Evaluation of a carbon calculator

Challenges and opportunities with calculating emissions from consumption behaviour

Master's thesis in Computer science and engineering

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Abstract

A range of carbon footprint calculators has emerged over the years, aiming at providing reliable estimates of a persons impact on the environment. Similar to the majority of eco-feedback technologies that has been developed, most of these calculators are focused on providing feedback about behaviour on an individual level. Svalna, a carbon footprint calculator, make use of financial data and user generated information in order to provide feedback on a person's green house gas emissions, but also offer a social and collective dimension not found in many other existing calculators.

This thesis aimed to study how people interact and use Svalna, in order to inform further development of the tool, as well as learn more about its implications for the design of eco-feedback technologies. The results describe a range of challenges as well as opportunities with this kind of application, from participants experiencing a dissonance between their everyday life and the app, to the potential participants see in the social features available in the app.

Acknowledgements

I want to thank my academic supervisor Wolmet Barendregt for guidance and support throughout this thesis project. I want to thank my advisor at Svalna, David Andersson, for all the help along the way. I want to thank everyone that participated in this study, making this study possible. Last, but not least, I want to thank my family for supporting me through this project.

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Introduction

Climate change is a pressing societal challenge. Despite the urgency to mitigate our environmental footprint, global greenhouse gas emissions are increasing [28]. The awareness about climate change is also increasing. For instance, Sweden is one of the countries with the most concerned populations and climate change is now the societal issue that worries Swedes the most [37]. The urgency to reduce emissions cannot be understated, but how this is done practically is a very hard challenge. Sustainability overall is a very complex topic with many interconnected factors and pitfalls, especially considering the massive scale and complexity of today's society.

Over the last 10-15 years, research within Sustainable human-computer interaction (S-HCI) has been exploring different ways in which HCI can contribute to reducing CO2 emissions. Examples of such work are diverse, such as how we design digital products and the services using them [7, 33], to impacting environmental policy more broadly [41]. As new technologies have emerged during the last decade, they have opened up new ways to measure our impact on the environment. Within S-HCI a lot of focus has been given to such technologies and how they can be used to influence people's behaviour by providing feedback on what impact actions have in terms of greenhouse gas emissions (GHG emissions). This has given rise to research on eco-feedback systems and persuasive technologies that aim to "convince" the user to adopt pro-environmental behaviour (e.g., [2, 20, 25]). In recent years, such approaches have been criticised for being too limiting, reducing such a complex and intricate issue as sustainability to a set of "simple" metrics, and by doing so narrowing HCI's vision of sustainability [9]. Furthermore, efforts targeting sustainability through eco-feedback and persuasive technologies have been criticised for primarily focusing on the individual, and have argued the research community to move beyond the individual and work with "larger scales" such as groups, communities and nation-states [9, 14, 15].

This thesis presents insights from a study of a carbon footprint calculator called *Svalna*, which has a lot of similarities with other eco-feedback technologies, measuring different metrics connected to individual behaviour, but goes further and also encompasses a social dimension. Svalna (www.svalna.se) is a carbon footprint calculator that provides individuals insights in what their impact is on the environment and how big a reduction is needed to be "in line" with the two degree target [34]. It provides users with an understanding of their GHG emissions from consumption. The service employs transaction data from the users' bank statements, together with registry data and data inputted by the users themselves. This is a novel approach

to continuously provide reliable estimates of users' consumption-related data. The user can also evaluate the emission reductions of different behavioural changes such as the effect (in CO2eq) of switching from car to bicycle commuting or the cost benefit analysis of installing solar panels. One of the key features with Svalna is that users can form groups with, e.g., friends or colleagues at work, and see their combined emissions, compare themselves to each other, set a common goal and share their results through social media, amongst other things. This social setting beyond measuring individual behaviour is interesting as it is a rather unexplored area of eco-feedback systems (see [1]), and connects well with the critique mentioned earlier. The combination of both an individual and a group perspective, together with the continuously collected data on consumption patterns also makes for a highly interesting case from a design perspective since people can use the tool in different ways (learn more and adjust, set goals and abide, form groups and collaborate and so on). These different types of usage can also be compared in terms of behavioural changes. For instance, the strength of group motivations and norm-activation has been shown to be a strong predictor for behavioural change [40]. Understanding what effects tools and services such as Svalna have on users are important, but not something which this thesis project evaluated.

1.1 Svalna 2.0

Svalna is created by Svalna AB, a small research-based company based in Gothenburg, Sweden (from now on called only *the company*). At the time of writing, Svalna can be found online as a website, and has since January 2018 had around 9000 registered users. On the website, visitors can create an account and a climate profile, and by doing so be able to see a breakdown of their emissions in different charts. Additionally, users can compare themselves to different sustainability goals, set an emission budget, see how different changes to their lifestyle impact their emissions as well as see and create groups where the user can compare themselves to the group on different metrics. The company is today in the later stages of developing a mobile application (app) that encapsulates the current version of the tool and will include both existing as well as new features, with a planned release June 2019. The main difference between the current and new version of Svalna will be an expanded group feature. A more detailed description of Svalna and its functionality will be provided in section 2.2 of the Background.

It is important to note here that the author has been involved in development of the app, working on the initial architecture and design of the app as part of a project course earlier in the master program between November 2018 - February 2019.

1.2 Aim

The aim of this thesis is to investigate how people use and interact with the mobile version of Svalna, and through doing so provide insights into how the design of Svalna can be improved. To accomplish this, a formative evaluation of Svalna will

be conducted as well as an interview study, with the goal of looking at usage from different angles. The expected result of this work will be an analysis of how people use and interact with Svalna, and a theoretical discussion of this.

1.3 Research Questions

To study how people interact with Svalna and their experience of doing so, the following two research questions have been formulated, including a set of sub-questions:

What kind of first-time experience do people have when interacting with Svalna?

What kind of longer-term experience do people have when interacting with Svalna?

A range of sub-questions can be added, elaborating further on the two research questions above, including: What problems do people meet when interacting with Svalna? What kind of emotions does interacting with Svalna elicit? How do people use Svalna over time? What do people think about the different features of the app and what they can do with them? How do people relate to their carbon footprint and the possible actions that can be taken to reduce it? These are examples of the questions that this thesis will touch upon when trying to answer the main research questions.

2

Background

This chapter presents the background of the thesis. It includes an overview of related work on eco-feedback technologies and carbon calculators. The end of this chapter also contains a more detailed description of the context and the design of Svalna.

2.1 Eco-feedback technology

Eco-feedback technology can be defined as technology that provides feedback on behaviour and what impact it has on the environment, with the goal of stimulating a rethinking of practices and reducing environmental impact (adapted from [1, 21, 38]). Feedback on behaviour in this sense can for instance be provided by measuring data on one or more activities (e.g., energy use), calculate the impact on the environment of this in terms of CO2 emissions, and present this information to the user. A key assumption behind eco-feedback technology is that through creating awareness about what impact a certain type of behaviour has on the environment through feedback, it will result in change towards more environmental friendly behaviour. Though there is mixed evidence for such an effect, a review done by Fischer [16] on research exploring the effects of feedback on energy consumption indicates a typical reduction in emissions of between 5 and 12 %.

Eco-feedback often coincides with persuasive technology. Within S-HCI the most common approach to persuasive technologies is to "design systems that attempt to convince users to behave in a more sustainable way" [14, p. 1977]. Persuasive technology has its roots in the works of Fogg [17, 18] and psychological theories of persuasion. As Froehlich and colleagues highlight, eco-feedback *could* be seen as an extension of persuasive technology, but note that research on eco-feedback actually stretches back much further to research within environmental psychology [21]. Systems designed with persuasion in mind often involve eco-feedback [e.g. 2, 19, 20, 22, 27], but rather than being a sub-field of persuasive technology, it can be argued that eco-feedback and persuasive technology are two interlinked, but distinct fields of research, resting on a common theoretical foundation from psychology.

There is an extensive body of research on eco-feedback technologies, both within HCI and beyond. This work covers a lot of different areas, ranging from visualisation of energy consumption [25] to exploring citizen participation in local climate policies [1]. Eco-feedback technologies mainly target different kinds of consumption behaviour, with researchers developing designs for a variety of domains such

as energy and water usage, transportation and waste disposal [21]. A majority of the research done on eco-feedback focuses on household energy use [1, 16, 21, 31]. In their comparative study of eco-feedback technology and research, Froehlich and colleagues found that 41% of papers within HCI and 92% of papers within environmental psychology had residential electricity use as their main target [21]. As mentioned in the introduction, research on eco-feedback technologies has been primarily focused on intervening at an individual level, and this approach has received a number of criticisms during the last decade, with the key argument being that such approaches have difficulty dealing with the complexities and nuances of everyday life, reducing sustainability to a set of "simple" metrics [9, 31]. This is not isolated to this specific area of research, but can be seen in the S-HCI literature overall [14]. There is limited work exploring eco-feedback technologies beyond the individual, looking at how eco-feedback systems function when used in larger social groups and what impact such systems have in terms of reducing CO2 emissions. A highly relevant exception is a study conducted by Hasan and colleagues [24], looking at how a team-based feedback system impacted the amount of paper an individual printed in an office environment. In their study, a number of teams got their printing practices monitored over a period of 58 weeks, and during this time, they received weekly feedback via email about their printing behaviour. This feedback was comprised of normative information, eco-metrics and comparative statistics between the teams. The results from this study showed a significant reduction in paper usage with an average reduction of 28% amongst the participants, and indicate a strong potential in approaches delivering feedback on a scale beyond the individual.

It is important to point out that research on eco-feedback is not conducted in the same way across disciplines. A majority of research within HCI has focused on the design and production of eco-feedback technologies, and rarely evaluated their design in terms of effect on behaviour, in comparison to research within environmental psychology, which mainly focuses on the effect of interventions [21]. As Froehlich and colleagues note, there is a certain gap between HCI and environmental psychology in terms of approach and methodology. However, they also argue that the two disciplines can complement each other, with evaluation of eco-feedback technologies within HCI rather focusing on e.g., understandability and usability over effects on behaviour. It is therefore difficult to say what effects eco-feedback technologies developed within HCI research have in terms of promoting pro-environmental behaviour. It also shows a potential for more integrated approaches.

2.1.1 Carbon footprint calculators

Carbon footprint calculators are a kind of "self-employed" eco-feedback technology that people can make use of to understand their impact on the environment. Through feeding a calculator with data about different activities, the user can get an estimate of their GHG emissions. There are many carbon calculators publicly available today, either developed for research, business or non-profit purposes. In a review of 31 internet-based carbon calculators, Bottrill [8] highlights the diversity of existing tools, with different calculators displaying a varying degree of complexity

and ways in which the user can interact with the tool, ranging from filling in a spreadsheet offline to web interfaces with a multi-step process in which the user fills in information about different areas in turn. Carbon calculators also vary in depth, with some only covering one particular domain such as energy use, whilst others provide a more holistic perspective by including activities such as consumption and travel behaviour. The type of results that carbon calculators provide to the user is on the other hand fairly homogeneous, with most mainly reporting the annual impact on the environment by the user [8, 30]. Carbon calculators also vary greatly in the calculated results, in some cases as much as several metric tons per year, showing a lack of consistency between calculators [30].

A concrete example of an online carbon calculator is klimatkalkylatorn[1], a tool developed by WWF[2] in cooperation with Stockholm Environment Institute. It provides the possibility to fill in information about housing, energy use, diet, transportation habits, shopping habits [buying things] and spare time activities. Overall, the battery of questions is extensive, covering many domains of everyday life. Additionally, the user can save the results and form groups with friends to compare with others. This type of feature is rare among the calculators mentioned in review papers, with most carbon calculators focusing on calculating individual emissions, and providing comparisons to e.g., national averages [8]. In a study by West and colleagues [46], the authors report on an evaluation of REAP petit, a carbon calculator similar to the example mentioned above, which allows users to both be part of groups as well as make pledges. As West et al. [46] explain, the motivation for including such features in the calculator is that social comparison and committing to pledges has shown to be a strong factors in affecting behaviour. Social comparison and commitment are two of many techniques that can be used for behavioural change, and which can be found in both carbon footprint calculators and eco-feedback technologies overall. An overview of these techniques can be found in chapter 3, section 3.2.

It is questionable what effect carbon calculators have on behaviour and if it leads to any change in behaviour. In a study by Büchs and colleagues [10], it was shown that participation in an experiment involving a carbon calculator significantly increased awareness, but did not result in any measurable reductions in energy use. One possible reason for the lack of reductions is the presence of barriers to adopting more environmental-friendly behaviour, such as infrastructural or social barriers [10]. However, other studies involving carbon calculators report actual reductions amongst their participants [1].

