Translating Knowledge into Action:
Bridging the Intention-Behaviour Gap with Customizable Information to Improve Personal and Ecological Health

Manuela Andrea Hummel

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Signed by the final Examining Committee:

Chair: Charles Reiss

Examiner: Carmela Cucuzzella

Examiner: Nathalie Dumont

Supervisor: Martin Racine

Approved by: Charles Reiss

Chair of Department or Graduate Program Director

2015

Dean of Faculty

Abstract

This study seeks to determine to what extent increased awareness of the implications of modal choice directly influences intention, translates into action, and increases the use of active methods of transportation to sustain or enhance personal and ecological health. The problem is that the general public awareness about the impacts of sedentary lifestyles on health and the environment is marginal and the systems that combine visualized information into meaningful knowledge about said issue do not respond to individuals' life circumstances. Previous work has failed to address the problem as no connections between psychological inquiries of awareness, the intention-behaviour gap, motivation, decision-making, and the impact of customizable information presentation have been drawn. In this thesis we introduce a future system that combines mobile media technology with sensed data to generate customizable information in a way that responds to the user and encourages a behaviour change toward a more active lifestyle. A research-through-design approach was applied that combined the development of five different knowledge visualization mock-ups with a presentation of those options in an online survey examining people's perception regarding a general interest in customizable information, a preferred information presentation style, and an estimation about the likelihood of how such information would affect use of the system and subsequently modal choice. We expect this approach to help in specific design practice while improving the quality of knowledge visualizations for systems that produce customizable information, and personal and ecological health in general.

Keywords

Customizable information, knowledge visualization, mobile sensing, health, environment

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My dear Montreal friends, I will miss you very much.

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Chapter 1: Introduction

Today's younger generations have a lower life expectancy than their parents, despite modern societies having reached an apex in terms of mobility, technology, and quality of life (Kumanyika et al., 2008). This reversal is largely a consequence of sedentary lifestyles and poor eating patterns.

Sedentary living has other pernicious effects. According to a NASA report, a vast majority of climate scientists attribute the significant global rise in temperature of the past few decades to human activities (NASA, Global Climate Change, 2014), and transportation powered by fossil fuel combustion is a major contributor. Respiratory diseases attributable to smog are also on the rise.

There are solutions, however. One of the more holistic is to substitute sedentary modes of transportation with active ones, such as walking or biking, whenever possible. This would reduce emissions harmful to the environment while also increasing our physical activity, thereby improving life expectancy.

Motivating people to adopt active modes of transportation is problematic, but with recent advances in mobile information technology that allow data of individual movement patterns to be easily collected and displayed, we have a new tool to encourage healthier living.

Health specialists, policymakers, and urban planners strive to develop more effective strategies for encouraging active lifestyles among urban dwellers. They design such programs as bike-share, congestion-charge, and tax-refund systems with the goal of shifting car-oriented societies toward a more balanced distribution of different kinds of road users.

Connectivity and data growth has increased exponentially over the past decades. The *Global Village* Marshall McLuhan envisioned decades ago has become reality. The internet and tech-

nological developments enables people to exchange, evaluate, and archive information in real-time, irrespective of distance. However, those opportunities have a drawback: the amount of information has grown rapidly, but the mental capacity a human has to absorb information has not evolved at the same pace. Because of this it is essential to find ways and develop new skills that enables people to make use of the information collected.

Sensor technology, wireless networks and improved battery capacity has empowered the idea of the "Quantified-Self", a concept of constantly monitoring and evaluating personal health stats. Global players in technology, such as Google with Google Fit, Apple with Apple Health, and Nike with Nike-Fuel and Nike+, but also companies from the medical field and software start-ups research, invest, and produce the kinds of applications and devices that allow a user to sense, measure, and control health and movement-related information. Certainly promising developments are systems that sense user data while "on the go". The collected information is visualized either directly or by connecting the device to a computer-based interface. Current products allow a user to create a profile, set goals, control progress, and compare personal achievements with peers. Technology of this sort presents certain challenges, such as the collection and archival of sensitive information, poor usability, and, especially for health-related data, a potential information overload that could result in unfounded concerns if measured values are incorrect or outside of average-based health guidelines. Moreover, available products generally follow a "one-size-fits-all approach", which means a product's functions, data collection, data presentation, and user-interaction are less responsive to individual needs and expectations than they could be.

The daunting, urgent problems facing humanity make surmounting the challenges of developing knowledge visualization and its customized presentation worthwhile. Herein I describe a research study that examined how presenting information to an individual about the effects that his or her chosen methods of transportation have on health and the environment can influence that individual's intention and modal choice.

1.1 Development research question

As a means to precisely formulate my research question I started off by identifying the problem. This exercise then resulted in the formulation of a hypothesis which finally led to the research question and at the same time provided information on how to construct the research design. The following illustration presents the structure of this problem identification.

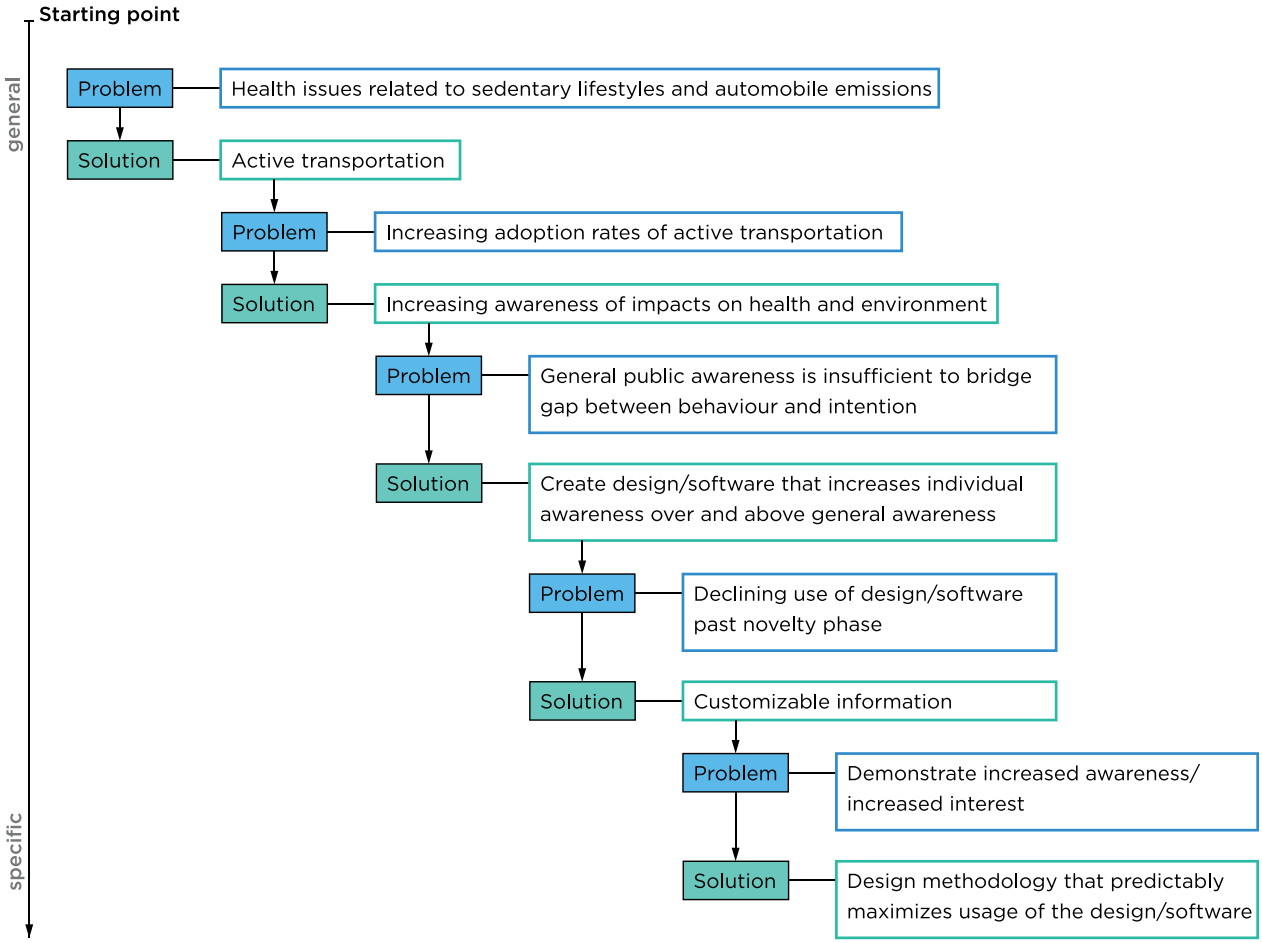


Figure 1: Problem identification

1.2 Hypothesis

A well-designed application layer added to Google Maps or the like that meaningfully presents to a user the predictable impacts of his or her modal choices upon their own health and the environment will likely improve that user's modal choices over the long term, thereby decreasing health issues related to sedentary lifestyles and transportation emissions.

Sedentary lifestyle habits contribute directly to the increasing number of diseases, and spaciously built environments induce a higher amount of vehicle miles travelled, consequently causing a higher amount of emissions harmful to health and nature. For example, more than 50 percent of Canadians are categorized as overweight or obese, a tendency that is rising. (Statistics Canada, 2014). According to the Canadian Census, in 2006, around 72 percent of Canadians travelled to work by car, 11 percent used public transport, and about 6 percent walked. The remaining 11 percent are divided among people whose usual place of work was their home and workers with no fixed workplace address. (Statistics Canada, 2009). To reduce the imbalances between methods of transport in favour of those that are environmentally friendly, this study inquired the following research question.

1.3 Research question

How can the design of a mobile application contribute to influence people's mode of transportation should it provide comparative information on ecological and health impacts of various options?

1.4 Research design

This research project consisted of three main parts: an initial theoretical part, a practical part, and a concluding theoretical part. Throughout the first theoretical part the framework development gave direction for the practical part. The practical part was characterized through a wave-like motion between phases of reflection and action. The reflective phases served two purposes: first to evaluate what evolved through the action stage, and second to define the subsequent step. One loop that connects the outcomes of the literature review is implemented to question the hypothesis and test the validation of the research approach. Another loop is integrated between the first set of the practical research phase and the literature review to ensure that the literature study prior to the research covered all topics of relevance. This respectively enabled the researcher to catch up on material that had not been examined in the first place. After completion of the practical research phase, a second theoretical phase concluded the study with a survey designed to explore the extent to which people are generally interested in customizable information and the extent to which such information influences one's travel decisions.

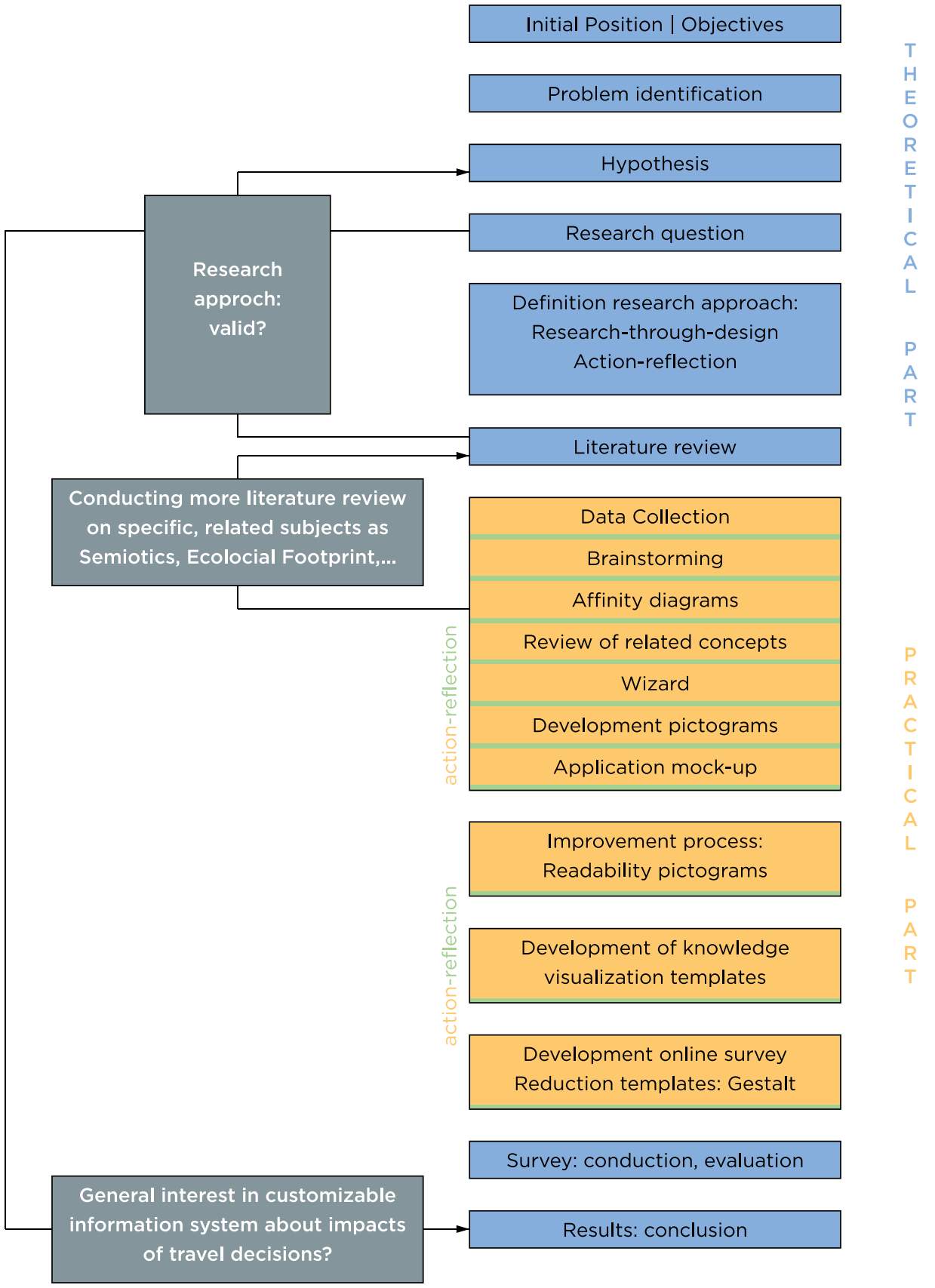


Figure 2: Structure research design

Chapter 2: Theoretical framework

During the past two decades the term 'sustainability' has become omnipresent in the media, economy, politics, research, and advertisement world, among others. A simple Google search query offers 115 million results, and Amazon's online store presents nearly 30,000 items that match a single search entry. The presence of the term, however, has resulted in a creation of awareness of the concept itself but also runs the risk of being washed-out. Already in 1987, when the Brundtland Commission defined Sustainable Development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987, p. 37), Brown, Hansom, Liverman & Merideth (1987) pointed out that "the meaning of sustainability is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic, or ecological perspective" (p. 713). The authors go on to say that any attempt to define sustainability also must establish the space and time in which the definition is reviewed. This being said, Johnston, Everard, Santillo & Robert, (2007), claim that the term *sustainable development* is self-contradictory, in a society that is based on an economy of constant growth, despite limited resources sustainable development cannot be achieved. In their attempt to reclaim the definition of sustainability Johnston et. al. (2007) stress that new ethical standards play a pivotal role in order to define — but also achieve sustainability. These standards for example are the unfair and unethical consumption and distribution of resources and profits resulting in the exploitation and destruction of ecosystems, the neglect of basic humans rights, and the failure of recognising, acknowledging and successfully implement countermeasures of climate change. (Johnston et. al. 2007).

