of people's thoughts, behaviors and experiences related to sustainability. The questionnaire included questions about the participants views on sustainability, the current state of the environment, their own behaviors regarding transportation, self-tracking applications, and similar questions related to these topics. The questionnaire also included demographic questions, such as age and employment status and age. The demographic questions were labeled as potentially important, if there were any major patterns that were specific for a certain group. The complete questionnaire design can be found in Appendix 1.

All together, 74 persons responded to the questionnaire, witch resulted in discovery of interesting user patterns in attitudes, thoughts, behaviors and opinions on several matters. From the result of the questionnaire, no major differences between age groups were identified. Also, since the age groups overall weighted more towards one specific group (age 21-29) with the employment status of a student, these demographic groups were not used for any age specific results. The weighted result towards the specific age group is a direct consequence of the researchers own constraints regarding social networks, family and friends, even if the researchers made an effort to reach out to a wider group of people. In the remaining parts of this section, some key aspects of the result of the questionnaire will be presented. The full result can be found in Appendix 2.

The interest for environmental questions among the respondents was moderate to high. This was a positive finding, since the initial though of the project was to be aimed towards potential users, meaning users with an interest in sustainability and a will to make changes beneficial to the environment. This finding made the answers even more valuable.

The majority of the answers showed that people stated that the environment is in a bad state but that a lot of effort might save it, although it would be challenging. This indicates that people could be willing to change behavior and act more environmentally friendly.

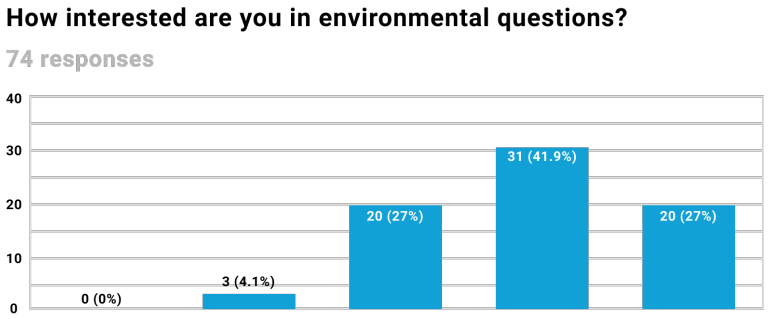

Figure 13: Graph displaying the result from question 1, asking for the users interest in environmental questions, in the Questionnaire that was executed during the user research.

Many of the respondents expressed that they had a good knowledge of the concept of carbon footprint, and used it to make informed actions. A majority of the respondents expressed that they had a good understanding of it or had heard about it, but did not use the knowledge when making decisions that could affect the environment.

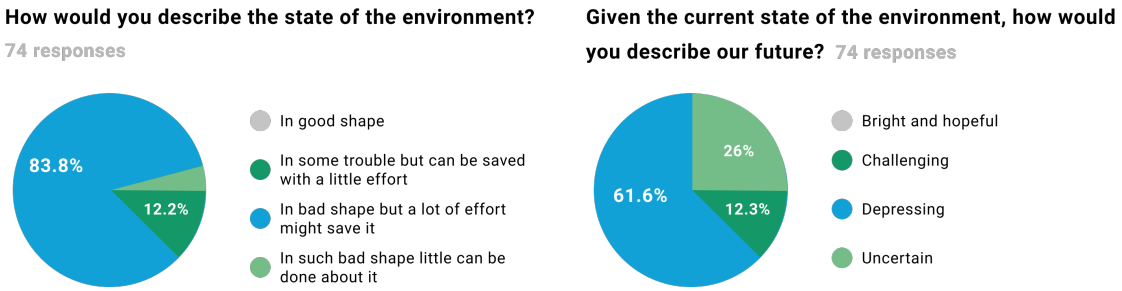

Figure 14: Graph displaying displaying the result from question 2 & 3, concerning the current and future state of the environment, in the Questionnaire that was executed during the user research.

The respondents also showed a somewhat correct knowledge of the main contributing sources to individual CO_2 emissions, where transportation, food and consumption came out as the options with the highest respondent choices.

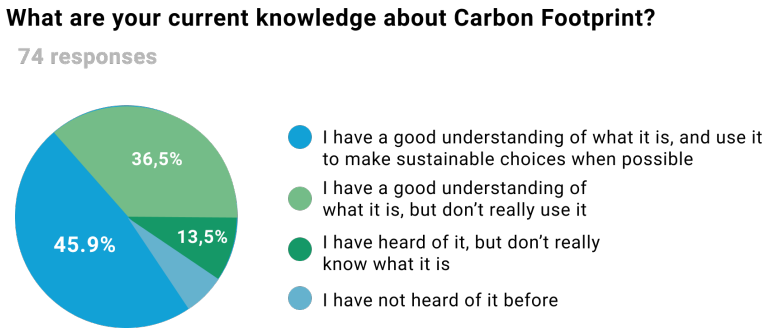

Figure 15: Graph displaying the result from question 4, about the current knowledge users have about Carbon Footprints, in the Questionnaire that was executed during the user research.

Questions regarding the use of wearable and self-tracking applications got various results. Less than half of the respondents stated that they used self-tracking applications, some stated "Every-

day", while others stated "Sometimes". On the other hand, a big majority stated that they never used wearable technology. These findings steered the project and acted as a constant reminder when developing the concept. It was decided that, although the implementation of wearable technology could be a big contributor to the concept, the concept was limited to a smartphone application, since this was within what potential users wanted.

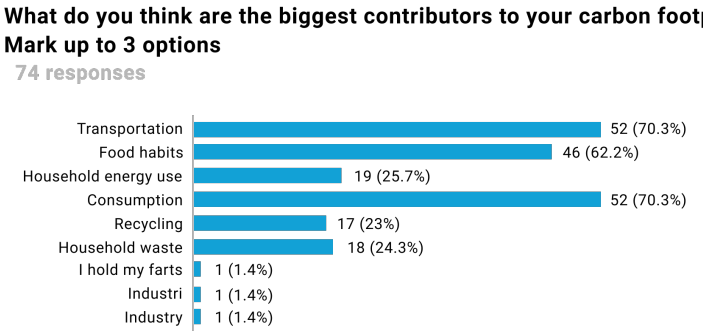

Figure 16: Graph displaying the result from question 5, about the biggest contributors to the carbon footprint, in the Questionnaire that was executed during the user research.

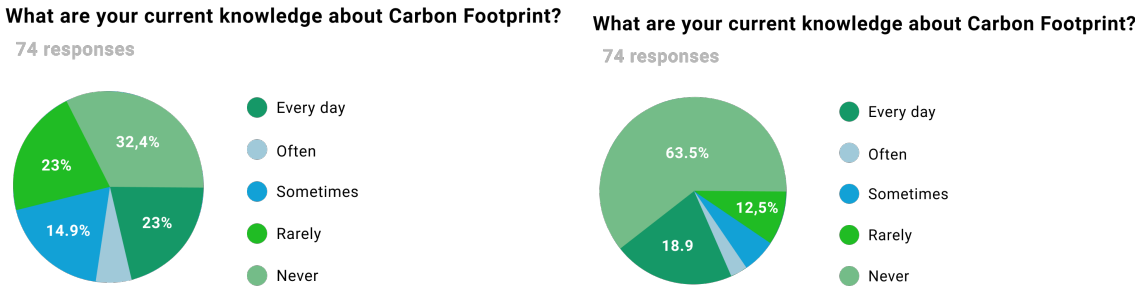

Figure 17: Graph displaying the result from questions of the Questionnaire that was executed during the user research, regarding the use of self-tracking applications and wearable technology.

6.1.3 Content Analysis

Eight overarching themes were retrieved from conducting an Affinity Diagramming session with the result of the questionnaire question *"What are your thoughts about having an app that monitors your carbon footprint?"*. For this question, participants got the opportunity to input free text, which resulted in important and rich feedback. The answers were written down on individual sticky notes and were thereafter arranged into emerging themes. 8 categories arose from this session, which were *Self-knowledge of Behavior*, *Environmental Awareness*, *Functionality*, *Reaching Goals*, *Positive Attitudes*, *Negative Attitudes*, *Usability Aspects* and *Fear of Anxiety*. Many of the notes that were placed in certain categories could be coupled with other category notes, due to the problem area being quite broad. A clear example was a note in the category *Goals* that could have have been included in the category *Negative*, which was:

"It's annoying if I feel that I'm not doing well."

This note was interpreted as a user need to have clear goals and to set these goals at an appropriate level. The category *Negative* contains, in this context, thoughts that are negative of the idea

of using an application within the researched area.

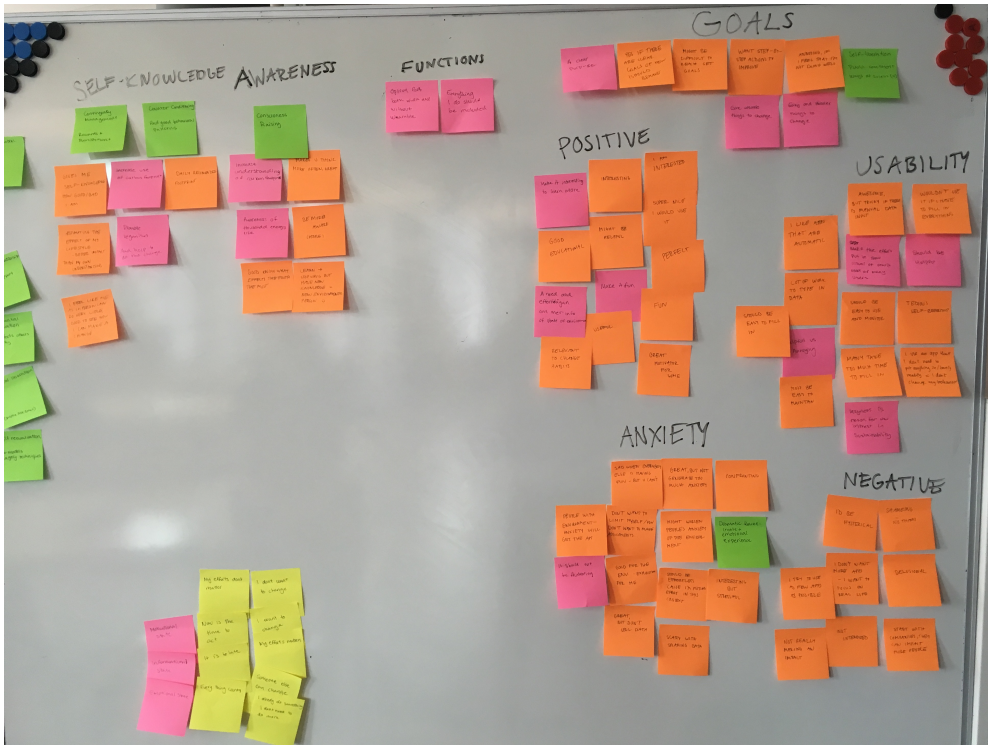

Figure 18: A picture of the Affinity Diagram created during the content analysis, made with the data from the user research.

1. **Self-knowledge of Behavior** gathered the thoughts of respondents about how self-quantification related to sustainability might increase self-knowledge of the individual environmental footprint. Respondents wished to know whether their behavior had negative or positive consequences on the well-being of the earth and that it could further be shown by displaying daily recommended footprint information, together with options to let the user know how to make a change.

2. Respondents thought that a solution monitoring their carbon footprint would increase their **Environmental Awareness** and have them reflect upon their part in the bigger picture. Some respondents explained that it could be valuable to get new information on what affected their footprint the most, and the least. One respondent answered that raising environmental awareness with a digital solution could result in people getting new knowledge and behaving more sustainable, which could result in people using the solution less frequently.

3. The **Functionality** category contains ideas of functions expressed by the respondents. Ideas for an application in the context were to have options to add wearable technology (e.g. smartwatches) to have more functionality. Some respondents also wanted an application to be able to track everything they do on a daily basis.

4. **Reaching Goals** contained aspects where respondents expressed a need for having a clear purpose and goals when changing behaviors towards a more sustainable lifestyle. Step-by-step actions for improvements, clear goal setting, easier and more complex things to change, and concrete suggestions were aspects that respondents deemed valuable for reaching goals.

5. **Positive Attitudes**. Several respondents were positive towards an application monitoring their carbon footprint, and thought it to be a great motivator for some. Many expressed an interest and wanted to learn more about the environment and how to live a sustainable life. They thought the research area to be relevant and useful, especially if it was made into an enjoyable experience.

6. **Negative Attitudes**. There were also some negative answers from respondents regarding their view on quantified self applications. A few people stated that they were afraid of caring too much, and be too involved in their sustainable lifestyle when using the application. Others said they wanted to use fewer applications or that the change instead should start with companies with greater power and influence than individuals. A few respondents stated something along the lines that they would not want an application that would shame their behavior and make them feel bad.

7. The category **Usability Aspects** contain mainly the question of data input, and how bothersome it can be from a usability perspective. A critical aspect in the research area is that applications in the context should be as automatic as possible, and try to eliminate the need of users to input big amounts of data. Several respondents claimed that they would not use an application if it meant that in order for the application to function properly they would have to do a lot of self-reporting.

8. **Fear of Anxiety** was another topic that arose. Respondents thought that an application in the context could be stressful if it was not designed with the correct motivational purpose. Some respondents also showed feelings of anxiety and stress in making sacrifices in their lifestyle, even if they thought the state of the environment to be highly important. As one respondent said: *"Good for the environment - bad for me"*.

6.2 Prototyping Cycle 1 (of 3)

The first iteration of prototyping was carried out to transform user insights into opportunities for design, and to come up with solutions that potential users would find usefull. The aim was to generate ideas that would make potential users aware of their individual carbon emissions, to make informed decisions to lessen their carbon footprint. This resulted in a first prototype.

Before moving towards the first sketching session, the scope was scaled down to only contain fundamental elements and areas that the questionnaire respondents deemed valuable. Aspects that were not included in the first iteration of sketching and prototyping were the social layer and the household energy section. To initially scale down the number of functionalities, we could focus on designing the core elements of the solution and produce a minimum viable product (MVP), instead of forcing all the potential functions in the early prototype.

Activities and methods used during iteration 1 were ideation based on theoretical frameworks, sketching, Affinity Diagram (Hanington and B. Martin 2012), and finally a paper prototype that was made interactive through an smartphone application named POP. The prototype was made interactive to get feedback from users about the concept and to check whether the flow of functions were effectively designed. The people who participated in the evaluation session also got to answer questions after the evaluation session, and discussions were held if the participant wanted to. This helped us evaluate our own ideas and identify how potential users wanted a solution to be designed, catching both their likes, and what they claimed needed to be clearer.

6.2.1 Ideation based on the Transtheoretical Model of Change

An ideation session was carried out based on the *10 Processes of Change* from the *Transtheoretical Model of Change* (TMC).

The 10 Processes of Change were written down on individual sticky notes, and were thereafter put on a whiteboard. A short brainstorming session was executed silently, with focus on one process at a time for approximately 2-4 minutes, with the aim of coming up with ideas and solutions of how these processes could be incorporated in the design. The ideas were written down on sticky notes and put together with the belonging process note.

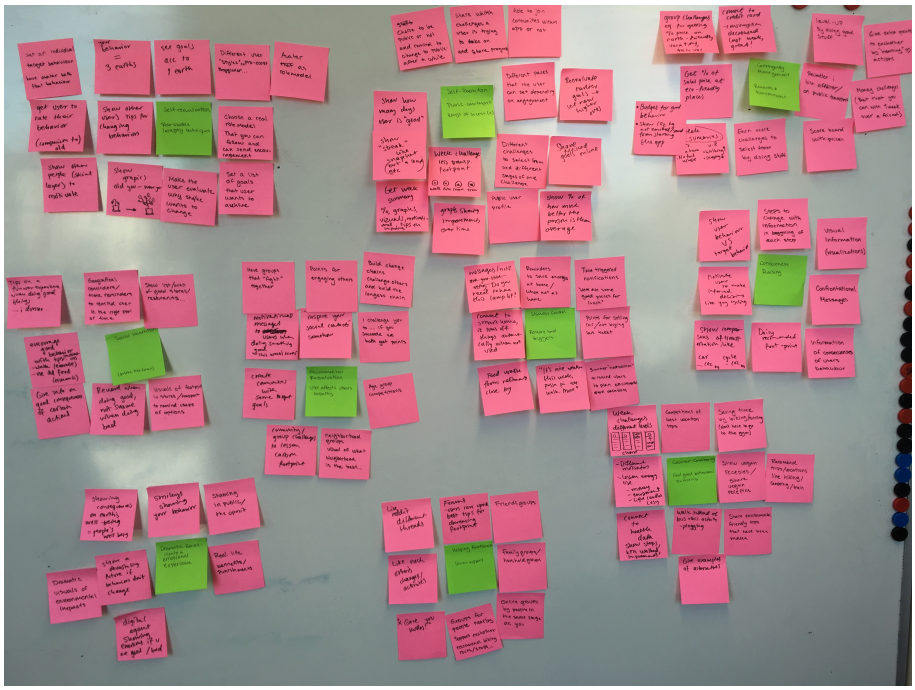

Figure 19: A picture of the result of the ideation based on the TMC. Each process of change was written down on green sticky notes, and each idea generated from the brainstorming session was written down on pink notes next to the process it is associated with.

In order to synthesise the ideas and retrieve more insights from the ideation, the process sticky notes were removed and the ideas were clustered into groups to create emerging themes. This activity was also carried out in silence, but ended in a discussion about the themes and thoughts of the final result. The 15 emerging themes of ideas found during the ideation session are listed below. After creating the themes, core functionalities were identified.

1. *Digital Avatar*
2. *Data Visualization*
3. *User Goals*
4. *Sustainable Stores & Brands*
5. *Create Environmental Awareness*
6. *Confronting*
7. *Social Layer*
8. *Challenges*
9. *Motivators/Encouragement*
10. *Social Groups*
11. *Points, Badges & Levels*
12. *Rewards*
13. *Footprint Summary*
14. *Health Benefits*
15. *Reminders and Notifications*

Figure 20: A picture of the 15 emerging themes were retrieved from the ideation session when we removed the green process sticky notes and carried out a clustering activity of all generated ideas.

6.2.2 Sketching

Several minor sketching sessions were held to utilize the ideas generated from the previous ideation sessions, and the concept development was initiated. The sketching sessions were conducted in an unstructured way, with no actual rules to how ideas were to be created, which created a base for discussions. Sessions were carried out individually in the project team to not limit each

other's creativity, or influence each other in certain directions. This was important in order to get a free creative space to generate as many ideas and sketches as possible. Thereafter, a mind map was modelled to connect the various ideas and functions to each other, to clearly see what functions were associated with each other.

Figure 21: A picture of some of the sketches that were created.

It was then decided to begin working on the three main screens, according to the result of the functionality modelling activity. These 3 main screens are the *Start/Daily* screen, the *Challenges* screen and the *Setting/Profile* screen. A more structured Sketch Storming session was carried out, using the *How Might We* method (designkit n.d.). For each function based on the earlier sketches that was added, we asked ourselves the problem statement questions according to the *How Might We* method, in order to create opportunities for design, and strive for a solution-seeking approach. A sketching session to find possible solutions was carried out for approximately 15 minutes, followed by discussions and decision-making of the sketched ideas.

The sketching session resulted in a rough outline of how these three main pages would be structured and what they would contain. Thereafter, the process continued with using the *Sketch Storming* method (*A guide to sketch storming - a design game for ideation* 2017) in order to solve the design of functions related to these three main screens.

6.2.3 Prototyping

Before we developed our first prototype, three scenarios were designed, which would later be included into the evaluation session. These scenarios were based on the sketches we had created in the earlier stage, and were used as a guide to steer what to prototype. The manuscript of the scenarios can be found in Appendix 3. The first Low-Fidelity prototype was created with the prototyping application POP (POP 2019). Based on the sketches, a set of slightly refined sketched screens were made. These screens were photographed and uploaded into a new POP project. Links were put on buttons and elements between screens to make the application interactive. For instance, when a user clicks on the profile icon in the menu bar, they will be directed to the profile screen.