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[1]https://www.klimatkalkylatorn.se/
[2]http://wwf.org/

2.2 Svalna

This section describes the design and structure of Svalna, and the theoretical aspects considered, and provides a brief description of how the users are initially presented with their GHG emissions. The description of the app and the pictures shown below follows how the app looked like at the time of the formative evaluation (10th and 11th of April, 2019. Android. Version 47).
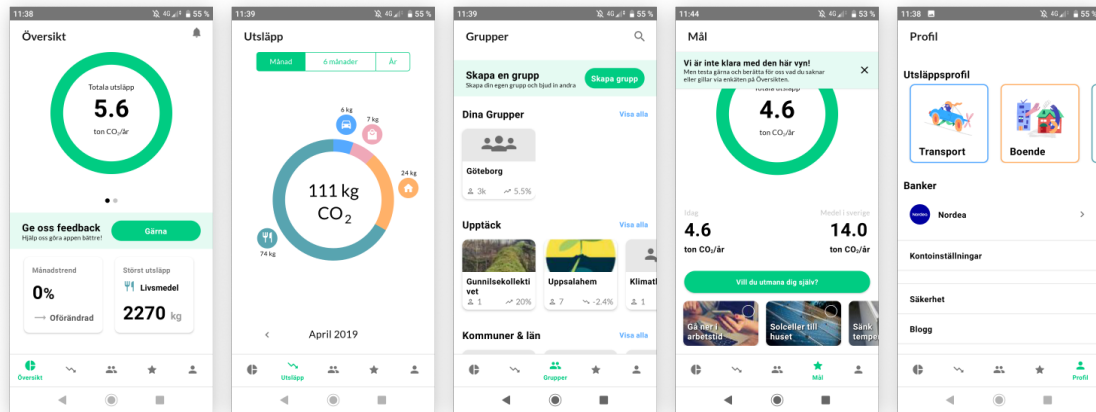
Figure 2.1: An overview of the five different sections of the app based on the main menu. From the left: Overview, Emissions, Groups, Goal, Profile.

Svalna is divided into five sections (see figure 2.1); *Overview*, *Emissions*, *Goal*, *Groups*, and *Profile*. The Overview summarises information from other parts of the app and provides the user with an orientation and update of their GHG emissions. The Emissions section allows the user to explore GHG emissions over different time periods and resolution, in order to be able to better understand how their consumption relates to GHG emissions. The Goal section allows the user to set a goal, and gives the user an opportunity to experiment with different behavioural changes and investments in order to see how they would affect future emissions in relation to the goal. The Groups section allow the user to engage in groups and compare themselves with others. The Profile section gives the user access to settings, as well as an overview of the users climate profile and what they answered on each question during the initial creation of their account.

It is possible to draw clear connections between these features and the most common intervention techniques found in behavioural psychology. Intervention techniques can be used to influence the behaviour of people in order to create behavioural change. The most common techniques are *information provision*, *goal setting*, *Comparison*, *Commitment*, *prompting*, *feedback*. For a closer review of these, see the theory chapter. In the app, some of these techniques can be found. Through providing information about the user's carbon footprint and on a continuous basis present emissions from transactions, it gives *feedback* on the users actions. *Comparison* between the user and others are provided in the Groups and Goal sections.

Both at an individual and group level it is possible to *set a goal* of reducing emissions. *Feedback* is also provided on the performance of a user or a group on their progression towards their goal.

2.2.1 Creating an account

To create an account, the user can use either e-mail or Facebook as verification. After the account has been created, the user is prompted to fill in a climate profile, consisting of a questionnaire divided into four sections: 1) consumption of goods and services, 2) transportation, 3) residential energy, and 4) diet. In the first section the user can choose to either connect their bank and get their transactions analysed by Svalna, or answer two questions about their income and savings. The rest of the questionnaire is built as a step-by-step process containing 25 questions in which the user answers one or two questions at the time (see figure 2.2). After the climate profile is completed, the user is taken to the Overview.
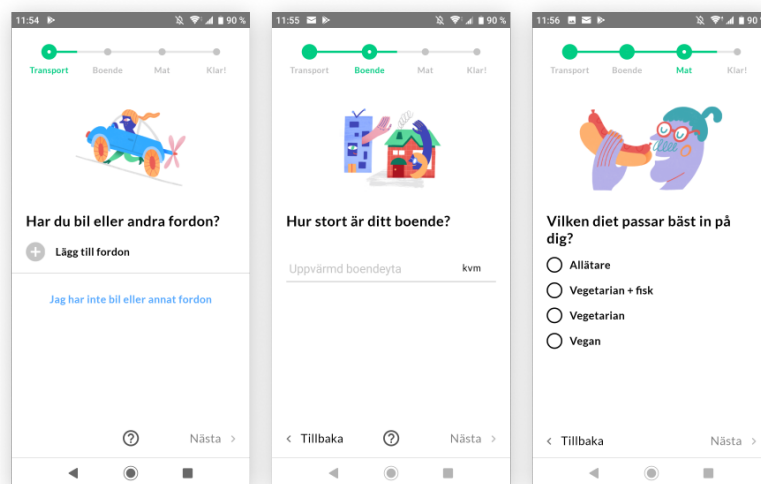
Figure 2.2: Three examples of questions in the climate profile.

2.2.2 The overview

The overview gives a brief glance of the user's emissions, both what the estimated total emissions in CO2 are, as well as a breakdown between the four main categories of emissions found in the app: Transportation, Housing, Food, and Shopping (see figure 2.3). Depending on whether the user has connected their bank account, they will see two slightly different versions of the overview (and app overall), with the main difference being that when the user has connected their bank, the app can display trends as well as a list of the latest emissions from transactions. By not connecting a bank account to the app, the data is more static, showing only a time stamp based on the answers provided by the user when creating a climate profile.
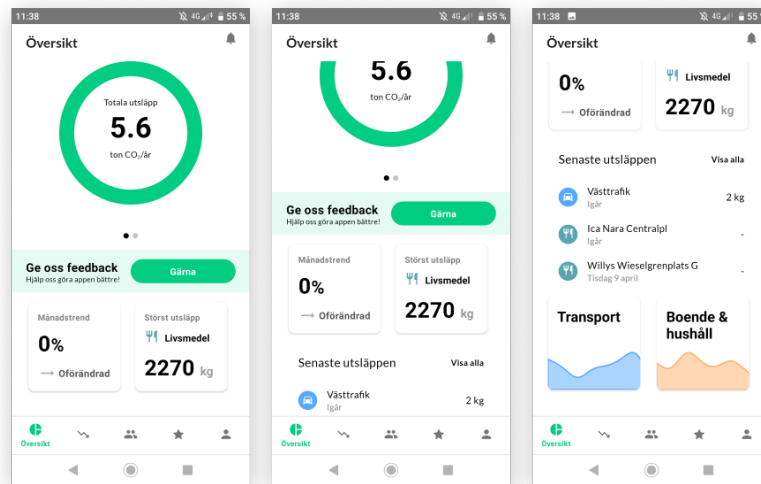
Figure 2.3: A snapshot of how the overview looks like when first creating an account. All three pictures show the same view, as it is scrollable.

2.2.3 See your emissions

The Emissions section allow users to explore how their GHG emissions from consumption vary over time and the relative size of GHG emissions from food, housing, transport and other consumption. As Figure 2.4 shows, the user can choose to see their emissions in the perspective of one month (pie-chart), six months (bar-chart) or twelve months (line-chart). The pie-chart shows the monthly composition of GHG emissions from the four main emission categories, while the bar- and line-chart show trends over time. The user can drill down to the individual transactions and their respective GHG emissions to get a more detailed understanding of which activities or transactions cause large or small emissions. It is also possible for the user to re-categorize transactions that were not correctly classified by the algorithm.
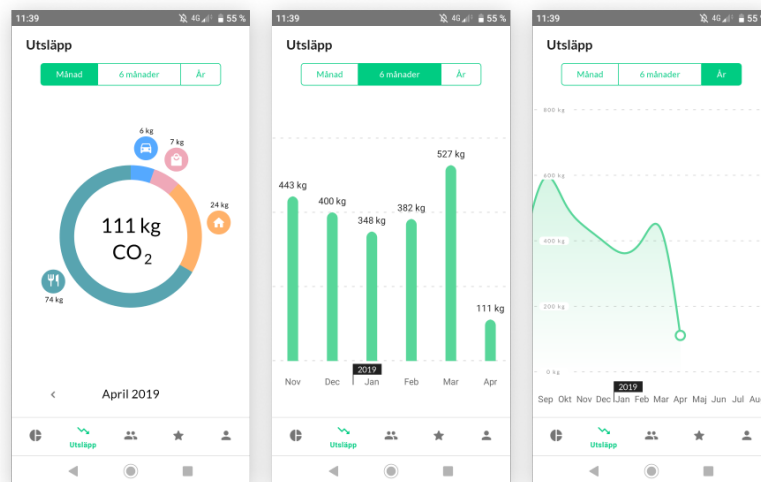
Figure 2.4: An overview of the Emissions section. On the left, a monthly review. In the middle, an overview of the last six months. On the right, an overview of the last 12 months.

2.2.4 Groups

Users in Svalna can form groups and compare, cooperate and set joint goals to help engage each other in reducing emissions. Groups could consist of, e.g., co-workers in a workplace, students in a class, friends with a shared interest, neighbours, or people living in the same municipality. There are different kinds of groups; all users are by default part of a municipality group that allows comparisons of different Swedish municipalities and allows the user to compare themselves within the municipality. Users can also create groups themselves, either public ones visible to others, or private and hidden, except from specially invited members. There are also organisational groups that include additional functionality and information on the company and its goal. Different groups demand different functionality and can be used in different ways. Municipality-based groups, e.g., offer a possibility for the local environmental administration in a municipality to get in touch with motivated citizens and inform them about current work and goals, and engage them in different activities. Organisational groups have been developed based on the concept of friendly contests, and also allow the company or organisation to inform about their corporate social responsibility work.
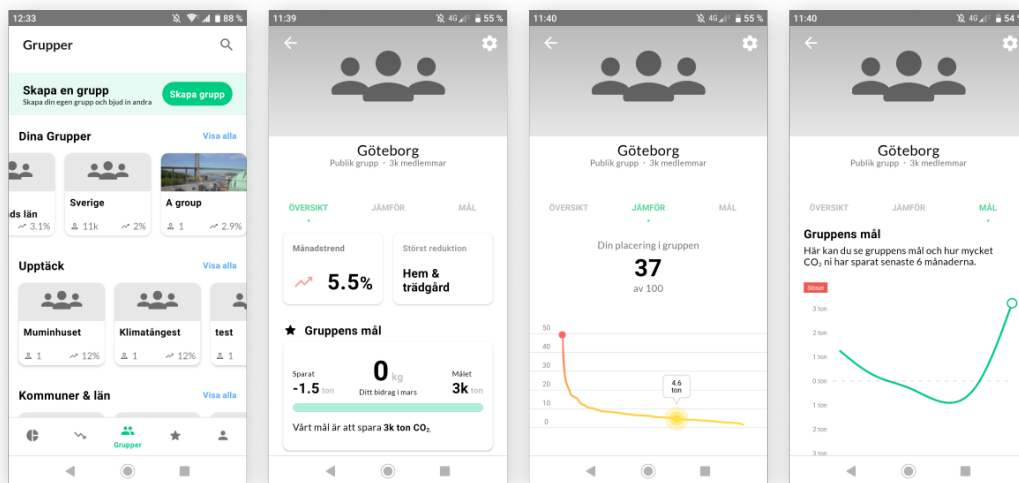
Figure 2.5: An overview of the Groups section. On the very left, an overview of the different groups available to the user. The three pictures on the right show a municipality group.

As Figure 2.5 shows, the group section consists of an overview of all groups visible to users, including surrounding functionality such as search, and separate "pages" for each group on the platform. These pages are structured into four parts. On top, details about the group can be found, such as name, picture, type of group, a bar with pictures of members, as well as a button to invite more members. Below a tab bar can be found with three tabs: *Overview*, *Compare*, and *Goal*. Within these tabs, the user can see a snapshot of how the groups emissions are, compare themselves to the group on different metrics, and see how the group is progressing toward their common goal. A ranking list can also be found in the overview of a

group, displaying the top three users with the lowest GHG emissions.

The ranking section intends to motivate users to reduce their emissions by evoking a sense of competition. Research shows that several motivational processes are triggered by allowing users to compare themselves to others, either by collaborating or competing. The relatively strong norms around GHG emissions and climate change are likely to form a response from users that are either above or below the average [11, 12]. Comparative feedback that includes some form of social interaction has also been shown to result in significant and durable reductions [39].
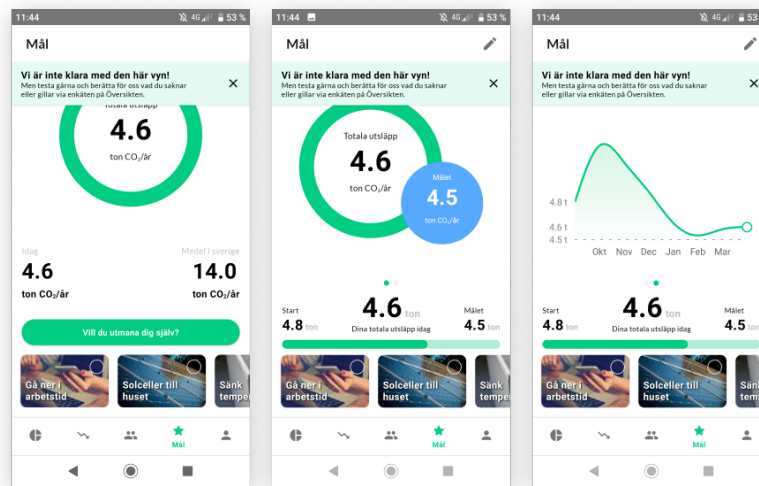
Figure 2.6: Overview of the Goal section. On the left, the initial view without a goal set. In the middle, the same view when a goal is set. On the right, feedback about the performance toward the goal.