2.0.1 Sustainability and sustainable development from a design perspective

In order to address standards that allow continued support of human life on earth I would like to draw attention to the importance of individual self-reliance and responsibility to-

wards oneself and future generations. In her article “Social Innovation and New Industrial Contexts: Can Designers “Industrialize” Socially Responsible Solutions?”, Nicola Morelli (2007) argues “the solution to problems that cannot be addressed by global production must be solved by mobilizing individual knowledge and skills” (p.9). Morelli (2007) refers to social problems that are usually ignored in profit-oriented policies. Design therefore has a tremendous potential to support small-scale sustainable development by raising awareness and offering new solutions. One example for this kind of practice is the project ‘Pumpipumpe’ that has been launched by three designers in Bern in 2012. The projects’ main idea is based on a system to share household goods, tools, and toys with people in your neighbourhood. Usually one doesn’t need a bike trailer, a drill , a lawn-mower, or a fondue set every day, therefore it does not make sense that everyone owns all of these items. Pumpipumpe’s founders developed stickers participants can order and stick on their mailbox. People that are looking for an item to borrow just need to walk through their yard and ask for the item they are looking for. This does not only reduce consumption, it also motivates people to contact their neighbours while sharing things and getting to know each other better.

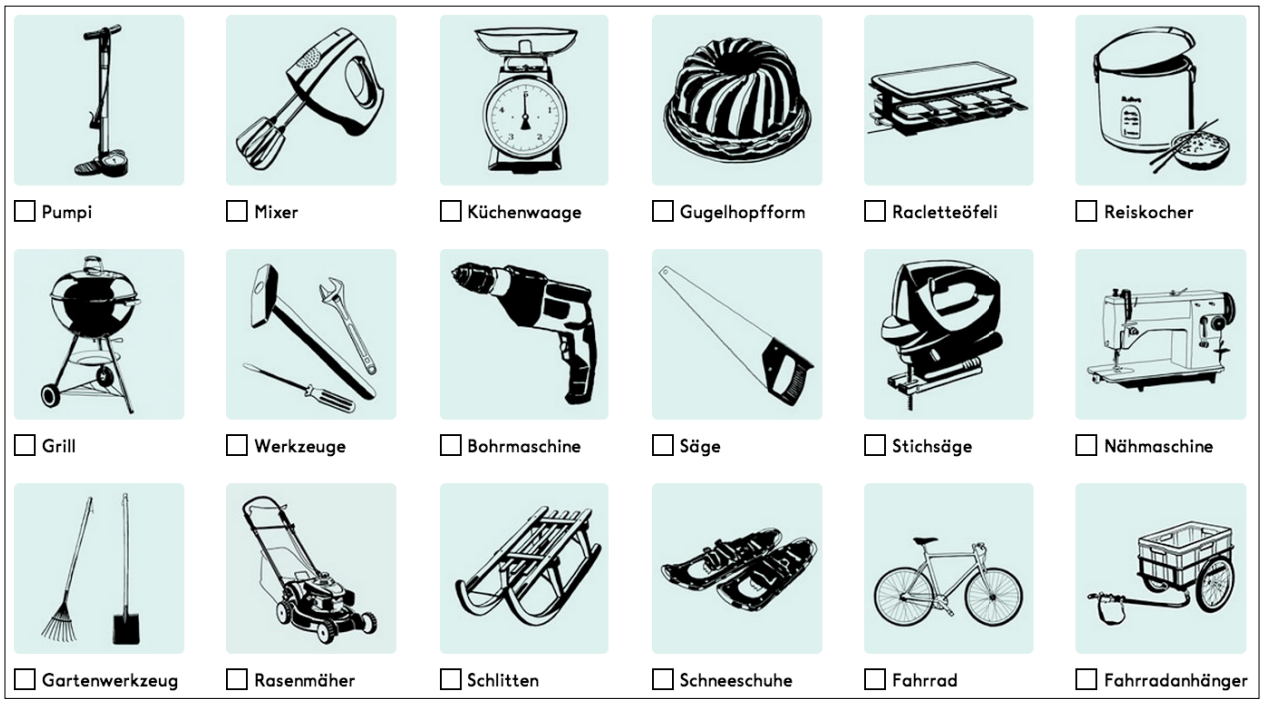


Figure 3: Untitled illustration of example stickers from “Pumpipumpe” for mailbox indicating items that can be borrowed. Retrieved April 28, 2015, from http://www.pumpipumpe.ch/sticker-bestellen/

Wahl and Baxter (2008) go one step further by ascribing a role to designers to facilitate sustainable solutions by pointing out that "sustainability requires widespread participation" (p. 72). In their opinion the concept of sustainability is developed through (within) society by applying solutions that involves people together to create a liveable future. (Wahl & Baxter, 2008). Another example where people engage to create awareness and intervene in existing built environment is the concept of "Guerilla Gardening". The idea behind guerilla gardening is to reclaim and reuse public (or sometimes private but abandoned) space to plant seeds that green the environment, support and conserve the diversity of species, and share vegetables within a community.

In summary, sustainability and sustainable development may be defined and tackled broadly or narrowly, in both ways however, it is important to acknowledge as Wahl & Baxter cite John Wood (2005, p. 75): "the complexity of the wholeness" and realize the connections between designing for individuals and the potential effect these products might have on society (John Wood, cited in Wahl and Baxter, 2005).

2.0.2.1 Health

In its constitution the WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 1995 p. 1). The text further says "the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition". (WHO, 1995 p. 1).

Nearly 70 years later unfortunately health is still a 'good' that is inequitably distributed among the world's population. There is a differential between developed and developing societies, as there is a differential in levels of income and education. For example, in a TED talk, health specialist Dr. Myriam Sidibe (2014) explained that having access to soap would allow

people in poor countries to wash their hands regularly and, as such, could prevent more than 600,000 children under the age of five from dying each year because of diarrhea; pneumonia; and other diseases such as respiratory infections, the flu, trachoma, and SARS. Hand washing with soap and therefore minimizing the risk of transmitting bacteria is a very simple but cost-effective solution in health promotion, however, the poverty in these areas keep people from using soap regularly (Sidibe, 2014).

Another example that reveals the differences in access to health sustaining and health promoting measures is a project done by Nathan Yau (2014). Using data that had been collected through a fitness app called Runkeeper, he presented maps illustrating peoples' favourite jogging and cycling routes in major cities of the U.S. and Europe. Although at first this might appear as a nice idea to get to know which areas people preferably spend time to engage with healthy behaviours, the illustrations also uncover the wealthier neighbourhoods of the cities Yau mapped. The maps depicted correlations of fitness and class status. People that have the financial means to live adjacent to parks and rivers also have leisure time to participate in outdoor activities whereas people with less money tend to neither live or spend recreational time in these areas, nor have 'fancy fitness devices' that track their activities. (Ehrenfreud, 2014).

Figure 4: Yau, N. (2014). Visualized running trails: New York, Retrieved April 11, 2015, from http://flowingdata.com/2014/02/05/where-people-run/

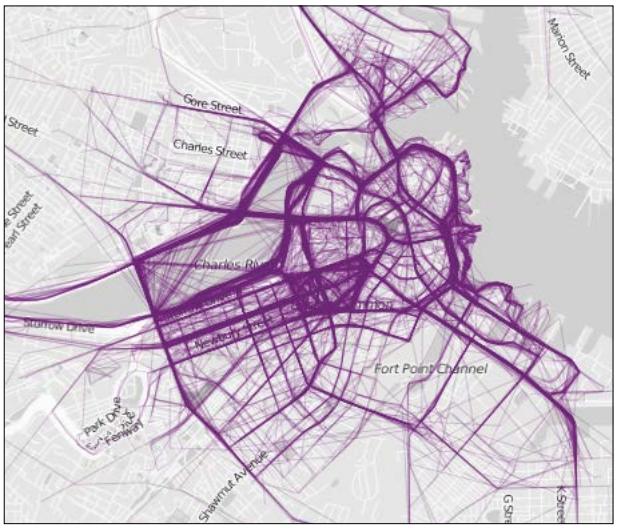


Figure 5: Yau, N. (2014). Visualized running trails: Boston, Retrieved April 11, 2015, from http://flowingdata.com/2014/02/05/where-people-run/

2.0.2.2 Health promotion

As the first International Conference on Health Promotion, held in Ottawa in 1986, concluded, "Health promotion is the process of enabling people to increase control over, and to improve, their health". (WHO, 1986, p. 1). In order to enable individuals to increase control over, and improve their health, people need to be informed about measures that support health. Achterberg (2010), stated that health promotion is most effective when knowledge, awareness, and facilitation techniques are combined. (Achterberg, 2010). By increasing the individual's awareness of both ecological and health impacts, we would expect that the individual would make better choices. Health promotion in this sense is not only a concern for health specialists and policymakers, the responsibility to improve and sustain good health is a matter for everyone. (WHO, 1986).

Controversial, but in fact effective in the application for anti-smoking campaigns is the concept of threatening communication. Since 2009 in the U.S. and 2010 in Canada by law cigarette packaging depicts the negative consequences of smoking on a person's health by using graphic pictures. A study done in America with more than 500 smokers examined that highly graphic pictures strengthen resolutions to stop smoking through evoking fear. (Kees, Burton, Andrews, & Kozup, 2010).

2.0.2.3 Health and physical activity

It is well established that physical activity has positive influences on both physical and mental health. Against a person's better knowledge up to 30% of Canadian adults do not meet the WHO's recommended minimum amount of 150 minutes of moderate-intensity physical activity per week. Brisk walking, dancing, gardening, housework and domestic chores are regarded as moderate-intensity physical activities. The alarming fact is, in 2012 non-communicable diseases — or so called lifestyle diseases were responsible for more than two thirds of

the world's 56 million deaths, 16 million of these were premature deaths under the age of 70. As previously stated, with around 20 minutes per day of medium effort the risk of cardiovascular disease, diabetes, and cancer could be reduced (WHO, 2014).

A symptom of passive lifestyles has increased the prevalence of overweight and obesity. According to Flegal, Carroll, Kit, & Ogden, (2012), more than one third of the U.S. adult population was obese. Obesity means that excess body fat has reached a morbid status of overweight. One method to increase peoples' daily amount of physical activity and therefore decrease the risk of gaining weight are walk-able and bike-able neighbourhoods. Active transportation and obesity are inversely related, yet the results do not proof causality. Countries where active travel is most common have the lowest obesity rates (e.g. Norway, the Netherlands), and countries with the highest rates of individual motor car traffic have the highest obesity rates (e.g. the U.S., Australia, Canada). (Bassett, Pucher, Buehler, Thompson, & Crouter, 2008).

2.0.2.4 Health and sensed health information: mHealth

Most people experience healthcare as a 'reactive' care where clinicians and individuals are used to the concept of treating a disease once it has appeared. Medical examinations focus on test results that are 'out of the range' and treatments are designed to bring these measurements back to 'normal' and within 'range'. However, with current mobile technologies that sense and collect all kinds of information, far superior and more detailed patient data compared to self-reports or a single medical examination can be accessed. People are more interested in observing their body's performance and applications and devices develop in a pace that presently exceeds that of scientific inquiry. (O'Reilly & Spruijt-Metz, 2013). mHealth — or the concept of the so called 'quantified-self' offers tremendous opportunities to monitor people's everyday health. Besides devices that use GPS-, acceleration-, and gyroscope sensors to detect peoples' movement and activity patterns, the spectrum of new technologies is spreading inexorably and penetrates individuals' lives in many categories. For example, the

‘Mimo Baby’ device informs parents about their child’s breathing, skin temperature, body position, and activity level while sleeping. ‘Proteus’ is an edible microchip powered by stomach fluids that transmits information about intake, activity and resting levels sending information to a smart phone. Using an infrared sensor, the ‘Moxi Monitor’ detects the amount of haemoglobin in an oxygen saturated muscle. The information its user gains helps to improve training intensities while avoiding the transition into anaerobic stretches. LG’s ‘HRM’ earphones measure metabolic and blood oxygenation, ‘Duofertility’ monitors changes in a woman’s body temperature every few seconds to predict when she is most likely to conceive, and a smart contact lens that evaluates blood sugar values for diabetes patients is currently under development by a joint project of Novartis and Google. The devices above were presented in a Wired UK article, reflecting on Wired Health conference held in April, 2014. (Kraft, D., 2014, p. 112-116). As genetics, environment, life circumstances, and many other factors influence health, mHealth now offers a way to help to control and regulate at least some of those factors in order to sustain or improve one’s well-being.

Figure 6: Mimo Baby, Retrieved April 27, 2015, from http://www.blogsrelease.com/index.php?module=Board&id=4690&template=Print&pname=print

Figure 7: Proteus: edible microchip, Retrieved April 27, 2015, from https://meramedicare.wordpress.com/page/2/

Figure 8: Moxi monitor, Retrieved April 27, 2015, from http://swinco.ch/shop/index.php?route=product/product&product_id=50

Figure 9: LG HRM earphones, Retrieved April 27, 2015, from http://plug-in.bestbuy.ca/t5/Visit-the-Plug-in-Blog/CES-2014-The-Year-Your-Technology-Became-Wearable/ba-p/81905

Figure 10: Duofertility, Retrieved April 27, 2015, from http://inventorspot.com/articles/duofertility_fertility_patch_allows_your_monitor_basal_body_temp_31543

2.1 Behavioural psychology

2.1.1 Intention-behaviour gap and value-action gap

The intention–behaviour gap theory is concerned with the phenomenon of a planned action and the non-performance of said action. The terms intention–behaviour gap and value–action gap are often used interchangeably; however, intention–behaviour gap most often refers to one's behaviours in regards to physical activity and eating patterns, whereas value–action gap is associated with environmental geography and refers to one's behaviours in regard to environmental issues. (Blake, 1999).

As seen in most people's New Year's resolutions, good intentions do not always result in behaviour change. In fact, a study showed that 78% of people that hold positive intentions in regards to increase physical activity levels, only half of them kept up with implementing those goals. (Rhodes & de Bruijn, 2013).

According to Rhodes and de Brujin (2013), research considers intention as the proximal antecedent of behavioural enactment. Therefore the gap that needs to be bridged lies between awareness creation resulting in a theoretical wilful intent and its practical implementation. Recent studies show different ways to bridge these gaps. Rhodes (2014) suggests three approaches in order to face the barrier: "Organization, automaticity, and self-obligation respon-

sibility". (Rhodes, 2014 p. 106). In his discussion of organization, the author describes ways by which planning can convert intentions into action. Automaticity has shown positive results, with people reporting that their action was motivated by unconscious intention. Self-obligation responsibility describes behaviours motivated by external factors, as opposed to intrinsic factors.

Scholz, Schüz, Ziegelmann, Lippke, & Schwarzer, (2008) explain that the process from forming the initial intention to the implementation is divided into stages. At the beginning stands a phase of motivation. During this phase the person is going through a contemplation process where he or she defines the outcome expectancies of a newly developed behaviour. During this phase the person will experience a growth in self-efficacy, as the new behaviour will result in an improved self. Based on these preliminary thoughts the intention is formed. Now the person enters a volitional phase, where he or she initiates the translation of the intention into action. (Scholz et. al., 2008). To overcome potential obstacles, it is important that the person creates scenarios in advance to keep up the motivation until a habit (automaticity) is formed. For example if one intends to run a certain distance twice a week, he needs to schedule a day and time to follow through this goal. The outlining of the actions is referred to as 'action planning'. The difficulty most often, however, occurs when 'coping planning' has not been done in advance. Coping planning describes clearly the future scenarios that take place in case running is not appealing enough to stick to resolutions, be it because of bad weather conditions, or just because a quiet evening at home seems more attractive. (Scholz et. al., 2008).

In a study applying a real world-setting, Lally, Van Jaarsveld, Potts, & Wardle (2010) found out that automaticity increased steadily over the days supporting the assumption that repeating a behaviour in a consistent setting increases automaticity. An action that is performed automatically, that is habitual behaviour, is beyond evaluation in terms of its positive outcomes. Therefore if a habit has formed the bridge has been gapped. However, the time to form a habit differs in individuals and depends on several factors. For example the level of difficulty plays an important role in holding up to new resolutions. (Lally et. al., 2010). The study revealed

that participants that chose to adopt a new behaviour such as drinking a glass of water while having breakfast faced less struggles than participants that chose to adopt a new physical activity. In the sample the average time for participants to form a habit was 66 days and its formation is asymptotic, meaning that over time new behaviour becomes habitual. (Lally et. al., 2010).