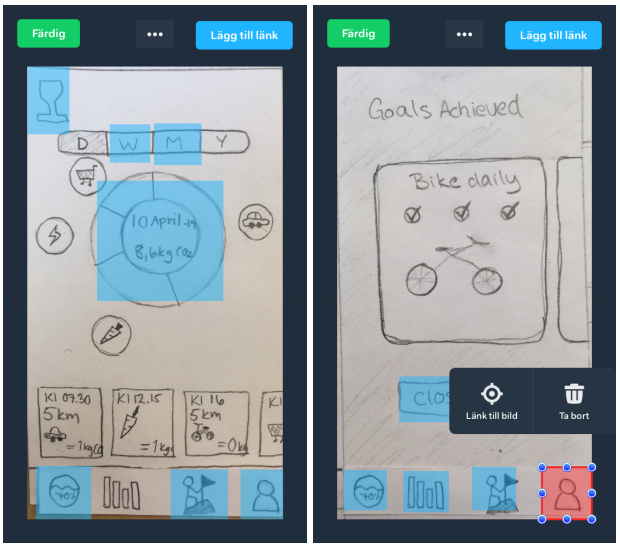

Figure 22: A screen shot of the first prototype, that was made by scanning sketches into the application POP

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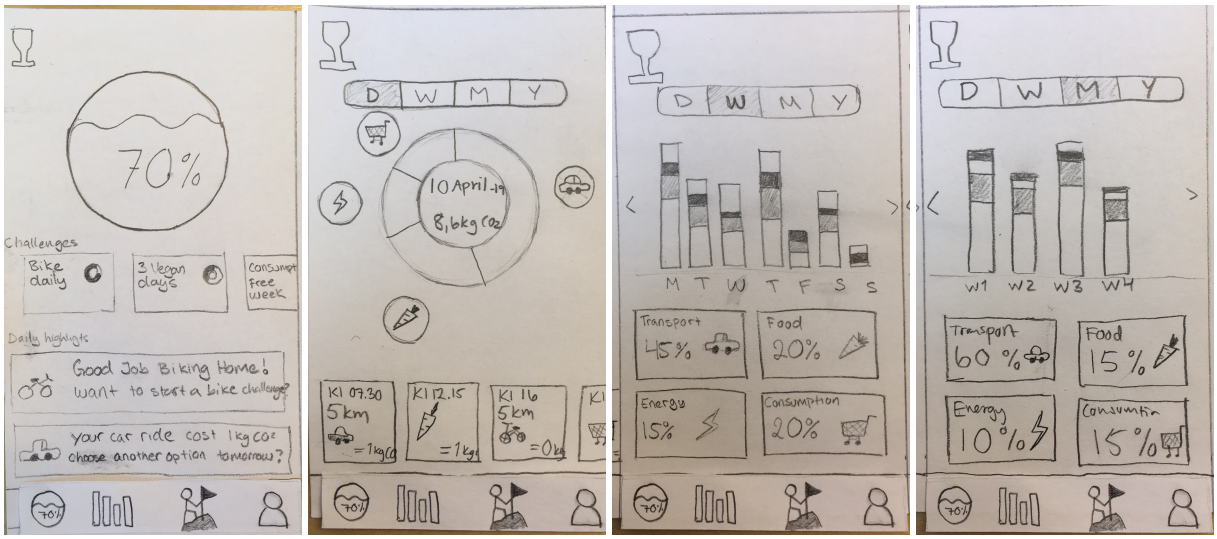

Figure 23: Pictures showing the sketches of the main and statistics screens that were used for the first prototype

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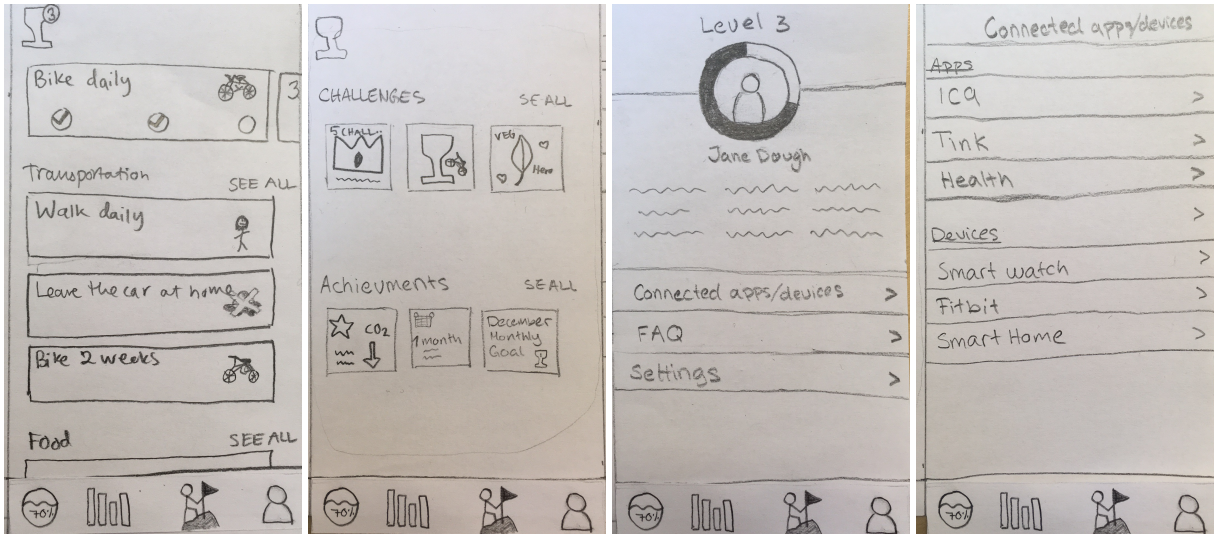

Figure 24: Pictures showing the sketches of the challenges, profile and settings screens that were used for the first prototype.

6.2.4 Evaluation of Prototype

Before the evaluation of the first prototype was initiated, we wanted to ensure that the quality and the usability of the prototype were adequate. The quality was established through a pilot test of the prototype, with having a person try the prototype and share their thoughts on potential improvements. After the pilot test, minor changes were corrected, but nothing major needed to change in order to begin the actual evaluation. What came up as unclear during the pilot test were mostly wording and icon ambiguity, and the lack of colours, which made it difficult for the participant to fully understand the association of certain functions, and knowing where in the application they were located. Minor changes were also made in the scenarios after the initial pilot test, like including a forth scenario including the profile screen.

The evaluation for the first prototype was carried out with 5 interaction design students in a semi-structured manner. This meant having the test sessions scenario-based with questions prepared in advance, mixed with suitable questions and comments made from us researchers whenever a topic we deemed interesting and valuable for the project was brought up. The scenario was divided into three overarching categories, being *Statistics of Carbon Footprint*, *Challenges* and *Badges*, and worked as a structure for guiding the participant through the prototype. After the participant had completed each scenario, there was a brief open discussion. The participants were not told the category names of the three scenarios, because we wanted to see whether they understood the underlying purposes of certain parts of the screens.

The test sessions were held in Gothenburg, Sweden, often in a University setting, although two sessions were held in a household setting. Th participants were recruited both at Chalmers University of Technology, specifically from the Interaction Design and Technology program, and by asking friends. The main attributes when searching for appropriate participants for the project were an interest in the environment and that they often used and were comfortable with technology, such as smartphone applications. Since many survey responses came from students, with many of them interested in living a sustainable lifestyle, asking mostly students to participate in the project was deemed valuable.

For each test session, the participant sat by a table and got to hold a smartphone displaying the prototype design. Often, the test participant sat next to one of the test facilitators and with the other person at the opposite of the table. The test was facilitated by one of us researchers, while the other one took notes of the session on a laptop.

The test sessions were initiated with a brief explanation of the project, and what was the goal of the project. The information explained to the participants was not too detailed, since we wanted the participants' initial thoughts and feedback directly, without them being too steered from the project brief. We wanted to see if the participants understood the prototype and wanted their honest opinions.

For each participant, the test lasted approximately 15-20 minutes, depending on the length of the discussion and ideas for potential improvements afterwards. If needed, the researcher taking

notes could also ask the participant questions and help the test participant with understanding the prototype. The test sessions were scenario-based and the participants were guided through the prototype through a number of prompts, together with the possibility of being able to explore the different functions by themselves.

Figure 25: A picture showing the user evaluation of the first prototype

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6.2.5 Result Analysis

In order to analyze the results of the user tests, a walk through of each session was carried out. Positive and negative feedback were highlighted and noted down into coherent categories, being *Main*, *Statistics*, *Challenges*, *Reward System*, *Profile* and *Groups*. These emerging categories were somewhat similar to the screen categories in the prototype. Since the tests were scenario-based, this was deemed as the most suitable way of properly collecting all feedback and potential ideas that could further improve the solution. Many interesting topics and ideas of improvements were discussed during the test sessions, and this proved to be valuable feedback in order to improve the concept in the next prototyping cycle. A richer understanding of what users actually wanted in a solution that would calculate their carbon footprint came out of the test sessions.

The participants understood the purpose of the concept and were mostly positive towards the prototype. What came out as a big critique from the participants was the use of the goblet for showing badges and achievements, and it was questioned for being too ambiguous and for disrupting the navigational flow. Participants stated that they felt lost whenever they navigated to the goblet screen, and felt uneasy when they did not know how to get back to the previous screen.

The goblet screen was, in fact, designed as a pop-up screen but the participants did not perceive it that way. When the purpose of the goblet pop-up screen was explained, participants reacted in a negative manner and provided us instead with ideas of improvements and how they wanted

the function to be designed. Most of the participants wanted the badges and achievements to be located on their profile screen, and one participant wanted them displayed together with badges and achievements that they had not yet earned. This, in order to know what to work towards and to raise their motivation.

As stated above, the idea with a social layer was not included in the first prototyping cycle. Still, we asked participants for their opinions on this matter during discussions afterwards. Most of the participants were positive when discussing this, and came with valuable feedback on what they would like to have in a solution with a social layer.

From testing the prototype, participants stated what they deemed unnecessary and stressful, and helped us to steer the concept in a better direction. Overall, every participant agreed that they wanted more clear information regarding their own behavior and how to make more informed actions based on a sustainable lifestyle.

6.3 Prototyping Cycle 2 (of 3)

The first prototyping cycle identified which aspects that worked well, and which that did not work as great. This cycle also generated new ideas of features to incorporate, which were further explored in the second prototyping cycle. The second prototyping cycle also had the purpose to further refine the concept and develop it more in line with what came out from the first prototyping cycle. The feedback from the involved users, on thoughts and ideas on improvements, were taken into the next iteration phase, and appropriate changes were made. The prototype in this prototyping cycle included the elements of a social layer. In the former prototype phase, users were positive on the idea to have a social layer and thought it would add a motivational aspect for them in their process to become more sustainable aware, and make informed actions according to the environment. By adding a social layer to the design we wanted to test our own and participants' hypothesis, that were also grounded in behavioral change theories, that the social community approach would add value, motivation and support.

Activities that were carried out in Prototyping Cycle 2 were sketching of ideas with new requirements in mind, making a digital prototype with a higher fidelity level, evaluation sessions with participants, and finally an analysis of the evaluation results, in order to further make improvements to a final design.

6.3.1 Sketching

Before beginning designing the second prototype, some sketching activities were held in order to figure out what needed to be changed and what functions needed to be added. This was an exploratory sketching session where several added elements were designed and tested. The former idea was to add the social layer to the existing first paper prototype, but it was later decided that a digital prototype would be better for the purpose. A digital prototype would also be more

clear for the test participants, and would also enable them to provide us with more feedback on certain design choices.

6.3.2 Prototyping

The collaborative interface design tool *Figma* was used to develop a second interactive prototype. The prototype was designed during a a span of a couple of hours and contained the screens from the former prototype, but with new screens for the social layer, being the *Communities* screen. The fidelity of the second prototype was higher than the first one, but the style of the elements were not too detailed and had no color. This was important so that the participants would focus on the functionality and information flow of the prototype, and not minor details such as styling of buttons, headings or color choices. Although colors are important cues in interfaces, e.g. when two objects have the same color it is interpreted that they are connected (Cooper et al. 2014), these were not used. Instead, contrasts were heavily used in order for users to understand what was connected in the prototype, since objects with contrasting colours are interpreted as having categorical differences (ibid.). It was decided that animations and transitions would not be used in a wide extent in the second prototype, only between the splash screen and the main screen. This decision was further strengthened when it appeared that Figma (Figma 2019) as a interface tool lacks when it comes to creating complex animations. The prototype was made interactive through the prototyping part of Figma, and it was used with the smartphone application *Figma Mirror*, in order to see and use the prototype in a natural way on a smartphone.

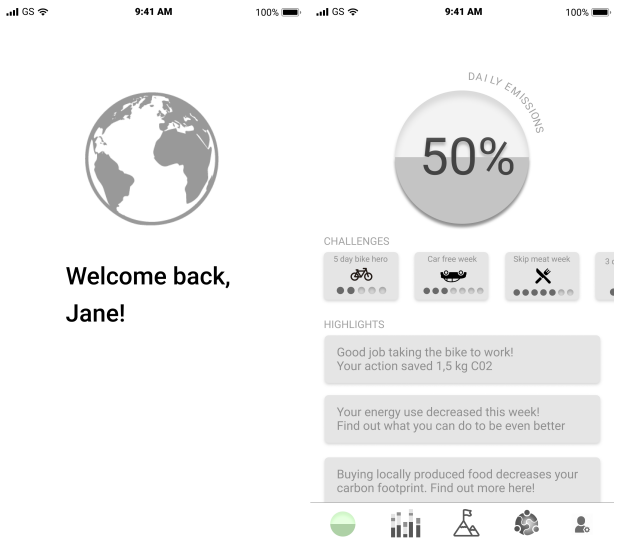


Figure 26: Screen shots of the splash and main screen of the second prototype. The splash screen displays a globe with a welcome back message for the user, and transitions after a couple of seconds into the main screen.

6.3.3 Heuristic Evaluation of Persuasive Features

An evaluation based on the method *Heuristic Evaluation of Persuasive Features* was executed in order to analyze the theories and frameworks used to create the different parts of the prototype. This was considered as important, since it can be difficult to evaluate the persuasiveness of the prototype in other ways. The process was initiated with summarizing and categorizing the theory frameworks that have been used within the prototype cycles one and two. After printing the screens of the second prototype on pieces of paper, notes were written about what theories were utilized for various components. In order to get a clearer overview of which theories were used more or less, these were color coded.

The result of the analysis gave both insights into the connection between theory and the prototype, and new thoughts about existing components and changes that would be made in the prototype before the evaluation with users was held.

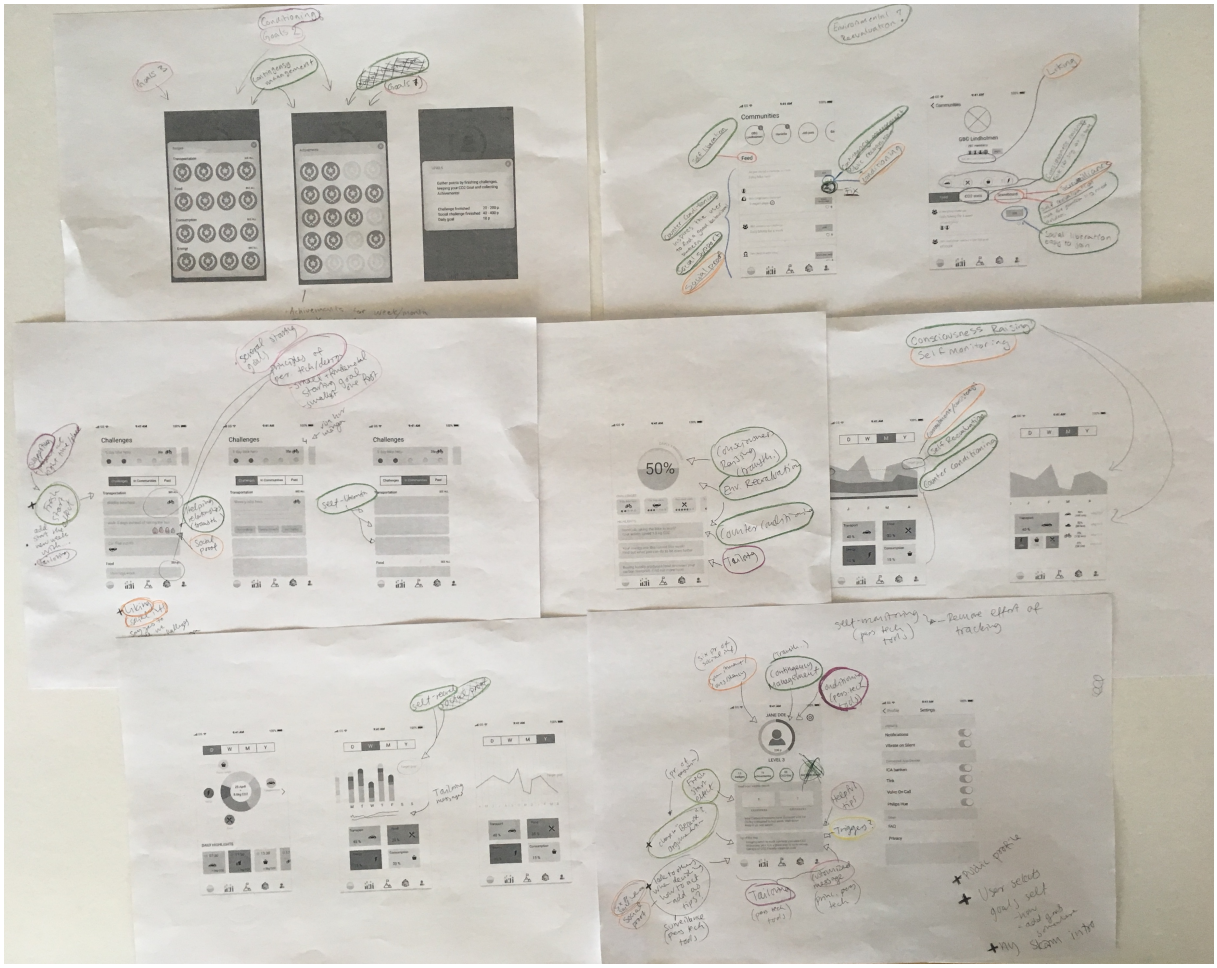


Figure 27: A picture showing the evaluation based on the method Heuristic Evaluation of Persuasive Features, which consists of printouts of the second prototype, with text and color markers of what theories the design utilizes.

6.3.4 User Tests and Evaluation

The second iteration of user evaluations were carried out in a relaxed setting, with a semi-structured approach where the participants followed the Think-aloud protocol using the Co-discovery setting, while answering certain questions and making comments about the various parts of the design. By using the co-discovery setting, test participants spoke freely of the prototype and the research area. The beginning of the first test was scenario-based, as the evaluation in prototype cycle 1, but having the evaluation scenario-steered was deemed unnecessary because of the test participants curiosity and freedom to explore. Approximately half of the test participants were interaction design students who, because of their knowledge and skill sets, provided in dept knowledge and suggestions of improvement of the design of the prototype and all its elements.

Before beginning the evaluation sessions with the participants, once again a pilot test session was held to identify apparent issues in the design, before initiating the actual user evaluation. The number of participants for the evaluation for prototyping cycle 2 were 6 people, and each test was carried out with 2 participant, as according to the co-discovery method. All except one of the test participants during this evaluation had not tested the previous prototype. A mutual characteristics for all participants was an interest in the environment, and a wish to change the individual behavior in order to make more well informed decisions related to a sustainable lifestyle.

6.3.5 Analysis

In order to analyze and structure the results from the user evaluation tests, a *Feedback Capture Grid* was used. The feedback, written down on individual sticky notes, was structured into four quadrants, being *Likes*, *Criticism*, *Questions*, and *Ideas*.

In the **Questions** category there were questions about challenges and who created them, sharing of content ambiguity, who decided the daily and target CO_2 goal, and what certain icons and buttons means.

The **Likes** category had various feedback regarding the community aspect and the motivation to accomplish goals together as a team, together with being positively motivated by being challenged by friends. New, valuable feedback provided from the evaluations was that people also wanted to compete with themselves and constantly strive to get better results than previous weeks. The participants also liked the visuals and statistics used in the prototype.

The **Ideas** category contained more feedback compared to the rest of the quadrants. The participants stated that they wanted more detailed information and focus on short-term and community goals, and more motivational feedback in the form of tips, challenges to reach target goal, and encouragement. Related to this, they also preferred to have a more detailed weekly report of all their accomplished achievements, together with a daily or weekly notification reminding them to explore these. In order to know how to improve themselves, users wanted more information in how to reach new levels, and stated that they would feel motivated in using the solution if there

were unlock features implemented when reaching new levels.

In the statistics section, several participants said that they would have preferred the year graph to be more similar in style to the month graph, with more clear information and details, as well as more information regarding their monthly behavior in any of the categories Transportation, Food, Energy and Consumption. For the challenges part, participants wanted a more distinct focus on their active challenges, and wanted the prototype to display what friends were enrolled in certain challenges. For challenges, participants also wanted themed events. Examples of themed events that the test participants wanted were: *Vegan Week*, *Plastic Free Week*, and *Bike Week*, which was a previous idea we actually had.

The **Criticism** category contained feedback about icons, wording of headings and usability concerns, as well as privacy and sharing opinions. People felt unsure about what they shared to others or not, and wanted to be able to decide this themselves to have it balanced as to not share exactly everything they did.

The Ideas section proved to be the one quadrant with the most content after having completed the user tests and structured the given feedback, while the Questions section had the least content. To get a more comprehensive understanding of the feedback and start synthesise it into valuable information, a quick categorization of the sticky notes inside the quadrants was carried out. Thereafter, a cluster session was held to combine all feedback into overarching groups, since many groups inside the quadrants were strongly associated with other groups in other quadrants. This way, we could understand what feedback groups needed bigger changes. For example, the *Challenges* group had many feedback notes from all quadrants. Consequently, we can draw a conclusion that challenges in the solution needed some changes and fine tuning, since it contained various likes, criticism, questions and ideas.

The categories created in this phase were *Statistics*, *Notifications*, *Motivations*, *Levels*, *Challenges*, *Community*, *GUI and Usability Aspects*, *Profile*, and *Privacy Concerns*. What were deemed as appropriate implementations for the next prototype were chosen, and then noted down. The result of the analysis of the second prototype was discussed and a list of changes to be made was created, which steered the process of the next iteration, prototyping cycle 3. Here, we will present the list of changes:

1. Main Screen. In the first screen, test participants were questioning that they did not know what the target goal was based on, and who had decided it. From this it was decided that more information and control for the user would be needed, to make sure that the users would feel in control and trust the application. The test participants also questioned what would happen if they went over their goal. It was suggested that the "bubble" would turn red and motivational information on how to success in the future would be provided. The test participants did not want to get feedback that made them feel too guilty or bad, but encouraged. The test participants were also a bit confused by the icons in the menu bar and expressed that they looked "weird".

2. Community. Some of the test participants expressed that they did not like having a feed, while

others liked the idea of having it. Most of the users were also positive about having goals within the communities and that they could work together with others to achieve them. A bit of mixed feelings about collaboration versus competition were also discovered. Some of the users liked the idea of competitions, while some thought that it would only create anxiety instead of motivation. The most discussed feature was the scoreboard, where some participants liked the idea of a scoreboard, but they would prefer to be able to hide their own score. There were also some discoveries of fixes that needed to be done in the user interface of the prototype. For example, the buttons of the groups were a bit confusing to the participants since they connected the buttons with stories functions of other applications. The add friends button was also a bit confusing to the participants.

3. Challenges. The participants had many ideas of how the challenge function could be further developed. One feature that was often brought up by the participants was that they would like to be able to join events or time limited challenges. Most of the participants were also interested in the ability of creating their own challenges. It was also experienced as important to the user to have more focus on the active challenges and showing the amount of times they had finished a challenge. There were also some discussions about how the "see more" button would work, the possibility of adding a search-field, the headings used and what would happen if you do not finish a challenge.

4. Statistics. Over all, the statistics pages was met with positive response. The ability to have details on demand was appreciated by the users, but the navigation was somewhat unclear to the participants. The participants also questioned some of the focus on the symbols versus the information that was displayed.

5. Profile. In the profile page the participants wanted to see more of an overview of improvements. It was also perceived as important to have settings about what to share and not, as well as data gathering settings and notifications options. The participants clearly described that control of information was important. Some ideas about levels, achievements and rewards were also brought up.

6. Other. It was noted that the participants thought that it was important with positive feedback and encouragement for their motivation. One of the things that was also discovered was that the design was not consistent enough and that made it hard for the users to navigate and understand the application.