2.2.5 Setting a goal

The Goal section allows the user to experiment with different behavioural changes and investments to see how they would reduce GHG emissions, and to set a goal for a longer time-period. The rationale behind this design is that it allows users to experiment with different changes in order to "get a feel" for their magnitude and hence a first impression of what is "possible". Users can be expected to have obtained a basic understanding of some climate friendly behaviours, but few of them will have factual understanding of the absolute or relative size of different changes open to them. This part of the section is hence designed to add to the user's carbon literacy. As can be seen in Figure 2.6, the section is organised in an upper element that shows the user's emissions and the effect of different proposals, and a lower element consisting of a swim lane of cards, which represents different suggestions available to the user and when clicking them the upper element changes size in order to indicate the related emission reductions. A suggestion could be to reduce the indoor temperature or not buying anything for 30 days. Users are also encouraged to adopt a goal to reduce their GHG emissions by clicking the button with the label

"Vill du utmana dig själv?" (English: Adopt a goal to reduce emissions). A goal is defined as what level of emissions in tonnes CO2 that the user wants to reach in comparison to her current, annual carbon footprint. For instance, a user might have an annual footprint of 10,5 tonnes CO2, and set a goal of reaching a annual footprint of 8 tonnes CO2.

3

Theory

This chapter contains a brief overview of theories and theoretical frameworks relevant for this thesis. It contains an overview of theories pro-environmental behaviour, as well as a review of the most common intervention techniques within behaviour psychology that can be applied to environmental behaviour.

3.1 Models of pro-environmental behaviour

Within environmental psychology there are several models and theories that try to explain environmental behaviour. These often fall into two "camps", either perceiving environmental behaviour as mainly driven by self-interest, or rather driven by pro-social motives and norms. Rational choice models are representatives of the former perspective, while the norm-activation model and value-belief-norm theory fall under the latter. It is important to note here that no definite explanation of pro-environmental behaviour has been found or decided upon [26], illustrating how complex human behaviour is.

3.1.1 Rational choice models

Rational choice models build upon the assumption that individuals are rational actors who make reasonable choices, and where the behaviour of such an actor is regulated by a systematic process of evaluating expected utility [21]. Two examples of such models are *Attitude models* and *the rational-economic model*. With attitude models it is thought that favourable attitudes translate into favourable behaviours [21], with a linear progression moving from knowledge to concern to pro-environmental behaviour. An issue with attitude models is that they do not take into account additional factors that might influence behaviour, and therefore is not always a strong relationship between attitudes and subsequent actions [13]. The rational-economic model assumes that people are rational actors who aim to maximise rewards and minimise costs. The thought here is that people will adopt pro-environmental behaviour that is economically advantageous to them. In other words, the model assumes that people understand the costs and benefits of acting in a certain way, which might not be the case. Additionally, this model can be seen as a simplification of behaviour, with the model not counting in additional, "softer" factors such as norms and habits.

3.1.2 Norm-activation

The Norm-activation model proposes that "pro-environmental actions follow from the activation of personal norms, reflecting feelings of moral obligation to perform or refrain from specific actions" [40]. According to Schwartz' version of the norm-activation model [36], the activation of norms can happen when a person becomes aware of the environmental problems or negative consequences caused by his or her behaviour, potentially leading to pro-environmental behaviour.

3.2 Intervention techniques

There exist various intervention techniques with origins in behavioural psychology that can be applied in order to promote behaviour change. The aim with these techniques is to influence the behaviour of people by providing various kinds of feedback on behaviour and actions that can be taken, and by doing so, hopefully trigger a change in peoples behaviour. For the sake of brevity, this section will cover the most common techniques and strategies used, based on reviews made by Froehlich et al. [21] as well as Steg et al. [40]. These are: *Information provision*, *goal setting*, *comparison*, *commitment*, *prompts* and *feedback*.

3.2.1 Information provision

One of the most commonly used interventions to promote pro-environmental behaviour is information provision [39, 40]. Through providing information about e.g., an environmental problem, the assumption is that people will gain awareness of this problem and behave in more an environmentally friendly way.

3.2.2 Goal setting

Goal setting is a technique that assumes that individual behaviour is goal-directed and that the anticipation of reaching an attractive goal motivates respective behaviour [40]. Setting a goal is a source of motivation through a comparison between the present and a desirable future situation [43].

3.2.3 Comparison

Motivating behaviour change can be done through providing comparison between different metrics, such as between individuals, groups, or even comparing between one's own behaviour across different points in time. Social comparison in particular can be used to "activate" social norms (i.e., approval or disapproval from other people).

3.2.4 Commitment

Commitment is an intervention technique in which a person or group promises to change their behaviour. The assumption is that making a commitment creates

cognitive dissonance, which results in behaviour change. Cognitive dissonance can be explained as "the tension that arises when one's beliefs or attitudes do not align with one's behaviour" [40].

3.2.5 Prompting

Prompting is a well known technique, which is focused on encouraging pro-environmental behaviour in very specific situations through providing simple messages or reminders to behave in an appropriate way. A prompt could be a short written message or a sign prompting someone to e.g., put their waste in the right recycling container or remember to switch off the lights when leaving a room. A prompt is usually directed at a specific behaviour in a given situation. Prompting is considered to be a "weak" intervention technique, most effective with less complex and easy behaviours [40].

3.2.6 Feedback

Providing people feedback on their actions is another technique that can be used to promote pro-environmental behaviour. Feedback can come in many different forms, such as providing people with information about their performance on a maths test, their consumption behaviour (e.g., their energy and water consumption) or their performance towards a goal. Froehlich and colleagues [21] break down feedback into two forms: *low-level feedback*, which can provide information about how to change or improve specific behaviour, and *high-level feedback*, which is summative and can provide information about performance towards a goal or in comparison to others.

4

Methodology

This thesis aimed to investigate how people use and interact with Svalna, and through doing so provide insights into how the design of Svalna can be improved. To reach this aim, two research questions was formulated: *What kind of first-time experience do people have when interacting with Svalna?* and *What kind of longer-term experience do people have when interacting with Svalna?*. To investigate the first question a formative evaluation of Svalna was conducted, looking at the usability of the app and the users' experience of interacting with it. To investigate the second question, an interview study was conducted with the same participants two to three weeks after the formative evaluation, exploring the participants usage of the app since the first session as well as broader themes concerning carbon calculators in general.

This chapter describes this work in detail, including the methods used, how the study was conducted, and how the data was analysed.

4.1 Methods

This section gives an overview of the methods used in this project.

4.1.1 Usability testing

Usability testing is an evaluation method used to observe users interacting with a product as they go through a task or set of tasks, with the end goal being to evaluate the usability of an interface [5, 29]. The method can be used to evaluate both low-, mid-, and high-fidelity prototypes, as well as launched products. In usability tests where the researcher is working with one person at a time, it is common to follow a think-aloud protocol, which means that the participant is asked to verbalise their thoughts and *"think aloud"* as they interact with a product [29]. By asking the participant to say out loud what they are thinking, it is possible to get an understanding of why the participant takes certain actions, as well as capture their thoughts, feelings and reactions while interacting with a product [5].

4.1.2 Desirability testing

Desirability testing provides a way for participants to "tell the story of their experience" [4] and describe how interacting with a product makes them feel [5]. The

method was originally developed by researchers at Microsoft, looking for a way to measure the more intangible aspects of the user experience [6]. Production reaction cards is another name for this method. A desirability test is most commonly used in combination with e.g., usability tests, and administered after the participant has interacted with a product. In order to conduct a desirability test, a stack of cards should be created, with a single adjective written on each card. The adjectives should consist of a balance between neutral, negative and positive words [5]. After interacting with a product, the participant is asked to pick a number of cards from the stack that describe how interacting with a product made them feel. Desirability testing is originally considered a summative evaluation method, usually applied to a very high fidelity prototype or a launched product, and it is usually recommended to conduct this method with 25 participants. [5]. In this thesis, desirability testing was primarily used to create an initial understanding of what kind of overall experience participants had after interacting with Svalna. For this reason, it can be argued that it becomes a formative version of the method using this approach. It also means that it cannot provide a conclusive answer to what kind of experience the participants had, and can only give an indication of the overall user experience. To give a more definite answer, a summative evaluation of the app should be conducted when Svalna reaches a more complete and finished state.

4.1.3 Interview

Interviewing is a method that can be used to gather first-hand accounts of people, and provides a nuanced and "humanized" perspective on a topic. It is one of the most common methods used for understanding users [5], and is well suited to be combined with e.g., quantitative data. An interview can be either structured, semi-structured, or unstructured [32]. A structured interview is the most controlled type of interview in which the interviewer follows a script strictly, and does not follow up with probes or questions not listed in the script. In many ways, a structured interview resembles a verbal questionnaire, and is usually made up of mostly closed-ended questions, though open-ended questions can be asked. An unstructured interview is, as the name implies, an interview with little or no structure, resembling more of a natural conversation that flows freely, though some preparation is required, usually consisting of open-ended questions. A semi-structured interview is a mixture of the two, guided by a script, but with room to deviate from it, allowing the interviewer to follow up and explore things mentioned by the interviewee. Data from interviews can be recorded in different ways, either through written notes, audio recordings or in a similar fashion. As Wadswort [45] states, digital recordings can generate a lot of work (e.g., listening, transcription), but can be useful for later note-taking and evaluation.

4.1.4 Content/thematic analysis

Content analysis is a method for "sorting, synthesising and organising unstructured textual data" in order to identify common themes in the data [5]. Content analysis can be either inductive or deductive, with the former being preferred and more

common [29]. In inductive content analysis, the researcher forms a set of categories or codes through a systematic reading of a sample set of the material to be analysed, and by doing so establishing the categories or codes that will be used to analyse all of the material. Deductive content analysis has a different approach, with the categories or codes being created prior to analysis of the material, often based on theoretical ground. After the material is categorised, it is grouped together based on its coding and synthesised in order to identify emerging themes in the data.

4.2 Participants

In total, seven unique people participated in this study, with five participating in the formative evaluation and six participating in the interviews. Four of these participants took part in both the formative evaluation and the interview study. They were all employees at a municipally owned housing company in Uppsala, Sweden, and were in the process of joining an internal campaign within the company focusing on sustainability. The demographics of the participants were not recorded in detail, though a few words can be said about their characteristics. There were 3 male and 4 female participants, of varying age (only three data points collected, 27, 27 and 42). In the following text, when referencing the different participants in the study, they will be named P1, P2, P3, and so on (e.g., Participant one = P1).

4.3 Process

This section describes the activities conducted in order to investigate the research questions, in chronological order.

4.3.1 Literature study

A literature study was conducted at the beginning of the thesis project, with the aim of identifying related work and research on eco-feedback and carbon calculators. Additionally, literature on methodology was studied. The search for relevant literature was done through snowballing, first identifying a set of papers using relevant keywords as recommended by Wohlin [47], followed by a widened search for key contributions based upon the citations and references found in the initial batch of papers.

4.3.2 Formative evaluation

A formative evaluation is usually conducted to inform and improve the design of a product during development, collecting qualitative data in order to identify and fix potential problems with the design, as well as get feedback from outsiders [3, 5, 23]. Usability inspection and usability testing are methods typically used do conduct a formative evaluation [5].

The formative evaluation in this study was designed as a two-stage process, with an initial usability test covering the usability of the app, followed by a desirability test evaluating the participants experience interacting with the app. The evaluation was planned to last for up to 60 minutes, and consisted of four steps:

- An introduction.
- A usability test.
- A desirability test.
- A debrief.

In the introduction, the study and its focus was explained to the participant was introduced, as well as what would be asked of them during the session. Formalities were also covered in this step, asking for consent by the participant to both audio and video record the session. The participant was asked to read through and sign a consent form. The usability and desirability test were conducted thereafter, and will be explained in more detail in the following sections. At the end of the session, a short debrief was done together with the participant, discussing any questions the participant might have had, as well as scheduling a time for the interview two weeks later.

A pilot test of the formative evaluation was conducted prior to the scheduled sessions with participants. The test was conducted with an employee at the company, leading to only minor changes in the script, such as adjusting wording and establishing a more structured testing protocol which was easier to follow. The initial testing protocol detailing all steps was written in running text, which made it hard to cover all details and things that had to be said. The revised protocol consisted of bullet lists which was easier to follow by the moderator.

4.3.2.1 Usability test

The usability test consisted of 11 scenarios, which the participant was asked to respond to, either by interacting with the app or answering detailed questions about the interface (see Appendix A for a detailed overview of the test protocol used). At the beginning of the test, the participant was asked to think aloud as much as they could while going through the different scenarios. The role of the moderator (me/the author) was also explained, and as recommended by Barnum [3], it was clearly stated that the moderator would not respond to detailed questions, and would not confirm that the participant had completed a scenario. The reasoning is that it reduces any risk of a biased moderator influencing the result of the test. The scenarios were presented one by one verbally by the moderator. The scenarios in the test related to the core features of the app (Creating a profile, viewing emissions, setting a personal goal, and groups). As Barnum [3] recommends, the scenarios were developed in steps, first defining the concrete tasks that the user was supposed to do with the product, and then crafting these into scenarios with a clear goal, avoiding a list of steps to complete a task or reach a goal.

To give an example, one one goal was to *"create a group"* and the corresponding scenario was:

> *"You are thinking about inviting your friends to use the app and together set a goal to save 10 tonnes CO2 together. See if you can find a way to set a goal together with your friends. Tell me when you think you have managed to do so."*

The usability test was recorded using Lookback [1], which enables recording of audio, video of the screen, as well as video of the participant through the front-facing camera of the device. To keep the testing consistent across participants, a Sony Xperia XZ2 Compact was used by all participants when interacting with the app. The usability tests were conducted in meeting rooms at the office building of a housing company in which all participants was employed, located in Uppsala. A description of each actionable scenario and its underlying task(s), as well as the "correct" way to complete the task(s) can be found in Appendix B. This was used as reference when analysing the material.