As mentioned earlier, forming an intention is characterized by the necessity of going through a motivational state. (Scholz et. al., 2008). To gain deeper insight in the psychological aspects of how motivation evolves, I will now investigate in interconnected concepts of motivation, reward and reinforcement in regards to behaviour change.

2.1.2 Behaviour change

Behaviour change is directly linked to a motivation for change that can be represented as a conscious will to move from one state into another. Hobbs, Hildon, Michie, and Campbell explain behaviour as an individual's reaction to all inner and outer influences. (Hobbs, et. al., 2011). In this sense, one must become aware of internal or external motives in order to control their impact on behaviour. This all presupposes that the individual who aspires to change has the required capabilities and opportunities. (Adamson, 2013).

2.1.3 Motivation

Due to a lack of consensus on the definition of 'motivation' researchers collected over one hundred defining statements. The study used an approach to classify this collection into categories, based on either their theoretical or phenomenal nature. (Kleinginna & Kleinginna, 1981). I will present three definitions from this collection of which I think cover the concept best in regard to this thesis.

In 1884 James Sully offered the following definition: “The desire that precedes an act and determines it is called its moving force, stimulus or motive” (Kleinginna & Kleinginna, 1981 p. 273) The psychologist’s statement describes the subjective experience of motivation. Hugh Brown however said in 1976 that “[m]otivation is the change in the biological state of the organism that relates to behaviors directed at self and species preservation” (Kleinginna & Kleinginna, 1981, p. 275). In other words, Brown assumes that the impulse for a certain behaviour is unconscious, and it is rooted in the instinctive desire for survival of any animate being. In contrast to Brown’s point of view, Donald B. Lindsley holds the opinion that “[m]otivation is the combination of forces which initiate, direct, and sustain behavior toward a goal” (Kleinginna & Kleinginna, 1981, p. 279) which implies that motivation is a result of a conscious will to attain a specific purpose.

Based on the definitions provided, motivation can be regarded from a phenomenological, a physiological, or a functional point of view. Yet, if motivation triggers intention, the question remains, what could strengthen it? This needs to be examined.

2.1.4 Reward and reinforcement

Rewards and reinforcements for example are two ways that affect motivation. (Cameron & Pierce, 1994). To provide clarity, I will present definitions of the terms, and in this context introduce the distinct difference between intrinsic and extrinsic motivation, and then explain the idea of self-rewards.

Oxford Dictionaries defines ‘reward’ as follows: “A thing given in recognition of service, effort, or achievement”, and “[a] fair return for good or bad behaviour”. (Oxford Dictionaries, 2014). Reinforcement, in turn, is defined as “the process of encouraging or establishing a belief or pattern of behaviour”. (Oxford Dictionaries, 2014).

In social sciences, Deci (1972) contributes to define 'reward' as follows: "[a] person is intrinsically motivated if he performs an activity for no apparent reward except the activity itself. Extrinsic motivation, on the other hand, refers to the performance of an activity because it leads to external rewards (e.g., status, approval, or passing grades)". (Deci, 1972, p. 113). Therefore we can assume, in an applied setting, a person who enjoys travelling by rail does not need to be extrinsically motivated to use the train for commuting, as long as the given circumstances favour the trip (network infrastructure, well-served schedule, etc.). An extrinsic motivation though might be convincing for people who for example would actually prefer travelling by car. Such people could be motivated to change their commuting strategy if many of their co-workers commute by bike and they appreciate the approval of their colleagues (Deci, 1972). According to Cameron and Pierce, "[a] reinforcer is an event that increases the frequency of the behaviour it follows. A reward, however, is not defined by its effects on behaviour. Rewards are stimuli that are assumed to be positive events, but they have not been shown to strengthen behaviour". (Cameron & Pierce, 1994, p. 369). In other words, through reinforcement, a given practice will increase in frequency. If a bicycle commute is being reinforced, whether by verbal or tangible reward, the frequency of bicycle commutes will tend to increase. On the contrary, a reward will not result in behaviour change, it is a simply a non-recurring acknowledgement of an activity. Cameron and Pierce note, a "reward becomes reinforcement only after its effects are shown to increase behaviour". (Cameron & Pierce, 1994, p. 369). That is to say, a reward becomes a reinforcement through repetition resulting in continuously changing attitudes.

Though rewards are considered beneficial (constructive), some researchers claim that rewards negatively affect intrinsic motivation. Deci (1972) believes "[i]f a person is engaged in some activity for reasons of intrinsic motivation, and if he begins to receive the external reward, money, for performing the activity, the degree to which he is intrinsically motivated to perform the activity decreases". (Deci, 1971, p. 113). Other social science scholars disagree with Deci (1972) and show that research has disproven his assertion. Cameron and Pierce (1994) conducted a meta-analysis of existent research and found that "overall, reward does

not negatively impact intrinsic motivation". (Cameron & Pierce, 1994, p. 363). In another analysis, Cameron and Pierce (1994) indexed intrinsic motivation as the difference in subjects' behaviour between pre- and post-reinforcement sessions. The findings suggested that, "reinforcement does not decrease a person's intrinsic motivation to engage in an activity". (Cameron & Pierce, 1994, p. 394). Nonetheless, it is important to say that "reward types (e.g., tangible, verbal rewards), reward expectancies (expected, unexpected), or reward contingencies (e.g., rewards delivered for engaging in a task, competing or solving a task, or meeting a specified level of performance)" (Cameron & Pierce, 1994, p. 394) differ in kind and degree of impact on intrinsic motivation and therefore in the degree of behaviour changes.

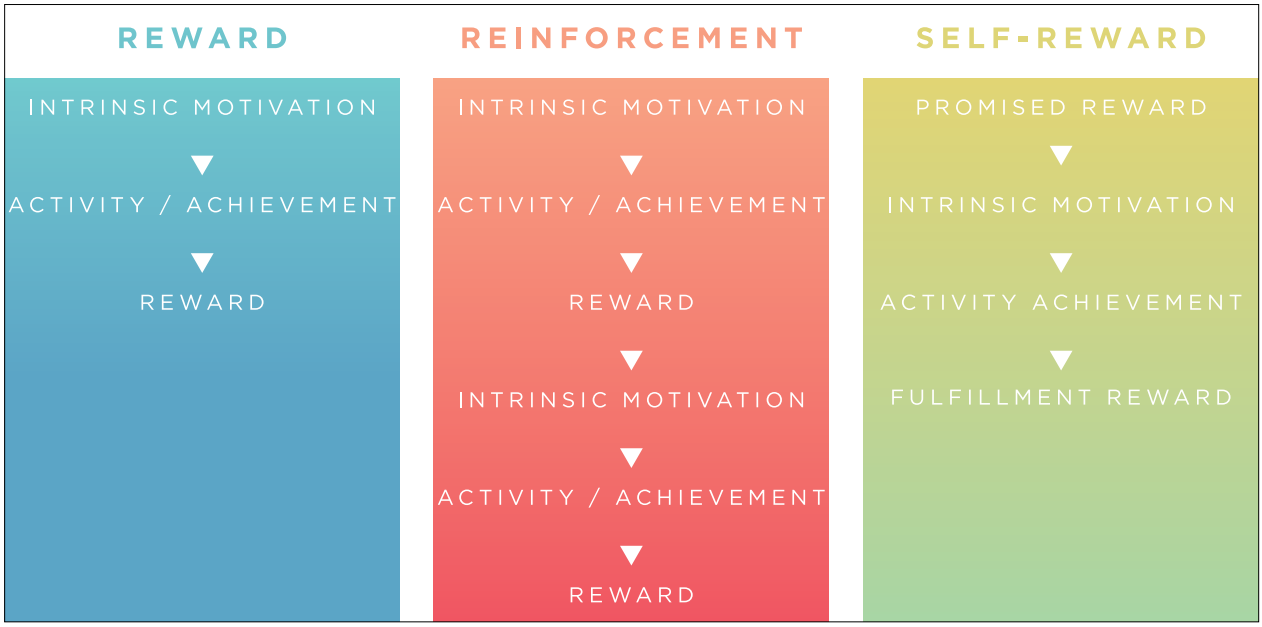


Figure 11: Visualization reward, reinforcement, self-reward. Created on findings of Judy Cameron and W. David Pierce, as well as Alexander K. Koch, Julia Nafziger, Anton Suvorov, Jeroen van de Ven

Another concept to increase motivation is self-administered awards. Through promising an incentive to oneself in the event that a personal accomplishment is reached, this type of reward can help to achieve goals or conquer one's weaker self (Koch, Nafziger, Suvorov, & van de Ven, 2014). Mick and DeMoss (1990) state "self-gifts can act as self-contracts in which the reciprocity for the gift is also personal effort and achievement". (Mick & DeMoss, 1990, p. 326). Put differently, an agreement with oneself can serve as a motivator, if completion of the task

results in a self-chosen reward. Yet, dedication and reward must strike a balance. For example, a task that requires a lot of effort to achieve has to be compensated with an according reward. The motivation to achieve the goal will not be high enough if the reward is not worth the effort. Also, the reward has to be something one desires but does not necessarily need. (Koch et. al., 2014). If the self-chosen reward is a good that the person will buy whether or not he or she achieves the goal, the reward loses its function as a motivator. Once the goal is achieved, the self-contract has to be fulfilled, which means one has to reward oneself with the promised motivator. If the reward is not paid out, the concept of self-reward will not improve motivation for further self-control tasks. One important finding is that even quite ordinary rewards are sufficient to increase motivation and achieve a goal. (Koch et. al., 2014).

One online platform that uses a reward system to form habits is called HabitRPG. After creating a profile the user is either awarded or punished by gaining or losing points, weapons, superpowers, and lives, when accomplishing or failing self-administered resolutions. HabitRPG, (2015) Retrieved from https://habitrpg.com/static/front.

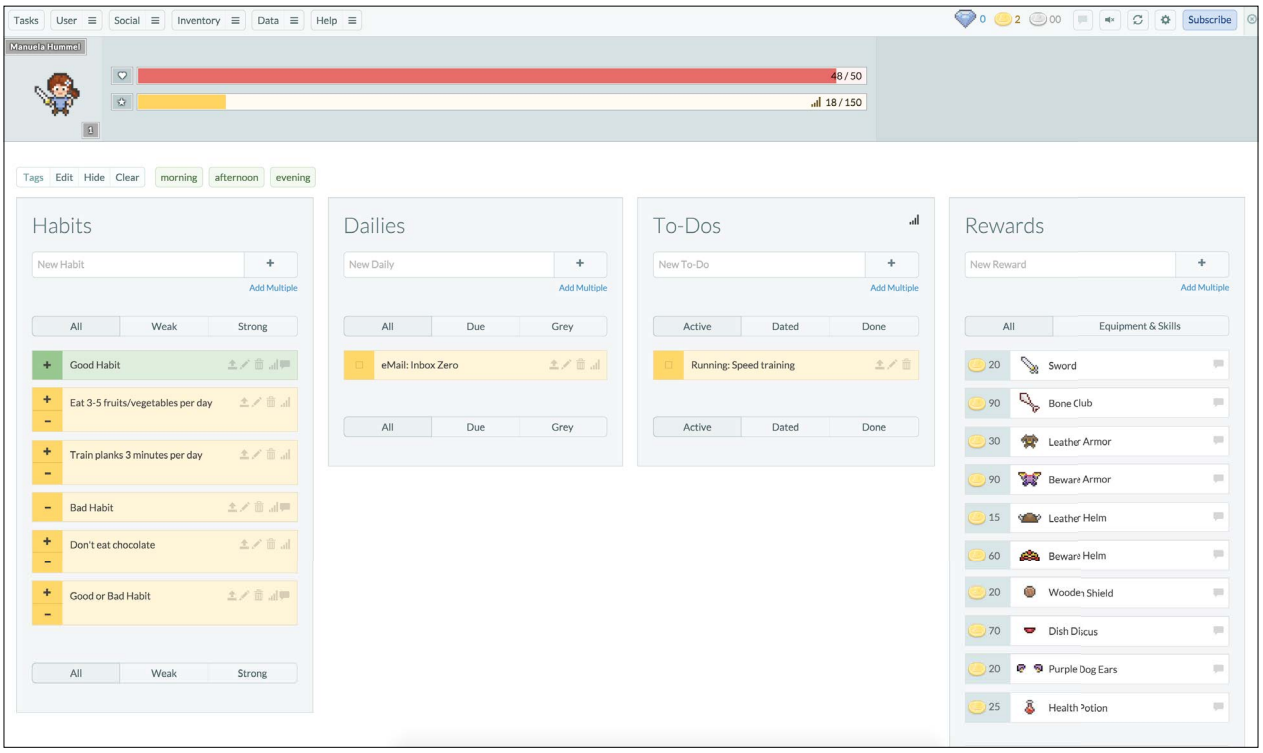


Figure 12: HabitRPG, Retrieved April 10, 2015, from https://habitrpg.com/#/tasks

2.1.5 How to design interventions that initiate and/or support behaviour change?

A major aspect of this study is concerned with the ways in which people behave and how design can play a role in influencing behaviour. At the outset, it should be noted that any form of planned manipulation has to be examined for its ethical implications. Designers must be aware of how their products can affect people and social norms. The considerations need to take into account not only the target group, but also how a potential behaviour change in the target group might affect their surroundings. For example, in an attempt to increase occupants' safety, the average vehicle weight has increased steadily over the past years. A study done in 2013 at the University of California, Berkeley, identified that being hit by a car that is 500 kilograms heavier creates a 40-50% increase in fatality risk. (Anderson & Auffhammer, 2013). In this way, security concerns for drivers of bigger cars have been considered, yet at the expense of other road users' safety and a development in car sales that compares to an "arms race".

Regarding the general aim of this study — finding ways to improve people's health — Ludden and Hekkert (2014) stated that "successful adoption of interventions aimed at healthy living by more people will eventually lead to a healthier population which will lower demands and costs in care" (p. 487). The authors further explained that design interventions in general are non-personal and location independent. With those two characteristics established, the question now is: how does change occur and how can design initiate and support change? According to Ludden and Hekkert (2014), change consists of a sequence of five stages in which different processes can be experienced. During the first stage in the sequence, called "pre-contemplation," people have not yet realized the need for change, and they do not compare potential benefits with the current situation. As design interventions are meant to support people while they are going through the distinct stages, a design strategy at this stage should provide general information as opposed to giving personal advice. In other words the process one experiences at this stage can be described as "awareness creation" and "advantages information". The pre-contemplation phase is followed by "contemplation," a stage in

which (according to the authors) the "decisional balance" shifts. People here begin to evaluate the benefits of change if applied to their personal life. The design intervention here should address self-assessment while enabling for change. Once these preliminary stages have been passed, a person enters the "preparation stage". During preparation willpower is built up, a commitment is made, and the knowledge of how to take action is acquired. The process one experiences at this stage can be described as "self-liberation". The design intervention therefore should focus on creating opportunities for behaviour change. The two final stages, "action" and "maintenance", are characterized by the adoption of new behaviours. The difference however is that in the former stage new behaviours have not yet become habits. Design strategies here focus on processes such as contingency management, stimulus control, and counter-conditioning, among others. (Ludden & Hekkert, 2014). In regards to stimulus control, a design intervention could focus on presenting the nutritional information of foods. For example, it has been shown that people's consumption of soft drinks is influenced when they know about the actual amount of sugar that has been added to beverages.

To create a framework to design healthier behaviours, the design interventions of this study correspond to Ludden and Hekkert's five stages of change as follows:

Stage 1:	Pre-contemplation • Raising awareness
Design intervention:	Providing general information about the impacts of different modes of transportation on personal and ecological health as well as the comparison of costs and benefits of these different modes.
Stage 2:	Contemplation • Enabling
Design intervention:	Giving the opportunity to customize: creating a user profile based on information of interest and personal preferences.