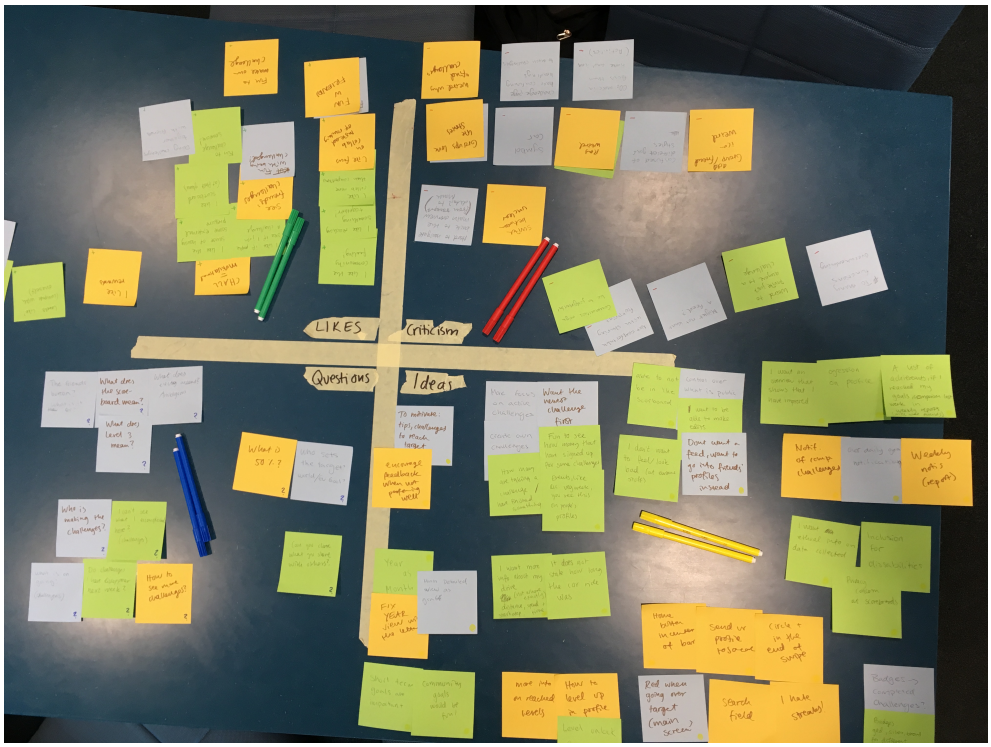


Figure 28: A photo of the feedback capture grid that was used to categorize the feedback of user evaluation in the second prototyping cycle.

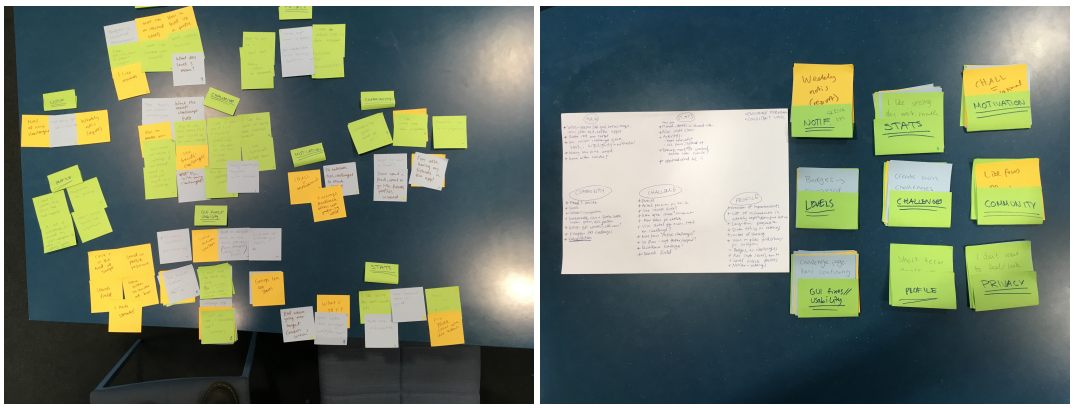


Figure 29: Pictures displaying the categorization of feedback, and the list of changes to make after the analyze of the second prototyping cycle.

6.4 Prototyping Cycle 3 (of 3)

The goal of the third prototype cycle was to incorporate appropriate changes generated from previous iteration, but also to create a high-fidelity prototype to fully test the concept with potential users. The purpose of the third and final iteration was to summarize all findings and insights provided throughout the thesis into a cohesive and consistent concept of a persuasive design exploring behavior change related to sustainability.

The third prototyping cycle was carried out in a similar manner as previous iterations, following the stages of ideation, prototyping, user evaluation and result analysis. For the final user evaluation, 5 user tests were conducted of the final prototype. The result and feedback from these sessions were used within the analysis phase to verify and make improvements to the concept.

The result of the third prototyping cycle is the final concept of this thesis called EcoHero. Prototyping cycle 3 is the final iteration for this thesis, although the final prototype is deemed as not entirely completed since more testing and fine tuning could improve it further, such as conducting more iterations and more extensive user evaluations, together with making a more consistent and perfected interface.

6.4.1 Prototyping

The goal of the third prototype was to make a high-fidelity prototype with a consistent design focusing on look and feel, incorporating the ideas and changes that came out from the user evaluation and analysis of previous iteration. A high-fidelity prototype was developed in order to test the concept and aspects of usability with potential users, where the potential users could behave as if they were interacting with an actual application because of the high degree of fidelity of the prototype. The third prototype was created using the interface design tool *Figma*, the same tool used for the second prototype. The design was based on the second prototype but with more focus on usability and seamless navigation, together with a much higher degree of look and feel. A higher level of functionality was included, meaning being able to scroll vertically and horizontally, animations and transitions, and a number of more functions and details overall. Through a of brainstorming session, a name for the concept was eventually selected, which became EcoHero.

The most apparent change for the third prototype compared to the last was the design being more consistent throughout the prototype. A design change made in the *Community* part of the prototype was a bigger focus on the joined community groups, instead of seeing specific friends and their actions on a feed. The solution was to list all the joined groups directly on the screen, and instead position the feed with individual friends' actions under the groups, so that users can choose whether they want to see this or not.

Test participants from the previous evaluation stated that they appreciated and were motivated by the communal spirit, and wanted more of this aspect throughout the application. Additions to the design were therefore made, making the social layer more obvious for users. One example

of the expansion of the social layer is that users' friends are now displayed on the challenges they are participating in, which can make it more compelling for the user to participate in those specific challenges.

6.4.2 Evaluation

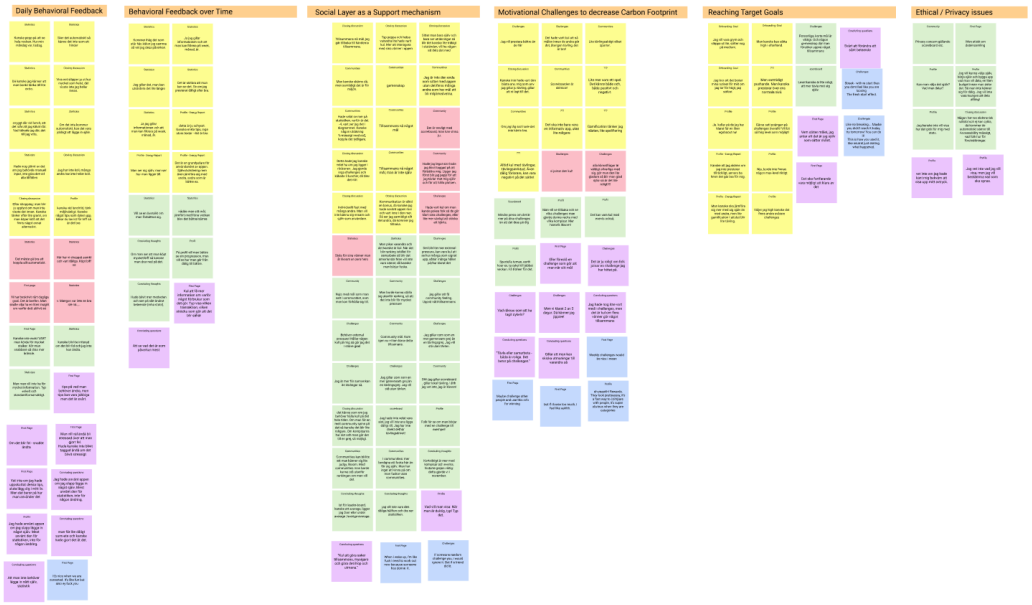
The user evaluation for the final design, EcoHero, was carried out in a similar manner to the evaluation of the previous prototype. 5 people participated in the evaluation of the third prototype, where 2 sessions were conducted using the co-discovery method, while 1 session was conducted with 1 participant using the think-aloud protocol. For the evaluation of prototype 3, one participant had previously tested the prototype from prototyping cycle 2, whereas the rest of the participants were new to the concept.

For each session, a brief introduction to the concept was held before the participants could begin to explore the prototype. The participants were thereafter asked to think out loud while testing the prototype. They were asked to explain how they interpreted various elements, and what would happen if they clicked on certain elements, such as buttons.

While conducting these evaluations, participants were encouraged to say whatever they thought and these subjects were discussed more elaborately, both during and after the user tests. Discussions were held afterwards as a way for us to gain further insights and probe into feedback given by the participants. Discussions often included the design of various elements, the participants' own behavior regarding sustainability, likes and dislikes, and their thoughts on the possibility on them using applications measuring their carbon emissions.

6.5 Analysis of user evaluation

In order to analyze the data from the evaluation an Affinity Diagram was used. This was carried out online using Figma. It was also decided to include both the results from the second and the third user evaluations, since all data was seen as equally important for the result. The method was initiated by writing down important notes and quotes collected during the tests on separate sticky notes. Each sticky note was marked with a color to keep track of which test it originated from, and by a heading of which part of the application was used when the notation was made. The notes were then grouped into six emerging themes; Daily behavioral feedback, Behavioral feedback over time, Social layer as a support mechanism, Motivational challenges to decrease Carbon Footprint, Reaching Target Goals and Ethical/Privacy issues. To analyze this further the notes were then sorted into a second level of themes within their initial theme. This is also the main source of what resulted in the six suggested features when designing persuasion for sustainability presented in the result chapter.



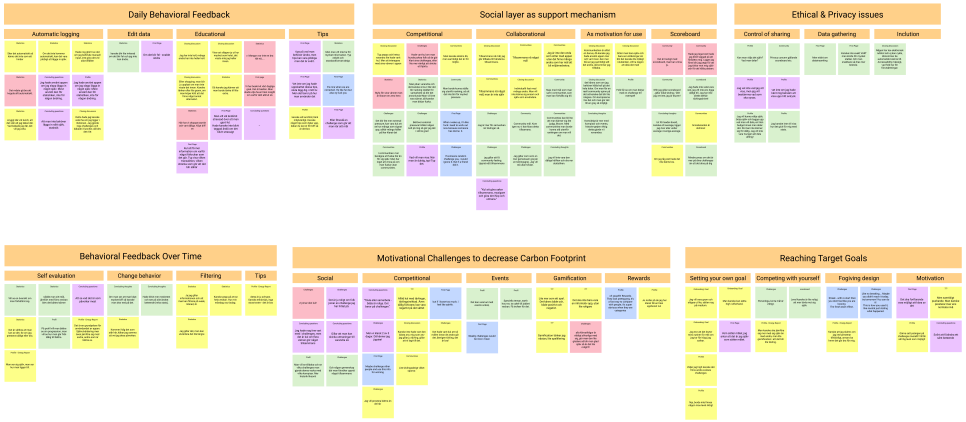


Figure 30: Screen shots of two stages of Affinity Diagrams created in Figma, that were based on data from user evaluation 2 and 3.

6.5.1 Evaluation of Persuasive Features

In order to analyze the result of the user evaluation of the final prototype, in relation to the used theories of behavioral change, a method based on the Heuristic Evaluation of Persuasive Features was carried out. This method was inspired by two different methods used for evaluating

persuasive designs (Faklaris, Dabbish, and Hong 2018b; Langrial et al. 2012).

To carry out this method, a list was created of the theories and frameworks that had been used throughout the project process. This was made to get a more cohesive overview of the correlation of theories, design choices and user feedback. For each theoretical design principle two short statements were formulated, one describing the *Goal*, and the other describing *How that goal could be achieved*, within that specific principle. Thereafter, examples from the design were put next to the statements and principle. After that, one or two quotes from the user tests were associated with each principle.

This analysis was done in an excel sheet to create a simple overview of the result in relation to the theory, and to see what was the result of implementing persuasive design principles for a solution that would aim to decrease individuals' carbon footprint.

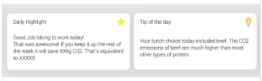
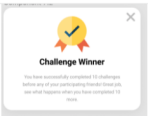
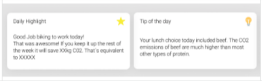
Theory	Goal	How	Example	Example 2	User Quote	User Quote 2
Transtheoretical model of change						
Consciousness Raising	Make the user **aware** of the behaviour and able to make informed choises	By providing informational education, feedback and confrontation			*"Oh, we have been shopping a lot and been bad. Bought beef and stuff...the mango was not a good idea"*	"You get enlighten if you did´nt know it before. Maby consider a bit, if you by meat that there are other alternatives. Compare in the list if you bought fish and meat"
DramaticRelief	Make the user **emotionally engaged** in changing the behaviour	By creating one or multiple emotional experiences			"You get a bit of a bad conscience and then mayby I would do something about it"	"You also want to get a bit stressed if you do something bad, I might get more spured if it was a bit stressful"
Self-reevaluation	Make the user realize and evaluate the importance of the change related to the users **self image**	By providing the application and information to make the user aware of the behaviour			*"We have exceeded our daily target. It is the beef, I would like to get an insight of why this happened"*	

Figure 31: A screen shot of an extract from the evaluation of persuasive design.

To present the result of the analysis in an understandable and clear way, each theoretical principle will be presented together with its corresponding user quote and design choice. Since some of the user evaluations were carried out in the test participants and researchers' native language, some of the user quotes have been translated to English, thus might have been somewhat altered to better fit the context.

Principles from the Transtheoretical Model of Change

Consciousness Raising

The goal of *Consciousness Raising* is to make the user aware of their behaviour and make sure that the user is able to make informed choices, by providing informational feedback and confrontation. Consciousness raising was utilized by showing the user how much CO_2 emissions that was caused by their various choices and by confronting the user when choices were made

that caused a high amount of Co_2 emissions. This principle is one of the most occurring principles that is used throughout the application. Consciousness raising as a concept is a big part of the concept.

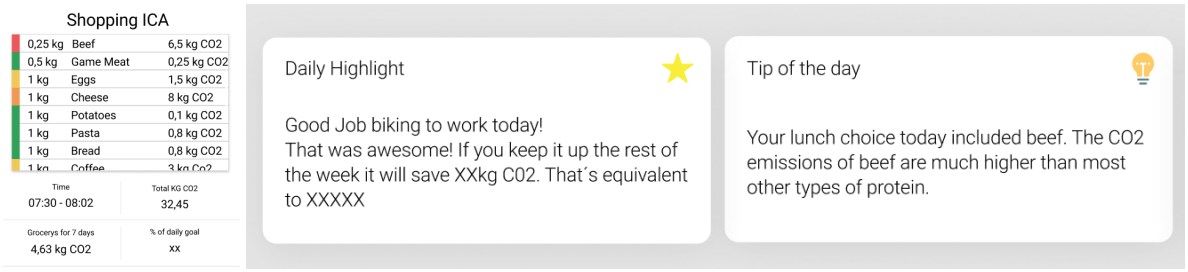


Figure 32: Screen shots from the third prototype, showing examples of how the principle of Consciousness Raising was implemented.

An insight from the user evaluations was that most users expressed appreciation towards the features of getting informational feedback of their actions, and that this would, for an extent, probably lead to them making changes while learning more about their behaviour in relation to sustainability. When testing the concept and approaching the elements that used the consciousness raising principle, participants stated:

> *"Oh, we have been shopping a lot and been bad. Bought beef and stuff... and the mango was not a good idea."*

> *"You get enlightened, if you did not knew about it before. Maybe you consider it. If you buy meat, that there are other alternatives. You can compare if you bought fish and meat in the list."*

Dramatic Relief

The goal of *Dramatic Relief* was to make the user emotionally engaged in changing the behavior, by creating one or multiple emotional experiences. An example of the use of dramatic relief is when the user exceeds their daily emissions goal target, and the "bubble" turns red. This can evoke certain emotions coupled with loosing or not being good enough. Instead, positive emotions can be evoked because when receiving badges or feelings of accomplishment and happiness when completing a challenge.

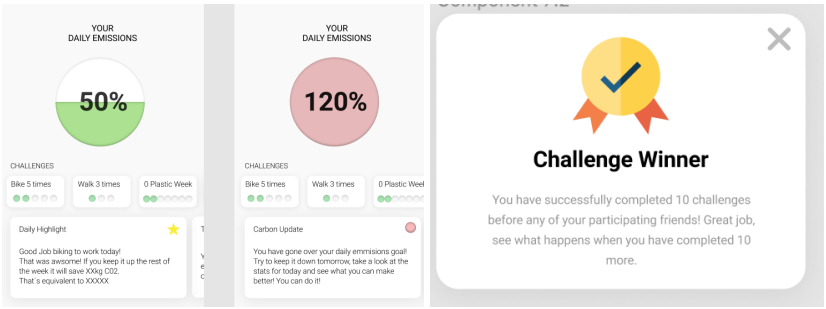


Figure 33: Screen shots from the third prototype, showing examples of how the principle of Dramatic Relief was implemented.

During the user evaluation, some participants had reflections regarding how they thought their emotional response would be to some parts of the application, and how that could ultimately affect their behavior in the future.

> *"Maybe I would feel a bit guilty, and then I might do something about it."*
>
> *"You want to get a bit stressed if you do something wrong. I might get spurred if it was a bit stressful."*

Self-Reevaluation

The goal of *self-reevaluation* was to make the user realize the importance of the change related to the user's own self-image. Self-reevaluation was utilised by providing information related to this context, in order to make the user aware of the behaviour and its potential consequences if left unchanged.

> *"We have exceeded our daily target. It is because of the beef. I would like to get an insight of why this happened.""*

Self-Liberation

The goal of using the principle *Self-Liberation* was to make the user commit to the change by enabling them to share the commitment publicly, and have more than one way to success. This meant having a social aspect as a common thread throughout the application, and to provide the user with various ways of decreasing their CO_2 and improve their behavior.

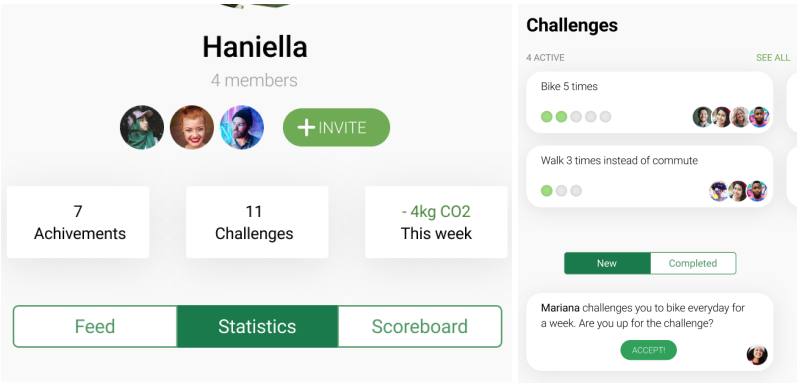


Figure 34: Screen shots from the third prototype, showing examples of how the principle of Self-Liberation was implemented.

"I need some external pressure! If someone is keeping track of me, I will do it to a grater extent"

Social Liberation

The purpose of using *Social Liberation* as a principle was to make it easier for the user to make behavioral changes. This was done by highlighting opportunities for the good behavior in the environment, to make the process of changing behavior easier for the user.

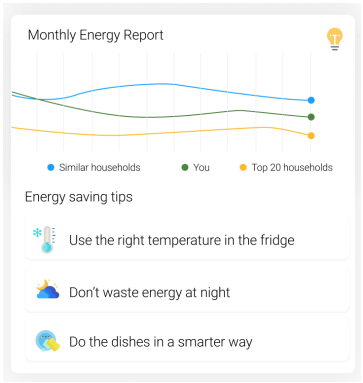


Figure 35: Screen shot from the third prototype, showing an example of how the principle of Social Liberation was implemented.

"I would like suggestions of what you need to change... Or recommended challenges to do to achieve my goal."

"This is nice! That's pretty easy suggestions!"

Counter-Conditioning

The principle *Counter-Conditioning* was implemented in the application to make the user find a better alternative to substitute for the previously bad behavior. Counter-conditioning was carried out by providing the user with tips, strategies, tasks, motivation and encouragement in various forms.

> *"You get enlightened if you did not know about it before. Maybe you rethink a bit, if you by meat that there is other alternatives"*

Stimulus Control

Stimulus Control was used throughout the application in order to remove the triggers of the bad behavior, by providing the user with information and options regarding a better behavior on the right time and place for the action.

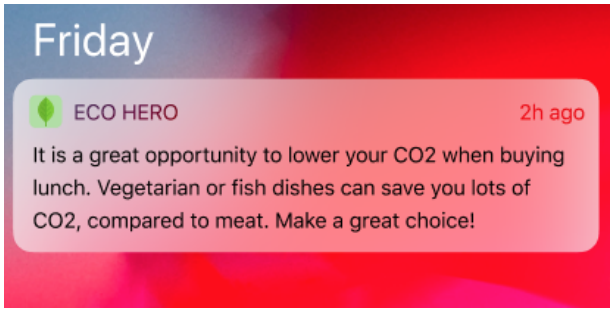


Figure 36: Screen shot from the third prototype, showing an example of how the principle of Stimulus Control was implemented.

> *"I would like a notification at lunchtime, think sustainable. Maybe a tip pops up, if you eat salmon instead of beef that's good"*

Contingency Management

The purpose of implementing the principle *Contingency Management* was to encourage the behavioral change through motivational rewards and public recognition for good behaviors. In Contingency Management, punishments can also be utilized together with rewards. This was deemed as not suitable for this project, considering the user insights that clearly stated that there should be no negative messages delivered to the user. As a result, only positive reinforcements

were used throughout the application.

> *"I look at the challenges I've finished, and got an ego boost now!"*
>
> *"I would want to see the points on challenges everywhere! I want to reach as high level as possible!"*

Helping Relationships

The goal of using the persuasive feature *Helping Relationships* was to provide the user with support from their family, friends, and communities. This was implemented by having opportunities for social relationships with contacts in the application. Having helping relationships was considered as an important aspect for making the atmosphere within the application positive and motivational.

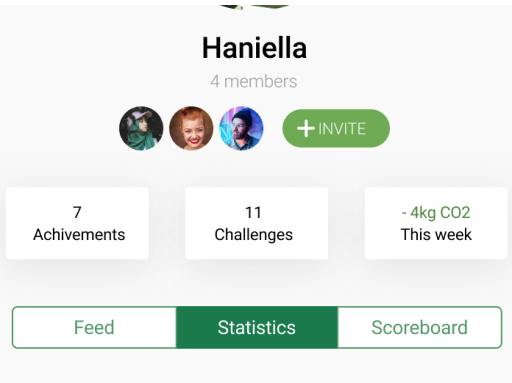


Figure 37: Screen shot from the third prototype, showing an example of how the principle of Helping Relationships was implemented.