4.3.2.2   Desirability test

Directly after the usability test, a short desirability test was conducted with the participants. The test followed the suggested setup described by Baxter and colleagues [5], in which a stack of flash cards with a single adjective written on each card was prepared, consisting of a balance between positive, negative and neutral adjectives. The adjectives used in the test were based on the original set of 118 adjectives developed at Microsoft [6], with a minor adjustment. To reduce complexity, a reduced list of 64 cards was used, adapted from [42]. See Appendix D for the complete list of adjectives used. Similar to Barnum & Palmer [4], the stack of cards was spread out on an adjacent table in the testing environment (table in meeting room). After the usability test, the participant was asked to go over to the table and pick 4 or 5 cards from the deck that describe how the app made them feel. They were then asked to bring the cards back to the "recording" station, where they were asked to tell why they picked each card. The participant's response was audio-recorded. Pictures of the cards picked were also taken for later reference.

4.3.3   Interview study

To capture the long-term experience of people's use of Svalna, semi-structured interviews with participants were conducted 2 or 3 weeks after the formative evaluation. The participants were the same as in the formative evaluation, except two who could not take part in the evaluation. The interview was based upon a script (see Appendix C), and was between 30-60 minutes long. The questions in the interview concerned the participants' use of Svalna during the two weeks up to the interview, their thoughts about the different features in the app, as well as their thoughts about sustainable behaviour and social aspects related to this. The questions were developed based on the results from the formative evaluation as well as the theories

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[1]https://lookback.io/

described in chapter 3.

The interviews were conducted either via video conferencing (Skype) or via phone call. The original plan was to conduct all interviews via video conferencing, but due to technical difficulties, two of the six interviews were conducted via phone call instead. The interviews were all recorded, either with both audio and video recording (video conferencing) or only audio (phone). The technical difficulties were unfortunate, but the quality of the interviews conducted via phone call was not judged to be lacking in comparison to the interviews conducted via video conferencing, except the lack of recorded video, revealing any potential visual cues.

4.3.4   Analysis

Different kinds of analysis were conducted, depending on the type of data gathered.

4.3.4.1   Analysis of the formative evaluation

For the formative evaluation, the analysis consisted of two parts. Data from the usability test was compiled and analysed by identifying any usability problems the participants experienced when interacting with Svalna. This was done through annotating the video recordings of the usability tests, noting observations of what the participant did and said during the test, focusing on any problems, confusions and so on that might have taken place. A description of each scenario and the "correct" steps required to complete each scenario were used as reference. For a review of these, see Appendix B. The annotations were thereafter coded using a set of predefined codes adapted from Vermeeren et al. [44], with a set of additional codes added before or during the analysis in order to code observations that did not fit onto the predefined codes. These additional codes that was added can be found in Table 4.1.

This process of coding the annotations was done in order to identify indications of usability problems in the app, drawing support from the codes in order to identify and classify what kind of problems that emerged. After this, the findings was extracted from the annotations and compiled into a list of usability problems. These problems was categorised based on affinity, i.e. grouped together based on what type of problem they represented. Each usability problem was also given a severity rating, which could be either:

- **High:** Findings that the majority of the participants encountered. This rating was also given to problems that became an obstacle or made it difficult for the participant to complete a scenario.
- **Medium:** Findings that two to three participants encountered. This rating was also given to findings that gave rise to frustration, but did not stop the participant from completing a scenario.
- **Low:** Findings that was problematic or led to confusion at first, but not frustrating enough to be considered a problem.

Code	Short description	Definition
Q	Quote, comment	Comments from the participant
SYS	System interactions	Interaction with the operating system of the device used for testing
OTR	Interaction with other device	The participant interacting with other devices, such as their own phone
GUD	Moderator guide or give directions	The moderator guides or give direction to the participant during testing
SUG	Suggestion, recommendation	Suggestions or recommendations made by the participant
TERM	Terminology	Participant indicate that they are confused or do not understand information presented in the app

Table 4.1: The additional codes used together with the adapted codes by Vermeeren and colleagues [44] to analyse the annotations from the usability tests.

The results from the desirability tests were initially compiled into a list, detailing which adjectives the participants had picked out, and how many times each adjective was selected. Following this, an analysis was done in order to identify potential themes or groups among the adjectives selected, including:

- How many positive words were selected?
- How many negative words were selected?
- How many of the same words were selected?
- How many similar words were selected?
- How many unique words were selected?

The response from each participant on why they picked each card during the desirability test was also audio recorded during the evaluation. The responses were later transcribed using word processing software. The transcripts was used to describe what kind of experience the participants had when interacting with the app.

4.3.4.2 Analysis of the interviews

The interviews were analysed using content/thematic analysis. The interviews were first transcribed using word processing software. The transcription was done in an *edited* format, meaning that word crutches or misstatements were omitted from the transcriptions [5]. Two out of the seven interview transcripts were then coded, forming a set of codes that was used to analyse all seven interviews again. All coded observations were thereafter synthesised in order to identify emerging themes in the data.

4.4 Ethical considerations

This thesis involved user research in several different formats (usability tests, desirability tests and interviews). To ensure the integrity of the participants taking part in this study, appropriate steps were taken, including asking for informed consent, informing the participants of their right to be anonymous, as well as their right to abort any ongoing research activity in which they take part. The data collected in this study was handled with care, and stored on an external, offline hard-drive only accessible by the author.

5

Results

This chapter describes the results from the research activities conducted in this thesis project. The results will be presented method-by-method.

5.1 Usability test

The usability tests uncovered both general thoughts from the participants about Svalna and its features, as well as small and big issues with the usability of the app. The severity of these varied, from stopping a participant from completing a task to creating frustration and confusion. Overall the participants managed to go through most of the scenarios presented to them, with the majority reaching scenario 10 before the testing session ended. One participant only went through the first eight scenarios due to lack of time. Two out of the five participants chose to connected their bank to the app. Two participants wanted to connect their bank, but could not due to technical issues with BankID, the digital ID used to verify their identity when connecting their bank. For reference when reading the results, descriptions and pictures of the app and its different features can be found in section 2.2 of the Background.

In total, 33 usability issues was identified. As the list of all the findings was too long to fit snugly into this chapter, a summary of the most severe and critical findings will be provided below. For a full review of the usability issues, see Appendix E. The usability issues found was organised into 6 categories:

- **Layout:** The placement of visual elements in the interface, and their effectiveness at guiding the user.
- **Navigation:** How well users can find their way around the app.
- **Mental model:** The process flow and design users expect to find and how well the app matches their expectations.
- **Terminology:** How understandable the information and elements presented in the app is for the user.
- **Technical issues:** Bugs and faults in the system, including errors causing the app to crash.
- **User requests:** Options the users want and expect but do not find.

One of the most severe problems found when testing the app was that several participants were not able to understand the main navigational menu in the app, or found it confusing. At least 4 of the usability issues found were connected to this

more general problem. For instance, in scenario seven, the participants were asked to find out what they emit from buying groceries. Three participants did not find this information at all or struggled to find it. One participant said: "*It is hard to know what these small symbols down here [in the menu] refer to, but when you tap them then it [text] appears, but it is not visible from the start*". This problem appeared in several of the usability tests, creating frustration, and for some participants, negative feelings, such as one participant saying: "*I was not any good at this...*", ultimately blaming herself for not finding her way. In connection to this, several participants tried to navigate by trying to press different elements in the Overview, such as the four cards that can be found in the horizontal list of cards in the bottom of the Overview, displaying the four main areas of emissions (e.g, Transport, Housing, Food, Shopping). These cards were not interactive, and so nothing happened when pressed, though it was clear that the participants expected them to reveal more information about their emissions, as one participant explained: "*I can't go further now from these cards [cards at the bottom of the overview]. I think it should lie under these here, under these big buttons*".

Several elements throughout the app gave rise to confusion amongst the participants. One example is the card showing the monthly trend for a group. This card displays a percentage as well as an arrow pointing in either an upward, straight or downward direction, meant to represent the average trend amongst all members of a group. One participant said: "*...and a monthly trend that points in some kind of direction, I don't know what it says really. A monthly trend that is 34%, is it 34% more than what, more than last month or what is it exactly?*". Another example of something that was problematic was the last step of connecting a bank account, in which the user is asked to select which accounts to include and if any of the accounts are shared with others. This led to confusion for the two participants who chose to connect their bank, due to a lack of information of what a shared account is and how to specify if an account was shared or not. This confusion resulting in one participant getting stuck: "*It does not say what shared account is, it's as simple as that. If it had said 'do you share your accounts with someone else' then it would be 100% clear. Now it just says 'Do you share accounts'. I interpret it as if I share them with someone else, but it is not completely clear. Since I do not share [accounts] with someone else I disable these items and can't proceed*". There were also several inconsistencies and issues when participants created their climate profile, which caused several participants to be unable to respond to every question, or which led them to respond incorrectly to certain questions, such as those related to commuting habits.

As the app was still under development, some technical issues were also encountered along the way. In particular, all except one participant experienced the app crashing during scenario eight when they were supposed to find a way to compare themselves with other people living in their municipality. Most participants navigated to *Groups* in the bottom menu, and tried to press the group "Uppsala", and when they did, the app crashed. Some participants tried several times, ending in the same result repeatedly, ultimately leading to some participants giving up trying to accomplish

what that scenario asked them to do. Another issue that occurred during the testing sessions was the potential disturbance from the tool used to record the sessions, Lookback, which placed a small round icon in the foreground of the screen. The icon could be moved around the screen by dragging it, and when pressed, it would open the Lookback app installed on the phone. Its presence and how to move the icon was explained to the participants, but several participants managed to accidentally press it during their sessions, momentarily showing the Lookback app instead of Svalna. Several participants were also not used to the Android keyboard and struggled a bit typing because of this. The main reason was that the keyboard differed from what the participants normally interacted with, since the device that was used during testing was an Android device and a majority of the participants used an iPhone.

5.1.1   User impressions

The first impressions of the participants when opening the app were mixed, though almost all said they thought it had something to do with their carbon footprint and climate change in some way. One participant noted that "*I see here that there is money that goes down a funnel and then goes on and that it will lead to a cost for the environment of course, and that I can get to know my carbon footprint using the app.*". Another participant said she also thought she could get help to reduce her impact on the environment. Despite this, it was not obvious for everyone what the app was about. One participant thought the illustration shown when first opening the app was a bit unclear, saying: "*the picture is a bit hard to interpret... you understand if you take a closer look. Had I used it [the app] by myself I would not have reflected much about the picture, but what you see clearly is money and then there is a gauge, so I would not think of emissions at first*". The same participant noted that as soon as she had read the text accompanying the illustration, she understood that it had something to do with the environment and [carbon] emissions.

All participants were also asked what they think about connecting their bank to the app. Overall, the participants were positive, especially when they understood how it worked: "*...I understand that it's important if you are going to be able to draw some reasonable conclusions about how my consumption affects my footprint. The alternative is that I fill in everything myself by hand...*". That said, the concept of giving the app access to transaction data from their bank also gave rise to mixed feelings. One participant did not want to do it as she thought it was "too" serious. Another was initially sceptical: "*... why should I connect my bank? It's strange*".

General comments and impressions:

- "*I love Facebook login. If its not provided it can stop me from using an app since I'm lazy and don't want to remember passwords and stuff like that*" - P3, reaction when creating an account.
- "*It looks very pleasant and fun*" - P1, reacting to the landing page.
- "*I think it is good to work a lot with pictures. Here there is three people that sit and bike together on a tandembike... a lot of colours.*" - P4, reacting to

illustrations in the app.

- "*This one was very fun*" - P3, reacting to animation when waiting for Svalna to analyse transactions.
- "*Ah! Cool! It was like, I started filling in [the text fields] without even reading what I was supposed to enter.*" - P3, reacting to the app explaining it will look for information about her housing.
- "*It shows exactly how much I drive and everything. Ah. That was good.*" - P5, reacting to the app automatically filling in information about her car based on the registration number.
- "*Wow, it knew already!*" - P5, reaction when the app finds information about her housing.

Suggestions:

- "*It could say 'Only me' here, but then there will be more text as well*" - P3, talking about the picker for choosing how many people share an account.
- "*Maybe they should be sorted so that the most common banks are shown first. I doubt many [people] have 'Chevrolet Big Plus card'.*" - P3, reacting to the list of bank.
- "*...it should show up when I write 'Arlanda'...he should recognize my latest [entry] when I write 'Arlanda'. Now I have to write the four first [letters] before it shows 'Arlanda'.*" - P2, when adding a flight in the climate profile.
- "*No, you can't write the airport code, or what?*" - P3, when adding a flight in the climate profile.

5.2   Desirability test

Overall, the participants described their experience interacting with Svalna in positive terms. 17 adjectives were selected in total, with a composition made out of 13 positive words and 3 negative words. The adjective *confusing* was selected twice, being the only adjective selected more than once. Several groups of similar words could be identified, such as adjectives related to things being fast and quick (*fast, effective, powerful*), adjectives concerning engagement (*engaging, inspiring*), adjectives signalling usefulness or easy access (*inviting, useful, friendly, approachable*), as well as adjectives related to confusion or complexity (*confusing, difficult, overwhelming, simplistic*). In table 5.1 a full overview of the adjectives can found.