Stage 3:	Preparation • Motivating
Design intervention:	Presenting potential benefits for personal and environmental health, time savings, cost savings, etc.

Stages 4 and 5:	Action and Maintenance • Reinforcement
Design intervention:	Presenting actual health improvements, a reduced CO_2 balance, and savings.

Now that we have looked at one approach to how design interventions can address behaviour change, I would like to draw attention to the concept of "mindful design," described by Niedderer (2013), which further examines how, where, and why design for behaviour change should be applied.

2.1.6 Designing "mindful design" interventions

> "The currently most prominent application of design for behaviour change is in design for sustainability ... or health. Although there is an emerging recognition of the social potential of design, design for social behaviour change has remained ignored and under-researched". (Niedderer, 2013, p. 4561).

In *Mindful Design as a Driver for Social Behaviour Change,* Niedderer (2013) criticized the lack of a body of research in the field of design for behaviour change, but also offered a helpful approach and explanation of why mindfulness is a key element when designing to positively manipulate people's actions. Niedderer pointed out the advantages of mindful design, which integrates the user and gives choice, as opposed to persuasive design, which by having pre-defined and aspired outcomes is rather authoritarian.

According to Niedderer (2013), mindfulness is a psychological concept that describes an open and conscious attitude toward new information and contexts while also critically reflecting to find and construct new solutions. In this sense, mindful design for behaviour change relies on the users' ability to evaluate their situation and undertake the steps necessary for improvement. As design interventions are non-personal — and therefore passive — design cannot force behaviour change. However, sophisticated design strategies certainly initiate voluntary engagement. As an example of mindful design, Niedderer gave the example of the redesign of a traffic junction in the Netherlands. The city of Groningen removed all traffic signs for cyclists after realising that less signage resulted in increased awareness and responsibility and a decline in the number of accidents.

By involving people actively in the solution-finding process, social problems can be tackled. Another way to do so is by applying participatory methods. Including people's opinions gathered through interviews or even developing common strategies, as in co-design, not only create a better understanding for the situation for both the designer and the target group, they also help to broaden perspectives of those involved by acknowledging different points of view.

In summary, mindful design for behaviour change has enormous potential, if regarded as an impulse generator for social innovation. Pol and Ville (2009) analysed numerous existing definitions for social innovation, from which they developed the following interpretation: "an innovation is termed a social innovation if the implied new idea has the potential to improve either the quality or the quantity of life". (Pol & Ville, 2009, p. 881).

In this sense, designers must become aware of how powerful their interventions can be and sensibly apply their knowledge to create better life conditions.

2.1.7 Value Theory / Appraisal Theory / Emotional Design / Social Status

The reasons for one individual's appraisal of another individual, a concept, or an artifact are studied in value or appraisal theory. In design research, scholars study how objects' qualities or characteristics create emotional attachment in their users. According to Cupchik (1999), emotional connections are categorized as "sensory/aesthetic, cognitive/behavioural, and personal/symbolic". (Cupchik, 1999 p. 76). Fundamental influences on emotion toward an object are ascribed to cognitive/behavioural factors, since the interaction requires knowledge and conscious examination of the object. Whether or not the handling of a designed product or software is enjoyable or disappointing depends on its usability; in other words, usability engenders an emotional reaction, thereby creating feelings toward or against the object. (Cupchik, 1999).

Likewise Desmet and Hekkert (2007)'s model examines product experience on three levels, namely: aesthetic experience, experience of meaning, and emotional experience. (Desmet, & Hekkert, 2007). Similar to Cupchik (1999)'s classification, an experience that pleasurably stimulates the senses falls under the category of an aesthetic experience. For example an aesthetic experience might be one's appraisal of a shape, a material, a sound, or even a scent. The second level which is experience of meaning, describes one's cognitive measures to evaluate a product's attributes and connotations. Here, the symbolic characteristics of a product like an intangible value affects the product experience. In contrast to the conscious evaluation of aesthetics and meaning, emotional experience is referred to the interpretation of the overall experience with the product. In other words, on the emotional level, feelings like desire, pride, or anger and disappointment are assessed in respect to the product. (Desmet & Hekkert, 2007).

An emotional relationship between an artifact and its user is also characterized through a symbolic value one gains through its possession. In this situation, the object acts as a communicator to transmit a certain message. Chapman (2009) states that material objects can be

interpreted as carriers of meaning that symbolize a person's ambitions and existence. (Chapman, 2009). In this sense, artifacts are people's requisites to write their own role in society. Or as Polonius put it when he gives advice to his son Laertes before leaving for France: "clothes make the man". (Shakespeare, The Tragedy of Hamlet, Prince of Denmark, 1599-1602 p. 3).

Following this line of thought, I would like to mention briefly the concept of social status. In psychological research the terms social identity and social status are used interchangeably. Middleton (2008, p. 621) states that "Social Status has been used throughout history to differentiate individuals and groups of people in order to maintain hierarchical systems (...)". Social status is "one's legal or professional standing within a group". In Social Identity Theory, Ellemers (2010, p. 798), describes social identity as follows: "When people interact in groups or think of the way their group relates to other groups, they do not always think of themselves as separate individuals (...). Instead, they may think of themselves and act as group members (...)".

Coming from this initial position, affiliation implies behaviour expectations as well as identity in the social context. People categorize and compare by distinguishing between in-group or out-group affiliation. Because of the fact that membership is a way in which one defines one's identity, it results in people attempting to improve the perception of their group to achieve higher esteem. (Ellemers, 2010). Ellemers (2010) explains a strategy for enhancing perception called social creativity. This strategy can be applied in three ways: firstly, by pointing out existing positive attributes to highlight differences with respect to applicable out-groups; secondly, by generating awareness within the group through accentuation of established advantages; thirdly, by contrasting in-group characteristics with a reference group, referring on potential amenities.

In the context of this thesis respectively regarding factors that influence one's modal choice, social status is directly connected with the perception of the status of a specific transport mode. Unfortunately, public transportation still suffers from an image that is associated with

inconvenient schedules, long waiting times, and crowded compartments during rush-hours. Whereas personalized individual traffic is often seen as a more flexible, comfortable, and privileged method of transportation.

One attempt to change this perception is to change the individual's experiences by informing them about comparable measures that illustrate the advantages and disadvantages of different transport modes. As mentioned earlier, product experience occurs on three levels through user interaction. Experience is not a product feature, it evolves through examination and naturally, as people differ from one another, experiences depend on local, temporal, and of course personal circumstances (Desmet & Hekkert, 2007). For that reason, an over-simplified product might improve usability for one user, but could disappoint another, as he or she does not feel challenged to master a product's capabilities and in turn the lacking accomplishment does not satisfy his or her expectations. In order to meet different users' dispositional requirements human computer interaction and personalization need further investigation.

2.2 Human-computer interaction theory

As Human Computer Interaction (HCI) is a relatively new discipline, it seems the necessity to define its realms is still ongoing. One difficulty in defining HCI is, that due to vast technological developments, the boarders of the HCI field need to be reset constantly. In 'User Interface Design Principles for Interaction Design', Blair-Early, & Zender (2008) remark that "in the past, HCI often has focused on interfaces primarily as tools that manage a computer or computer software. However, computer interfaces are no longer experienced only as tools for using computers, but as frameworks for exploring content". (Blair-Early, & Zender, 2008, p. 87). Put differently, the authors state that interfaces constitute an underlying structure in order to delve into its material. On the other hand Karray, Alemzadeh, Saleh, & Arab (2008), frame HCI as "a design that should produce a fit between the user, the machine and the required services in order to achieve a certain performance both in quality and optimality of the services"

(Karray et al. 2008, p.138) which rather appears as a description for an adapter — a connecting piece that brings units together that do not match naturally. Starting from these varying perspectives, a closer look on how HCI evolved can shed light on its interpretation.

With the beginning of the era of personal computing, HCI channelled into two paths. Coming from an interface for programmers to design and test software, a new interface for users comprehending and applying the application was required. (Carroll, 2014). Apple's Original 1984 Mac OS desktop interface serves as an example for these first attempts to create an interface that met operating users' needs. The concept called 'messy desk metaphor' is based on the idea that the physical desktop is projected into a digital environment. This translation of familiar circumstances into a virtual context helped users to grasp the overall context of a new file system. Icons for folders, files, and a trash bin were displayed as pictographical signs reflecting physical appearances of these objects in the physical world.

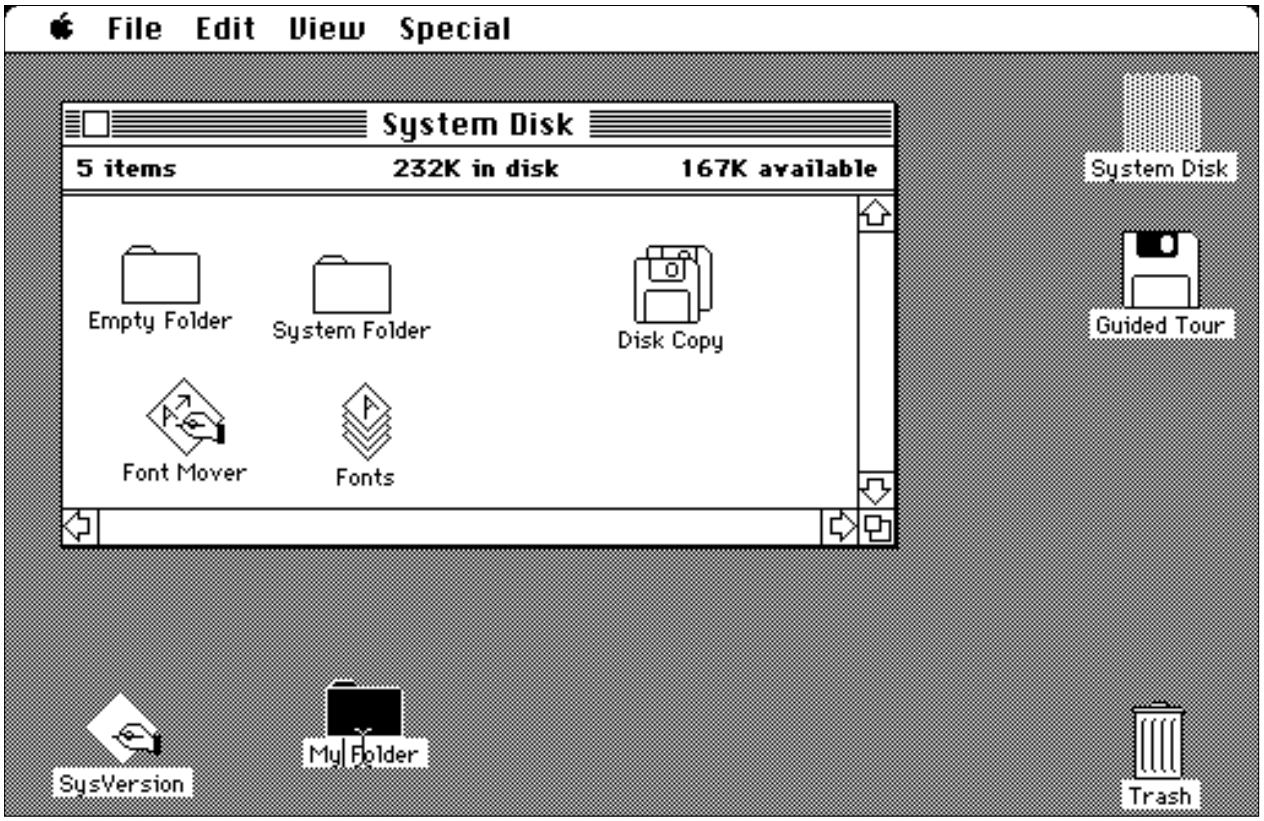


Figure 13: Original 1984 Mac OS Desktop, Retrieved April 27, from http://en.wikipedia.org/wiki/History_of_Mac_OS

In 'The Encyclopedia of Human-Computer Interaction' by Carroll (2014) the author presented the development of HCI as a three-step process. HCI moved beyond the desktop when personal productivity interactions (e.g. text processing) began to occur. During this phase the design of the interface acted as a translator to enable communication between the operator and the software. With further technological developments, HCI and interface design then moved to a state where the interface turned into a receiver, translator, and sender to support communication with another human being, using the computer as a communicative aid (Carroll, 2014). The third phase of HCI design is characterized by constant communication with and through computing, based on ubiquitous devices as laptops and smart phones with constant data exchange. (Carroll, 2014).

During these stages of development, HCI and HCI research did not include designers and design researchers. Similar to other disciplines that stem from an engineering background, HCI — if at all, treated design as a stylistic post-production tool and therefore considerations on human-centered design did not take place. As a result, engineers did not completely examine what users wanted and therefore the information regarding what needed to be built was missing. (Evenson, Forlizzi, & Zimmerman, 2008). Because of this, product development without upfront research did not reveal potential gaps in the engineers' models.

A common expectation toward HCI recommends that the interface's design must be 'easy-to-use' or 'implicit'. For example, Ju and Leifer (2008) argue the key to optimized services — and, therefore, to a well-functioning human-computer interaction — is when interactions become implicit and communication between human and system, or vice versa, is a dialogue that does not require tools for communication. (Ju & Leifer, 2008). In contrast, (Blair-Early & Zender, 2008) point out if implicity is equated with familiarity, "then creativity and novelty certainly will suffer". (Blair-Early & Zender, 2008 p. 86). An advancement in a setting where well-known principles are applied will not occur in an advancement that will move away from an unsatisfactory status quo.

2.3 Mass-personalization and mass-customization

The Knowledge Discovery and Data Mining (KDD) association board describes personalization as “a process of collecting and using personal information to uniquely tailor products, content and services to an individual”. (Tuzhilin, 2001, p. 116). In other words personalization can be described as managing personal content material to evaluate and generate information that adapts to individual needs or the interests of the user.

In scientific literature the terms ‘mass-personalization’ and ‘mass-customization’ are sometimes used interchangeably. However, Valenzuela, Dhar, & Zettelmeyer (2009) explain that the terms have different meanings. Mass-personalization describes a process where the producer decides which product configuration will best suit to the customer’s needs, according to previously collected customer data whereas mass-customization occurs when the customer is proactively involved into the specification process of his or her product. (Valenzula, et al., 2009). Within this thought, one example for mass-personalization would be Amazon’s web-shop recommendations based on former search entries and purchases. Mass-personalization meanwhile occurs more frequently than customers would expect, for example Google’s search results are by default a selected presentation of findings that correspond to prior queries. Mass-customization on the other hand requires the customer’s engagement with the producer’s choice of services. In this case the producer offers an interface where the user is given either a choice of product alternatives or product attributes to choose from. (Valenzula, et al., 2009). An example for a ‘by alternative’ customization method is Apple’s web-shop where the user can compare specifications and prices of available hardware models. Another example would be MyMüesli.ch which offers customers the ‘by attribute’ customization, a web-shop where clients can choose from over 80 different cereals to create their own mixture.

In the article “Personalized Content Recommendation and User Satisfaction” the authors present three theories regarding why personalization and customization produce clear benefits. At first, user-tailored information increases satisfaction, as the user is not confronted

with an information overload, but with information that responds to the user's interests. Secondly, a positive impact on user satisfaction results from encouragement of applications and compensations. Thirdly, users favour selected subject matter, provided that it corresponds to previously entered preferences or settings. (Liang, Lai, & Ku, 2006/2007).

Pine and Joseph (1993) state that mass-customization is one out of four options for business competition. According to the authors, companies only can succeed if they apply and outplay opponents by invention (advanced solution), mass-production (corrected costs), continuous improvement (quality management), and finally — mass-customization (increased satisfaction). To achieve mass-customization, Pine and Joseph (1993)'s solution is "that products [can] be modularized to provide unique combinations for any customer". (Pine & Joseph, 1993, p. 1).

Kumar (2007) states that the more a product is 'soft' the more a company can transform to offer mass-customized solutions. 'Soft' in this context means, if a product can be manufactured electronically. (Kumar, 2007). Kumar (2007) goes on to further state that six underlying factors are a prerequisite for implementing the transformation. Among these are a Web 2.0 interface, ubiquitous internet access, and of course the customer's willingness to interact.