> *"You can brag to your friends that you are a Carbon Zero Hero."*
>
> *"You can reach a goal together, you're not alone. I'm not the only one using the application, there are many others that are trying to become more conscious of the environment too."*

Principles from principles of Persuasion

Making an argument

The goal of using the persuasive strategy *Making an argument* argumentation, was to make the user understand why the behaviour change, or beneficial action, is good by providing the user with reasons why. Providing a reason to an request results in a higher success rate for the request.

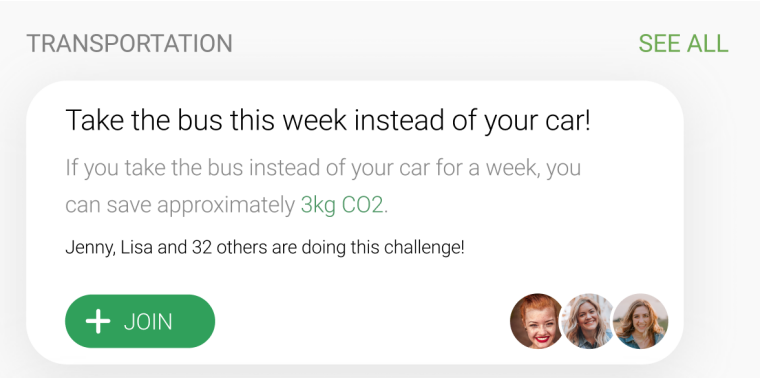


Figure 38: Screen shot from the third prototype, showing an example of how the principle of Making an argument was implemented.

Fresh Start effect

The goal of using the persuasive feature *Fresh Start effect* was to keep the user's motivation, when not preforming their best. This is done by providing opportunities for a fresh start, to start over and try again. Setting new goals and reaching milestones are an important aspect when trying to change behavior.

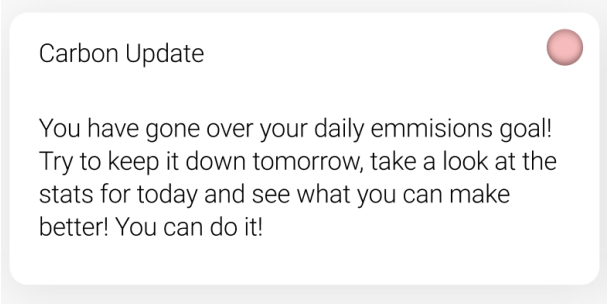


Figure 39: Screen shot from the third prototype, showing examples of how the principle of the Fresh Start Effect was implemented.

"Because you can start over, you don't feel like you are loosing, because you can

try again."

"Maybe you didn't reach it today, but try tomorrow! You can do it! This is how you used it, it was stated in a neutral way, what occurred."

Six principles of social influence

Authority

The goal of using the persuasive feature *Authority* was to make the user feel more motivated from seeing other people's success, carried out by showing the user's behaviour in relation to other people. To compare oneself to others might act as a motivational aspect.

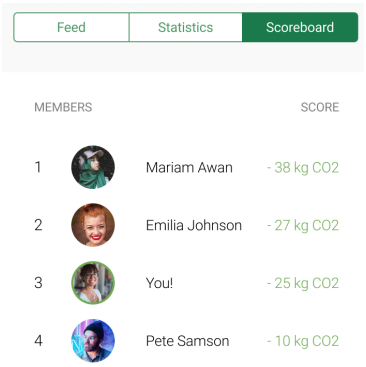


Figure 40: Screen shot from the third prototype, showing an example of how the principle of Authority was implemented.

"If I was on last place, I would want to become better. If I was leading, I would compete against my self, and want to keep being in first place."

Commitment / Consistency

The goal of using the persuasive feature *Commitment / Consistency* was to keep the user's motivation through wanting to act according to their values and commitments. This is done by providing the user with multiple ways of setting goals and achieving them.

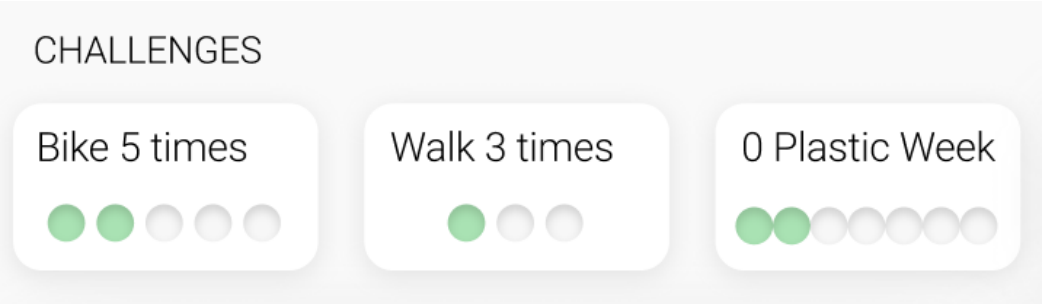


Figure 41: Screen shot from the third prototype, showing an example of how the principle of Commitment/Consistency was implemented.

"It is like self-evaluation, but also comparing to others that are better. It is good not to include low performing users, you should not compare yourself to those not performing as well as yourself."

"I don't want to be the bad half and pull down the statistics. That is why I must continue."

Liking

The goal of using the persuasive feature *Liking* was to make the user commit to make changes on a social level by providing ways to commit to changes, in a social setting with what the user likes.

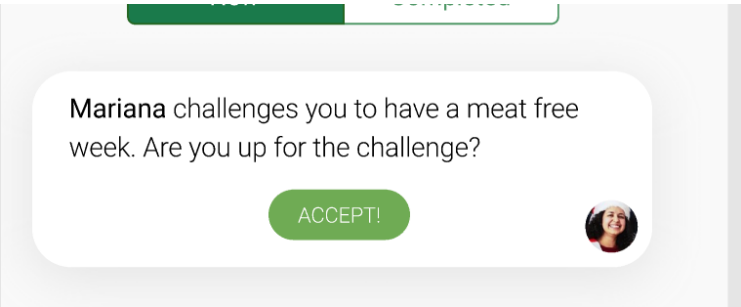


Figure 42: Screen shot from the third prototype, showing an example of how the principle of Liking was implemented.

"I like getting the community feeling - to achieve something together."

Social Proof

The goal of using the persuasive feature *Social Proof* was to increase the user's motivation and believe in a positive outcome after making the change, by providing the user with the possibilities to look to other people's behavior and success. This, in order to get inspired to proceed with the behavior change.

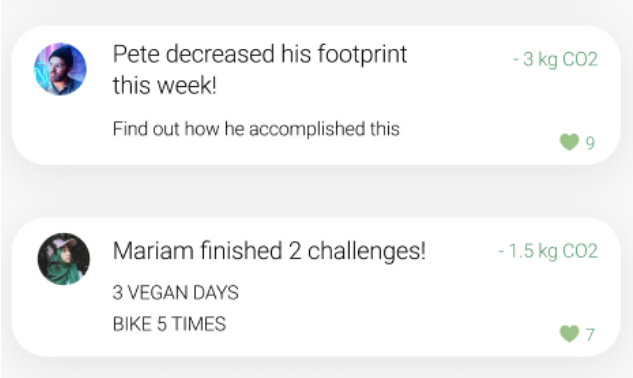


Figure 43: Screen shot from the third prototype, showing an example of how the principle of Social Proof was implemented.

Principles of Persuasive Technologies and Design

Goals 1

The goal of using the persuasive feature *Goals 1* was to make sure that the user's motivation is kept during a longer period of time, by making sure that the user is able to set smaller goals, and that new goals are provided gradually.

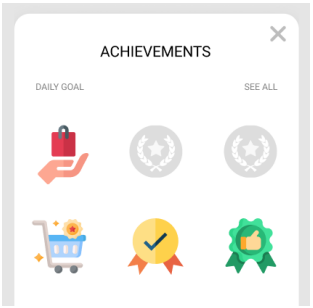


Figure 44: Screen shot from the third prototype, showing an example of how a principle of goals was implemented.

"It should be possible to reach it [the goal]."

"Personal, short goals are important."

Goals 2

The goal of using the persuasive feature *Goals 2* was to make sure that the user's motivation is kept. This is done by informing the user that there is more than one way to success in a process or activity.

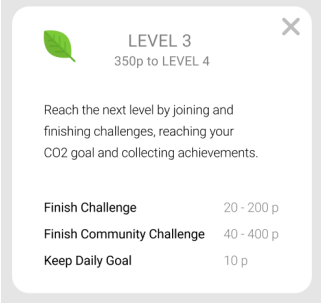


Figure 45: Screen shot from the third prototype, showing an example of how a principle of goals was implemented.

Goals 3

The goal of using the persuasive feature *Goals 3* was to increase the user's motivation, by letting the user be free to set goals by themselves.

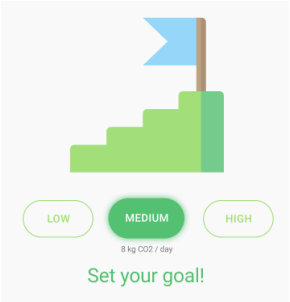


Figure 46: Screen shots from the third prototype, showing an example of how a principle of Goals was implemented.

"I want to be great and have little emissions. I think I would choose the medium level. I think it is too hard to change my routines too much if I were to pick the highest level. I will play it safe. Then, I can change to the higher one later."

Process

The goal of using the persuasive feature *Process* was to make sure that the user is motivated to take action to change the behaviour, by enabling the user to quickly start a process with the support of the persuasive design principle. This action should feel as an easy process to start for the user. Displaying how the process could look can help users prepare themselves and get a richer understanding of the change that they might want to make.

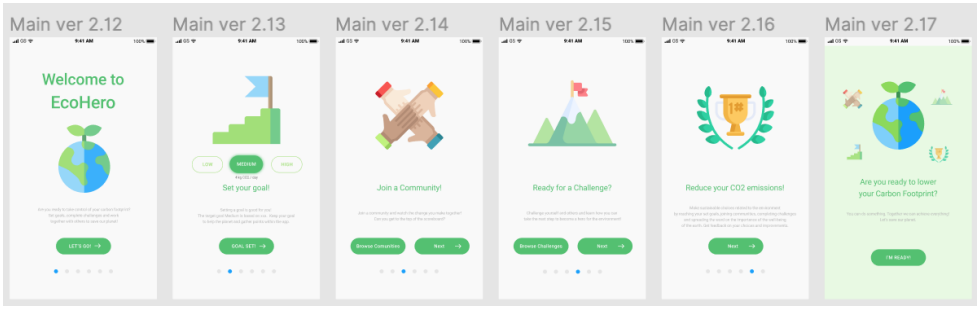


Figure 47: Screen shot from the third prototype, showing examples of how the principle of process was implemented.

Action

The goal of using the persuasive feature *Action* was to make sure that the user is motivated to take action, in order to make changes of the currect behaviour. This is done by encouraging the user and provide them with helpful tips, to make them improve a certain behavior that is desirable for the cause.

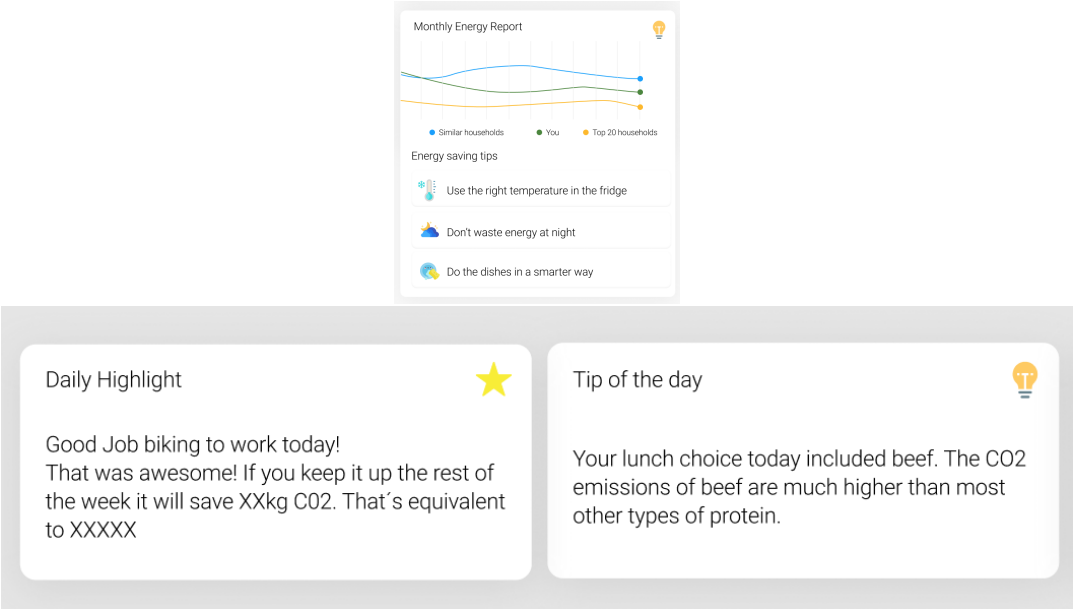


Figure 48: Screen shots from the third prototype, showing examples of how the principle the Action was implemented.

Encouragement

The goal of using the persuasive feature *Encouragement* was to encourage the user to make changes by providing customized choices and messages, reminders, point systems and communities, which are aspects that often act encouraging and motivational.

The Fogg Behavior Model

Motivation

The goal of using the persuasive feature *Motivation* was to make sure that the user is motivated to make changes by evoking motivational emotions like pleasure/pain, hope/fear, social acceptance/rejection.

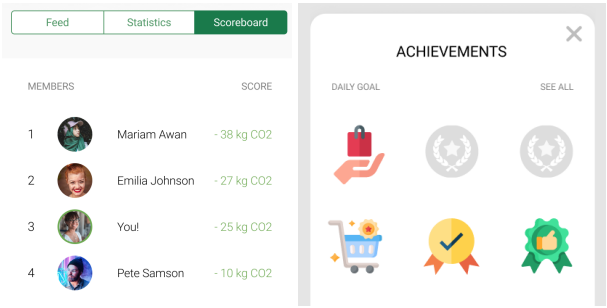


Figure 49: Screen shots from the third prototype, showing examples of how a principle of Motivation was implemented.

"It should not just be an informative application, it should be a bit more fun. It should be a bit more like a game."

"You sort of get a bit of a bad consciousness, and I would maybe do something about my behavior."

Ability

The goal of using the persuasive feature *Ability* was to make sure that the user has the ability to make the change by providing different levels of tasks, tips and information, in order for the user to make their own decision.

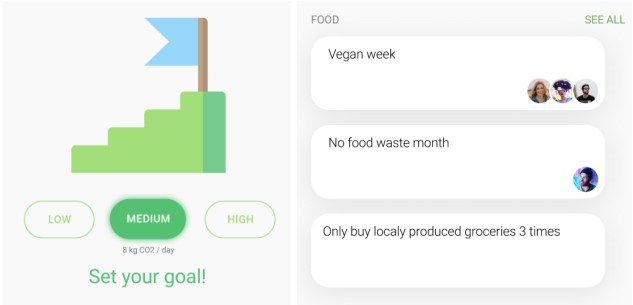


Figure 50: Screen shots from the third prototype, showing examples of how the principle of Ability was implemented.

Triggers - Sparks

The goal of using the persuasive feature *Triggers - Sparks* was to make sure that the user is triggered to make the change by motivating a certain behaviour that is desirable.

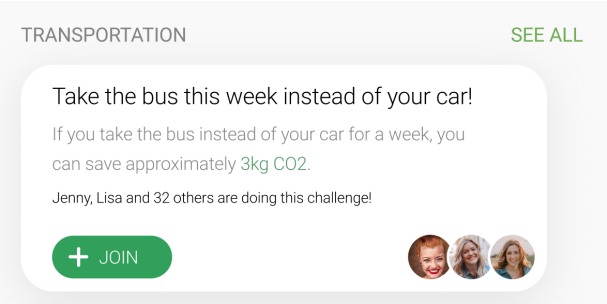


Figure 51: Screen shot from the third prototype, showing examples of how the principle of sparks was implemented.

Triggers - Facilitators

The goal of using the persuasive feature *Triggers - Facilitators* was to make sure that the user is triggered to make the change by making the new behaviour interpreted as easier to reach and carry through. By providing step-by-step instructions and suggest smaller activities, the desired behavior change can be regarded as possible to carry out.

Triggers - Signals

The goal of using the persuasive feature *Triggers - Signals* was to make sure that the user is triggered to make the change, through the use of reminders and indicators. This is implemented in the concept by notifications that are timely and informative.

Persuasive Technology Tools

Reduction

The goal of using the persuasive feature *Reduction* was to increase the user's motivation and positive thoughts about changing the behaviour by making complex tasks and interactions simple.

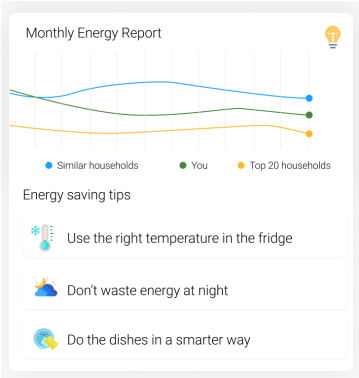


Figure 52: Screen shot from the third prototype, showing an example of how the principle Reduction was implemented.

"This is nice! Those are pretty easy suggestions!"

"Or suggest a challenge that makes you reach your goal."

Tunneling

The goal of using the persuasive feature *Tunneling* was to engage the user in new activities and mindsets, and influence the behaviour in a positive way by guiding the user through tasks. This was implemented in the prototype by the help of onboarding screens, to summarize the fundamental parts of the prototype.

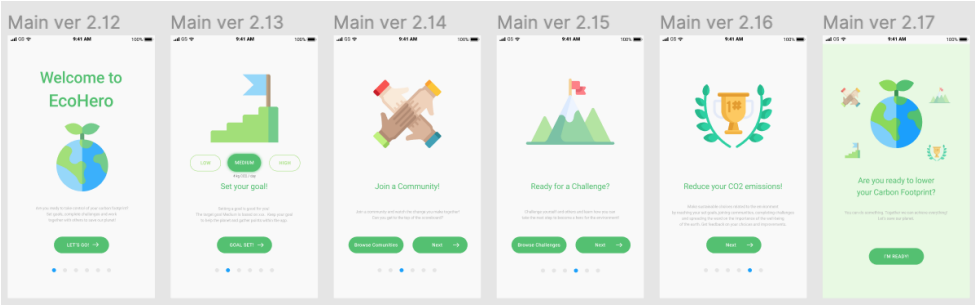


Figure 53: Screen shot from the third prototype, showing an example of how the principle of Tunneling was implemented.

Tailoring

The goal of using the persuasive feature *Tailoring* was to make it easier for the user to change the behaviour in a positive way. This is done through tailoring the information based on, for in-

stance, the user's physical state or knowledge. In the application, this is implemented through personalized messages and feedback.

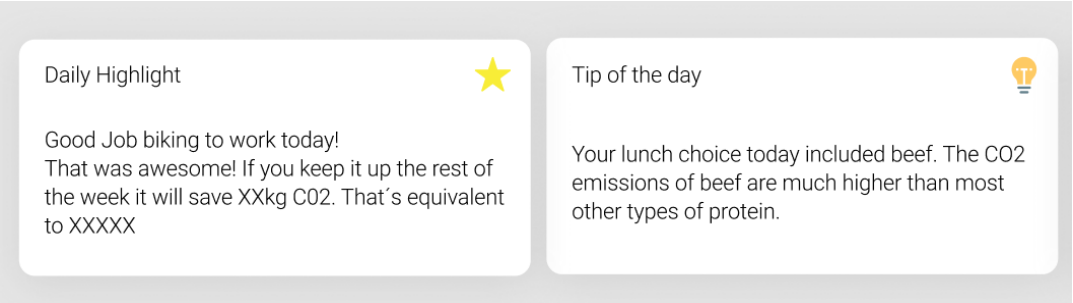


Figure 54: Screen shot from the third prototype, showing an example of how the principle of Tailoring was implemented.

Suggestion

The goal of using the persuasive feature *Suggestion* was to support the user into making informed choices beneficial to the environment. This is done by presenting the user with suitable information at the right time or place, to remind and encourage the user to make a good decision.

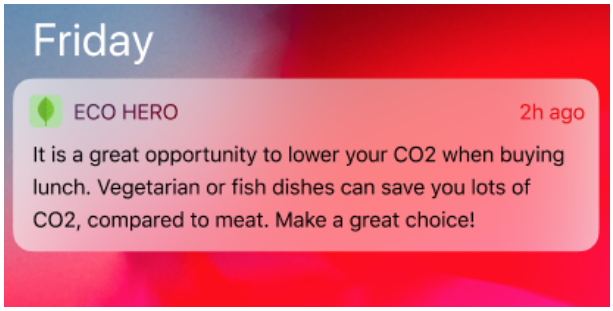


Figure 55: Screen shot from the third prototype, showing an example of how the principle of Suggestion was implemented.

> *"Perhaps before buying lunch, it could remind me to act more sustainable. Maybe a notification that says "If you buy salmon instead of beef for lunch, your will save X amount of CO_2".*

Self-Monitoring

The goal of using the persuasive feature *Self-Monitoring* was to make the user aware of their state of progress. This was implemented in the prototype by providing real-time data collections, and an overview of progressions made, preferably without the need of manual user input.

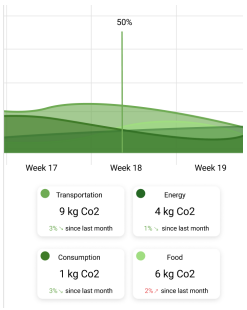


Figure 56: Screen shot from the third prototype, showing an example of how the principle of Self-Monitoring was implemented.

"If we have finished 2 out of 5 days then I feel happy, like "Yay!".

"If it is done automatically it would not feel like an obstacle. I would probably forget about it [the application], if I needed to do manual input, I would probably not do it every time."

Surveillance

The goal of using the persuasive feature *Surveillance* was to make the user reflect on their behaviour by making them aware of others and their behaviour, and that their behaviour is being observed by others.

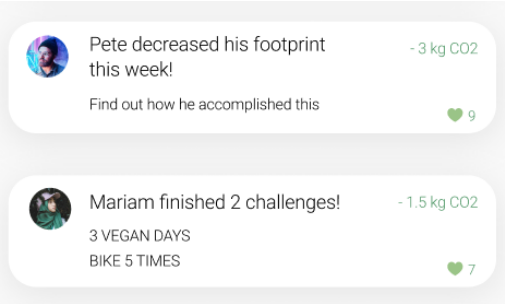


Figure 57: Screen shot from the third prototype, showing an example of how the principle of Surveillance was implemented.