The participants described their experience interacting with the app as positive in many different terms. They described the app as *fast* and *powerful*, with one participant noting: "*In the matter of seconds it has done all calculations needed... it gives a powerful impression and I quickly get to see a lot of relevant information*". Others again picked adjectives such as *friendly* and *inviting*, saying that the interface was colourful and had pleasing visual elements that made the app more fun to look at. *Engaging* and *inspiring* was also chosen, with one participant saying: "*[it is] engaging as I as a person am interested in questions concerning climate change and want something here, that's why I am here and it contributes to keeping that*

engagement strong since it gives the feeling that 'Yeah, here's a lot of useful information available'".

The participants were not only positive towards the app. Two participants described their experience interacting with the app as *confusing* as they had difficulties navigating and understanding certain elements of the interface. One participant in particular, who picked both *simplistic*, *confusing*, *difficult* and *overwhelming* explained: *"I didn't really understand where to look. It was not like natural steps for me [to take]. Because of this I became confused since I could not find my way, and thought it was a bit difficult and felt a bit overwhelmed"*.

Adjectives	Times selected	Tone
Personal	1	Positive
Powerful	1	Positive
Engaging	1	Positive
Attractive	1	Positive
High quality	1	Positive
Inspiring	1	Positive
Effective	1	Positive
Inviting	1	Positive
Useful	1	Positive
Fast	1	Positive
Friendly	1	Positive
Confusing	2	Negative
Approachable	1	Negative
Difficult	1	Negative
Overwhelming	1	Negative
Simplistic	1	Negative

Table 5.1: The adjectives selected by participants in the desirability test. The column with the title "Tone" indicates if the adjective had a positive, neutral or negative tone

5.3 Interview study

In this section, the results from the thematic analysis of the interviews will be presented, divided into four parts. First, a brief presentation of the participants and their lifestyles will be given, along with a description of the participants' experience using Svalna over a two week period. Their experience with other carbon calculators will also be presented in the same section. Second, the themes identified in the analysis will be presented, divided into three sections - *Approaches to sustainable behaviour*, *Dissonance between the app and real life* and *Reflections about sharing and comparing with others*. Third, the effects of using Svalna will be presented. Finally, general feedback, suggestions and ideas about improvements from the participants

will be presented.

5.3.1 The participants and their use of Svalna

The participants displayed a wide variety of lifestyles and interests, but also had some things in common. They all worked at the same company, but in different roles. For instance, P1 worked with management systems, P3 worked with maintenance planning, and P6 worked as a trainee within the sustainability department. Outside work, the participants led different kinds of lifestyles, some single while others lived with their families. Concerning their interests, many said they enjoyed travelling, being outdoors, and working out. Several of the participants (P3, P4, P7) also noted that they are not overly interested in spending time with their phones, such as P7 saying that "*I think it's quite annoying to have too many digital tools*".

Carbon calculators were something that the majority of the participants were not familiar with before being introduced to Svalna (P1, P4, P5 and P6). As P1 said: "*It has mostly been a lack of knowing that such tools exists. I try to the best of my ability live as wisely as possible, but I have not, until Svalna showed up, even known that such tools exists.*". Others, like P4, speculated that a reason for him not checking out other carbon calculators previously was that he always believed he was doing well concerning his environmental impact compared to others and did not feel a need investigate it further. These thoughts were also clouded with a bad conscience for not looking into it earlier. Two of the participants (P3 and P7) had tried out other carbon calculators previously, mostly being one-time occurrences and nothing that followed them over a longer period of time. The calculators that they had used were of the more static type in which they could answer a set of questions about their lifestyle or calculate the emissions from travelling.

In the two to three weeks after the usability test, before the interview, the participants had spent a varying amount of time with the app. Several of the participants had spent around five to ten minutes with it (P4, P5), while others estimated that they had played around with the app on several occasions amounting to ca. 30 minutes in total (P1, P6, P7). Both P3 and P4 said they either did not have time or had no interest to look at the app except from having another look just before the interview. P3 mentioned one reason for not being interested in using the app: "*…I am probably not so interested in learning more… I know what I need to do in order to reduce my emissions and that is to travel less because that's where I emit the most. I do not feel like I need to follow more closely what more there is [to see]*". Most of the participants said that they had taken a closer look at the app and tried to get an understanding of their emissions in more detail (P1, P3, P4, P6, P7). Almost all of the participants indicated that they had connected their bank to the app and had investigated their transactions and tried to recategorize some of their transactions. P5 was the only participant not connecting her bank to the app, and said she spent just a few minutes looking at the app together with colleagues. She expressed scepticism towards connecting her bank as she thought it felt risky, as

well as feeling that the app was not so accessible: "*We have examined the app and how it looks, and [thought] it was not so accessible somehow. They did not think so either. Another thing that I was a bit unsure of was connecting my bank. It felt a bit risky as it is a new app*". Some of the participants also briefly mentioned how they imagined using the app in the future. P1 said he would try to spend more time with the app, maybe once a month to keep track of things, while P7 said she wouldn't want to spend so much time with the app on a regular basis, but rather use it as a tool for creating conversation when meeting with friends.

5.3.2 Emerging themes

In this section, the themes identified in the analysis will be presented, divided into three sections - *Approaches to sustainable behaviour*, *Dissonance between the app and real life* and *Reflections about sharing and comparing with others*. **In the following text, the themes will be highlighted in bold, and described in running text**.

5.3.2.1 Approaches to sustainable behaviour

All of the participants expressed an interest in sustainability and thought it was an important topic. They also said that they wanted to contribute to reducing emissions, with some participants less engaged than others. P6 explains: "*… I think it is very important, but realise that there are probably many people that think it much more fun and interesting than I do. I have always been thinking that I let them pull the heaviest load, but gladly help out a with the smaller things…*". The interest in sustainability among the participants was reflected in what they do on a daily basis. The participants described a range of different actions they take in their everyday life, such as sorting their waste (P4-P6), buying ecological when grocery shopping (P4), and buying furniture second hand (P3). As P6 is saying: "*I try to do these small things you know. I don't eat completely vegetarian, but I eat a lot of vegetarian. I don't recycle perfectly, but I recycle almost everything. I have no car. I take the train. I bike. That kind of stuff. Small decisions all the time. It is not like I… I am not extreme in any way. I'm a just a normal Swede, you know*". The motivations behind these actions are many, ranging from very practical and detailed to more general and all-encompassing motivations. For instance, P3 says she does not have a car because it is expensive and that it is much easier to bike, while P4 says: "*All means are good as long as it leads to a reduced climate footprint*", reflecting a "deeper" motive connected to reducing emissions overall. Social norms and the importance of not standing out from the crowd were also mentioned as motivations - these will be explored later in section 5.3.2.3.

Despite this interest in sustainability, several participants described a **tension between doing good for the environment, and wanting to do what they enjoy**. Personal freedom was valued highly amongst the participants. For instance, P6 expressed a disliking for strict rules and would not want to hold back if there is something he wants to do, or eat: "*I would not put a label on me saying 'I am a vegetarian' because if I want to have a ham sandwich, then I want to be able to*

eat it". While it was important for the participant to be able to do what they want, they also a willingness to change or tweak certain behaviours, but not stop completely. This was particularly evident when it comes to travelling and flying. P3 puts it this way: "*Flying less is doable of course, but to completely stop flying I would not be able to do. I could also eat less meat, but not stop completely since I am so interested in making food...*". P5 and P7 expressed similar thoughts, with P7 saying that she had a hard time imagining a future where she would not travel, but that she was open to travel in other ways than flying. The interviews also revealed tensions between trying to act more sustainable, and there being obstacles to doing so. P1 described a situation with him and his family trying to buy groceries with as little packaging as possible, but ending up with a lot of packaging anyways as every little thing they buy has some sort of plastic and/or paper packaging. P4 and P7 mentioned this also, calling for a need to make it easier to make sustainable choices.

5.3.2.2 Dissonance between the app and real life

Svalna is meant to measure a user's carbon footprint, using data from bank statements and details about a person's lifestyle to calculate this in CO2 emissions. While all participants did get their carbon footprint and emissions calculated in the app, a majority of the participants did not think the app provided them with a correct or complete picture of their carbon footprint, for several reasons. This led to both frustration and confusion, and impacted the participants' trust in the system and how they used the app.

A big challenge for the participants was the categorisation of transactions from their bank. Both P3, P6 and P7 said they had **difficulties with transactions being wrongly categorised by the system**, such as savings, resulting in a high carbon footprint. P6 put it this way: "*We have just recently bought an apartment, which is super fun, and then I paid 130 000 [SEK] in deposit on an apartment. Then I get it as some sort of housing cost [in the app] and that it would generate 600 kg in CO2 emissions, but it is only a transaction. That transaction does not generate any emissions at all...*". He continued to say that he did not feel like the reliability of the system is good enough, and after several cases such as the one mentioned above he gave up categorising more transactions as he thought it was hard and too many transactions to go through. Several participants also had difficulty recategorising certain transactions themselves due to not remembering what a transaction concerned, especially if it was a few months back in time. Internet payments through a third-party provider (e.g., Klarna[1]) represented a particularly hard problem, as these transactions usually only have the name of the third-party (e.g., "klarna"), making it hard to discern what the transaction really was for, if it was for a book or a new pair of shoes or something else.

This miss-match between what goes on in real life and what the app depicts was also evident in the participants' interpretation of the numbers and calculations provided by the app. A majority of the participants did not feel like the app and the carbon

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[1]www.klarna.com

footprint it provides reflected their everyday life properly. In the app, the user can fill in certain information about their lifestyle and connect their bank account, but it is clear that it is **not fully capable of capturing every aspect of a person's life** in the current version of the app (it is probably impossible to do so). For instance, P7 described a situation where she bought food for four people during her skiing vacation which made her emissions go up considerably, with no possibility to specify how many that shared that cost somewhere in the app. Several of the participants also expressed a wish to add more information about their lives in order to better reflect their situation and choices. P5 explained: "*For example I have a summer-house. Like, I have a second house. That is something you should be able to add somewhere*". This dissonance between how well the app is able to capture reality and what actually goes on in the lives of the participants is further emphasised by the fact that the emissions calculated for each transaction does not reflect what was bought, only the amount of money spent on a certain category of transaction (e.g., rent, restaurant visits, jewellery). For those participants who did not connect their bank account, such as P5, the carbon footprint shown in the app is an estimated number of their total emissions, and not based on real transaction data. This also created uncertainty about the truthfulness of the numbers provided. P5 said this, when asked if she understood her carbon footprint shown in the app: "*No, I don't really think so. I did not think it was correct or it did not feel like it was correct or I did not feel convinced that it was correct, but maybe it is...*". P4 did connect his bank, but reiterated similar concerns about the numbers feeling more like estimates rather than the correct and true calculation of his emissions. He noted, when asked if he thought the app provided him a fair picture of his emissions: "*It is a bit early still, it becomes a bit too hypothetical I feel like to really give a good answer [to that question]. In a couple of weeks or months*". Somehow P4 was expecting the numbers to become more reliable over time. P1 was one of the few who thought the numbers and his carbon footprint was correct, or at least as correct as they could be, but also said it is hard to know *how* true and scientific the calculations really are.

On a more practical level, the challenges mentioned in the previous paragraphs concerning how well the participants trusted the numbers and calculations provided by the app had some unexpected and problematic consequences. Due to the uncertainty concerning their carbon footprint and worries that it was not correct, P6 and P7 deliberately chose not to try or use other features in the app such as groups. P7 explained that if she is supposed to make a sensible comparison with others in a group, she first has to understand her own footprint and make sure it is correct, or as correct as it can be. P6 had similar thoughts: "*I have not done anything with the groups really and not compared myself to others. I have tried to get a grip on my emissions. That is what I have done*".

5.3.2.3 Reflections on sharing and comparing with others

The participants expressed hesitation toward wanting to share and compare themselves to others in the interviews, being both positive and critical to the concepts of groups in the app. Overall, the participants told of a **sensitivity towards sharing their own carbon footprint with others**, with the majority of participants being

sceptical to doing so. Some of the participants was more sceptical than others, such as P4: "*I don't really have a need to share... everyone should take responsibility for themselves somehow. I don't use social media much... I am quite restrictive with stuff like that*". P3 said explicitly that she did not want to share her carbon footprint, and hinted at reasons for why, saying that she's maybe not be proud of her own footprint and do not want to put it on public display. Willingness to share information about their carbon footprint also depended in part upon what kind of information would be shared. P1, P5 and P7 said that *if* they would share information about their carbon footprint, they would want to share more general, summarised information and not in any way detailed information such as e.g., emissions at the transaction level or what they emit daily. Sharing absolute numbers was also problematic, and both P6 and P7 said that they would rather share a change in their carbon footprint than concrete numbers of their carbon footprint.

The group feature was something that the participants had spent little time with, due to reasons mentioned in the previous subsection. Despite this, the majority was positive towards the idea of being part of a group. P1, P4, P6 and P7 all said that they would be up for creating a group together with friends or family, though it became clear that **it really depends upon who's part of the group and who one is compared to**. P6 explains when asked if he would be willing to start a group with either family or friends: "*Friends in that case. My family... if you think about my partner. We live together. We have the same footprint, more or less. We buy stuff together, we eat the same food and you know. And my family... my sisters with their families or my mom and dad. I don't think that would be so interesting*". P7 relates to this when talking about the group feature in the app, saying that she thought the section of a group dedicated to comparing the her to the group was a bit hard to understand, in particular how the comparison was done: "*I can imagine that many of my colleagues who are part of this group do not live alone and then I don't know... am I being compared with other single households or am I being compared with someone who has a family and has a bigger home because they have children and buy food for more people. It's been a bit hard to know how the comparison works*". Later, P7 said it would be more interesting to compared with people similar to herself, which live in single households. P5 also raised similar concerns.