In the context of this thesis, the focus of mass-personalization and mass-customization clearly lies not in maximized business profits, instead advanced user satisfaction with the service per se are the desired outcome, resulting in an increased frequency of usage.

2.4 Knowledge Visualization

"Today an ever-changing visual stream flows before our eyes: never before has all that we see around us altered so completely from day to day. We shut our front door in the morning, posters shout at us from wall and tube station. Even when the motorist seeks the country

he finds both his road and the finest landscape disfigured by great advertisement hoardings proclaiming the worth of beer and soap, hotels and cars and the latest fruits of Hollywood." (Neurath, Eve, & Burke, 2010, p. 3) This eloquent quote has not lost its relevance, however, it is more than 70 years old. When Otto Neurath worked on his so called 'visual autobiography', these were his introductory words.

As time has passed, the amount of availability and access to information, whether written or illustrated has increased tremendously. The sheer amount of data that is stored, produced, and requested has reached an unconceivable volume. Nowadays, on average Google processes around 2.4 million search queries per minute. In the same amount of time, 2.5 million posts are shared on Facebook, 300,000 tweets are published, and the list goes on (Gunelius, 2014). Distinguishing between useful data and useless data has not only become more difficult, it is also a tremendously time-consuming task. In 'Information Graphics' Sandra Rendgen (2012) describes data as the new raw material. Nonetheless, according to her, the raw material is of trivial value, as only refined and classified information becomes useful and precious information. (Rendgen, 2012). In this regard the expectations toward future developments in systems that collect, process, and display data in ways that are easily understood, are high.

Starting from this perspective, the aim of knowledge visualization is to structure a high volume of information into smaller, easy accessible and understandable materials. In information design, knowledge visualization plays an important role, as it is the way in which graphic design supports receptivity and comprehension.

Tergan and Keller (2005) put it as follows: "Visualizations of knowledge are needed to make knowledge explicit and better usable, as well as to make sense of information structures". (Tergan, & Keller, 2005, p. 2).

Burkhard (2004) also stresses the importance of knowledge visualization. First, because knowledge visualization pre-distinguishes information into a big picture and its details.

Second, it respects its readers' limited time and capacity to receive information. Third, it acknowledges different levels of cognitive experience. And fourth, it supplies differing groups of interest with the facts. (Burkhard, 2004).

In his famous book: "Interface: An Approach to Design", Gui Bonsiepe (1999) argues:

> "A typographer designing a book layout not only makes the text visible and legible, the interface work also makes it interpretable. Competency in handling visual distinctions like size and type of font, negative space, positive space, contrasts, orientation, color and separation into semantic units makes the text penetrable to the reader. Typographic design is the interface to the text". (Bonsiepe, 1999).

Building upon this analogy, a designer developing knowledge visualization not only translates abstract information into physical, yet two-dimensional attributes, the knowledge visualization also must make it understandable in terms of applying cognitive principles the human brain can perceive.

In "Gestalt psychology: An Introduction to New Concepts in Modern Psychology", Wolfgang Köhler (1947) presents a collection of different ways in which visual information is translated by the human brain into patterns and forms to make it understandable. To name a few, 'proximity' is one principle that relates objects to each other and therefore are perceived as a group. Objects with related appearance in shape, colour, or size are perceived as an entity. Köhler (1947)'s principle of 'enclosure' describes the collection of objects with a visualized boundary

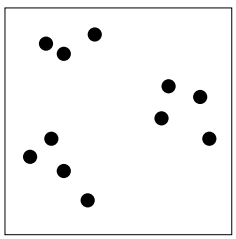


Figure 14: Proximity

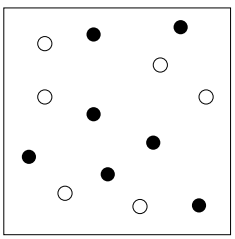


Figure 15: Entity

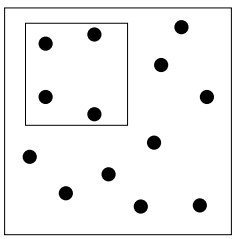


Figure 16: Enclosure

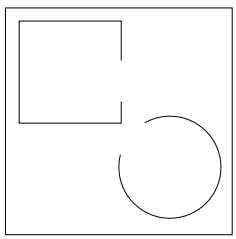


Figure 17: Closure

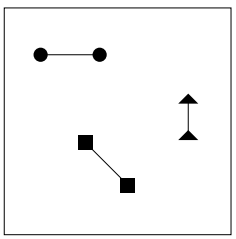


Figure 18: Connection

in form of an embracing line or surface as a method to perceive grouped objects, and on the contrary, 'closure' refers to objects that are perceived or interpreted as a whole. Another principle is 'connection', attached objects are identified as a group.

A pioneer in the field of knowledge visualization, Edward R. Tufte (1990), stated:

> "Even though we navigate daily through a perceptual world of three spatial dimensions and reason occasionally about higher dimensional arenas with mathematical ease, the world portrayed on our information displays is caught up in the two-dimensionality of the endless flatlands of paper and video screen." (p. 13).

This being said, new technological developments already open up new ways to escape from two-dimensional constraints into three-dimensional, animated, and constantly updated visualized information.

In this sense, Donald Knuth (2011)'s response to "What would provide the greatest impact on (to) humanity? What is left to discover, built, or create?":

> "On top of my list would be in the medical field, making patients' histories visually easy to understand (...) and all kind of things about health [easy to understand]. And I think there is a tremendous opportunity not just to give things in terms of pie charts (...)" (Knuth, 2011),

is a ground-breaking conclusion of both: future design opportunities in knowledge visualization and in terms of how to improve personal and ecological health.

Chapter 3: Review of current technological developments toward improved fitness and transportation behaviours

3.1 Mobile sensing systems

Current generations of smart phones are equipped with several types of sensors and have opened up a whole new world in terms of mobile sensing. In combination with other technologies integrated in smart phones (e.g., wireless sensor networks, GPS), data collection, data exchange, as well as data evaluation are processed nearly simultaneously. Mobile sensing already pervades life in modern societies, and future developments will have a revolutionary impact on micro- and macroscopic individual, communal, and societal levels. Information from human-centered sensing — whether gathered and applied in private or public spaces — as well as information from environment-centered sensing as urban or vehicular data offer great potential to understand peoples' interactions with their surroundings in a new way.

Access to the potential information that can be sensed has been gained by making smart phones programmable. A software application (app) installed on a smart phone is required to be able to do so and serves as a translator of sensed data. Depending on the position of the phone, the app for the mobile sensing system displays information of "personal (healthcare sensing), vehicular (vehicular sensing), home (smart homes), urban (urban sensing) or city (smart cities), rural, a local geographic area or a global geographic area...". (Macias et. al., 2013, p. 17293).

For better understanding, table 1 gives an overview of four popular smart phones and presents different kinds of integrated sensors they are equipped with.

Sensor Type	Google Nexus 6	HTC One M9	iPhone 6	Samsung Galaxy S6
Accelerometer sensor	x	x	x	x
Compass sensor	x	x	x	x
Gyroscope sensor	x	x	x	x
Image sensor	x	x	x	x
Light sensor	x	x	x	x
Proximity sensor	x	x	x	x
Touch sensor	x		x	x
Temperature sensor	x			x
Humidity sensor				x
Atmospheric pressure sensor	x			x
Capacitive sensor	x			
Audio sensor	x		x	
Step counter and detector	x		x	
Touch ID fingerprint reader			x	
Gesture sensor				x
Hall effect sensor				x
Infrared sensor				x

Table 1: Sensors in smart phones, information based on manufacturer's data

The accelerometer sensor detects the orientation of the phone, adjusting the displayed content to the reader. Compass and gyroscope sensed data give additional information to the GPS measured position of the phone. The image sensor (camera) is used for taking pictures — that is, the user actively applies the sensor, which is defined as participatory sensing, or, as an example, the image sensor is used to track the eye movements of the user to identify utilization patterns. If the user is passively participating in collecting data, the process is called opportunistic sensing. (Macias et. al., 2013, p. 17293). Light sensors detect the ambitious light situation and adjust the screen brightness. The proximity sensor tracks physical objects nearby and the touch sensor enables the user to operate the phone and enter information. Anoth-

er important sensor is the microphone, which records audible data. Some smart phones are also equipped with sensors for temperature, humidity, atmospheric pressure, capacitive, step counter and detector, gesture, and hall effect. Apple's iPhone 6 has an integrated fingerprint reader. Additionally, common technologies in smart phones are GPS, WiFi, and Bluetooth.

Through activity recognition from human-centric sensing or environmental-centric sensing, different travel behaviour patterns can be monitored and exploited. Given that the data collection, data exchange, and data evaluation are being processed in a trustworthy manner, the information gathered is of great value for users, researchers, and the economy. However, the collection of personal data, which contains information about health, location, or behaviour patterns, must be handled carefully. Future developments handling sensed data have to come up with solutions that will assure that data abuse is impossible. Another concern with mobile sensed data is the energy consumption required for their collection. Sensing, tracking, and communicating still consumes relatively high amounts of battery power. To create mobile sensing systems that create precise data, battery life must be increased.

3.2 Mapping applications

For both common platforms like Android and Apple, plenty of mapping applications are available. Whether they are for free or they need to be purchased, in general their functions are very alike.

During the past few years their accuracy has also increased dramatically, and either developed from a tech-giant e.g. Google (Google Maps), Apple (Apple Maps) or a crowd-sourced community (Waze), information provided by these applications generally include search directions, turn-by-turn voice-guided GPS navigation, live traffic conditions, route recommendations, speed warnings, data about points of interest (cultural and business locations), estimated time of arrival, and the feature to save maps for offline access as well as several other

features. Some provide information on fuel price differences along the trip, others inform the user about public transport fares, while others automatically program coordinates from destinations that are saved events from the calendar software.

Based on a search results in both app stores, Google Play and iTunes, the most common mapping applications for smart phones are Google Maps, Apple Maps, Waze, OpenMaps, Nokia Here, Scout GPS, TomTom, and MapQuest.

3.3 Health applications

Similar to the variety on mapping apps the selection of health and fitness mobile applications is extensive. Users can choose from a wide range of topics, e.g. nutrition for healthy diet or weight loss, physical activities for fitness, guides for meditation and relaxation, heart rate-, step count-, or sleep pattern monitoring. Based on user ratings, among the most popular apps is *Fitbit*, a GPS connected software that tracks active time and for more precise information allows pairing with additional Fitbit device(s) to keep its wearer informed about personal accomplishments and a food diary. Likewise, *Jawbone UP* features physical activities, diet, and sleep patterns and sends reminders to motivate the user to keep his or her resolutions up. *RunKeeper* is specialized for running-training, suggesting routes, measuring pace, elevation, effort, and progress. The user creates his own profile and can connect to others, comparing stats and achievements. Peer comparison is also a main feature of *30 Day Fitness Challenges*. The app motivates users to endure a certain activity (planks, squats, jumping jacks...) on a daily basis for at least one month.

Apple's health app *Health* collects all kinds of personal data and allows access to emergency information (name, emergency contact, blood type, allergies...) while the phone is locked, ensuring that health information is not only available for one's personal interest but also one's personal safety.

Chapter 4: Review state of the art projects on active commuting as a way to improve personal and/or ecological health

4.1 Project Peacox

Peacox is an international research project, formed in 2011, and financed by the European Commission, with the aim to provide users with personalized information that persuades people to move towards more environmentally-friendly trip planning and as a result causes a behaviour and attitude change. Currently the project is still under development and not available for public use. Through web and mobile based technology the travellers' personal needs, situations, and preferences will be considered for trip recommendations that reduce CO_2 emissions. Peacox's concept idea is based on real-time updates that will support improved navigation, and motivate users to choose more sustainable means of transportation. With these features Peacox's goal is to offer a solution that contributes substantially in reducing the carbon footprint while respecting travellers individual circumstances and their comfort. The project members state that their main focus is on user-centered information, tailored to support decision-making for sustainable transport solutions. Project Peacox, (2014). In *Project Overview,* Retrieved from http://www.project-peacox.eu/project-overview/

Peacox explains that an achievement of a behaviour and attitude change stems from user-engagement. Collected material from research and user behaviour will allow Peacox to create automated analysis and subsequent prediction of movement patterns and trip purposes. Moreover, the project plans to provide precise data on CO_2 emissions and exposure levels, taking into account traffic conditions, weather, etc. With its strategies and interfaces Peacox combines ecological trip choice with guidelines to implement behaviour change strategies Project Peacox, (2014). In *PEACOX – Your personal travel assistant for a greener city,* Retrieved from http://www.project-peacox.eu/home/

Although the project has eight collaborators from six different countries, including well-known universities and independent research institutions, and is funded by the European commission, the website of the project has not been updated since 2014 and the latest research results have been published as of November 2013. The application is not available for download, however after sending a contact request the author was permitted to share a restricted beta-version download link. The Peacox real-time approach combined with user-centered design and user-engagement certainly goes in a good direction, however, it lacks the component of including personal health benefits when advertising sustainable travel modes.

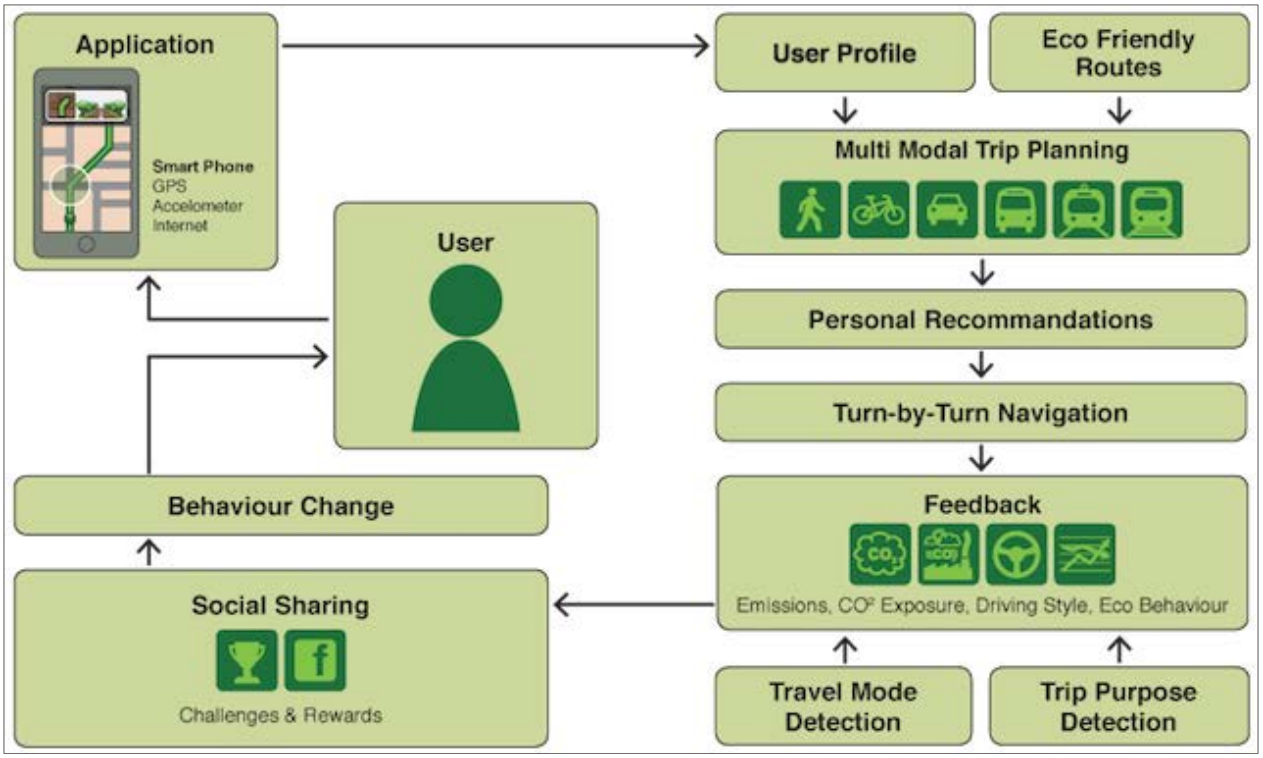


Figure 19: Illustration Peacox model, Retrieved April 28, 2015, from http://www.project-peacox.eu/project-overview/

4.2 Mobility Lab

Mobility Lab is a start-up organization created by Arlington County, Virginia to measure the impacts of Transportation Demand Management (TDM) services in the area. Mobility Lab is interconnected with several transportation agencies that provide the greater Washington D.C. area with public transportation infrastructure. One of Mobility Lab's goals is to communicate research of its in-house TDM as well as its partners to improve and strengthen alternatives to driving (by car). With its efforts Mobility Lab has helped to shift more than 40,000 car trips per work day from personalized motor vehicle transport to other forms of transportation. The organization posts its activities on a blog and has a wide collection of information on the topic, including the fields of economy, health, technology, policy, community design, and travel. The start-up also works closely with national TDM agencies in order to share and improve sustainable transportation solutions for enhanced infrastructure. Mobility Lab describes itself as a think tank based on three pillars, namely research, collaboration, and communication. (Mobility Lab, 2014). In *Moving People Instead of Cars,* Retrieved from http://mobilitylab.org/about-us/

One of Mobility Lab's supported projects is the Transit Tech Initiative, with a web-based trip planning tool called 'CarFreeAtoZ' that allows users to choose from different modes of transport in the Arlington County area. This project offers solutions tailored to individual needs and preferences by comparing modal choice availabilities, trip lengths and durance, as well as trip fares. CarFreeAtoZ works with open transport data from OpenStreetMap and planning engines like the multi-modal trip service offered from OpenTripPlanner. (Mobility Lab, 2014). In *Moving People Instead of Cars,* Retrieved from http://mobilitylab.org/2014/11/07/the-who-what-when-where-whys-of-carfreeatoz/

With the aformentioned collaborating partners CarFreeAtoZ connects important places in a person's life through various travel options, evaluates in real-time how strong those connections are, and supports simplified decision-making for the best transportation choice.