"I need external pressure! If someone keeps an eye on me, then I have to perform better."

"Maybe challenge other people, and use this information for winning. When I wake up, I am like "Oh, I need to work out now because someone else has already done it"

Conditioning

The goal of using the persuasive feature *Conditioning* was to encourage the user to keep using the application, and to keep changing the behaviour towards the better. This was implemented in the prototype by providing rewards and goals to achieve, when the user completes certain actions and challenges. This way, the good behavior is praised and acknowledged.

> *"You get some positive feedback on the things you did well."*

Ethical considerations

The goal of using Ethical Considerations can be, among other things, privacy concerns, to make the user feel comfortable with using the application, and in control. This was implemented in the prototype by letting the user decide what other applications they want to connect for data collection purposes, as well as giving the user control over what is public and not.

7 Result

This Master's Thesis design process has resulted in the creation of a concept for an Eco-Feedback and motivational application, called *EcoHero*. EcoHero provides users with their carbon footprint feedback, and makes it possible for them to take on challenges related to a sustainable lifestyle in order to lower their carbon footprint.

The concept is demonstrated through a prototype utilizing persuasive features and behavioral change frameworks to motivate users to make a behavioral change. Principles and features to consider when designing applications related to behavioral change within sustainability are presented as a result, which could work as guidelines and suggestions for future projects within similar research context. The results presented below are this project's answers to the stated research questions; "How can individuals' carbon footprint be decreased through interaction design incorporating methods for behavioral change in the design of smartphone applications?" and "What features should be considered when designing products aiming to decrease the carbon footprint of individuals?"
The first question is answered with the development of the concept, prototypes, and the evaluation of the prototype, while the second question is answered with the features that will be presented in this chapter.

7.1 The Concept

When initiating the design process, we asked ourselves how we could raise awareness about the environment, so that people are motivated to change behaviors in order to have a lesser impact on the environment.

This initial thought led to a design process with three iterations which, through several ideation sessions and valuable user research, resulted in the creation of the concept *EcoHero*, a smartphone application approaching this context. The concept is to display the user's total carbon emissions feedback, which is gathered through connected solutions and applications, such as applications managing and monitoring people's economy and transportation habits.

When a user first starts to use *EcoHero*, they choose a CO_2 goal to strive for. Thereafter, the user is free to join communities, start challenges and collaborate (or compete) with others to reach a certain goal. The more people that join, the more CO_2 can be saved. New challenges arise when the user completes challenges and collect achievements, and they can follow their progress in their profile and see what they can do to progress to a new level.

When reaching new levels, certain features are unlocked, which can motivate the user to continue their journey to become a person with sustainable habits. In parallel, *EcoHero* detects the user's actions, both transportation choices and all events related to transactions and makes calculations to show the user their carbon footprint. *EcoHero* is built upon theoretical frameworks

and principles related to behavior change, to support, make it easier, and motivate the user in their progress to make a sustainable change. The user receives weekly reports related to their weekly CO_2 impact, to gain insights into how the behavior affects the environment and to identify opportunities for improvements. *EcoHero* provides the user with personalized information, messages, tips and encouragement.

7.2 The Final Prototype

The concept is illustrated with a final prototype, which was created through a design process of three prototyping cycles. *EcoHero* consists of five screens, being the screens Main, Statistics, Challenges, Communities, and Profile. Setting a CO_2 goal is a fundamental aspect of the concept and it is done through onboarding screens, which introduce the user to the prototype and concept. These screens and their content will be described further in this section. *EcoHero* is an Eco-Feedback concept, where the common thread is the carbon footprint coupled with a social layer.

7.2.1 Onboarding

The onboarding screens are an introduction to the application for the user. They are shown when logging in to the application for the first time. The screens use the persuasive principle *Tunneling*, which makes it easier to guide and engage users with new kinds of technologies or features. Using onboarding screens can engage the user from start, so that the user makes a commitment and remembers the application. The user goes through every screen in the category, and is then directed to the actual application.

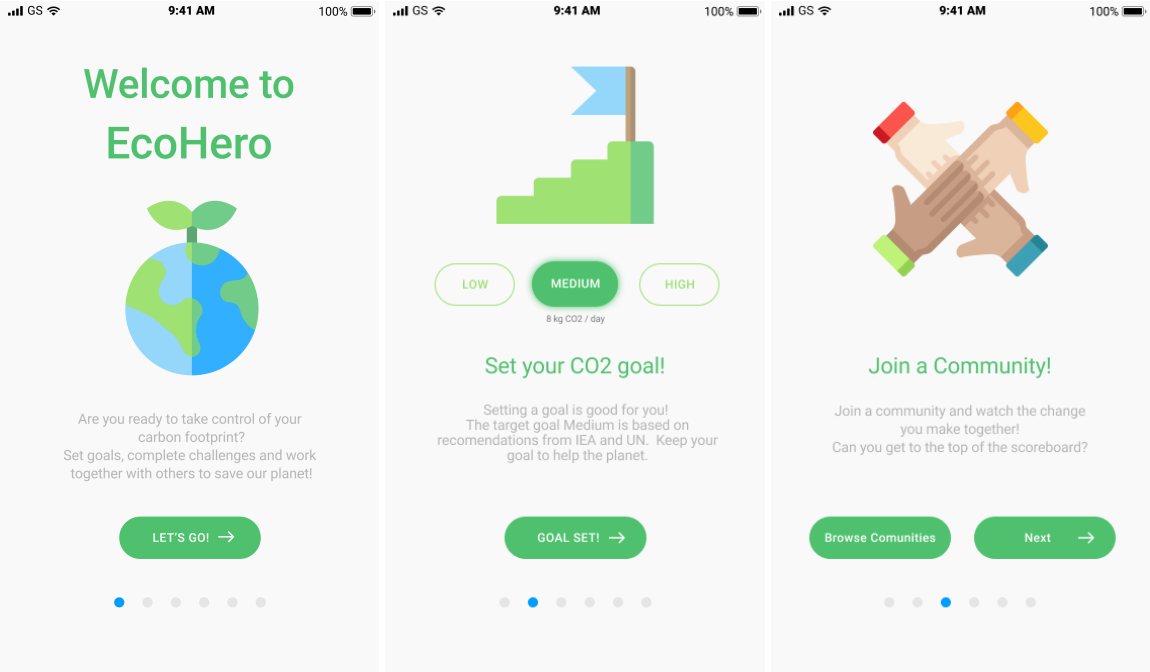


Figure 58: Screen shots showing the Onboarding screen 1, 2, and 3 of the final prototype.

The goal of the first onboarding screen is to let the user know what the application is about, and spark a bit of curiosity and motivation. The second screen lets the users pick their own daily CO_2 goal and by setting the default choice to Medium, it can lower the risk of the user choosing a lower daily goal. As presented in earlier chapters, a strong persuasive motivation is for the user to be able to pick their own goal. The second screen also informs the user what the goals are based on. The third screen lets the user know about the Community and social features of the application.

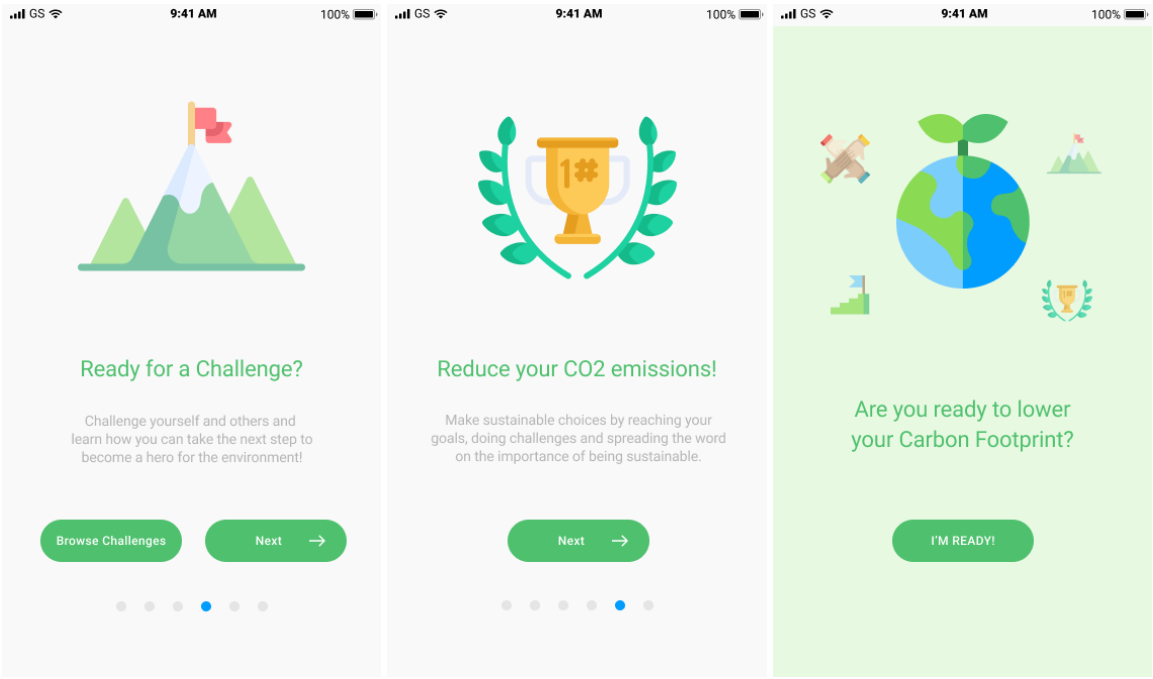


Figure 59: Screen shots showing the Onboarding screen 4, 5, and 6 of the final prototype.

The fourth onboarding screen provides the user with information about the Challenges features, and gives a call to action (CTA) to take on a challenge. The fifth screen explains how to succeed when using the application, while the sixth and last screen prepares the user to start using the application, providing an image that summarizes the fundamental parts of the application.

7.2.2 Carbon Footprint Summary

The main screen of the prototype provides the user with a summary of the used CO_2, the user's challenges and a personalized message. On top of the screen, the user is shown how much of the daily target CO_2 that has been used for the current day. This aims to make the user aware of their emissions and try to motivate them to keep their goal. If the user exceeds the target goal the "bubble" will turn red.

The user will also be notified with a motivational message to try to get the user to reflect on why this have happened and how to improve tomorrow. Beneath the goal bubble the users can see the challenges that they have been taking on and the status of success. In the bottom of the screen messages to the user will be shown. These messages can be things such as tips of improvements, encouraging feedback, warnings of a bad behaviour or weekly reports.

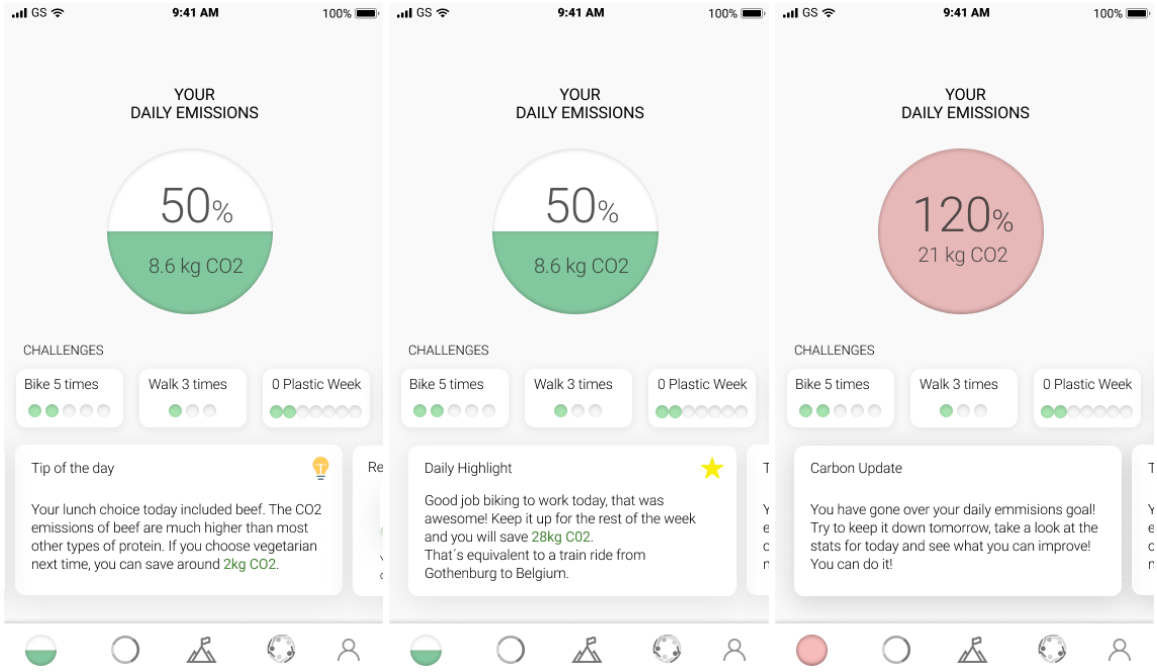


Figure 60: Screen shots showing three different states of the main screen of the final prototype

7.2.3 Statistics

The statistics screen informs the user about their behavior and enables and supports them in making informed decisions related to a sustainable lifestyle further on. The statistics screen is divided into four parts, being the views; Day, Week, Month and Year, which the user can switch between because of the segmented control.

In the Day view, the user can see their emissions of the current day, and is also able to swipe to get to previous days to see the emissions. The pie chart graph of the screen lets the user know which categories the emissions stem from. The four categories, as described in previous chapters, are *Transportation*, *Energy*, *Food* and *Consumption*.

In the Activities pane, positioned right under the pie chart graph, the user can see what activities that have contributed to the emission levels, and how much CO_2 each activity caused. The user can also choose to see more information about the various activities, and this is carried out by tapping on an activity. Thereafter, the chosen activity pops up in a new window, where the user can get additional information and details.

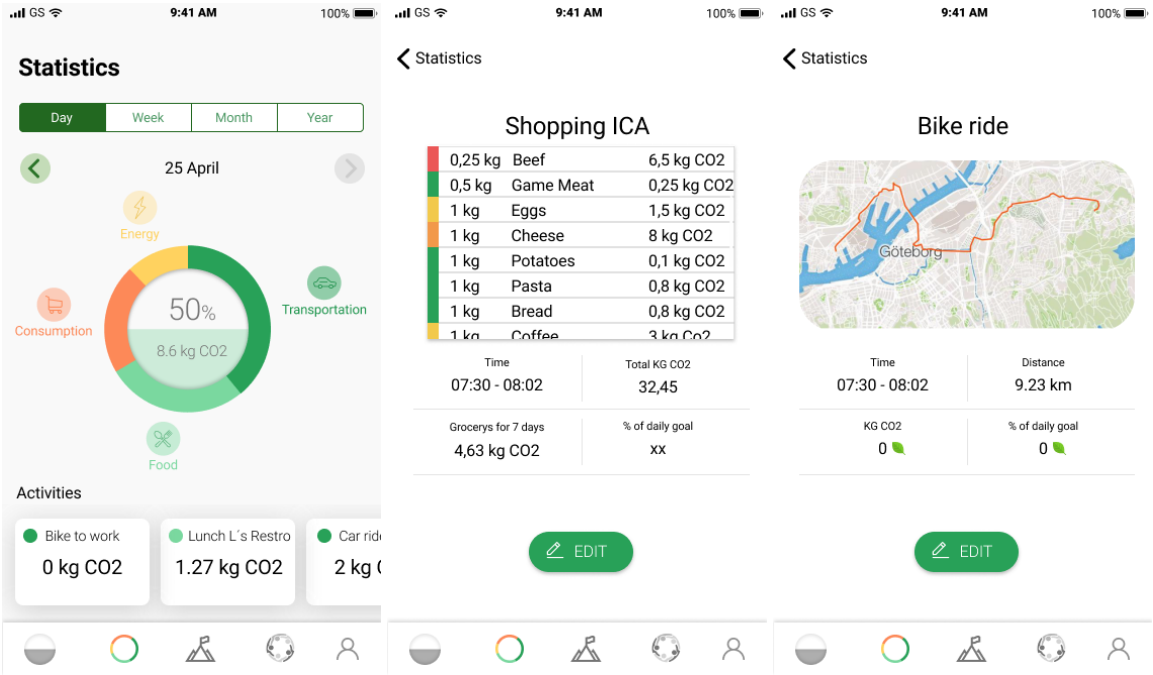


Figure 61: Screen shots showing daily statistic screens of the final prototype.

The weekly view shows the user how their actions have resulted in a certain amount of carbon emissions, which have been divided into four categories in the prototype. The graph type of the weekly view is a bar chart graph, to fully display the different emission categories.

This view helps the user get insight in how their statistics change through time, and may help them to spot destructive patterns trough the correlation between actions and emissions. Information about potential improvements or drops from the previous week are also displayed in this screen, located in the various emission categories. By tapping on one category, the user can choose to only display the weekly statistics for that specific category.

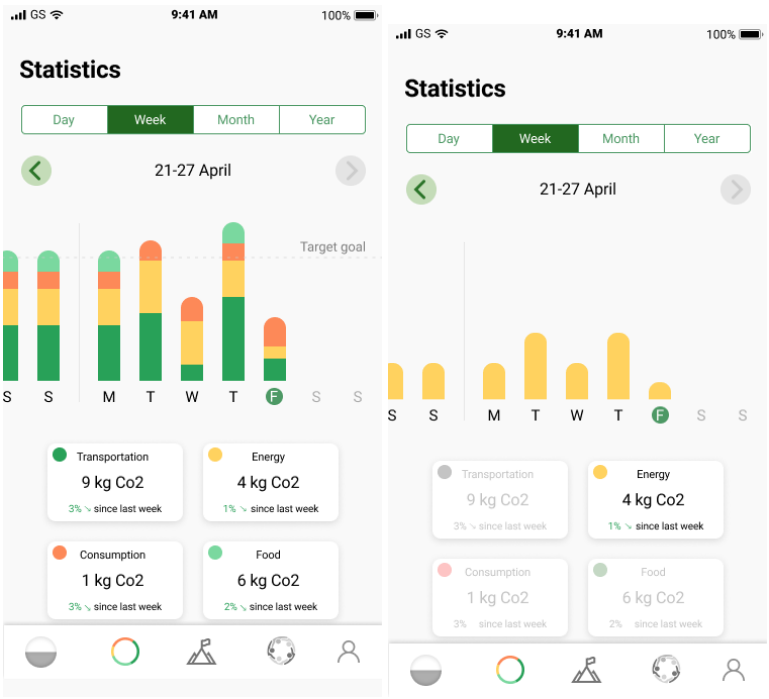


Figure 62: Screen shots showing weekly statistic screens of the final prototype.

The monthly and yearly statistics views are designed in a similar manner as the weekly statistics view. These graphs aim to help the user monitor their carbon footprint and see their progression during a longer period of time. This view uses a line chart graph style.

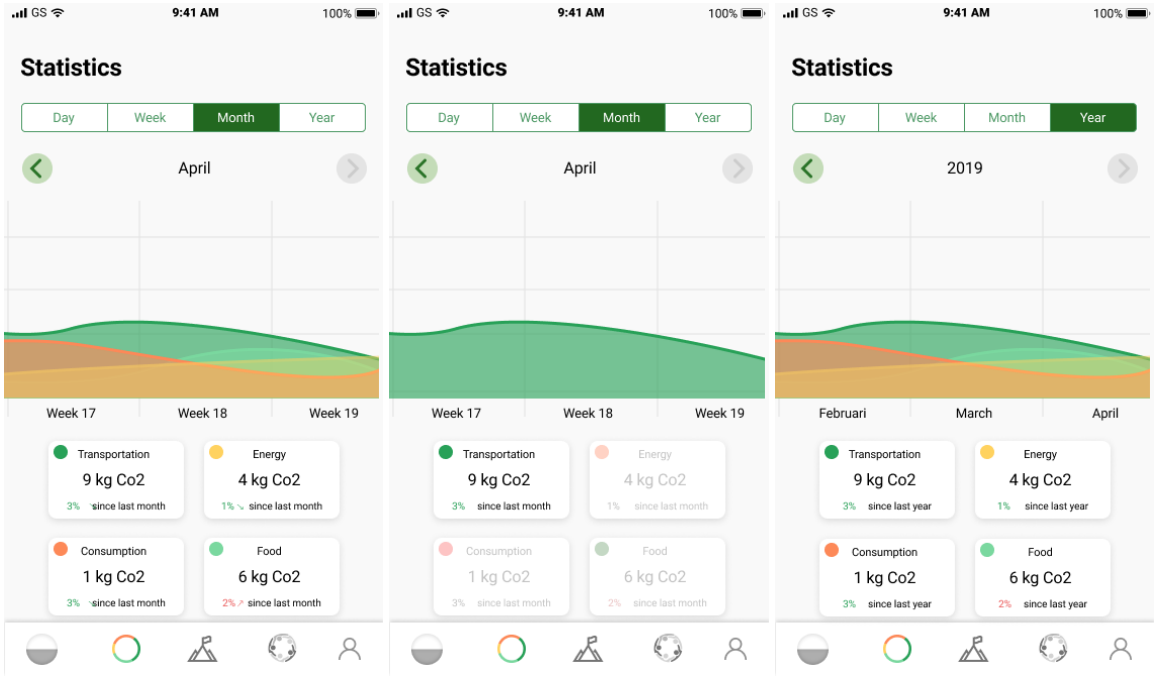


Figure 63: Screen shots showing monthly and yearly statistic screens of the final prototype.

7.2.4 Challenges

The *Challenges* screen is the third option in the menu bar. The challenges screen provides the user with an overview of their active challenges, new challenges to enroll in, and completed challenges.

The challenges that the user is currently participating in are located in the top of the screen. For the active challenges, the user can see which of their contacts who is also partaking in the specific challenge, and can also see their progress for each challenge. The user can easily join new challenges by pressing them, and thereafter press the "Join" button that appears. After pressing the "Join" button, the user is able to invite friends to partake in the challenge by pressing the "Invite Someone" button that appears, which makes a friend list show up. The user can then choose friends to send an invite to.

The new challenges are divided into four categories, being: Transportation, Food, Consumption and Energy, which correlates to the categories in the Statistics view. The user is shown three different challenges for each category, but can easily see more challenges if pressing the "See All" link to the right of each category. The user is shown the most popular challenges among their communities, and what friends that are currently doing these challenges.

There is no limit in how many challenges a user can partake in at the same time in the application. To see all the active challenges, the user can swipe the interface or press the link "See All" to get them in a structured list for a better overview.