Even though sharing their carbon footprint with others was a sensitive issue, and forming a group depended upon who's part if it, most of the participants saw a potential in groups. P1 thought groups could create a solid base for discussions about questions concerning the climate, and how to reduce impact. Both P1, P4 and P7 imagined that groups could be used to "kick-start" a conversation amongst people on these issues. Several participants also noted that they did not think it would work to only have a group in the app, but that something more was needed. Things that was mentioned to give the group feature the extra push was: dedicated members of a group that would contribute to creating discussions, competitions within the group, social activities in real life, a positive employer, as well as ways to interact with each other in the app. P7 mentioned that rather than using the

app a lot and interacting with each other digitally, the app could function more as a tool for discussion rather than having a discussion in the app, in formats such as study circles. Having commitments or common challenges in the app, although such interventions does not exist in the app today, was something the participants was positive to as well. P1, P4 and P7 imagined that a common challenged could be motivating and create a sense of community. P7 puts it this way: "*… it creates a bit of 'peer pressure'. Then you do not want to be worse [than others] and it also becomes more fun. That you do it together… it becomes some sort of community around it. Members can tip each other and so on. I think I would find it more fun than if I would do it by myself*". This all shows that the participants are sensitive to sharing and comparing their carbon footprint with others, but that they also find it interesting and attractive to be part of a group.

5.3.3 Effects of using Svalna

The participants described many different effects of using Svalna, as well as consequences of not trusting the calculations and carbon footprint provided by the app. Both P1, P3 and P4 said that they had started thinking more about their behaviour and all the smaller choices that have an impact. P1 and P4 also highlighted that the app provided facts that could be acted upon, compared to earlier when they only had their subjective understanding and assumptions about their carbon footprint. On the other hand, both P5, P6 and P7 said that they did not think using Svalna had led to any changes in how they lived or their understanding of their emissions, as P6 explained: "*I can't say that I have become wiser…*".

5.3.4 Feedback and suggestions

During the interviews, the participants gave some more general feedback on the app as well, and explored ideas about how the app could better cater their needs. For brevity, general feedback on the app will first described, followed by a list of the suggestions and ideas mentioned by the participants.

5.3.4.1 General feedback

Several of the participants were positive towards the app overall. P1 thought the app was a great initiative in addressing questions related to climate change, and that it was positive that such things happened. P4 thought the app was very friendly and accessible. Both P3 and P7 thought it was fun to explore their transactions and emissions, changing category and looking at the division between the different categories. P4 highlighted the importance of answering correctly when creating a climate profile and avoid situations where a user has to guess. This all affects what footprint a user gets. For that reason, P4 thinks its best that people connect their bank so that people get real facts and not only rough estimates. P1 also said, for him at least, that information in the app about how to reduce his emissions needs to be as concrete as possible in order for him to act upon it.

On a more critical note, P3 mentioned that the app often had chosen wrong category or subcategory for a transaction, and thought it was a bit strange what categories it had chosen sometimes (similar to issues described in the previous section). P4 thought it was a bit hard to understand or relate to his emissions being described in *tonnes CO2* equivalents. He puts it this way: "*What is it? I have eight tonnes CO2... it is not really obvious what it is...*". Both P3 and P6 also noted that the app was a bit slow, either when browsing content (e.g., scrolling in a long list of transactions) or when starting the app. P6 says: "*If you think about how much time you spend with an app and then 15 seconds on Facebook and then scroll through a newspaper from top to bottom, and that it takes ten seconds to start the app. Its gone already there. A smooth app that categorises in a way that makes sense for people. It's probably not so hard really*".

P1 raised an important issue about the app overall, saying that he thinks there is a risk or danger with it becoming a happening if there is nothing more to keep the "questions" alive. He said that opening the app a week from now would most probably show the same data as today, and that people might not open the app again after that, thinking that there is no benefit using the app frequently. He did not only highlight this risk, but suggested how engagement could be retained: "*So I think it needs to "live" and groups are a contribution to make it so, but I think it needs to be more lively. There needs to be loads of things happening that give me value and tips along the road, gives me a kick in the butt in order for me to get on with these questions...*".

5.3.4.2   Suggestions and ideas

Below a list of suggestions and ideas from the participants are presented.

- Add or include nice looking and inspiring pictures of nature.
- Make it possible to press the four cards in the horisontal list of cards at the bottom of the Overview.
- Make it possible to add more information:
    - Information about recycling habits.
    - How much meat you eat.
    - If you grow your own food.
    - If you have a second or more houses.
- Get prompted after buying groceries with the questions "*Did you buy any meat today? Press yes or no*".
- Make it possible to detail that transactions from certain stores should be split between in half or in thirds or what not depending on their purpose. For instance purchases made at a furniture store could always be split in half, while purchases made at a clothing store could always be divided in three.
- Add a feature allowing the user to see how much emissions different choices generate, such as choosing alternative modes of transportation or renting instead of buying.

- Be able to send or give a gold star to other members of a group, or write comments (in a broader sense: make it possible to interact with other members of a group).
- In groups, allow for a comparison with other demographic groups of people beyond the average in the whole of Sweden. P7 imagines it could be several different "profiles" such as single households in the city, families living in the suburbs, people living in a house on the countryside, people living in an apartment in the city.
- Possibility to detail if you save money in sustainable securities.

6

Discussion

In this chapter, the results and its implications will be discussed, along with a discussion of the methods used in this thesis project. At the end, opportunities for future work will be presented.

6.1   Results

The combined results from the formative evaluation and the interview study make evident that Svalna is still a work in progress, with many issues to sort out in order to deliver a consistent and good experience for users. The usability test uncovered several critical issues, which had a negative impact on how well the participants completed the scenarios given to them. Most of these issues were related to navigation in the app. In some cases, participants had expectations that were not fulfilled, while in other situations, faults in the design hindered the participants from reaching their goal. For instance, a few of the participants were not able to understand and navigate between and deeper into several of the key features of the app. This led to at least one participant blaming herself for not finding her way. These issues were further propagated by instances of confusion throughout the interface, mainly due to participants not understanding certain information presented to them or because they got stuck when misunderstanding how to interact with the interface. Despite all of the issues found, the participants rated their experience interacting with Svalna in very positive terms, which might indicate that the issues found did not really disturb the participants as much as initially thought. They chose adjectives which indicated that they thought the app was fast, accessible and engaging, as well as adjectives related to confusion and complexity. This does not in any way mean that the severity of the usability issues should be downplayed, but rather that it indicates that the overall first-time experience was positive.

The majority of participants was also positive toward connecting their bank to Svalna, although a dose of scepticism could be heard among the participants. This is understandable, as it represents a very intimate part of a persons life. Calculating emissions based on transaction data is an integral part of Svalna, and being able to make the user feel comfortable enough to trust the app with their most private information is key. It might be to early to say whether this is a show-stopper or not for many potential users, but it is clear that it should be handled with care.

Svalna represents a novel approach to calculating emissions from consumption. Pro-

viding calculations on a persons carbon footprint using user generated profiles and transaction data from bank statements can possibly deliver a high accuracy and reliability in calculating emissions. That said, how this is done is not trivial. The results show that a users trust and confidence in the numbers clearly influence *how* they use Svalna and their willingness to explore certain features such as Groups. Several participants expressed a distrust or lack of confidence in the footprint the app presents, in part because they do not feel like it reflected their lives properly or due to faults in the system giving the impression that the calculations were wrong. It can be argued that Svalna does provide a "correct" picture of a persons emissions, but if the results are not trusted by the user, it does not really matter. This potential mistrust in the data the app provides also impacts further use of the app. As described in the results, the reliability of the app and the experienced accuracy of the carbon footprint it provides would need to be higher in order for several of the participants to be comfortable participating in a group. The question is what more would be needed in order to gain the user's trust. Increasing the reliability in the system and making it categorise transactions better is a start, but the larger issue concerning how to better capture the nuances of everyday life that lie beyond the transaction data from the bank still remains. Today the user can create a climate profile consisting of 25 questions covering the core of a person's life (transport, housing, diet + consumption data from the transactions), but it is not possible to capture absolutely everything. This frustrated some of the participants, and created a sort of friction between the real world and the world the app presents. This friction can be related back to the critique mentioned at the beginning of this thesis of approaches trying to reduce sustainability to a set of "simple" metrics. The results highlight that it is in fact hard, if not impossible to provide a complete reflection of a persons life and the choice that one makes. Additionally, as the participants themselves noted, their lifestyles and actions trying to live more sustainable are complex, which makes it hard to measure and quantify. The question is how systems like Svalna can better or optimally reflect the lives of its users, or if that is the point at all.

Svalna contains a series of features that provide the user with the possibility to get feedback on their behaviour, compare themselves to others, set a goal, explore how they could reduce their emissions and so on. Relating back to the intervention techniques reviewed in the theory chapter, it can be argued that some of these features fall short or were not personalised enough to be relevant for the participants. As mentioned in the previous paragraph, the trustworthiness of the calculations was questioned, impacting how some participants used the app. It also impacts the quality of the feedback provided, basically undermining it, when it is not trusted. Furthermore, the participants showed a "sensitivity" towards several of the more social aspects of the app, which can be related to the intervention technique *comparison*. The participants expressed hesitation towards sharing information about their own carbon footprint with others, and several participants experienced the comparisons found in the app as unclear or too general, requesting more personalised comparison to people leading similar lives as them. This has consequences for the features which needs to be considered in future development. Sharing infor-

mation about ones emissions on an summarised level, i.e., not disclosing any details delving deeper into a persons emissions, might be more attractive for users than sharing more detailed information as it can be seen as intrusive. Relevant comparisons with demographic groups leading similar lives as the user might be more engaging than the more general comparisons.

The group feature was unfortunately something the users did not interact with a lot due to reasons mentioned above. Despite this, the participants were positive towards the concept, and imagined several possible use cases. One was that Svalna could function as a tool to start conversations about this topic, but not something that you interact with on a daily basis. In relation to this, a risk was mentioned of the app becoming a happening in its current format. Salo and colleagues [35] highlights this issue in their study of 10 Nordic carbon calculators, in which the hosts of the different calculators pointed out that it is challenging to retain user engagement beyond their first visit. Groups could be a contribution to keep engagement up, but that of course rests upon other parts of a service working properly as we have seen. The results also show that the participants thought something more would be needed in order for a group to work [in the long term], such as either activities in real life using Svalna as a tool for discussion or a engaged individuals to keep the conversation going. This has been explored by other studies such as [1] and [46], combining the use of a carbon calculator with other measures such as meetings with peers and experts, providing informative newsletters and so on. These studies report interesting findings, and concrete reductions in emissions amongst participants. It would be interesting to see how a tool as Svalna could be used in a similar way, with a particular focus on the group functionality.

6.2 Methodology

This thesis project has applied several methods to investigate the research questions. Overall, the process of designing the study and collecting data went well. Some minor issues took place during the study, disrupting the planned procedure. One example was when one of the participants who was signed up for the formative evaluation could not attend, and a notice of this was given just a few hours before the test was going to take place. This particular situation solved itself nicely as another participant was recruited fairly quickly, but as this study had only a few participants, "losing" one participant could have had a big impact. Another thing that is worth mentioning related to the formative evaluation is the implications of using Lookback [1] for recording the usability tests. When recording, a icon from Lookback was placed on top of the interface, which at several occasions interrupted the participants when testing the app. As can be seen in Figure 6.1, the icon occluded elements of the interface, but it could also be moved by dragging it around. This was explained to the participants, and was not judged to be too big of a disturbance to invalidate the data, but a better solution could have been chosen to reduce this risk.

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[1] www.lookback.io
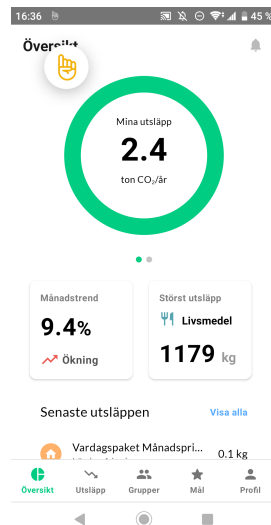
Figure 6.1: Screenshot when Lookback is recording the screen of the phone used. The icon can be seen in the top left of the screen (yellow, hand w. pointing finger).

Conducting the thematic analysis of the interviews was challenging, but also a great learning experience. The initial steps was to code the interviews and then compile and synthesise these in order to identify emerging themes. This process of synthesising the material was challenging, especially to find an appropriate level of abstraction. The initial analysis of the interviews resulted in a set of emerging themes, but these were quite diffuse and all-encompassing, which was more like topics of interest than themes. In order to chisel out more distinct themes, I chose to do two more, not planned, iterations of analysing the material, mostly through writing, which resulted in the current text. I thought initially that one iteration of analysing the material would be enough, but as described, it was not enough in order to reach a appropriate level of abstraction and clarity. One reason might be that the initial analysis created an understanding of the material, but not enough to connect the dots properly and be able to describe it in the report.

6.2.1 Limitations

This thesis project was aimed to evaluate Svalna. The evaluation was conducted and analysed by me, the author. I have taken part in the development of Svalna, working on the information architecture and design of the app. This opens up for biased decisions, observations and analysis that could have negative effects on the results. A range of measures was taken to minimise possible bias, especially in the design of the formative evaluation. As a moderator I for instance was not allowed to answer any questions or verify if a scenario was completed. A list of neutral probes was made in order to not deviate or guide the participant in any way during the tests. That said, bias cannot be excluded entirely since I was doing this project alone.