The extensive network helps to promote alternatives to solo-driving, however, the project CarFreeAtoZ does not include personal health benefits from active commuting and the software has not been made available as a mobile application.

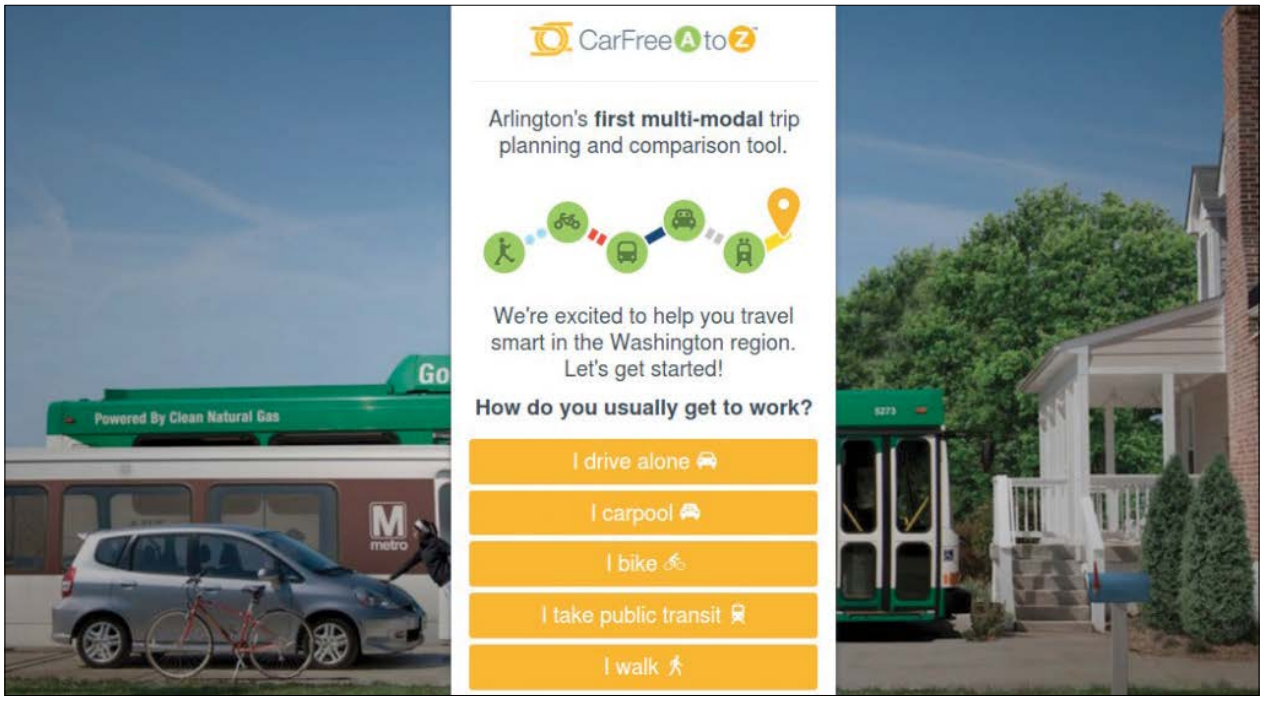


Figure 20: Application CarFreeAtoZ web application, welcome screen, Retrieved April 14, 2015, from http://mobilitylab.org/wp-content/uploads/2014/11/welcome_screen.jpg

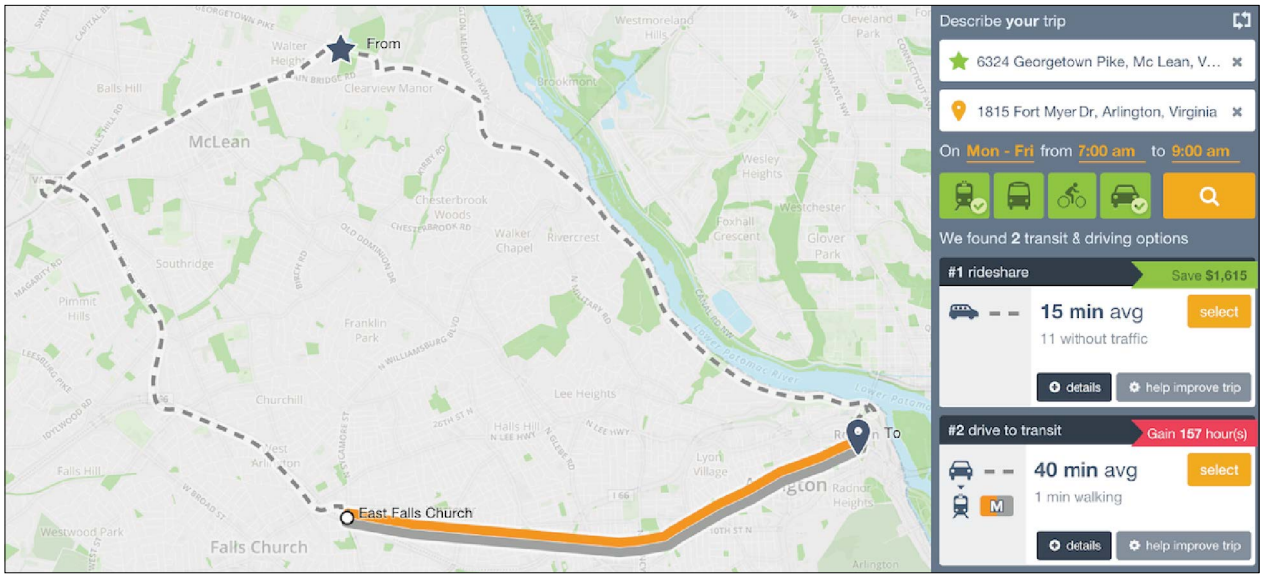


Figure 21: Application CarFreeAtoZ web application, directory query, Retrieved April 14, 2015, from http://arlington.dev.conveyal.com/planner?from=4301%2013th%20St%20NW%20Washington%2C%20DC%2020011&to=2100%20Wilson%20Blvd%2C%20Arlington%2C%20VA&modes=BICYCLE%2CBICYCLE_RENT%2CBUS%2CTRAINISH%2CWALK%2CCAR&start_time=7&end_time=9&days=M%E2%80%94F

4.3 TEAM

TEAM is a European research project that turns static mobility into elastic mobility. The European Union supports this collective research with co-funding. The project's vision is a compelling advancement in traffic safety and efficiency while considering environmental developments. Through mobile devices TEAM targets all road users to collaborate for optimized mobility and improved safety. The project length is four years and was started at the end of 2013. Its 28 members cover a broad spectrum including research institutions, car manufacturers, telecommunication providers to traffic infrastructure planners, among others. (Team, 2013). In *TEAM Basic information*, Retrieved from http://www.collaborative-team.eu/

According to the project's website, TEAM's main goals are optimized algorithms that support joint decision-making, development of technological units for a traffic cloud network, instant adaptation of traffic users' needs, traffic user participation, analysis of the TEAM's impacts and accomplishments, and the promotion of collective mobility. (Team, 2013). In *TEAM Research and methodology*, Retrieved from http://www.collaborative-team.eu/overview/methodology.

The outcome of the TEAM project aims to improve marketability within the next decade. Though the project description highlights the importance and equity of all road-users, with the project's compilation of collaborators from the automotive and infrastructure sector, and with no collaborator from an environmental organization, the focus of TEAM appears to be mainly on optimization for motorized traffic users, less on alternative travel modes, and little on ecological aspects. Moreover, TEAM does not feature personal health implications of optimized mobility except from its goal in reducing traffic fatalities.

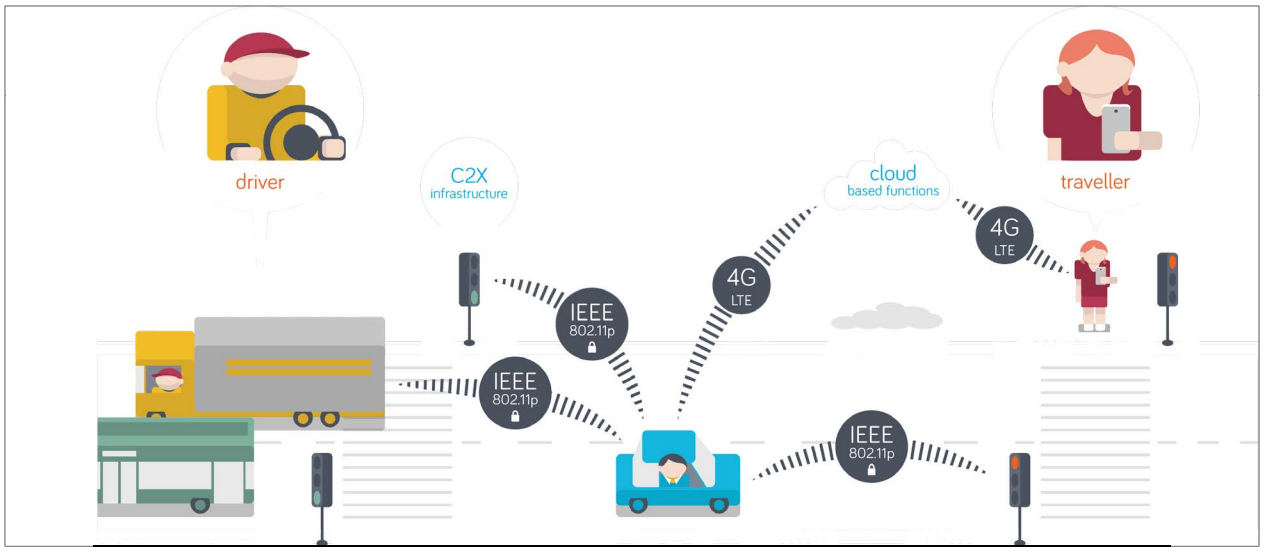


Figure 22: Illustration TEAM model, Retrieved April 14, 2015, from http://www.collaborative-team.eu/overview/

4.4 Moving Forward: Trip Calculator

Moving Forward is a data journalism project about the future of transportation in downtown Vancouver. It was started in 2012 to create an area for journalists to undertake self-initiated research on transportation issues instead of merely picking a side of existing opinions. Moving Forward is a web-based platform where news and information about Metro Vancouver's infrastructure, planning, costs, but also transportation issues in general are published and discussed. One of the Moving Forward projects' investigates the full cost of a commute. In order to answer this question a team of journalists and researchers worked together and developed the 'Trip Calculator', an interactive calculator that takes into account hidden costs of transportation such as the expenses that occur through taxes to provide road infrastructure or health costs that happen due to traffic injuries. (Moving Forward, 2015). In *1.4 What is the full cost of your commute?*, Retrieved from http://movingforward.discoursemedia.org/costof-commute/

In addition, the tool also considers benefits of certain means of transportation and therefore enables comparison. The model the calculator applies is called 'full-cost-accounting' and its main goal is to uncover how different methods of transport affect the individual and society.

The trip calculator is an interesting concept that allows Vancouverites to do their own math and consequently make up their mind about political discussions as well as their choices. Though the calculator respects a great number of influencing factors, the project does not include the idea of customized information in its concept.

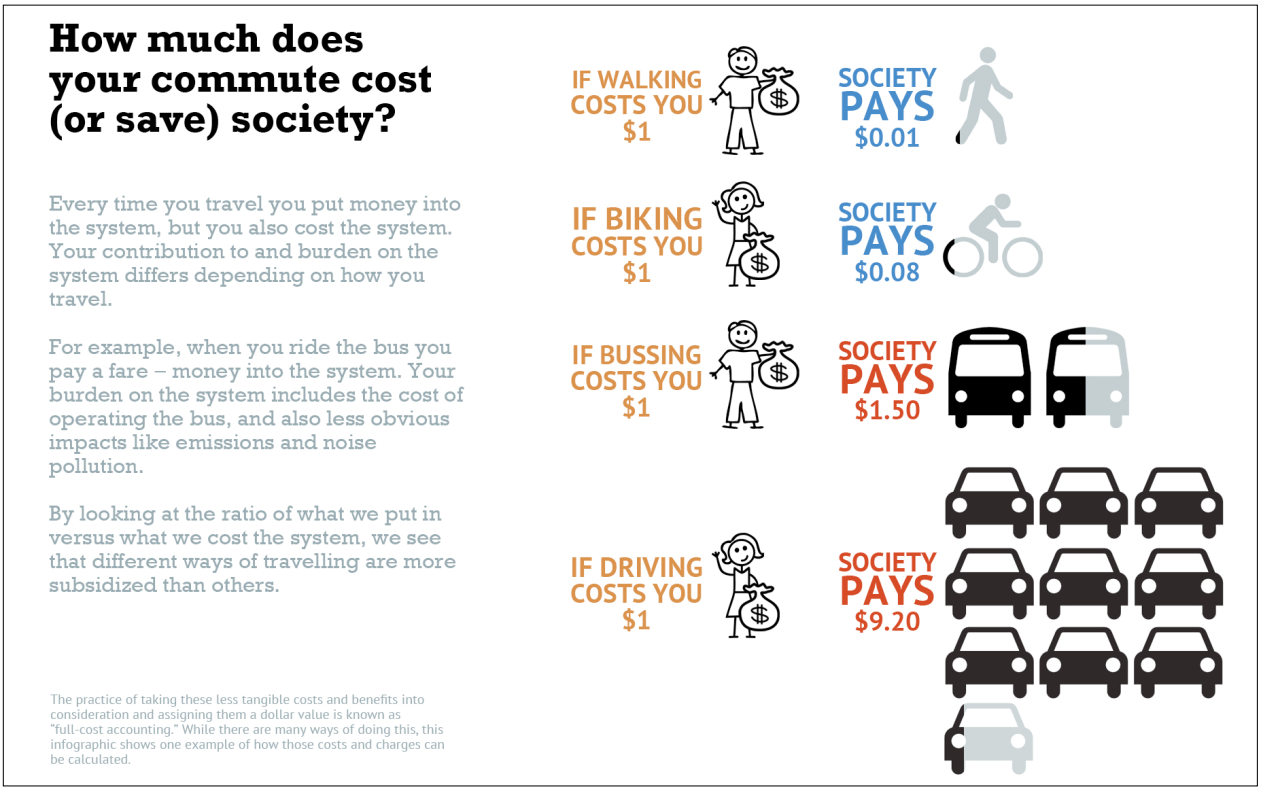


Figure 23: Illustration Moving Forward 1, infographic_2_subsidy_v03, Retrieved April 14, 2015, from http://movingforward.discourse-media.org/costofcommute/