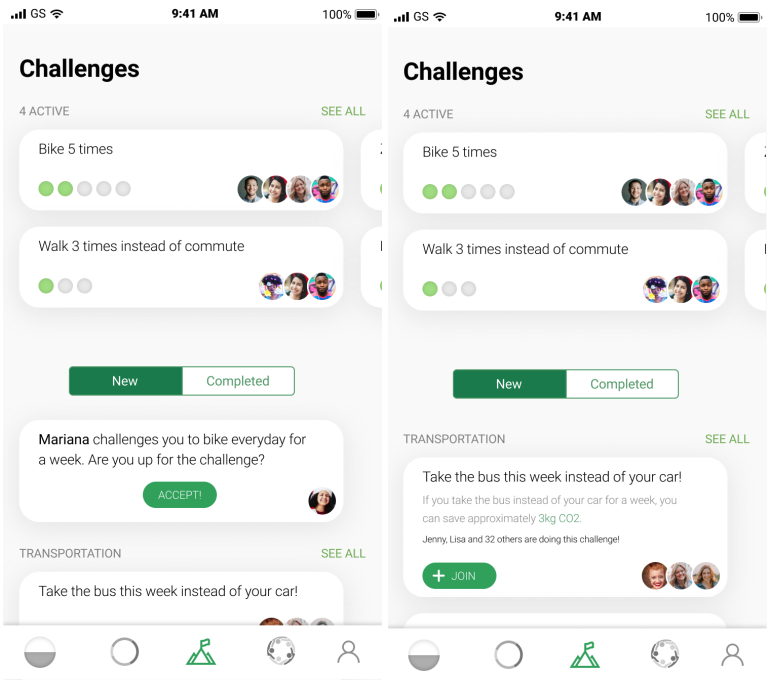


Figure 64: Screen shots showing two states of the challenges screen of the final prototype.

7.2.5 Communities

The Community part of the prototype consists of a screen displaying the communities the user is a member of. The communities are positioned on top of the screen, while there is a friend feed at the bottom of the communities, if the user wants to see the actions of their friends. For each community, the user can see how many members the community has, the number of active challenges, and any other happenings. Most importantly, the user is provided with information regarding the total emissions of the community.

To get to a community page, the user taps on one of the communities. While seeing a community page, the user is provided with community details, the community's members, an invite option, a feed, CO_2 statistics, and a scoreboard, where the feed, statistics and the scoreboard are three parts of the segmented control.

The community feed shows information about the community members' actions, such as challenges and goals. CO_2 statistics provides information about the community's total CO_2 emissions, and weekly reports with more detailed information with, for instance, information about the emissions related to the four different categories. The scoreboard shows users their CO_2 emission ranking compared to others in the group. The scoreboard is showing the placement of the various members, and how much their individual CO2 emissions have decreased or increased.

In the community page, the user can see what challenges the group have been enrolled in, what achievements they have received, and a shortcut to see the weekly CO2 emission number.

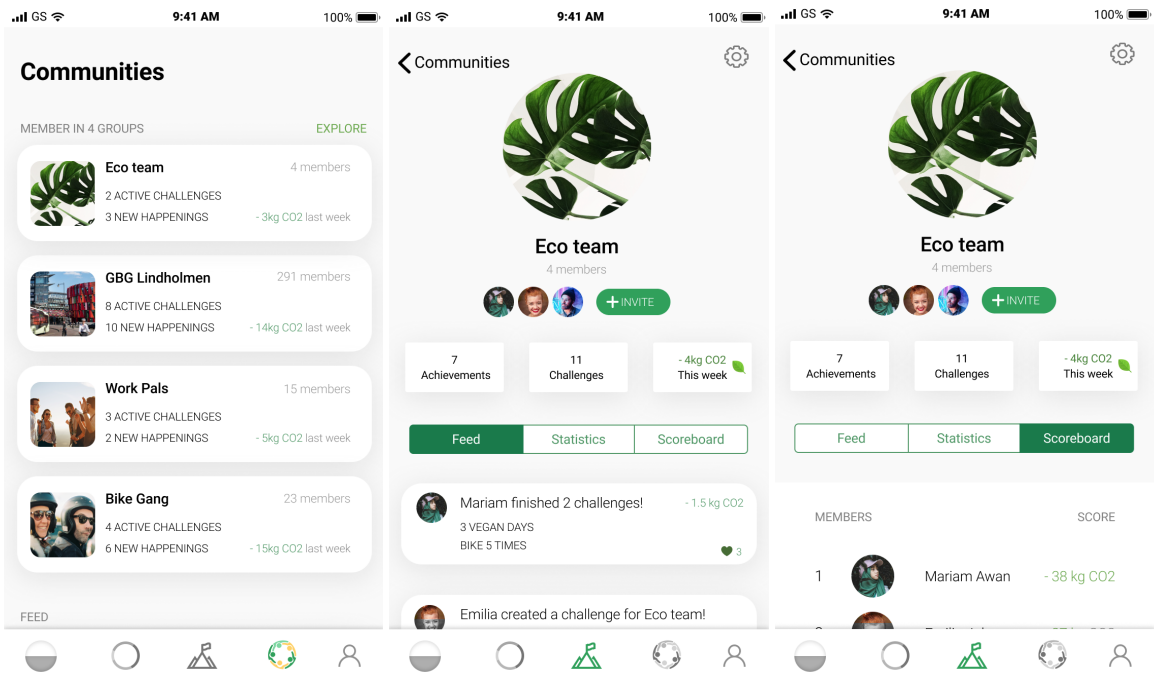


Figure 65: Screen shots showing three states of the communities screens of the final prototype.

7.2.6 Profile

The last screen of the menu bar is the Profile view. The profile view contains elements such as details about the user's achievements, completed challenges, friends, weekly CO2 reports, monthly energy reports, to name a few.

On the profile screen, the user is able to find out more about the points system, in order to reach a new level and unlock features of the application. To get more details of this matter, the user taps their profile picture, which triggers a window to appear on the screen that contains some information.

The user can see their achievements on the profile view by tapping the "Achievements" button, which is positioned below the profile image to the left. When the user does this action, a list of achievements is triggered and appears on the screen. Here, the user can get an overview of the achievements that are gathered, as well as the achievements that are yet to be gathered. These unfinished achievements provide the user with a hint on how to get them.

To see what challenges have been completed, the user taps the "Completed Challenges" button that is located below the profile image to get the list of challenges. In the completed challenges list, the user can also see what challenges have been done several times, and what friends that have also completed these. The completed challenges are structured into the four categories, to keep the consistency throughout the whole application.

To make adjustments and connect other applications and devices to the application, there is a settings screen also, which is reached from the profile screen.

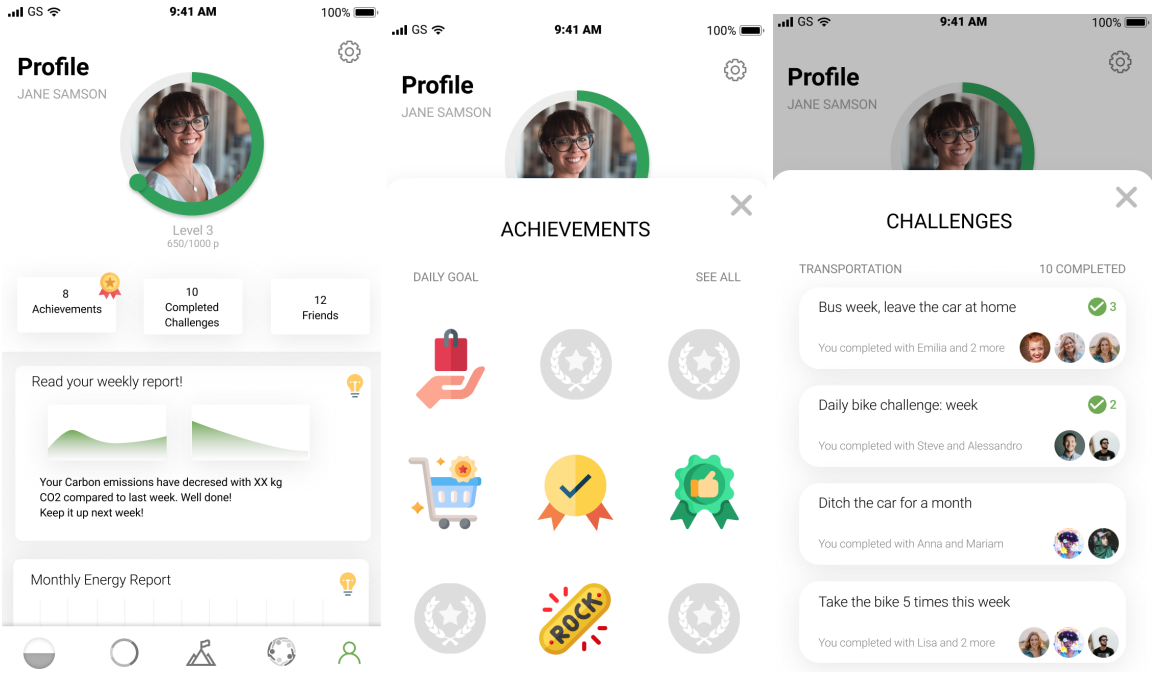


Figure 66: Screen shots showing three states of the profile screen of the final prototype.

7.3 Features to consider when Designing Persuasion for Sustainability

Through a design process with three iterations, various theoretical frameworks and concepts have been explored and several insights have emerged. These features have emerged through a design process involving potential users in every evaluation phase, and their feedback have steered the project into a final concept.

Although these features are a final result of the project, they are not considered as completely *final* features or guidelines for projects within the same research area, but suggestions for future projects with a similar aim. To be deemed completely final guidelines, a more extensive user evaluation and testing would need to be had, especially to see whether a long-term behavior change can be supported by implementing these features. Through this project, a total of 6 features, have been found to be effective when designing application related to behavior change, through the lens of sustainability.

7.3.1 Daily Behavioral Feedback

Providing the user with daily behavioral feedback, and what the potential consequences of their behavior could lead to, is a fundamental and important aspect when trying to change behavior. By providing the user with self-knowledge, awareness about their lifestyle can be raised, which can lead to a behavior change when it is more clear what activities can be done in order to reach a target behavior. Making it easy for the user to see and track their actions is critical in this context, both providing the ability for the user to connect their behavior to something concrete but also to enable the user to enjoy the process.

One of the most important features found in this project was the ability to track activities related to CO2 emissions without including the need of any manual user input. This was, according to a majority of the test participants, a critical aspect that would decide if they would use the application or not. Although it was acceptable that some manual changes would have to occur if any actions happened to be incorrectly recorded, it was important that it did not turn into a habit of adjusting inaccuracies.

We conclude that the ability of tracking a behavior of the user together with information about possible improvements, are important features to include when designing applications related to sustainability. Important to think of is that the less manual input the user have to make the better and that users often seeks more information to understand their own behavior. It is also to keep in mind that help-full tips of improvement can be seen as both help-full and annoying.

7.3.2 Behavioral Feedback over Time

In the process of behavior change, the user should be provided with behavioral feedback of their actions and behavior over time. To be able to overlook their progression over time, the user can get motivated, understand what actions worked well or not related to the desirable change, and feel committed to maintaining the behavior change that is occurring. When providing behavioral feedback over time, it is critical that the information is visualized in an suitable way to the user. This means visualized information and data in a way that makes sense for the user, where focus lies in the various categories or actions that the behavior can be divided in, with a clear design that is commonly used and easy to comprehend.

Behavioral feedback over time is displayed in EcoHero through a number of different graphs, which show the user their behavior divided in a daily, weekly, monthly and yearly breakup. The graphs clearly show whether the behavior has improved or not, and provide the user with a detailed overview of why this occurred, if the user wishes for more details.

Behavioral feedback is also displayed through weekly and monthly reports of the user's behavior where the user can, similar to the graphs, get detailed information to fully understand the relation between their actions and emissions. To be able to compare the previous bad behavior with the new, better one, users can more easily commit to a change that is beneficial in the context.

7.3.3 Social Layer as a Support mechanism

According to the Transtheoretical Model of Change, Helping Relationships is a vital part when trying to make a change. In EcoHero, helping relationships is a key factor to behavioral success because of its supportive and motivating quality. The results showed that some users prefer competitions as social, while others preferred more collaborative aspects. Because of this, we advise that both aspects should be included. It should be optional to use features including aspects of competition, since a competitive atmosphere can trigger anxiety or negative feelings for some users. Instead, some users preferred features where they were able to competes against oneself.

The result showed that the social part of the application was a critical part of the motivation to use the application. Several participants in the study expressed that the social interactions would be the main part of why they would continue to use the application.

7.3.4 Engaging features for initial and long-term motivation

One of the most important feature is to raise motivation and make the user engaged in the prototype, in order for them to make the desirable change. This feature was shown to be a complex problem to solve during this project. There is definitely a need to explore this feature more in-depth, and conduct further evaluations during longer periods of time in order to study a possible

long term motivation, as well as in a real world setting.

A conclusion that can be drawn from the analysis is that all users get motivated by various aspects, and it is therefore important to provide several sources of motivation. Some users prefer the social aspect, where they work together with others to complete challenges or reach goals, while others prefer to compete against other people. Some of the users liked the idea of including scoreboards, but preferred to be able to hide their score. Even though there are differences in the preference of competitions and collaborative features, the possibility to connect with friends and communities is important for the motivation of use.

Some of the features that were received as positive during this project were Challenges, Events and Rewards, while scoreboards and tips were received differently, with both positive and negative attitudes. To create a initial motivation it should not be too complicated or take too much time for the user to learn and set up the application.

The evaluations with the on-boarding screens taught us that it was a effective way of creating a quick initiation and engagement for the user for the different features, which was made possible by using the principle Tunneling. It further showed that these types of features should not need too much effort from the user. The informational texts, of about two sentences per screen, were seen as too long by the users, while the call to action buttons worked well.

7.3.5 Reaching Target Goals

One vital aspect of the application is to make sure that the user is able to reach their target goal, and that the user is motivated to do so. One important factor to enable this is by letting the user set their own goals, and that there are multiple ways of reaching success. Users have different starting points and abilities, and it is therefore important that the goals can be set on an individual level.

Trying to reach goals was perceived as positive for the users' motivation, since they stated that they felt motivated in competing against themselves, and not wanting to be unsuccessful. Critical in this context is that the design is forgiving and encouraging when the user is not preforming well, or not according to their set target. Therefore, providing the user with motivational messages and implementing the fresh start effect throughout the application were equally important for maintaining user satisfaction and motivation. Features, such as streaks, where the user has something to lose was not received as positive regarding motivation, and was therefore not implemented in the final solution.

8 Discussion

The discussion chapter is divided into several parts covering the process and frameworks, the result (concept, prototypes, and features), ethical considerations, limitations, generalizability, and potential future work and improvements.

8.1 Execution Discussion

The design process was initially staked out as a first process plan, but was reformed as the project progressed and decisions were taken, such as carrying out certain methods that were deemed suitable for a specific project phase. This was a perk of using an iterative design project process, since its flexibility allowed us to make rapid changes in the process plan and quickly choose new alternatives to move forward.

Since this project had an exploratory approach and followed the generated user insights, the initial project plan was destined to be changed as new results emerged. In the initial project plan, the phases were divided into similar time frames. By using an iterative and flexible approach with activities that spanned over several days or weeks, activities could be moved closer or further away in the time plan if this was needed. This was especially valuable when we, for instance, wanted more respondents for the questionnaire in the user research phase. Instead of solely waiting for more people to respond to the questionnaire, the analysis could be initiated earlier than previously planned, while still waiting for more respondents.

Having the flexible mindset allowed us to put more time into more complex activities, such as making the interactive high-fidelity prototype which was the result of prototyping cycle 3. When developing the third prototype, much time were needed in order to make the prototype fully interactive. This meant having to learn more prototyping functionalities in the design tool, together with finding and solving glitches and mistakes in the prototype, which was time consuming. Making the prototype fully interactive was important, since this would allow test participants to fully focus on the prototype and imagining it being a functioning smartphone application.

Carrying out the project in an iterative manner with three prototyping cycles made us focus on producing at least one prototype each cycle, while focusing on the research question at hand. This approach made it easy to quickly produce big amounts of sketches that would turn into a testable prototype and, if needed, make changes to the result in the next cycle.

Starting the research phase in the project, we soon realized that there was extensive research regarding behavioral change, persuasive design, and similar areas within the area. There are enormous amounts of research about behavioral change and the psychological aspects of the area. Due to the restricted time limitations of this project, we have only been able to include a limited amount of these concepts. Since this is a project within the interaction design discipline, behavioral change was not the focal point but acted as a research base to steer the project in an

appropriate direction.

Including main principles of behavioral change theories has probably had a major impact throughout the project, especially considering the findings and final results. If we would have included further theories the results might have differed, perhaps for the better. The final result is still something that brings value from the perspective of an interaction design discipline through persuasive design principles, which can be of value for disciplines surrounding the researched area.

The project tried to follow a user-centered approach and include potential users along the way in the different phases. This was implemented by involving users in every evaluation stage and encourage them to share their opinions, in order for us to get rich feedback to refine the concept. As stated in previous chapters, we initiated the user research with sending out a questionnaire on social media platforms to get a wider spread. A problem with this approach is that the questionnaire was mainly reached by our own social media contacts, friends and family, and that this could have affected the result, compared to a questionnaire that would be sent out in a space where we had no connection to the respondents.

We discussed the possibility of contacting organizations related to environmental or sustainability purposes to get support in finding suitable respondents, but this approach could have led us to a respondent group where participants were too similar. Our aim was to include various participants to respond to the questionnaire, to get a varied result of attitudes and behaviors, instead of choosing the "correct" kind of user right away. With this in our minds, we sent out the questionnaire and received 74 responses.

8.1.1 Discussion of Evaluation Methods

An issue that has been present during this project has been regarding the evaluation of the concept and prototypes. With the limited time frame and resources of this project, it was experienced as difficult to evaluate the behavioral change aspect of the prototype and concept. This was also a critical issue since it was in the centre of the research question and aim of the project. This is a common problem with these types of technologies where long term behavioral change is the goal, as stated previously.

For future work, it would be necessary to test the behavioral change aspects in a natural setting where users can interact with the prototype during a longer time period. This would require a prototype with a much higher fidelity and with totally working functionalities, such as data handling and memory storage. A possibility could be to test some functionalities by, for example, sending text messages to participating users with customized messages mimicking the application. In the end, it was decided that this would not be a good enough representation of the concept to be relevant, especially considering the resources needed in order to be carried out.

Related to evaluation purposes, another solution could instead be to make a web application and use static data or to fake responses to users' actions. For this, using Wizard of Oz techniques

could be effective, where we could test the effects of using the application by letting users interact with it during a period of time, while we would steer the application according to the users' actions. This was considered as too time consuming to carry out within the time frame of the project, and it could also be challenging to find users willing to participate during a longer time period and being motivated throughout the study, while providing us with feedback. This activity could be somewhat time consuming for the user, which could contribute to a weak motivation and affect the evaluation result concerning user motivation in their behavioral change.

In order to handle this problem situation to our best abilities we chose, as described in the Execution chapter, to conduct both user testing of the concept, and do expert analyses of the persuasive features of the prototypes.

8.1.2 Selection of Frameworks

During this Master's Thesis the theoretical focus has been surrounding behavioral change from a perspective of persuasive design, including the Transtheoretical Model of Change, although there are various theoretical frameworks and research areas that could be implemented or used instead.

When initiating the research phase, an extensive literature research was carried out. When analyzing articles surrounding behavioral change, many described or mentioned motivational systems and persuasive design principles as valuable in projects. After having explored persuasive design, the area seemed to be suitable for the aim of the project leading us to study it further, in parallel with the Transtheoretical Model of Change. The Transtheoretical Model of Change was, compared to the area of persuasive design, something that we had prior knowledge of, and something that was considered effective in collaboration with persuasive design.

For this project, it was decided that focus would be put on fulfilling user needs and to make the user motivated and informed about their choices, designed in a positive way. Instead of using behavioral change theory and persuasive design principles, another option could have been to use a critical design approach to raise awareness in the researched context. The decision of using the chosen approach was made during the ideation phase, together with being based on current research gathered through the literature review and user research, where valuable user feedback was provided to us.

8.2 Result Discussion

The aim of this project was to measure individuals' behavior and provide them with this information in the form of self-knowledge and insights. A general speculation has been if this approach might result in a positive change or not. Another thought has been if this solution results in the user being motivated from an intrinsic or extrinsic perspective, and what consequences there might be if the result is one or the other, or even both. Do these aspects contribute to a behavioral

change?

We can question whether concepts, such as EcoHero, can contribute to a behavior change. Testing for a long-term behavioral change is difficult, and something that was presumed as unattainable due to the time constraint of the project. Although this question is difficult to fully answer, we believe that we have approached it in a research and user-centric way, and that the result highlights design opportunities for projects in similar fields.

The result of this project consists of a concept, prototypes, and features that we present as important to consider in the context, which will be discussed in the following section.

8.2.1 Concept and Prototypes

While a prototype was created, it is important to keep in mind that the prototype itself was not the main interest in this study, but more of a tool to develop a concept. If there had been a greater focus on the prototype itself, the methods of choice would most likely have been very different. Since the focus was on the concept and not the prototype we put less focus on, for example, the GUI and the aesthetics (look and feel), and more focus into the underlying motivations of use. The concept was a tool for us to explore and implement ideas and the use of frameworks, and not intended for presenting a design solution, as Stolterman and Wiberg (2010) explains about concept driven design strategy.

In the beginning of the project, the intention was to put more focus on including wearable technologies to a higher extent, although this was not implemented in the prototypes. This decision was made due to time limitations and the fact that a majority of the questionnaire respondents were not using wearables. Since the wearable technology would stand mostly for data collection and smaller additional features it was decided that it was not the most important thing to focus on. Although, during the user evaluations, wearables were often brought up and discussed in relation to the concept. These topics were often brought up by participants that had prior experience or used wearables daily. From involving users in the evaluation studies, we could see that there are opportunities of involving more wearable technologies to support smartphone applications in the researched area.

By focusing solely on smartphone application prototypes, we could progress faster than if we would have included wearables as part of the concept. This freed up the work load related to prototyping, and made us focus on developing prototypes with varied levels of interactivity. Having prototypes with a higher degree of fidelity was valuable, since it allowed us to test the concept with potential users.

Although the final prototype had a high degree of interactivity and was valuable during testing, it could be discussed how the predefined information and data in the prototype made the participant react. By choosing certain content to be displayed in the prototype, we might have influenced or enhanced certain attitudes or behaviors that steered the participants during the evaluation.

This situation might have led to participants acting and expressing certain things based on that content, and not about the prototype itself.