6.3 Future work

The findings in this report provide many insights that can be used as starting points for further research. Svalna is a one-of-a-kind carbon calculator and there is much more to learn about its implications. One possible strand of research, that also can be seen as a logical next step, is to evaluate what impact has on its users in terms of behavioural change. As previous work have shown [1, 10], other carbon calculators can lead to actual reduction of emissions, but it can also lead to no change, only heightened awareness. It would be interesting to see how Svalna influences the user, especially in the long term.

This thesis project evaluated the overall experience interacting and using Svalna, but there is still a lot of unexplored territory when it comes to the more unique features of Svalna, such as calculating emissions from bank statements and groups. Particularly interesting is how groups in the app operate and how people use them over time. Will such features create the engagement needed to sustain use of Svalna and promote long term behavioural change? How would Svalna fit into more integrated approaches where it is used in combination with other interventions? How does the group dynamics work? These are just examples of questions that can be explored further.

Beyond research, this thesis project has shown that there is lot of potential in improving the quality and usability of Svalna. Through clarifying the navigation and make the content more understandable, a lot of confusion and frustration could be reduced. Improving how the app categorises transactions could potentially increase the reliability and trustworthiness of the system. The participants also provided valuable feedback and suggestions on further development that could be followed up, such as improving the possibility to include more information on their lives in order to improve the accuracy of the calculations or make the app more alive in order to encourage continued usage.

7
Conclusion

The purpose of this thesis was to investigate how people use and interact with the carbon footprint calculator Svalna. Two research questions was created in order to guide this work:

What kind of first-time experience do people have when interacting with Svalna?

What kind of longer-term experience do people have when interacting with Svalna?

In order to address the first question, a formative evaluation was conducted, consisting of a usability test and a desirability test of emotions. In order to investigate the second question, a interview study was conducted two to three weeks after the initial evaluation of Svalna.

The combined results from the formative evaluation and the interview study show that the participants' experience in using and interacting with Svalna was both positive and negative, and raised a number of concerns with the design and functionality of the app. In the participants' first encounter with Svalna, a range of big and small usability issues were found, which created both frustration and confusion. Despite this, the participants rated their experience interacting with Svalna in very positive terms, which indicate that the overall first-time experience was positive. The initial evaluation also generated a lot of concrete feedback from participants on how to improve the app. In the long term, the participants were more critical towards Svalna. A prominent issue was that the participants felt a dissonance between the app and real life, not feeling like the app truly reflected their behaviour despite its increased level of detail. The reliability and trustworthiness of the app was also questioned by some participants, finding the categorisation of transactions faulty. Transactions wrongfully categorised caused high or extreme emissions. These issues had unexpected consequence, impacting how the participant used Svalna. The participants also expressed a sensitivity towards the more social features of the app, such as sharing information or being part of a group. While being open and positive towards the concept of interacting with others, the participants were for instance not willing to share every detail about their emissions with others, nor did they want to be in a group with people living very different lives from themselves.

Overall, the results from this thesis provide valuable insights into this novel approach of providing calculations of a person's carbon footprint, and describe both challenges and opportunities with calculating emissions based on financial transaction data.

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A
Testing protocol

This test protocol has been translated into english for this report. The test is planned to take 60 minutes, with 10 minutes for introduction, 40 minutes for the usability test, and 10 minutes for the desirability test.

Part 1: Introduction to the project and evaluation (10 min)

- Greet the participant and break the ice.
- Inform the participant about the thesis project and what I am studying: I am doing my master thesis where I am studying how people use and interact with the app Svalna. One goal with my work is to evaluate Svalna and reveal insights that can be used to improve the design of the app further. To do this, I am conducting user tests where I investigate how users interact with the app, what problems they meet along the way, and how their experience are interacting with the app. My thesis is done in cooperation with Svalna, the company behind the app.
- Tell the participant that during the next hour we will try out the app in different ways, where they get to do several tasks when using the app. We will finish off with an activity in which the participant get the chance to describe how their user experience was.
- Inform the participant that I want to record the session in both audio and video, and ask the participant if they allow this through filling out the consent form.
- Ask if they have any questions before we start.
- Ask if the participant has used Svalna before, as well as what phone they use/have.

Part 2: Usability test (40 min)

- Inform the participant that the app is not a finished product and that feedback is greatly appreciated for further development.
- Explain that I will provide scenarios that the participant will be asked to "do" or respond to. I will provide one scenario at a time.
- Explain my role in the evaluation, which is to moderate the test and probe for responses through asking questions if the participant falls silent. Explain that I will not confirm if a task/scenario is completed or answer questions during the test.

- Briefly explain what think-aloud is and encourage them to talk/think out loud as much as possible during the test.
- IMPORTANT! Declare that I am testing the app and not the participant.

1. *Scenario 1: Take a look at the landing page* (onboarding)
   Open the app and tell me:
   - Your first impressions
   - What you think the app is about
   - What you think you can do with the app
   - Without clicking anything, what you think you would click on first

2. *Scenario 2: Getting started*
   You now want to get started using the app. Can you show or tell me how you would do this?

   IF/WHEN Creating an account: Go ahead. You can go through the process and tell me when you think you are done with creating an account.

3. *Scenario 3: Do you want to connect your bank?*
   In this situation you have two choices. Can you tell me your thoughts about the two options, and then show/tell me what you would have done in this situation?

4. *OPTIONAL! Scenario 4: Connecting a bank account.*
   You now chose to connect your bank account. See if you can find a way to connect your bank. Tell me when you think you are done with this step. I want to note here that the recording will not be able to record your personal details in BankID except for your personal number when filling in this information in the app. We will only proceed with this step if you are comfortable with doing this.

5. *Scenario 5: Create a climate profile*
   IF BANK: You now have connected your bank account and are asked to answer some additional questions. Proceed and answer the questions, either based on your own lifestyle or by using the information provided on this paper [hand the participant paper with data].

   IF NOT BANK: You now chose to not connect your bank, and are asked to fill in some information about your lifestyle. Proceed and answer the questions, either based on your own lifestyle or by using the information provided on this paper [hand the participant paper with data].

6. *Scenario 6: Take a look at the overview*
   You have arrived at a new view/screen. Can you take a look at it and tell me:
   - Your first impression
   - What purpose you think it has
   - What kind of information you find on this page
   - Without clicking anything, what you would click on first and why

7. *Scenario 7: Investigate carbon footprint*
   You are curious about your carbon footprint from buying food. See if you can find information about how much CO2 emissions you cause from buying groceries (the last month). Tell me when you think you have found out.

8. *Scenario 8: Compare yourself to others*
   You are interested in knowing how your emissions compare to other users of Svalna. See if you can find a way to compare your emissions with other people living in Uppsala.

9. *Scenario 9: Use Svalna together with Friends*
   You are thinking about inviting your friends to download the app and together set a goal for saving 10 tonnes of CO2. See if you can find a way to set a goal together with your friends. Let me know when you think you managed to do so.

10. *Scenario 10: Setting a personal goal*
    You are thinking of reducing your emissions, and want to know what kind of actions you could take to live more sustainable. Can you show me where you think you can learn more about how to reduce your footprint?

Part 2: Desirability test (10 min)
Ask the participant to go over to the table with cards distributed on it and choose 4 or 5 cards which represent how the app made them feel. Ask them to bring them to the "testing" area (close to the microphone), and then ask why they picked each card.

Part 3: Debrief and goodbye (1-5 min)
To round of the sessions, ask if the participant have any questions or thoughts that he or she wants to raise. Say *thank you* for having the opportunity to participate and confirm their participation in the interview two weeks after the test.

B

Description of actionable scenarios

This appendix describes each actionable scenario (scenarios in which the participant was prompted to interact with the app) and its underlying goal or task, as well as what the correct actions was in order to complete the task or goal.

1. *Scenario 2: Getting started*
   The goal with this scenario was to have the participant create an account using their method of choice (either Facebook or Email). The scenario was as follows:

   > *You now want to get started using the app. Can you show or tell me how you would do this?*
   >
   > ***If or when the participant want to create an account:***
   > *Go ahead. You can go through the process and tell me when you think you are done with creating an account. If you do not want to use your own personal detail you can use the information on this paper (hand participant paper).*

   The following set of steps needs to be taken to create an account with facebook:
   (a) Press the button "Skapa konto".
   (b) Press the button "Forsätt med Facebook".
   (c) Log into Facebook using the dialog that shows up and press "Continue".
   (d) The goal has been reached. You arrive at a new view telling the you that an account has been created.

   The following set of steps needs to be taken to create an account with email:
   (a) Press the button "Skapa konto".
   (b) Type in your email address in the text field with the label "Ange din e-post".
   (c) Press the button "Fortsätt med epost".
   (d) Type in a password in the text field with the label "Lösenord".
   (e) Press the button "Nästa".
   (f) Type in your name in the text field with the label "Vad heter du?".
   (g) Press the button "Klar".
   (h) The goal has been reached. You arrive at a new view telling the you that an account has been created.

2. *OPTIONAL! Scenario 4: Connecting a bank*
   The goal with this scenario was to have the participant connect their bank of choice. The scenario was as follows:

   > *You want to connect your bank account. For this to work you need to use "Mobilt BankID", something you have to do on your own phone. In a normal situation you would do all steps on your own phone. I want to stress that we only continue on this path if you are comfortable with it.*

   > **If the participant wants to proceed and connect their bank:**
   > *See if you can find a way to connect your bank. Let me know when you think you are done with this step.*

   The following set of steps needs to be taken to connect a bank account:
   (a) Press the button "Anslut bank".
   (b) Browse the list and pick the bank you want to connect.
   (c) Type in login details in the corresponding text field. The default is a text field with the label "Personnummer". The personal identification number has to be written as YYYYMMDDXXXX, otherwise it is not accepted.
   (d) Press the button "Anslut".
   (e) A iFrame from Tink shows up and you press the button "Forsätt".
   (f) Verify with BankID on your device. You have to close the app and open the BankID app to do so, or on a seperate device.
   (g) Navigate back to the app and wait while it processes the information.
   (h) Select the accounts you want to include using the check boxes on the right side, and specify if any accounts are shared by pressing on the drop down menu "Delat konto" and selecting the number of people who have access to the account.
   (i) Press the button "Fortsätt".
   (j) The goal has been reached. You arrive at a new view confirming that your bank was connected, as well as asking you to respond to a set of questions.

3. *Scenario 5: Create a climate profile*
   The goal with this scenario was to have the participant go through and create a climate profile. The scenario ended when the participant arrived at the overview. The scenario was as follows:

   > **If the participant connected their bank:**
   > *You now have connected your bank account and are asked to answer some additional questions. Proceed and answer the questions, either based on your own lifestyle or by using the information provided on this paper (hand the participant paper with data).*

   > **if the participant did not connect their bank:**
   > *You chose to not connect your bank, and are asked to fill in some*

information about your lifestyle. Proceed and answer the questions, either based on your own lifestyle or by using the information provided on this paper (hand the participant paper with data).

The steps taken to complete this scenario will not be detailed due to the large number of steps needed to complete it. In brief, each questions in the climate profile consists of a title and description, as well as ways to input data (buttons, sliders and so on. On top a progress stepper can be found, indicating where in the process a user is. At the bottom a navigation bar can be found, allowing the user to navigate between questions. In the bottom bar a question mark can also be found which, when pressed, opens up a dialog with an explanation of why the user should answer the question and what the app uses the information for.

4. Scenario 6: Investigate carbon footprint
   The goal with this scenario was to have the participant take a closer look at their emissions and find out specifically what they emit from buying groceries (food). The scenario was as follows:

   You are curious about your carbon footprint from buying food. See if you can find information about how much CO2 emissions you cause from buying groceries (the last month). Tell me when you think you have found out.

   The following set of steps needs to be taken to find out how much emissions buying groceries generate, when starting from the overview:
   (a) Dismiss notification dialog through pressing "Inte nu" or the "X" in the top right corner.
   (b) Press the second menu item, "Utsläpp", from the left in the bottom navigational menu.
   (c) Press either the *fork and knife* symbol or the dark turquoise section of the donut chart.
   (d) The goal has been reached. Emissions from grocery shopping can be found in the list on the right hand side of the screen.

5. Scenario 8: Compare yourself to others
   The goal with this scenario was to have the participant take a closer look at a group in the app (the geographical group for Uppsala municipality (Kommun) or the Uppsala region (län), and compare their emissions to the members of that group. The scenario was as follows:

   You are interested in knowing how your emissions compare to other users of Svalna. See if you can find a way to compare your emissions with other people living in Uppsala.

   The following set of steps needs to be taken to find and compare yourself to either the municipal or regional geographical group for Uppsala, when starting

from the location where the last scenario ended (in the second step of the drill-down in "Utsläpp"):

 (a) Press the back button on the top left.
 (b) Press the third menu item, "Grupper", in the bottom navigational menu.
 (c) Locate the relevant group. For users living in uppsala, the municipal group called Uppsala could be found in the first swimlane in this view.
 (d) Press the relevant group card.
 (e) Swipe left or press the "jämför" tab in the tab bar.
 (f) The goal has been reached. Comparisons between you and the group can be found below the tab bar. First a chart is shown, providing information on what percentile of the group you are in. Below the chart your emissions and the average emissions of the group are shown in tonnes. Further down a breakdown of your emissions onto the four different categories can be found, compared to a breakdown of the groups emissions.