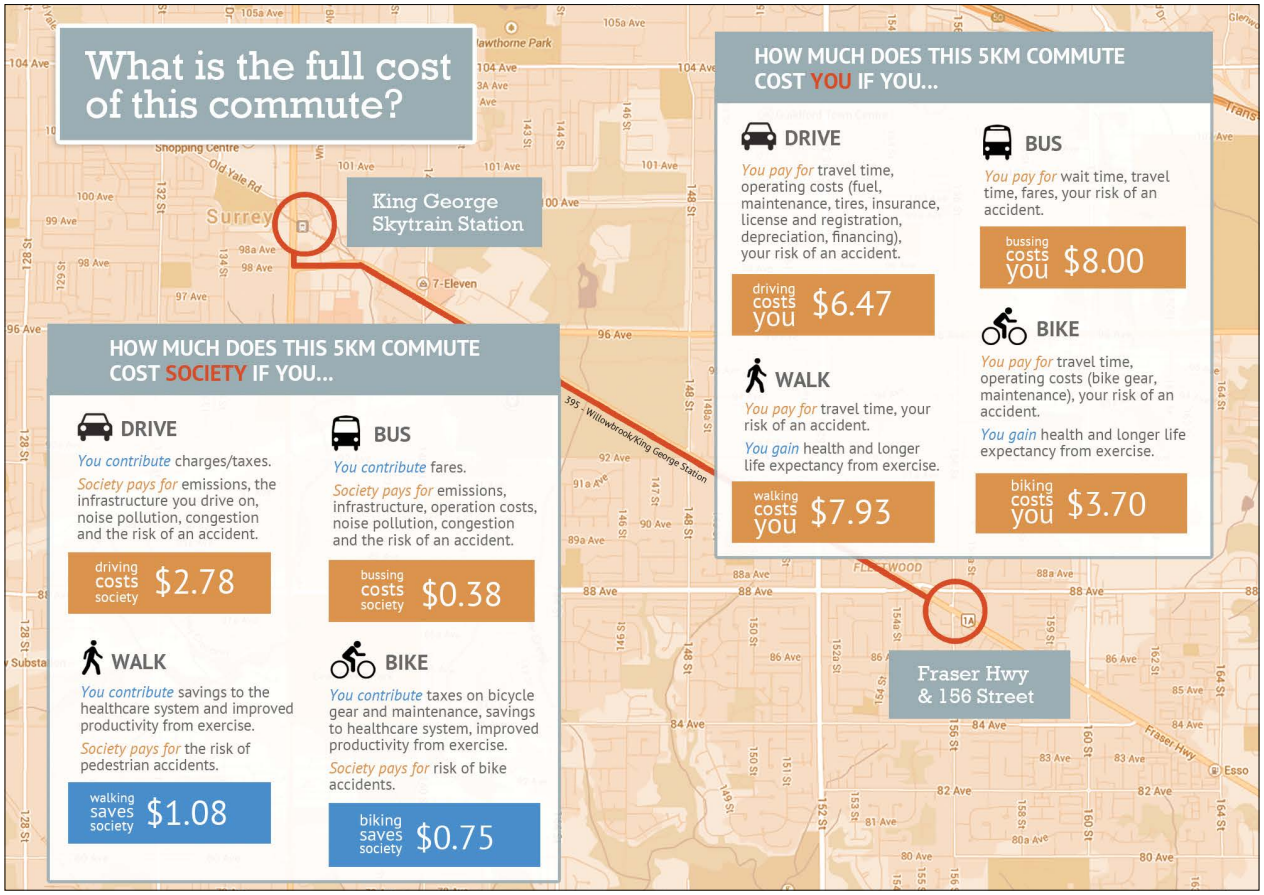


Figure 24: Illustration Moving Forward 2, Infographic_1_scenario-map_v04, Retrieved April 14, 2015, from http://movingforward.discoursemedia.org/costofcommute/

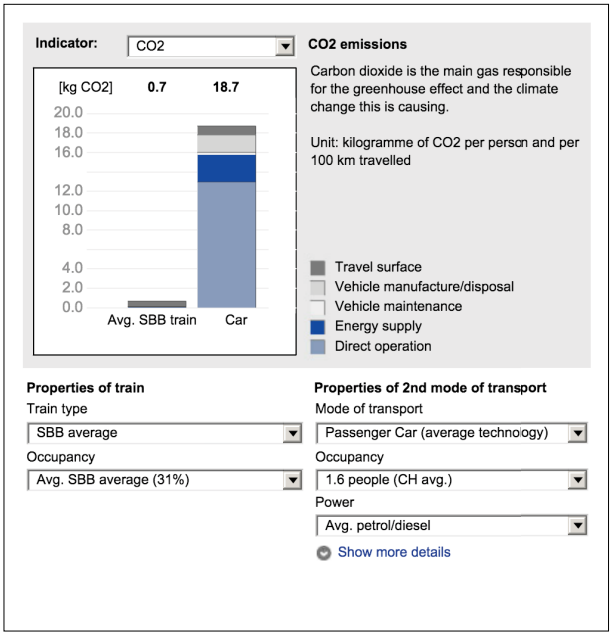
4.5.1 European Railway Companies

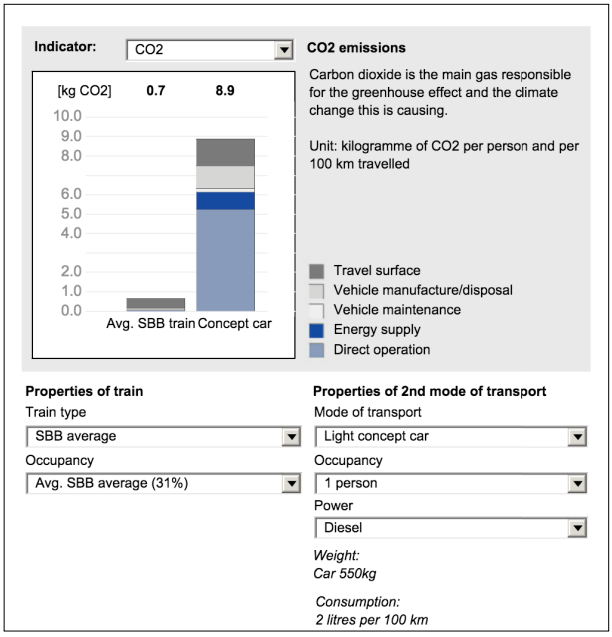
Public transportation is a very common method of transport in Europe. For example, nearly 130,000 people live in the city of Bern, whereas Bern's train station deals with twice as much travellers, around 260,000 people each day. (Wikipedia, Die freie Enzyklopädie, 2015). In *Bahnhof Bern*, Retrieved from http://de.wikipedia.org/wiki/Bahnhof_Bern. Though Europe's public transportation network certainly can compete with the benefits of personalized individual traffic, federal railway companies are subsidized and need to point out advantages of their services in order to keep commuter figures high and receive sufficient public funds. One way to illustrate advantages of public transport in comparison to individual motorized traffic is to present the ecological impact of a planned trip.

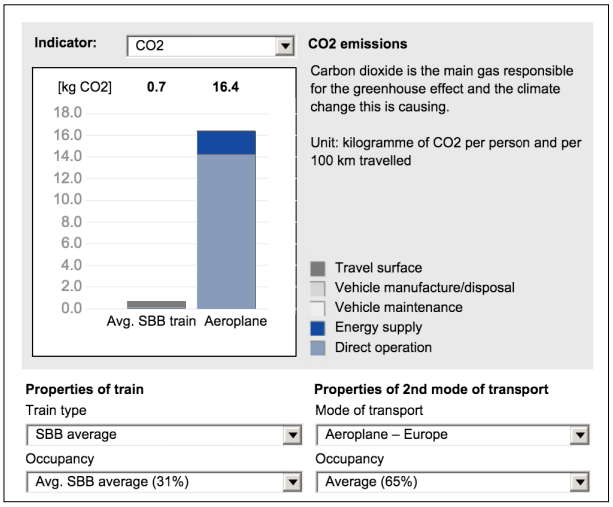
4.5.2 SBB (Schweizerische Bundesbahnen) | Swiss Federal Railways

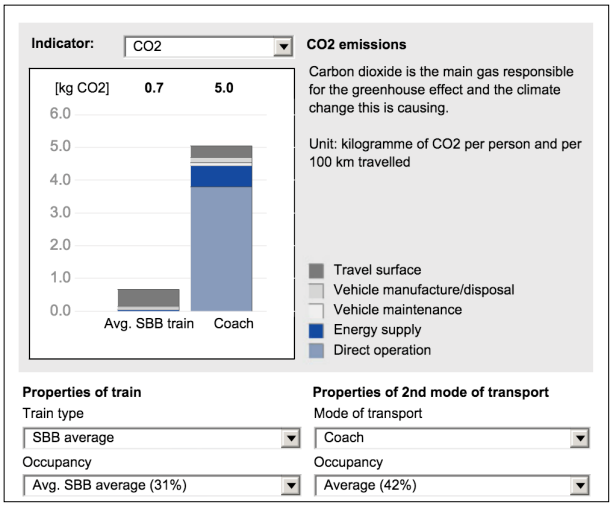
According to SBB's website, the calculated figures are based on default averages for capacity utilisation and fuel consumption. Additionally, the tool considers hidden costs from construction, maintenance and disposal of infrastructure and vehicles. The calculator also features a comparison with other modes of transportation and allows more detailed specification, e.g. type of car, number of passengers, etc. (SBB, 2015). In *Timetable*, Retrieved from http://www.sbb.ch/en/home.html

Figure 25: SBB Ecocalculator, Retrieved April 15, 2015, from http://www.sbb.ch/en/timetable.html









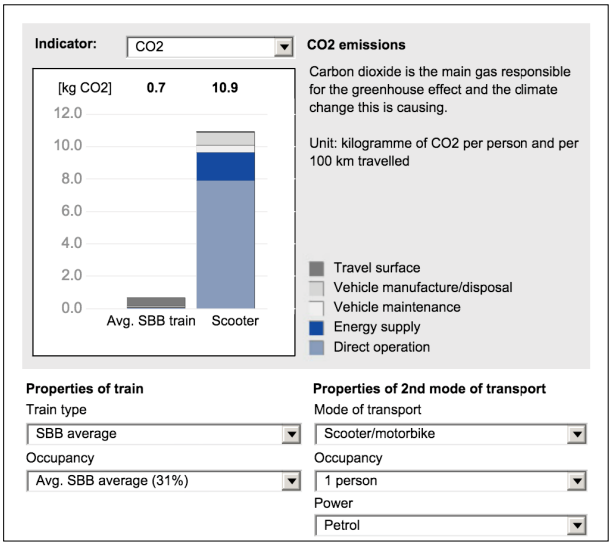


Figure 26-30: SBB Ecocalculator, comparison of transportation methods, Retrieved April 15, 2015, from http://www.sbb.ch/en/timetable.html

4.5.3 NS (Nederlandse Spoorwegen) | Dutch Railways

The Dutch railway company aims to reach high ecological objectives. The transportation provider states that mobility in the Netherlands is responsible for over 20 percent of CO_2 emissions. To reduce this amount, NS plans to increase its usage of renewable energy from wind farms from about 50 percent at the moment to 100 percent within the next three years. (NS, 2015). In Journey Planner, Retrieved from http://www.ns.nl/en/travellers/home. In other words, the Dutch railway company plans to virtually cause no more CO_2 emissions. The calculator on NSs' website presents figures of CO_2 emissions by comparing trains in general with three different types of cars. In addition, the tool informs the user that on average a train journey emits 75 percent less CO_2 than a trip done by car. (NS, 2015). In *Journey Planner*, Retrieved from http://www.ns.nl/en/travellers/home.

Figure 31: NS CO_2 comparison 1, Retrieved April 15, 2015, from http://www.ns.nl/en/travellers/home

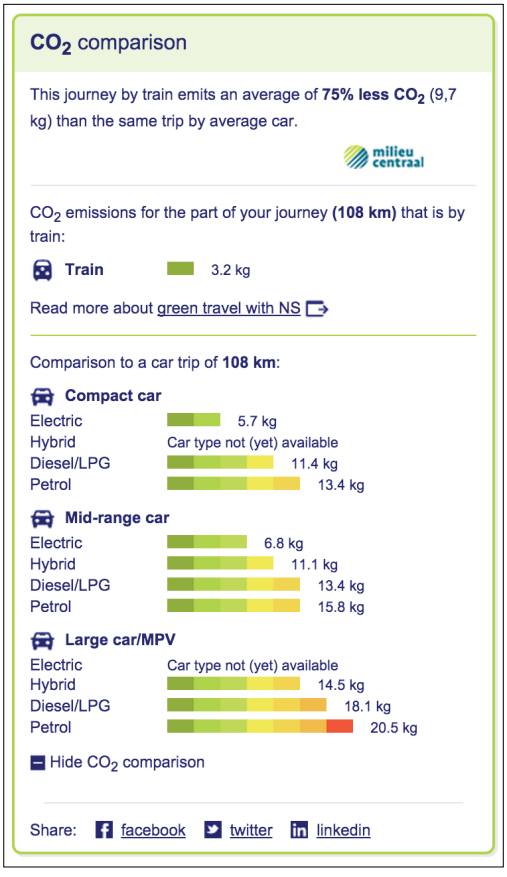


Figure 32: NS CO_2 comparison 1, Retrieved April 15, 2015, from http://www.ns.nl/en/travellers/home

4.5.4 SNCF (Société nationale des chemins de fer français) | French National Railway Company

SNCF's eco information is based on CO_2 emissions of one passenger travelling one kilometre, by type of train. The comparative data builds on national statistical data from France. (SNCF, 2015). In Billets & Info trajets, Retrieved from http://www.sncf.com/. The calculator is not designed to be user-friendly, as it is the traveller's responsibility to check the type of train for his planned trip in order to be able to calculate the emissions. For example, among other figures SNCF's website provides information on different means of transportation, but does not do the calculation:

Train TGV (bullet train):	3,4 g CO_2 per kilometre, per passenger,
Train intercité (inter city train):	11.9g CO_2 per kilometre, per passenger,
Bus:	101 g CO_2 per kilometre, per passenger,
Autocars interurbain (urban traffic):	171 g CO_2 per kilometre, per passenger, etc.

Chapter 5: Epistemological examinations

5.1 Action-Reflection: Why this approach?

With the identification of the problem it became clear that my thesis deals with a so-called "wicked problem". (Rittel & Weber, 1973). Scenarios with changing variables and different approaches cannot be solved with one solution that fits all. The variables as existing infrastructure, weather conditions, traffic policies, financial resources, access, and of course each individual's differing opinion and needs, influences the way in which the problem of insufficient awareness about impacts of sedentary lifestyles on personal and ecological health could be approached. Buchanan (1992) described wicked problems as "indeterminate" and argues that it is the design discipline that offers the ability to tackle wicked problems, because "design ... has no special subject matter of its own apart from what a designer conceives it to be". (Buchanan, 1992, p. 16). The subject matter of design is potentially universal in scope, because design thinking may be applied to any area of human experience. But in the process of application, the designer must discover or invent a particular subject out of the problems and issues of specific circumstances". (Buchanan, 1992, p. 16). Buchanan (1992) goes on to say that the designer creates "intuitively or deliberately" the scenario, recognizing all associated points of view, and designs the initial layout to establish an approach. (Buchanan, 1992, p. 17). Following this line of thought applying design thinking for problem-solving by analysing the current state, becoming aware of the variables and the scope of the situation, is essential to define a starting point. Papanek (1985) shares this idea and explains that "design is a problem solving activity and can never, by definition, yield the one right answer: it will always produce an infinite number of answers, some "righter" and some "wronger". The "rightness" of any design solution will depend on the meaning with which we invest the arrangement". (Papanek, 1985, p. 5).