Our aim when creating content for the prototype was to display various activities that the user would have carried out, plus to show the prototype in different states, such as if the user has spent over their daily carbon emissions or not, to observe the reactions of the participants. We decided to include a width of activities to make the user reflect on various aspects, even if this meant that the user reflected on an activity that they would never carry out in their everyday life. It could have been beneficial and valuable to provide each participant with personalized content when testing the prototype, which might have made the situation for the participant more natural. EcoHero is supposed to provide the user with personalized content and providing this to the participant in the evaluation could have been useful. This is something that would have taken too much resources to carry out in the project.

Using the tool Figma for designing the prototype was an overall good choice. The collaborative feature of Figma enabled us to work simultaneously, regardless of us being located in the same room or not. The feature of making comments in Figma also simplified the process of us carrying out work at various times by making it easier to point out aspects that needed to be redesigned or added, or to communicate thoughts or design decisions to the other member.

Because of the broad functionality of Figma, design assignments could be carried out together as a team or separately. Using the functionalities of components in Figma was effortless when making both minor and major changes without the need of remaking, for instance, connections between objects. Although Figma possesses countless valuable features for making prototypes, making connections correct between screens became increasingly more difficult as the number of screens grew.

8.2.2 Features

During the user evaluations we had some discussions about internal motivation versus external motivation. The features including statistics and personal challenges were concluded to contribute to the internal motivation, while features, such as scoreboards and competition functionalities, contributed to the external motivation. During discussions we found both positive and negative aspects of each motivation type, and it differed among the participants what they preferred. It was therefore important to include both. Also brought up was that the external motivation might result in users being more susceptible to cheating and manipulating data, while this would not be a problem with the features using internal motivation, since there is no point of tricking one-self.

Out of all design principles from the selected frameworks, there were three that were decided to not be included in the concept. Environmental Reevaluation, from the Transtheoretical Model of Change, was excluded since it was considered too complicated to include within the prototype, considering the limited time frame. Reciprocation, from Six principles of social influence,

was not included because of its implementation could mean using dark design patterns to pressure the user into using the application, in any way. The principle Scarcity from Six principles of social influence was neither used, since it was seen as not valuable or contributing to the concept.

A feature that was frequently discussed, but not included in the final prototype, was the ability to create one's own challenges. For the overall concept, creating challenges is an important function that some participants expressed as desirable. This was not included due to time limitations, but would be interesting to add to a future version. Creating challenges would need more research and evaluation, and the interaction design of this function would have to be seamlessly designed.

What needs to be emphasized for this project considering features is that the features presented as a result is not tested in a real world setting or for a longer period of time.

8.3 Ethical Considerations

During the project, a number of ethical considerations have been brought up. Whenever participants were involved, they were informed about the project, what data would be collected, that the data collected would be anonymous, and that the researchers and main stakeholders would be the only ones with access to the data. When participants were involved, they were informed that they can, at any time, resign their participation in the project, and that the data they have provided the researchers with could be deleted at any time.

If the prototype would be realized into a real product reaching real users, additional ethical aspects such as data gathering and storing, would be important to consider. For the application to fully function, it is critical that the user understands and trusts in the data gathering, and that the application is transparent in how the user data is gathered, processed and stored. It is also important that the features of the application follow current laws and standards to ensure that the user's integrity is kept at all times.

8.4 Future Work

One important future work priority would be to evaluate the concept during a longer period of time, and with a working application that could store data and information appropriately. During this extended evaluation, wearables could also be included to enable testing of certain features that utilize wearable technology. Since the application would collect various data from their users, it would be important to explore the user attitudes about it more thoroughly.

Exploring the context further through the use of additional frameworks that were not used during this project, could also be valuable. Additional frameworks that we ran into during the pre-study phase, but that were not included in the project are Affective Computing, Emotional Aspects,

Gamification and Ambient Awareness. Using one or more of these frameworks in the making of an application in the research area could lead to new insights and a refined application that users deem as useful.

9 Conclusion

In this Master's Thesis we have made an attempt to answer the question:

> *"How can individual carbon footprint be decreased through interaction design incorporating methods for behavioral change in the design of smart phone applications?"*

Assuming that the answer to this first question is positive, the aim was to answer an additional question:

> *"What factors should be considered when designing products aiming to decrease the carbon footprint of individuals?"*

To answer the first question, a concept including a prototype was designed and evaluated. For the second question, 5 features to consider in the context were discovered as a result of the project. The 5 final features to consider when designing for sustainable behavior that were discovered are:

- **Daily Behavioral Feedback**: show the user what the result of their behavior is related to sustainability, such as their carbon footprint. Valuable can be to show the user a comparison of their behavior to the recommended level in the context.
- **Behavioral Feedback over Time**: show the user their behavior over time, to make them aware of their progress and that it is clear that their efforts in improving their behavior have had an effect.
- **Social Layer as a Support Mechanism**: provide the user with a social layer, since it can act supportive and help users in the process of behavior change.
- **Engaging Features for initial and long-term motivation**: show the user features which make the experience of the behavior change more engaging and motivating, in order to motivate the user to keep making suitable actions that are beneficial to the cause.
- **Reaching Target Goals**: provide the user with functionality in order for them to reach their target goals: make the user involved in setting their own goals, provide various goals on different levels, guide the user towards reaching their goals, and reward the user when they work towards reaching their goals or eventually reach their goals.

To approach the research context we have based the process and guidance on behavioral change theories. Due to this, we see the solution as potentially being able to support a behavioral change for individuals, depending on where individuals are in the Process of Change individuals.

Despite the project not being able to evaluate the solution in a long-term behavior context, we have found features to incorporate in digital solutions that raise awareness and motivate users to think and act more sustainable. When designing digital solutions that measure the environmental footprint of an artefact, these features can be considered as suggestions to incorporate. Critical in the context is to evaluate whether a feature is suitable for a specific cause or project, since the aim and scope of projects in the research area can wary.

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10 Appendixes

10.1 Appendix 1 - Questionnaire

Behavior Change for Sustainability

Hello!
We are two students from Chalmers writing our Master's Thesis at the Interaction Design and Technologies programme. We are exploring ways of designing for individual behavioral change related to sustainability.

We would love it if you could respond to this survey. Your feedback will guide us and provide us with insights and data to enable us to go further with our thesis project. The questionnaire takes approximately 5 min to answer and it is anonymous.

We want to know:
- Your attitudes and habits related to sustainability
- Your thoughts on improving one's carbon footprint
- Your attitudes and habits about certain types of applications/wearables

Thank you!

/ Hannah & Daniella

Introduction

First we would like to know some information about you. This is only done to see if there are any clear differences between certain groups, and this will not be used for any other purposes. If you don't want to share this information you can simply choose not to answer.

1. **Employment status. Are you currently...?**
   Markera endast en oval.

   - ◯ Employed for wages
   - ◯ Self-employed
   - ◯ A student
   - ◯ Out of work and looking for work
   - ◯ Out of work but not currently looking for work
   - ◯ Retired
   - ◯ Unable to work
   - ◯ Övrigt: _____

2. **What is your age?**
   Markera endast en oval.

   - ◯ 17 or younger
   - ◯ 18-20
   - ◯ 21-29
   - ◯ 30-39
   - ◯ 40-49
   - ◯ 50-59
   - ◯ 60-69
   - ◯ 70 or older

3. **How does your household look like?**
Markera endast en oval.

- ◯ I live by myself
- ◯ I live with a partner
- ◯ I live with my family
- ◯ I live with friend(s)
- ◯ Övrigt: _____

4. **How interested are you in environmental questions?**
Markera endast en oval.

	1	2	3	4	5	
Not very interested	◯	◯	◯	◯	◯	Very interested

5. **How would you describe the state of the environment?**
Markera endast en oval.

- ◯ In good shape
- ◯ In some trouble but can be saved with a little effort
- ◯ In bad shape but a lot of effort might save it
- ◯ In such bad shape little can be done about it

6. **Given the current state of the environment, how would you describe our future?**
Markera endast en oval.

- ◯ Bright and hopeful
- ◯ Challenging
- ◯ Depressing
- ◯ Uncertain

7. **What are your current knowledge about Carbon Footprint?**
Markera endast en oval.

- ◯ I have a good understanding of what it is , and use it to make sustainable choices when possible
- ◯ I have a good understanding of what it is, but don't use it
- ◯ I have heard of it, but don't really know what it is
- ◯ I have not heard of it before

8. **How likely are you to change your lifestyle to better suit the environment?**
Markera endast en oval.

- ◯ Not very likely
- ◯ I might do something
- ◯ Very likely
- ◯ I have already made changes
- ◯ Övrigt: _____

9. **What do you think are the biggest contributors to your carbon footprint? Mark up to 3 options.**
Markera alla som gäller.

- [ ] Household energy use
- [ ] Consumption
- [ ] Recycling
- [ ] Household waste
- [ ] Food habits
- [ ] Transportation
- [ ] Övrigt: _____

10. **Do you have enough information on the state of the environment?**
Markera endast en oval.

- ◯ Yes, I know everything I need to know
- ◯ No, I would like to know more
- ◯ No, but I don't need to know more
- ◯ Övrigt: _____

11. **Do you think that you could make a difference by changing some parts of your daily life?**
Markera endast en oval.

- ◯ Yes, I can make a difference
- ◯ Yes, but it won't be noticeable
- ◯ No, my efforts would not make any difference

12. **What do you think is the best way of engaging people to make active choices for a better environment?**
Markera endast en oval.

- ◯ Having laws that regulate it
- ◯ More information about what you could do
- ◯ Implementing sustainability taxes / taxes
- ◯ Making information about emissions more visible (signs of products/services emissions etc)
- ◯ Övrigt: _____

Lifestyle

13. **Do you think about the environment while...**
Markera endast en oval per rad.

	Yes	Sometimes	No
Choosing daily transportation			
Planning longer trips and vacations			
Grocery shopping			
Cooking			
Managing waste			
Shopping clothes and products			
Using water			

14. **What do you do to support the environment? You can mark several options.**
Markera alla som gäller.

- [ ] Avoid cars or carpool instead
- [ ] Second hand instead of newly produced items/clothes
- [ ] Fewer flights per year
- [ ] Gone vegetarian/vegan
- [ ] Nothing
- [ ] Recycle
- [ ] Eat less meat
- [ ] Buy organic/eco food
- [ ] Less food waste
- [ ] Övrigt: _____

15. **What is your main transportation method? You can mark up to 3 options.**
Markera alla som gäller.

- [ ] Car
- [ ] Train/Tram/Subway
- [ ] Bus
- [ ] Biking
- [ ] Walking/running
- [ ] Electrical bike/scooter
- [ ] Flying
- [ ] Övrigt: _____

16. **In what areas do you think you could realistically improve your environmental impact? You can mark several options.**
Markera alla som gäller.

- [ ] By choosing another transportation method when commuting (daily)
- [ ] By choosing another transportation option when traveling longer distances
- [ ] By eating more plant-based
- [ ] By reducing home electricity use
- [ ] By improving recycling routines
- [ ] By consuming less (shopping)
- [ ] By consuming more from sustainable brands
- [ ] By buying less plastic, paper, etc
- [ ] Övrigt: _____

Quantified Self (QS)

Quantified self is a concept of including technology into data for aspects in people's daily life. The goal is often to improve physical, mental or emotional performances and habits. It is described as "self-knowledge through self-tracking with technology".

Common apps with the quantified self aspect often track what you eat, how you sleep, exercise, your productivity, and similar.

17. **How often do you use quantified self / self-tracking applications?**
Markera endast en oval.

- ◯ Every day
- ◯ Often
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

18. **How often do you use wearable technology (such as smartwatches, activity trackers)?**
Markera endast en oval.

- ◯ Every day
- ◯ Often
- ◯ Sometimes
- ◯ Rarely
- ◯ Never

19. **If you use these kinds of applications/devices, what do you track? You can mark several options.**
Markera alla som gäller.

- ☐ Food
- ☐ Exercise
- ☐ Health aspects
- ☐ Sleep
- ☐ Transportation
- ☐ Habits
- ☐ Screen time / computer usage
- ☐ Locations
- ☐ Lifelogging
- ☐ Your economy
- ☐ Smart home (electricity monitoring etc)
- ☐ Övrigt: _____

20. **What do you think about quantified self apps? You can mark several options.**
Markera alla som gäller.

- ☐ Interesting
- ☐ Unnecessary
- ☐ Cool
- ☐ Unsafe
- ☐ Safe
- ☐ Educating
- ☐ Frustrating
- ☐ Important
- ☐ Fun
- ☐ Helpful
- ☐ No opinion
- ☐ Övrigt: _____

21. **Do you use any applications related to the environment?**
Markera endast en oval.

- Yes
- No

22. **If yes, what kind of application(s)?**

_____

23. **What are your thoughts about having an app that monitors your carbon footprint?**

_____

_____

_____

_____

_____

24. **What aspects would you like to track in an app that monitors your carbon footprint? You can mark several options.**
Markera alla som gäller.

- [ ] My transportation
- [ ] What I eat
- [ ] My waste habits
- [ ] How I travel (vacations, weekends, etc)
- [ ] My energy use
- [ ] Carbon footprint through time
- [ ] My shopping behaviors
- [ ] My water use
- [ ] Övrigt: _____

10.2 Appendix 2 - Results of Questionnaire

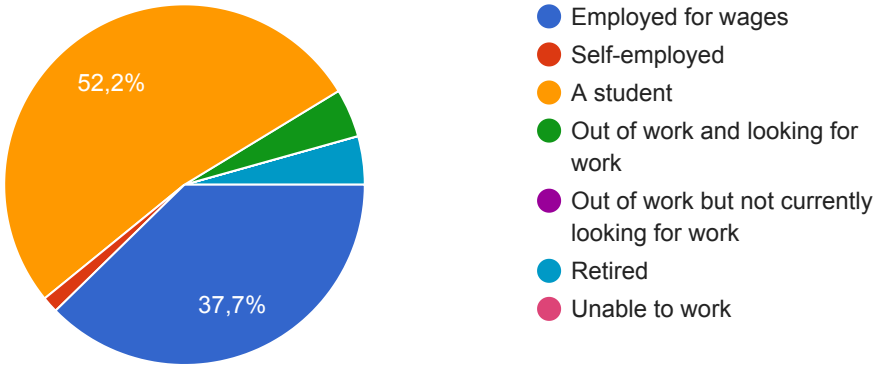
Behavior Change for Sustainability

74 svar

Introduction

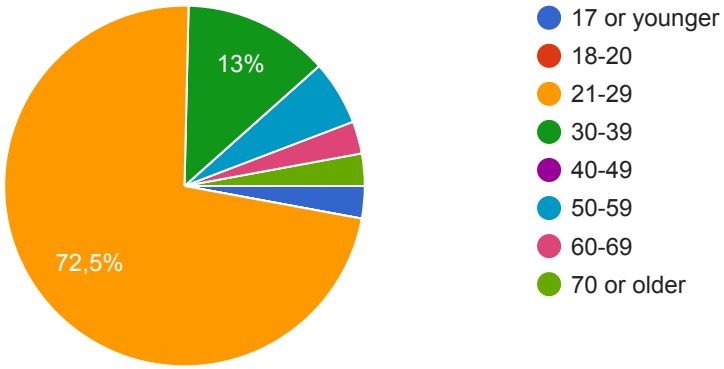
Employment status. Are you currently...?

69 svar



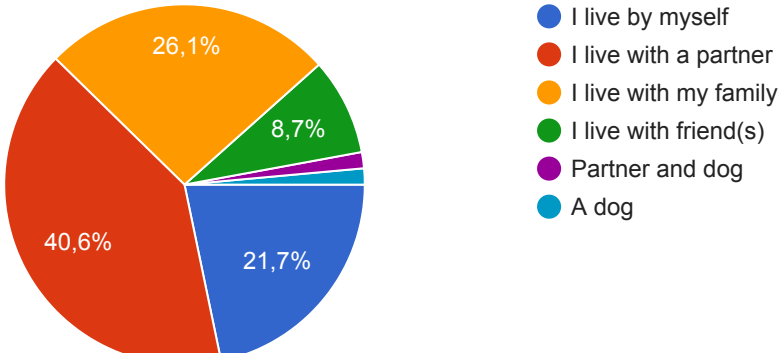
What is your age?

69 svar



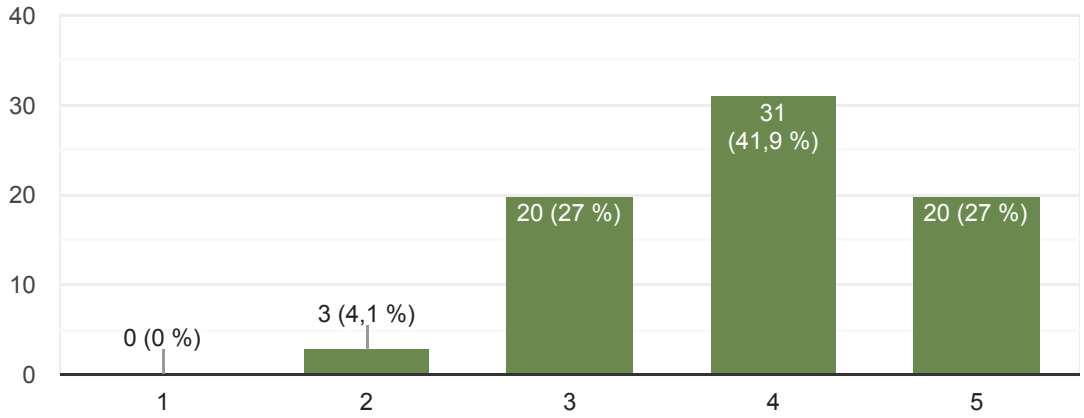
How does your household look like?

69 svar



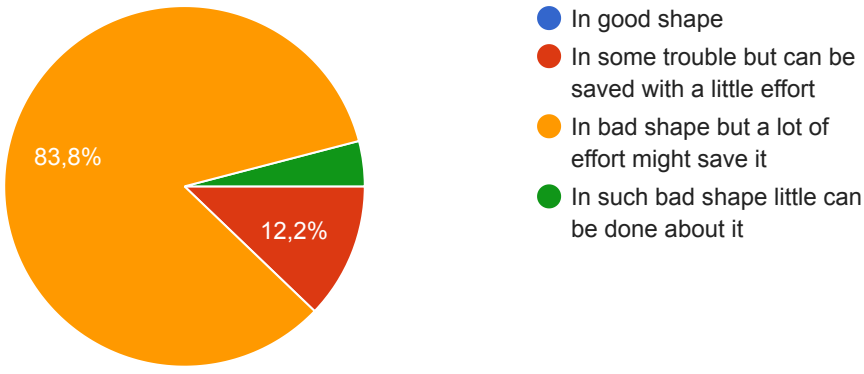
How interested are you in environmental questions?

74 svar



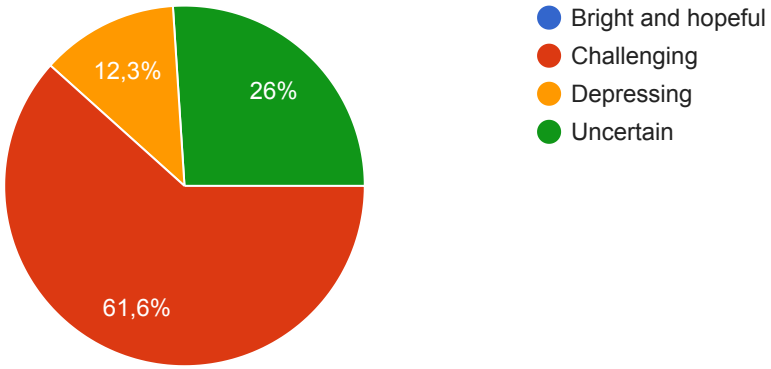
How would you describe the state of the environment?

74 svar



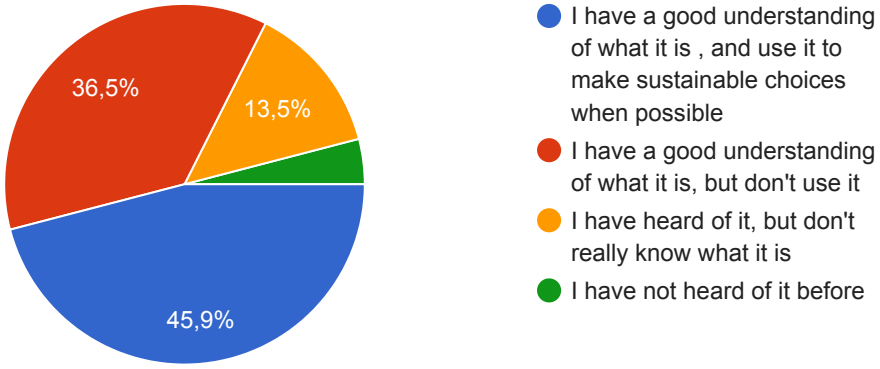
Given the current state of the environment, how would you describe our future?

73 svar



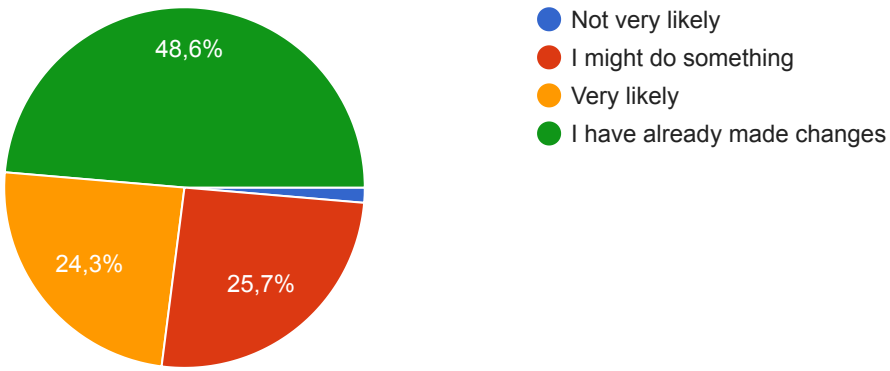
What are your current knowledge about Carbon Footprint?