6. *Scenario 9: Use Svalna together with Friends*
   The goal with this scenario was to have the participant create a group, as well as create a goal for that group. The scenario was as follows:

   > *You are thinking about inviting your friends to download the app and together set a goal for saving 10 tonnes of CO2. See if you can find a way to set a goal together with your friends. Let me know when you think you managed to do so.*

   > **If creating a group, and the participant wants to add a picture:**
   > Use the first picture in the library.

   The following set of steps needs to be taken to create a group and set a goal for that group, when starting from the location where the last scenario ended (the "Jämför" tab in a group):

   (a) Press the back button in the top left.
   (b) Press the button "Skapa grupp" found at close to the top of the view, directly under the navbar.
   (c) Press either "publik grupp" or "Privat grupp" based on preference.
   (d) Type in a name and a description in the two text fields found in the view.
   (e) Press the button "Nästa".
   (f) Press the little camera icon in the bottom of the circle presented in the middle of the screen.
   (g) Press "Choose from library".
   (h) Confirm permissions to share data.
   (i) Pick the first picture presented in the library.
   (j) Press the button "Skapa grupp".
   (k) Press the text button "Inte nu" when asked if you want to invite others.
   (l) You arrive at the overview of the group. Swipe right until you reach the "Mål" tab in the tab bar, or press "Mål" in the tab bar.
   (m) Press the button "Skapa ett mål".

(n) Optional! Edit the goal through typing in the number of tonnes you want to set as a goal.

(o) Press the button "Spara".

(p) The goal has been reached. A group has been created and a goal has been set, shown directly under "Mål" in the tab bar.

7. Scenario 7: Setting a personal goal

The goal with this scenario was to have the participant navigate to "Mål" and browse the different suggestions made to reduce emissions. The scenario was as follows:

> *You are thinking of reducing your emissions, and want to know what kind of actions you could take to live more sustainable. Can you show me where you think you can learn more about how to reduce your footprint?*

The following set of steps needs to be taken to navigate to "Mål", when starting from the location where the last scenario ended (the "mål" tab in a group):

(a) Press the back button in the top left.

(b) Press the fourth menu item, "Mål", in the bottom navigational menu.

(c) The goal has been reached. Your total emissions are shown in the upper part of the view. Below a set of cards showing different suggestions for reducing your emissions are shown.

8. *Scenario 8: Setting a personal goal*

The goal with this scenario was to have the participant navigate to "Profil" and locate what answer the participant gave to the question "Vilken typ av uppvärmning används i din bostad?". The scenario was as follows:

> *You remember that you wanted to double check what you answered on the question "Vilken typ av uppvärmning används i din bostad?". See if you can find out what you answered on the question. Let me know when you think you have found out.*

The following set of steps needs to be taken to find out what you answered on the question, when starting from the location where the last scenario ended ("Mål"):

(a) Press the fifth menu item in the bottom navigational menu.

(b) Press the card "Boende" in the swimlane called "Utsläppsprofil".

(c) Press the list item labeled "Typ av uppvärmning".

(d) The goal has been reached. The question and what you answered is shown on screen.

B. Description of actionable scenarios

X

C
Interview Guide (In Swedish)

Intervjuguide
"Begin interview by informing the participant that there are no right or wrong answer - if they do not have an opinion or experience with something, they should feel free to state that".

Syfte
Jag håller på att skriva min masteruppsats som har som syfte att studera hur folk använder och interagerar med appen Svalna. Ett mål med arbetet jag gör är att komma fram till insikter om hur designen kan förbättras ytterligare. I den sammanhang gör jag användarstudier där jag bland annat undersöker hur användare interagerar med appen, vilka problem dom stöter på, och hur deras användarupplevelse är. Uppsatsen sker samarbete med företaget Svalna som har skapat appen.

Förklaring av samtyckesformulär
Om du är intresserat i att delta i denna studien måste jag få fråga dig om att läsa och signera detta samtyckesformuläret. Formuläret förklarar syftet med studien och vad vi kommer göra/prata om under intervjun.

För att göra det lättare för mig som forskare önskar jag också fråga din tillstånd att spela in intervjun. Syftet med inspelningen är att jag inte behöver att skriva ner allting du säger och istället kan jag lyssna på dig/vad du säger, och att jag senare kan transkribera intervjun. All insamlad information och material kommer att behandlas konfidentiellt samt anonymiseras, så att inga påståenden, citat eller åsikter kan kopplas till person.

- Har du några frågor innan vi startar?
- Känn dig fri att ställa frågor om du undrar på något under intervjun.

Icebreaker & introduktion
- Skulle du kunna berätta lite kort om dig själv?
  - Om personen inte tar upp det själv:
  - Sysselsättning?
  - Var hon/han bor?
  - Intressen?
  - Ålder?

- Hur skulle du beskriva ditt intresse/engagemang för miljö- och hållbarhetsfrågor i allmänhet?
  – Är du engagerad i klimatfrågan på något sätt?
    ∗ Aktiv i någon organisation?
    ∗ Välgörenhet?

- Skulle du vara villig att ändra på din livsstil för att reducera dina utsläpp?
  – Är det något i ditt liv som du tror hade varit extra svårt att ändra på?
  – Är det något i ditt liv som du tror hade varit lätt att ändra på?

- Har du använt [andra] klimatkalkylatorer tidigare?
  – **Om nej:** Varför inte?
  – **Om ja:** Kan du berätta lite mer om det?

- Använder du några andra appar in din vardag för att mäta saker, till exempel dina träningspass eller vad du äter?

- Har du använt Svalna-appen något mer sedan vi sågs i Uppsala?

- Om du skulle säga 5 saker som du gillar och 5 saker som du ogillar med appen, vad skulle det vara?

Deltagarens användning av appen

Om deltagaren har använt appen senaste två veckorna:

- Hur mycket har du använt appen sedan vi sågs i Uppsala?

- Kan du berätta lite om hur du använt appen?
  Följ upp om deltagaren säger något intressant här.

- Använde du grupp-funktionaliteten på något sätt?
  – Skapade du en grupp?
  – Blev du med i någon grupp?
  – Vad är dina tankar om grupper och det du kan göra där?

Om deltagaren inte använde grupp-funktionaliteten alls:

- Vad tror du orsaken är till att du inte använde grupp-funktionaliteten?

- Vad tror du skulle få dig att använda den delen av appen mera?

- Vad tycker du om möjligheten att ansluta din bank till appen?
  – Valde du att ansluta din bank till appen?

- Upplever du att appen ger dig en rättvis bild av dina utsläpp?
- Skulle du säga att du förstår ditt klimatavtryck och dess storlek med den informationen du hittar i appen?

- Är det någon del av appen du tycker fungerar bra eller dåligt?

- Vad tycker du om det visuella språket till appen?

- Satt du dig själv ett mål i appen?

Om deltagaren inte har använt appen senaste två veckorna (fallback):

- Kan du berätta lite mer om varför du inte använda appen?
  - Är det något särskilt som gjorde att du inte ville använda appen?

- Vad tror du skulle få dig använda appen mera?

Grupper och sociala aspekter

- Skulle du vilja dela information of ditt klimatavtryck med andra?
  - Hur skulle du vilja göra det i så fall?
  - Hur känner du inför att dela med andra hur ditt klimatavtryck ser ut?

- I appen går det att skapa grupper tillsammans med vänner och bekanta där man kan jämföra med varandra, tävla och sätta ett mål tillsammans. Tror du det är något du skulle vilja göra tillsammans med dina vänner eller din familj?
  - Varför?
  - Varför inte?

- - Skulle du vilja sätta ett mål tillsammans med andra om att reducera era utsläpp?

- Vilken roll spelar det andra gör för dig?

- Är det viktigt för dig att vad andra tycker om ditt beteende?

- Vad upplever du när du jämför dig själv med andra, till exempel inom en grupp?

Feedback, interventioner och bredare perspektiv

- Vad tror du skulle motivera dig till att leva mer hållbart?

- Skulle du vara villig att anta en utmaning om att reducera dina utsläpp om det fanns möjlighet för det?

- Efter att ha använt appen ett tag nu, kan du jämföra hur du tänkt kring ditt klimatavtryck då med nu?

Wrap-up

- Är det någon funktionalitet du saknar i appen?

- Är det något vi inte pratade om idag som du vill berätta/prata om?

D
Adjectives - Desirability test

Entertaining	Patronizing	Irrelevant	Predictable	Organized
Innovative	Impersonal	Poor quality	Effective	Inviting
Convenient	Trustworthy	Professional	Stressful	Confusing
Cutting edge	Annoying	Familiar	Straight Forward	Efficient
Essential	Flexible	Powerful	Dated	Exciting
Attractive	Approachable	Simplistic	Difficult	Clean
High quality	Complex	Engaging	Dull	Desirable
Unrefined	Comfortable	Time-consuming	Unpredictable	Intimidating
Inconsistent	Satisfying	Fast	Exceptional	Useful
Easy to use	Comprehensive	Inspiring	Overwhelming	Unattractive
Consistent	Advanced	Busy	Undesirable	Friendly
Relevant	Personal	Rigid	Helpful	Reliable
Unconventional	Creative	Collaborative	Ineffective	

E

List of usability problems

In this appendix a list of significant usability problems found during the usability tests is presented. It includes a short description of the problem, how many participants that was affected, as well as a severity ranking:

- **High:** Findings that the majority of the participants encountered. This rating was also given to problems that became an obstacle or made it difficult for the participant to complete a scenario.
- **Medium:** Findings that two to three participants encountered. This rating was also given to findings that gave rise to frustration, but did not stop the participant from completing a scenario.
- **Low:** Findings that was problematic or led to confusion at first, but not frustrating enough to be considered a problem.

Usability problem	Affected	Severity
Navigation: Users try to learn more about their emissions by tapping the cards in the Overview, but nothing happens when the cards are tapped. & 4/5 & High		
Navigation: Users have trouble finding information about their emissions from groceries	3/5	High
Navigation: Users are have trouble finding information about what they can do to reduce their emissions	3/5	High
Navigation: User get stuck when the back arrow does not work when looking at a single transaction	1/5	High

Layout: User is confused about how to select if an account is shared or not. He thinks he should use the checkbox at the very right to signal which accounts that are share and unchecks every account as he has no shared accounts, resulting in him not being able to continue. One checkbox/account needs to be check in order to proceed and he is stuck.	1/5	High
Mental model: Users hesitated to give the app permission to access the camera or file system in order to add a picture when creating a group, denying it once before being forced to accept permissions in order to proceed. Frustrating.	2/5	High
Layout: User has trouble finding a way to invite her friends to the app and set a goal together with them. Can't find the button "skapa grupp".	1/5	High
User request: User expects the keyboard to activate automatically when asked to respond or fill out text fields in the climate profile, and when it does not they get confused.	2/5	High
Technical issues: App crashes when users press a specific group in "Grupper"	4/5	High
Mental model: Users are confused whether to fill in their personal ID number with 10 or 12 digits when connecting their bank	2/5	medium
Terminology: Users are confused as to what the card 'Monthly trend' means in both the Overview and when looking at the overview of a group.	3/5	Medium
Terminology: Users misunderstood or was confused as to what 'Commuting' means when answering questions in the climate profile, either omitting walking and biking from those questions or not answering at all.	4/5	Medium

Layout: User thinks it is strange to see a dialog asking if she has any shared accounts just moments after she has answered the same question in the climate profile	4/5	Medium
Layout: User tries to tap the slider, rather than dragging it, when answering how many kilometers she commute every day	1/5	Medium
Mental model: Users think they can select several suggested actions for reducing their carbon footprint at once, but realise after pressing several of the cards found in "Mål" that they can only select one at a time.	3/5	Medium
Layout: Users struggle to get the keyboard to appear when entering in destinations when adding a new flight in their climate profile	2/5	Medium
Mental model: User does not understand what she is looking at and the visual elements when in the view where she can set herself a personal goal.	1/5	Medium
Layout: User has a hard time picking the right number of kilometers when answering the questions on how many kilometers she commute every day. Overly sensitive slider.	1/5	Medium
Mental model: User is confused whether to fill in full name or only last name when creating an account	1/5	Low
Terminology: User is confused what "Delat konto: 1" means when selecting which accounts that are shared.	1/5	Low
Layout: User can't see the goal for a group right after setting a goal.	1/5	Low
Layout: User did not initially discover that he could scroll amongst the cards in the bottom of the Overview	1/5	Low

Layout: User has to tap 3-4 times in order to activate the radio button for "Returresa" when adding a new flight in the climate profile	1/5	Low
Aesthetics: User does not think the icon for "Utsläpp" is clear and symbolises emissions	1/5	Low
User request: User wants to type in airport code when entering destination for a flight.	1/5	Low
User request: User expects to verify the password he has written when creating an account, but did not get that opportunity.	1/5	Low
User request: User wish the list of banks was sorted after the most "normal" or common banks.	1/5	Low
User request: User complains that the app does not remember earlier destinations inputted when adding a destination to a flight.	1/5	Low
User request: User thinks the app should indicate that there is information "outside" the area currently visible (e.g., when looking at the goal of a group).	1/5	Low
Technical issues: User becomes confused when she is able to look at dates in the future when adding a new flight in the climate profile	1/5	Low
Technical issues: User discover that the calendar-picker that is used to input the date for a flight does not correspond to the calendar in his own phone.	1/5	Low
Mental model: User thinks he gets to see a summary of his emissions from houshold energy use, when in fact he only get to see emissions from one transaction	1/5	Low
Terminology: User is confused of what '55 kg' really means when looking at her emissions from Groceries as she has nothing to compare it with	1/5	Low

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