74 svar



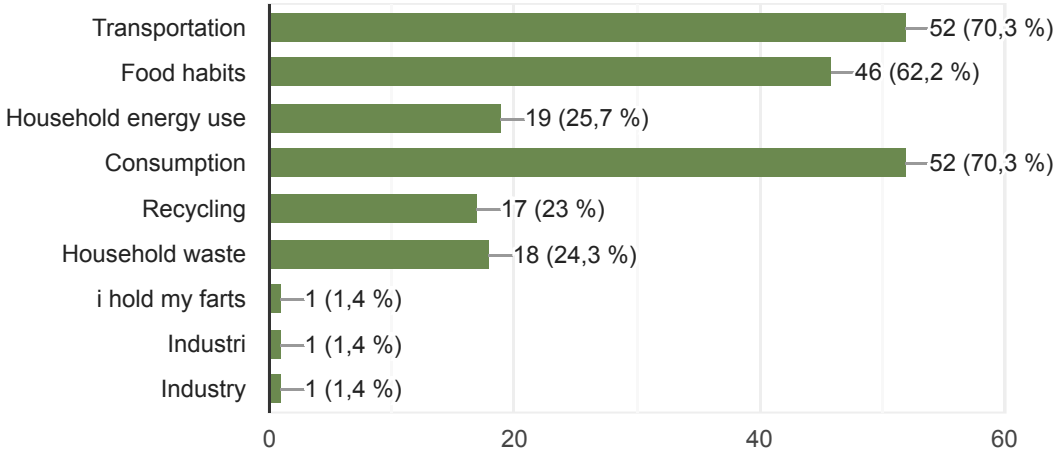
How likely are you to change your lifestyle to better suit the environment?

74 svar



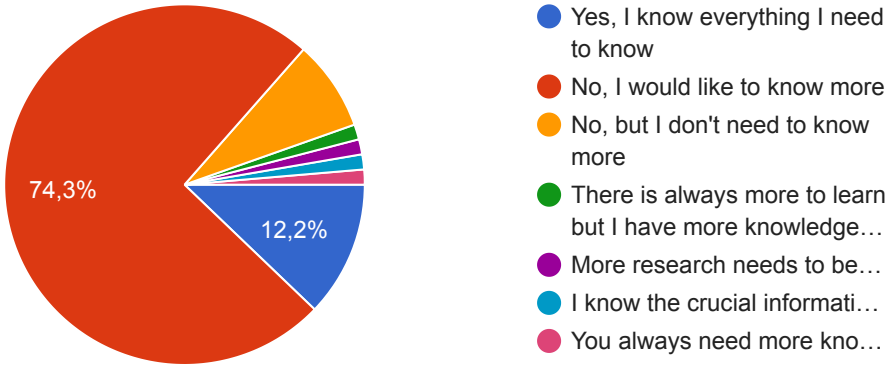
What do you think are the biggest contributors to your carbon footprint? Mark up to 3 options.

74 svar



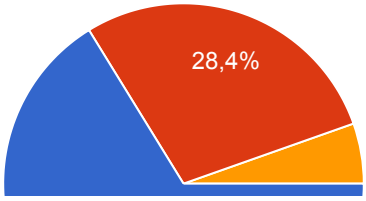
Do you have enough information on the state of the environment?

74 svar



Do you think that you could make a difference by changing some parts of your daily life?

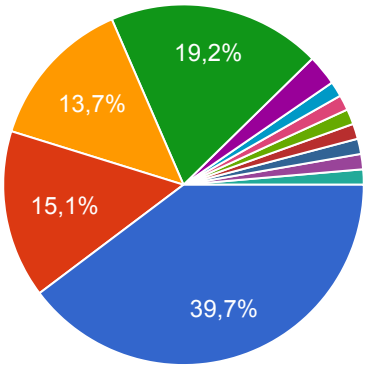
74 svar



Yes, I can make a difference
Yes, but it won't be noticeable
No, my efforts would not make any difference

What do you think is the best way of engaging people to make active choices for a better environment?

73 svar

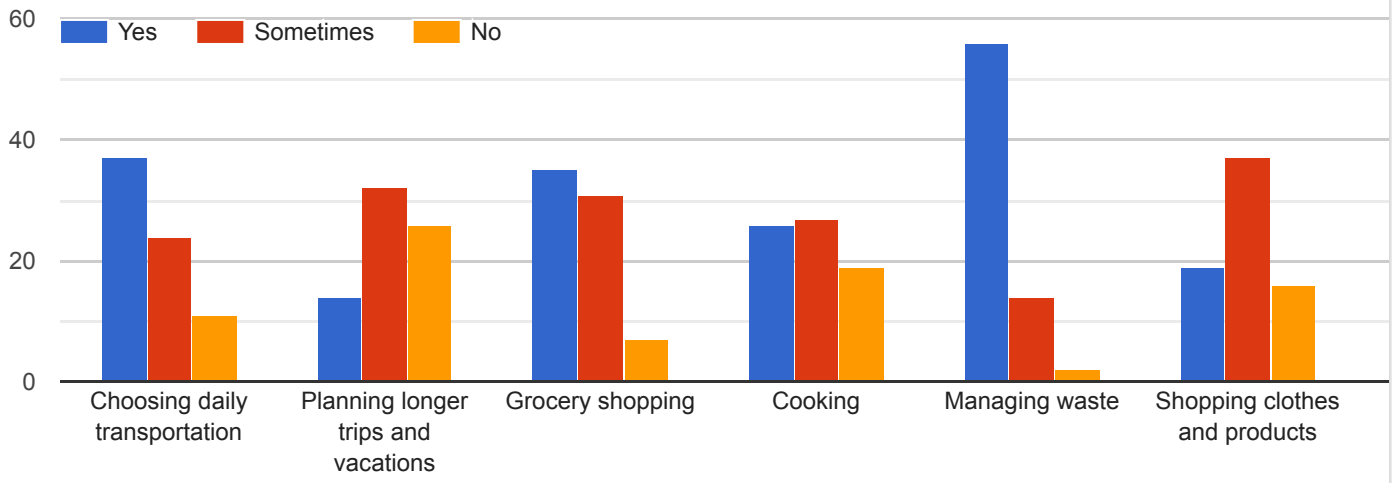


Having laws that regulate it
More information about wh…
Implementing sustainability…
Making information about e…
Implementing sustainability…
A combination of the sugge…
A combination of taxes and…
Making environmental frien…

1/2

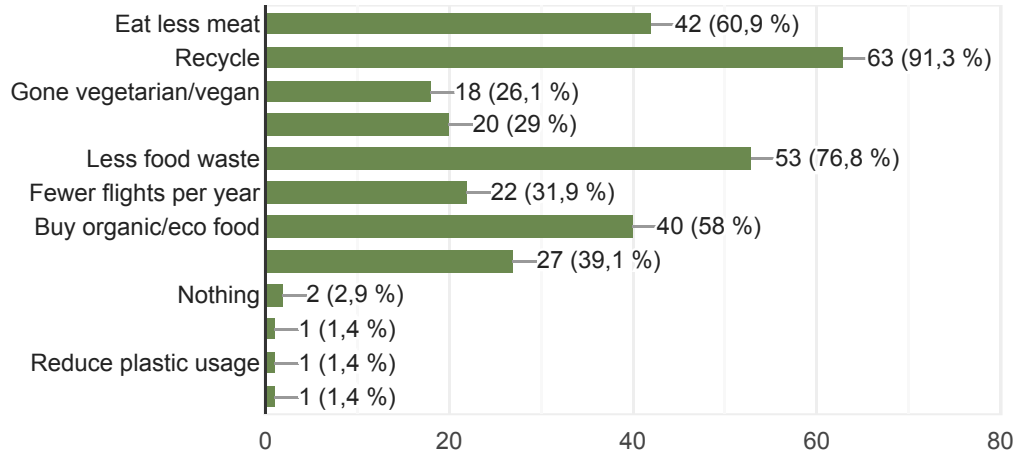
Lifestyle

Do you think about the environment while...



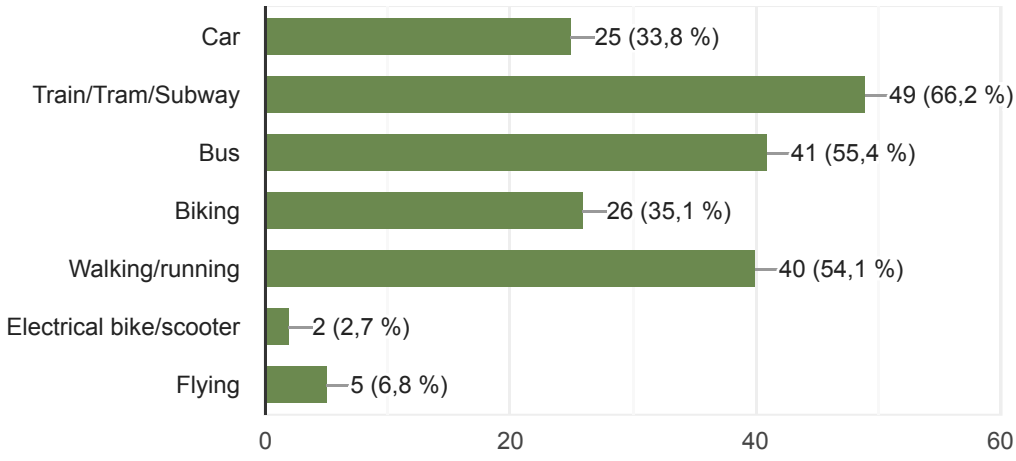
What do you do to support the environment? You can mark several options.

69 svar



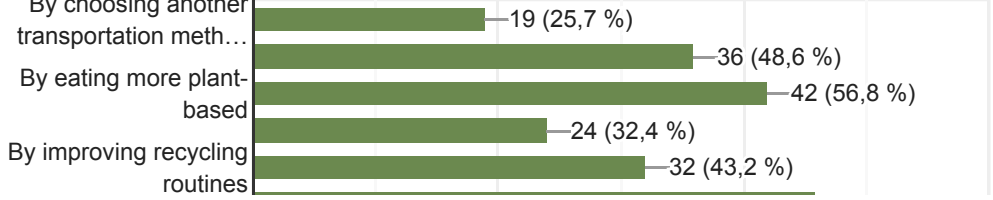
What is your main transportation method? You can mark up to 3 options.

74 svar



In what areas do you think you could realistically improve your environmental impact? You can mark several options.

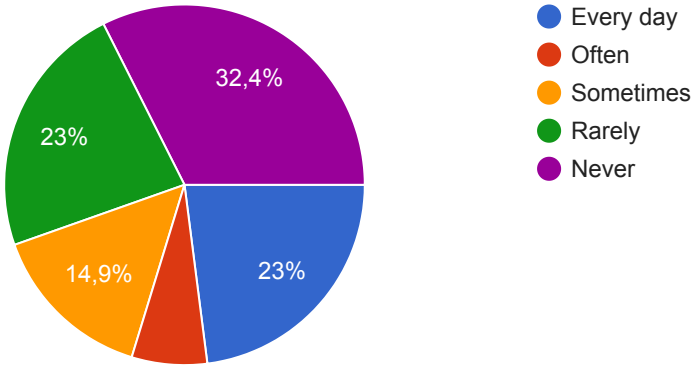
74 svar



Quantified Self (QS)

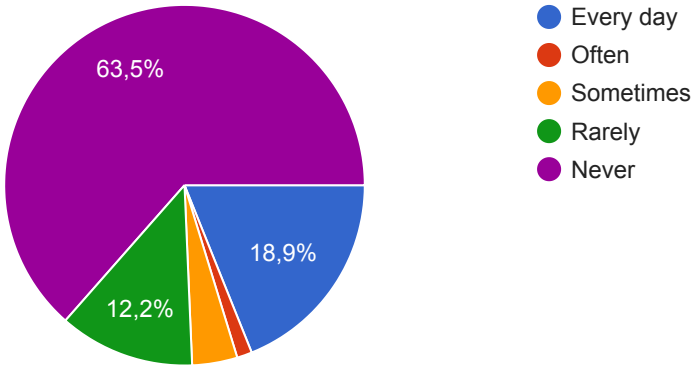
How often do you use quantified self / self-tracking applications?

74 svar



How often do you use wearable technology (such as smartwatches, activity trackers)?

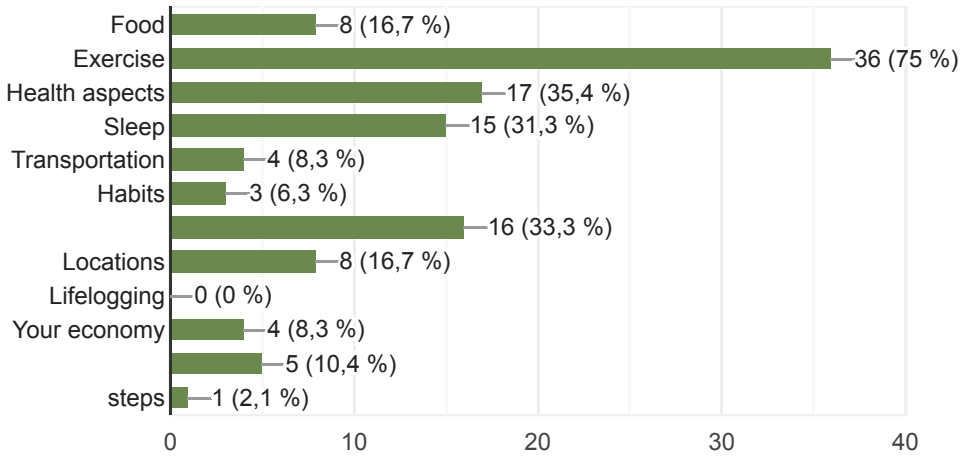
74 svar



If you use these kinds of applications/devices, what do you track? You can mark

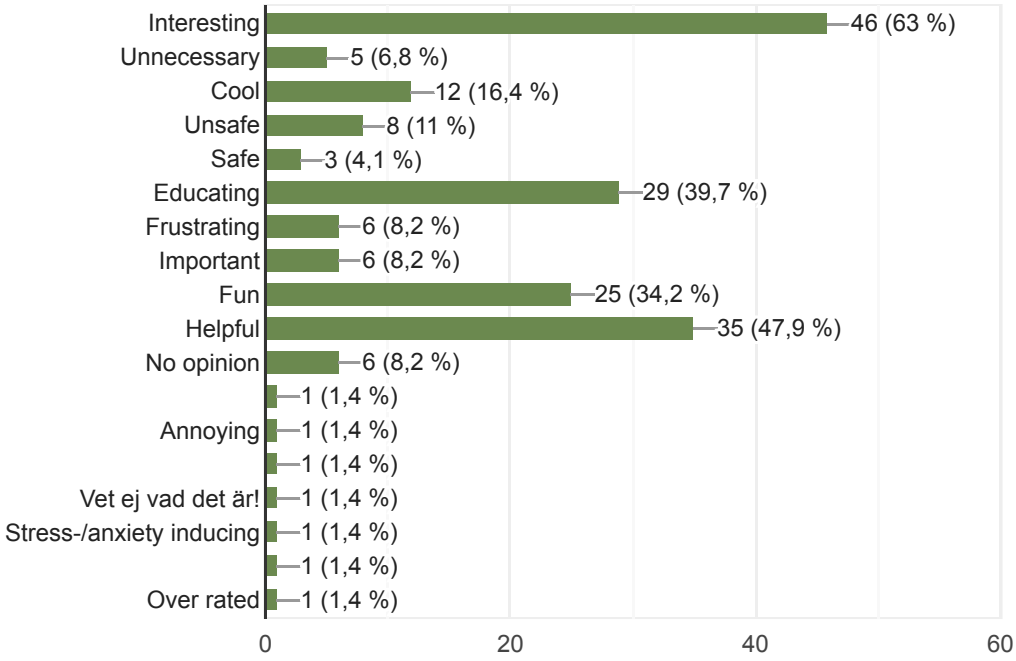
several options.

48 svar



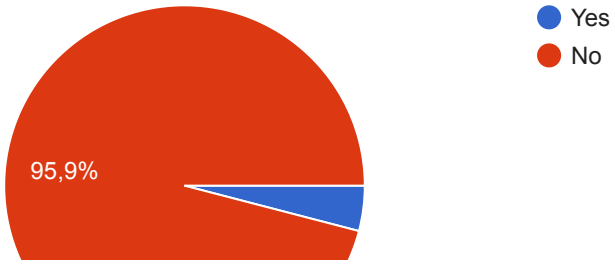
What do you think about quantified self apps? You can mark several options.

73 svar



Do you use any applications related to the environment?

74 svar



If yes, what kind of application(s)?

3 svar

Air quality apps

Carpooling

olio, kivra

What are your thoughts about having an app that monitors your carbon footprint?

56 svar

Would be helpful in order to make people more aware

Not interested

j

Could be interesting if it is not shaming me too much, it should be helpful and give me the appropriate information whenever I need it

Could be interesting, but sounds like it would be a lot of work for me typing in all data. I am interested in apps that works by themselves, without me entering all the information. But if it could be made automatically I think it would be an interesting tool.

Good, educational

Perfect!

I would be interested

Good! Though it should be easy to fill in. Many take too much effort and time.

if it had very clear goals for what a person should output, and _everybody_ used it, it could make a small difference. but everybody won't use it.

It could be informative but I'd probably barely use it if it's me that has to input my daily data or habits. The exercise one that I use does not require me to input any data and I rarely modify my behaviour because of it.

I'm not sure that I'd want an app, perhaps rather a website. I like the idea though, but honestly I'm afraid that I have to limit my own fun too much, selfish as that may be, in order to lower my footprint. And it's pretty sad when you see your friends taking weekend holidays and you know that you can't, if you want to live as you preach.

Fun

It would be nice, and give me an actual idea of how good or bad I am in regards to the environment

I'd ending up a little bit histerical

Good if I get step by step easy actions to improve it. Else I don't think I would use it.

Would be a good Idea, it should in that case be easy to use and monitor.

Confronting

Not really making an impact

Estimating the effects of my lifestyle choices it could have a greater impact on those choices than the vague understanding I have of them now.

Good, although some people allready have anxiety over the environment/global warming and I think such an app might make that worse because I think those are the people who will likely get the app.

Awesome, but sounds tricky to make easy to use without having the user constantly feeding it data manually.

Sounds difficult to implement without tedious self-reporting

Would be nice

Super good idea, I would use it

Would be great

Good idea

Could be nice if made in a way that makes people use it

As stated previously, I think it will be more useful (for people themselves and the environment) to make people reflect more upon their carbon footprint than it will be in its current setting. E.g. sleeping, walking, eating habits, etc.

great thoughts making you think of the enviroment moore often, but only if it is used for a good cause.

Delusional

I think yes, BUT it will need to be some sorts of intrest with people who download it. I would start with companies, so they can track their Co2. They have the ability to reach out to many people at once.

That would be great as long as it doesn't generate too much anxiety.

I would rather not have more apps but less to focus on real life

Interesting but stressful. It would make me think about it 24/7, which might be good for environment, but perhaps exhausting for me

Scary to think what might happen to the data, but might be helpful.

It would be great! If we also could get a daily recommended footprint

Interesting!

That would be awesome, and educational! But it would need to be kind of easy to maintain.

Can be useful and relevant to change peoples' habits

it would be a step in the right direction

Jag försöker använda så få appar som möjligt

It might be bothersome to use an app to track my carbon footprint, if i am going to do the effort of substantially reducing it, I might feel that the time put into tracking in the app is counter productive seeing as my effort to reduce my footprint is time consuming as it is.
That being said i believe it could help people realise what affects your footprints the most and after using it for a while might give up on using it, but by then you have made another environmental aware person who knows how they can change the world for the better :)

That sounds awesome! It can sometimes be scary to think about how little I as an individual can do for the environment, and I feel like an application where you can clearly see how your daily choices make an impact in some way might be a great motivator for some people.

Great, as long as no one can take profit from it by selling the data/ using it for something other

A bit annoying probably because I would feel that I am not doing very well and it might be difficult to reach set goals.

Educating!!!

Useful

I would like to have one

Yes!! It can help me (and others) improve

Great! Gives you information on what you can change in your daily life to improve your carbon footprint

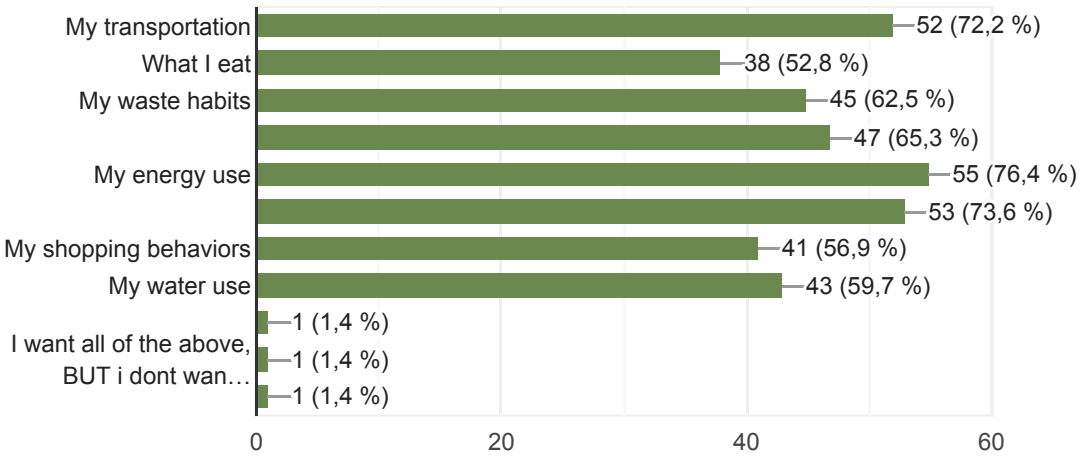
It would be OK.

🤷‍♀️

Sounds good if it does not take alot of time to use.

What aspects would you like to track in an app that monitors your carbon footprint? You can mark several options.

72 svar



10.3 Appendix 3 - Manuscript/Senarios from usertests

1. Statistics of Carbon Footprint

It's evening.

- You enter the app, what are your first thoughts?
- You noticed the daily carbon footprint. You want to find out how the carbon is divided today.
- What do you think this means?
- You wonder if this whole week has been similar to today's carbon footprint.
- What do you want to explore now?

After scenario:

- What information would you like to have here?
- Do you think that you have received the information you needed?
- Do you think that the information was shown in an understandable way?
- How would you use this information?

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2. Challenges

Go back to the start screen.

- You have a couple of active challenges but want to start a new challenge
- What are your initial thoughts?
- What do you think these challenges mean?
- What do you want to do now?

After scenario:

- What information would you like to have here?
- Do you think that you have received the information you needed?
- Do you think that the information was shown in an understandable way?
- How would you use this information?

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3. Badges

Go back to the start screen.

- You see that something new has happened on the screen.
- Go check it out!
- What are your initial thought on this?

After scenario:

- What information would you like to have here?
- What do you think about having the Badges-symbol on every screen?
- Do you think that you have received the information you needed?
- Do you think that the information was shown in an understandable way?
- How would you use this information?

- Do you understand the difference between challenges and achievements?

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4. Profile

- You are a bit curious about what your profile page look like, go check it out!
- You want to connect you ica account, so that the food you buy registers in the app

After scenario:

- What information would you like to have here?
- Do you think that you have received the information you needed?
- Do you think that the information was shown in an understandable way?
- How would you use this information?