This statement involves the crucial difference between hard sciences and design research: “Scientists problem solve by analysis, whereas designers problem-solve by synthesis”. (Cross, 2007, p. 6), keeping in mind that the main goal of design research is to improve overall design practice.

Herbert Simon (1969)’s famous words summarize the idea of the design practitioner’s responsibilities in one sentence: “the engineer, and more generally the designer, is concerned with how things ought to be — how they ought to be in order to attain goals, and to function”. (Simon, 1969, cited in Cross, 2007, p. 24). In this sense, “the practitioner (the designer) must construct an understanding of the situation as he finds it. And because he finds the situation problematic, he must reframe it”. (Schön, 1991, p. 129). Schön (1991) also argues that an attempt to approach such problems is reflective research. In advocating the method of reflective research, Schön (1991) believes that competent professionals usually know more than they can say and therefore an approach that provokes intuitive action leads to a new pathway of knowledge. (Schön, 1991).

However, it should be noted that the ability of defining — or, rather, interpreting — the problem does not imply that there is now one applicable approach. It cannot be compared to a mathematical equation, where finding the rule is the only task. Designers solve challenges in a holistic, solution-focused approach, obsessed with achieving the desired result. (Cross, 2007). Within this line of thought, my background as a designer with more than ten years of experience in a professional career, and a Master’s degree in design obtained in Germany, Switzerland and Finland, it was evident that the way in which the topic must be addressed is through a ‘research-through-design’ approach.

During the past decades the discussion around design research and its manifestations, realms, and of course its necessity has developed into a vivid conversation among design researchers and scholars from others disciplines. Bonsiepe (2007) presents two reasons why design research has come to have a greater significance in the first place: firstly, he states that “design

problems can no longer be solved prior or parallel to research (...) [because] we cannot rule out in advance the possibility that design activity will raise questions that will, in turn, yield new knowledge as a result of the research involved in answering them". (Bonsiepe, 2007, p. 27). Secondly, academia requires appropriate qualifications in order to respect design education's credibility. (Bonsiepe, 2007).

Though Bonsiepe (2007) gave an explanation as to why design research as a discipline evolved, it still left the question how the discipline should be organized. Furthermore, as no clear definition for the discipline of design research exists, embracing what it is and what not, has resulted in a general acceptance of three different approaches that are distinctive for design research. Frankel and Racine (2010) offer a helpful framework, distinguishing these main categories, namely 'Clinical Research', 'Basic Research', and 'Applied Research'. With a review of the current literature on the discourse the authors summarize coherently the characteristics of those three categories. Clinical research takes place in unique situations. It involves the examination of data collection that is specifically related to the problem to be solved. Basic research describes any theoretical undertaking in research about design and is therefore an inquiry about the discipline's epistemological nature. The concern of the third category, applied research, is a general concern. Building on existing experiences and points of view this approach is systematically dialectic with the aim of identifying emerging patterns. (Frankel, Racine, 2010).

Under the category of applied research falls the research-through-design approach and as mentioned earlier, I have decided that this method was most appropriate to inquire for my thesis. I will now clarify, why.

According to Wolfgang Jonas (2007) the research-through-design method is the most authentic as it creates knowledge on the basis of action and reflection. (Jonas, 2007). Donald Schön (1991) advocates the idea of professional knowledge that evolves in the process of application. Holding this opinion he criticises the positivist approach, which assumes that va-

lidity is based only on credible scientific knowledge. A difficulty in the process of this application is that the researcher is a scientist and a practitioner at the same time. Or, as the word 'process' implies, the researcher has to adapt the methodology during the evolving project according to the job that is being worked on. Schön (1991) recognizes the complexity of the 'action-in-reflection' method and admits that the term per se is misleading. Schön (1991) believes that reflection-in-action is contradictory, as thinking while performing would distract the flow of tacit work movements. In this regard, as a design researcher and as a designer, applying a research-through-design approach I had to be aware of the roles I assigned myself to. On the one hand I had to investigate analytically the overall situation, creating potential scenarios and imagining potential outcomes. On the other hand I was also required to maintain creativity, come up with ideas, drafts, and desirably new ways to give answer to the problem at hand. This required two different work modes. At one point I was the researcher, looking down on my project from a meta-perspective, being challenged to work systematically, plan ahead, and make meaningful decisions. At other times I was required to free myself from pressure that comes with the responsibility of managing a thesis project and being able to focus on designing. In these situations I was required to delve into potential users' worlds, asking myself what their needs, requirements, and expectations are? How would solutions I was to propose serve them best, and what creative means were most effective to respond to those questions? Answering those questions, the following chapter explains the methods I used to carry out the study, with an emphasis on the creation of data, applying a research-through-design approach. It should be noted from the outset that — though roughly outlined in my thesis proposal — the methodology was an evolving one that developed as the research advanced. The evolving methodology provided me with the freedom to use the most appropriate method according to the results I gained from earlier examinations during the research process. Although it was clear from the beginning that the study was designed from a qualitative perspective to focus on phenomenological perceptions of individuals, as a means to investigate humans' views I chose, for example, an online survey over in-depth interviews based on developments throughout the process. Furthermore, the research-through-design approach seemed most pertinent as the wave-like work modes between designing and design

researching require reflection on action and therefore respond best to design practice, where a) knowledge evolves in the process of application (Schön, 1991), b) the recognition of the circumstances is established based on findings (Schön, 1991), c) the problem is reformulated (Schön, 1991), and d) the focus on solution leads to the desired outcome (Cross, 2007). The research-through-design approach is also highly flexible, as the designer's instinctive actions open up new directions. (Schön, 1991).

Chapter 6: Methodology

6.1 The general perspective

The described research consisted of both qualitative and quantitative perspectives. The methods applied are presented in a research-question order and subsequently in a chronological order. The research-question order helped to determine the sequence of methods by finding appropriate measures to answer sub-questions individually to move toward a potential solution of the problem. The combination of the following methods resulted in the methodology I applied in this study:

- Brainstorming
- Affinity diagrams
- Development of a wizard
- Creation of knowledge visualizations (general)
- Creation of knowledge visualizations (specific)
- Online survey

I will now explain why I chose this combination of methods and how they were applied.

6.2 Procedures

The brainstorming phase, which can be described as preliminary research, was the starting point for the practical part of my thesis. Writing down anything that was related to the topic; reading magazines, websites, and blogs; and observing and realizing people's everyday travel behaviours helped to build-up a pool of material that needed to be organized. As many factors can have an influence on personal and ecological health, to cluster ideas and connect important variables I used a method called affinity diagrams. IDEO, a design and innovation-consulting firm, described the affinity diagram method as a tool to "cluster design elements according to intuitive relationships such as similarity, dependence, proximity". (Moggridge, 2007, p. 671). The objective of applying the affinity diagrams in this methodology was to gain an overview of the most important indicators that would be necessary for calculations to provide users with additional information about impacts on their health and the environment of their modal history or hypothetical trips. For example, when I thought about how age, weight, country of residence, or workout regimens relate to each other, I realized which factors needed to be connected in order to gain more detailed information. Drawing these connections also helped to eliminate the factors that were not of relevance for this study or that were too distinctive in regard to the scope of this research. In this sense, the objective of applying the brainstorming method followed by the method of affinity diagrams served the objective of firstly creating an extensive body of information and then boiling it down to the essentials. With the outcome of the affinity diagrams — for the health and the environment category — I realized that the subsequent method needed to be designed as a tool that would guide potential users of an application through the initial settings that are required to increase awareness and produce customized information. To meet different levels of users' interests and levels of interaction, the steps a user would be guided through needed to be determined. To do so, I decided to develop a mock-up of a "wizard" that simulates the stages a user would be directed through. The affinity diagrams again have proven to be a helpful method, as I was then able to use the diagrams to divide the initial data entry into three steps, which were then implemented in the wizard.

The definition for a software wizard, according to Wikipedia is, an assistant to set up a user interface by guiding a user step-by-step through a series of dialogue windows. A wizard simplifies dealing with functions that are new, difficult, or users' are not experienced with. Wizard (software), Wikipedia, the free encyclopedia (2015). Retrieved from http://en.wikipedia.org/wiki/Wizard_%28software%29

The decision for the method of developing a wizard had benefits in addition to user guidance. Firstly, it forced me to imagine how the information I had collected so far needed to be processed for a real-world setting. I had to ask how to best present the information in a coherent way, how a potential user would want to create a profile, and which style — appearance and data entry — would be most appropriate. These questions were answered during the implementation process. Due to the wide distribution of Google Maps web and mobile version I decided to develop the wizard and the knowledge visualizations simulating Google's design. Though I had made this decision, I still had to figure out the order in which I would present the questions related to health and the environment, how I would design information entry options (e.g., check-box, text-based, scroll bar, etc.), and how I would present the results. To begin, I familiarized myself with Google's design guidelines called Material Design, which served as a framework to develop information entry options, information presentation, and in general the interaction with the software (mock-up). Once the desktop-based action-wizard was developed, it became obvious that a mobile-based design for the application was required.

The next method therefore was designed to create knowledge visualizations for a mobile device. This decision however required that the researcher familiarized herself with Google Map's mobile application design and the ways in which the customized information, based on the user profile previously created through the wizard, could be displayed. As mobile screen dimensions limit the amount of information that can be presented at once, to develop a mobile application mock-up I had to come up with solutions that support information presentation in a simple and easy-to-comprehend manner. One way to present simplified information is using

pictograms. Therefore the next approach in this methodology was the creation of pictographical knowledge visualizations. To do so, I studied what methods have been used or are still in use to develop aesthetically pleasing as well as easy-to-understand pictograms. Based on the findings from this phase, I was then able to apply my new skills in designing pictograms to present the information related to health or the environment. The software I used to design those pictograms was Adobe Illustrator and Adobe Photoshop. As I simulated the design of a Google mobile application, I attempted to design pictograms that matched Google's corporate design. With the completion of the Google design mock-up, the subsequent step became obvious. Firstly, I was not satisfied with the outcome of the previous process and I felt the need for improvement. Secondly, as my main objective was to offer a solution to health issues related to sedentary lifestyles and automobile emissions, and based on the literature reviewed, I came to the conclusion that offering only a Google-style application would not meet users' individual preferences, and therefore not support the idea of bridging the intention-behaviour gap by providing customized and customizable information.

In this sense, I applied the method of knowledge visualization creations a second time, now characterized by conducting a new, independent design process. With what I had learned during the previous phase, I realized a need to create a spectrum of different knowledge visualization styles, offering potential users the choice to use a design that would best meet their individual preferences and expectations. For example one user may be particularly interested in comparing certain methods of transportation in regard to the overall influence on personal health, while another user might be mostly concerned about CO_2 emissions and therefore a total personal contribution to climate change. Likewise some users may be satisfied with rough estimations presented in an easily comprehensible way, while other users may prefer an exact numerical display of their pre-defined set of information of interest. Moreover, some users may want a neutral appearance presenting facts, whereas others might prefer a friendly style that has the effect of making users feel good about using the application and their travel behaviour choices. A way to investigate different users' preferences was the application of a Sinus-Milieu diagram. However, after having tried to place different user profiles in this

model, I realized that I did not want to design for persona — fictitious people — of different statuses and different habitus in society. I wanted to create independent designs and subsequently examine users' preferences through an evaluation method. Though I decided against designing for a virtual target group or persona, an illustration in the next chapter depicts the examinations that took place at this point in this study.

The method of developing new, independent knowledge visualizations then occurred in three phases. At the beginning, I decided how many and what styles I wanted to develop. To offer a range, the goal was to create four to five different application mock-ups.

The decision emanated from the objective to develop three different pictogram styles and one or two versions that would be text based. After having created four different styles, a meeting with my supervisor helped to improve the first designs. Some pictograms needed to be revised to improve readability, and one version got dismissed, as it did not meet the expectations of transmitting information in an easy-to-understand manner. The discussion can be regarded as a reflection-on-action within an action phase, as a result of which a new idea for a fourth version evolved. After having improved three existing versions and created a new fourth version, the researcher implemented a second reflection-on-action phase to critically examine the design work. Subsequently, another improvement process occurred, where pictograms that had passed the first reflection but failed the second were revised. With four final versions, a method to evaluate their impression with a test group needed to be applied. To present a coherent style to a test group, the four versions needed to be adapted one more time. To bring the versions more in line with each other, it was decided to use the same information on each application mock-up and reduce the versions to an equal background colour. The evaluation method I decided to use was to conduct an online survey. The reasons for this decision were its advantages for this study compared to other methods that examine user opinions. For example, the method of the online survey allowed me to access individuals in distant locations and therefore I gained a broader spectrum of opinions. Data collection is processed automatically which resulted in time saving and reduced the risks of errors that can happen

in capturing data manually. The costs for conducting an online survey are low compared with costs for material that needs to be provided in paper-based surveys, expenses for meetings with interviewees, or phone charges in telephone surveys. Moreover, based on experiences through ethnographic fieldwork I did in the past, conducting an online survey ensured that both — interviewee and interviewer — would not affect the survey due to their relationship. Another aspect that made me choose the online survey over a paper-based questionnaire or in-depth interviews was the fact that I was able to reach more people in less time, and the results were then easier to compare as I designed the questionnaire with a feature not enabling participants to skip required questions. If a participant wanted to refuse answering a question this would have resulted in leaving the survey. Being aware of this I carefully developed the survey in a way to avoid participants from cancelling prior to completion.

My decision for an online survey included the consideration and the acknowledgement of the disadvantages of said research tool, however, in regard to my particular research project they seemed to not outweigh the advantages. For example the risk of falsified results due to multiple participation seemed negligible and a general concern over the validity of data due to the channels of communication I would use to contact potential participants did not dissuade me. I planned to use active and passive sampling recruitment methods and I expected that the research participants I would reach through this method would in fact correspond with the target group my thesis project was designed for, namely people of all ages that live in developed societies, preferably in urban environments, who have access to methods of active transportation. To conclude, it should be noted that the survey is a method to inquire and improve future design practice. In the current context of global information exchange, I aimed to collect opinions not only from different points of view but also from users with different cultural and geographic characteristics.

Data analysis was carried out after one week of keeping the online survey accessible. The online survey software provider offers the option to download the results as a Microsoft Excel file. Within seven days, 126 people entered information in the questionnaire. Not all respond-

ents finished the survey, and the data needed to be cleaned up, with the result of there being 102 valid votes. The results were then examined with a focus on general interest in the research problem, preferences of information presentation style, as well as demographic differences in the responses. A percentaged report of the evaluation gives precise information in the next section of this thesis.

This chapter has explained the methods of the research-through-design approach of this qualitative study. A more detailed description of the research and design work and its evaluation is provided in a narrative text in the next chapter that illustrates the results obtained with those methods.

Chapter 7: Research and design | results of methods

7.1 Results of the brainstorming method

As mentioned earlier, the brainstorming method helped me to collect material that was related to my topic. I used Post-Its to write down ideas and organized them around the centre point, namely the human. The brainstorming sheet structured indicators that affect decision-making in regard to considerations about personal and ecological health as well as external factors, such as infrastructure, safety, convenience, etc. It also showed that a goal to solve the problem at that stage of the work was to increase awareness by providing information. However, at this time, I had not yet decided how I could apply information to attain this goal.

The brainstorming sheet became more approachable once I organized it into sub-elements, connecting factors that led to further information. Affinity diagrams, which will be explained in more detail in the following paragraph, are used to drawing connections.

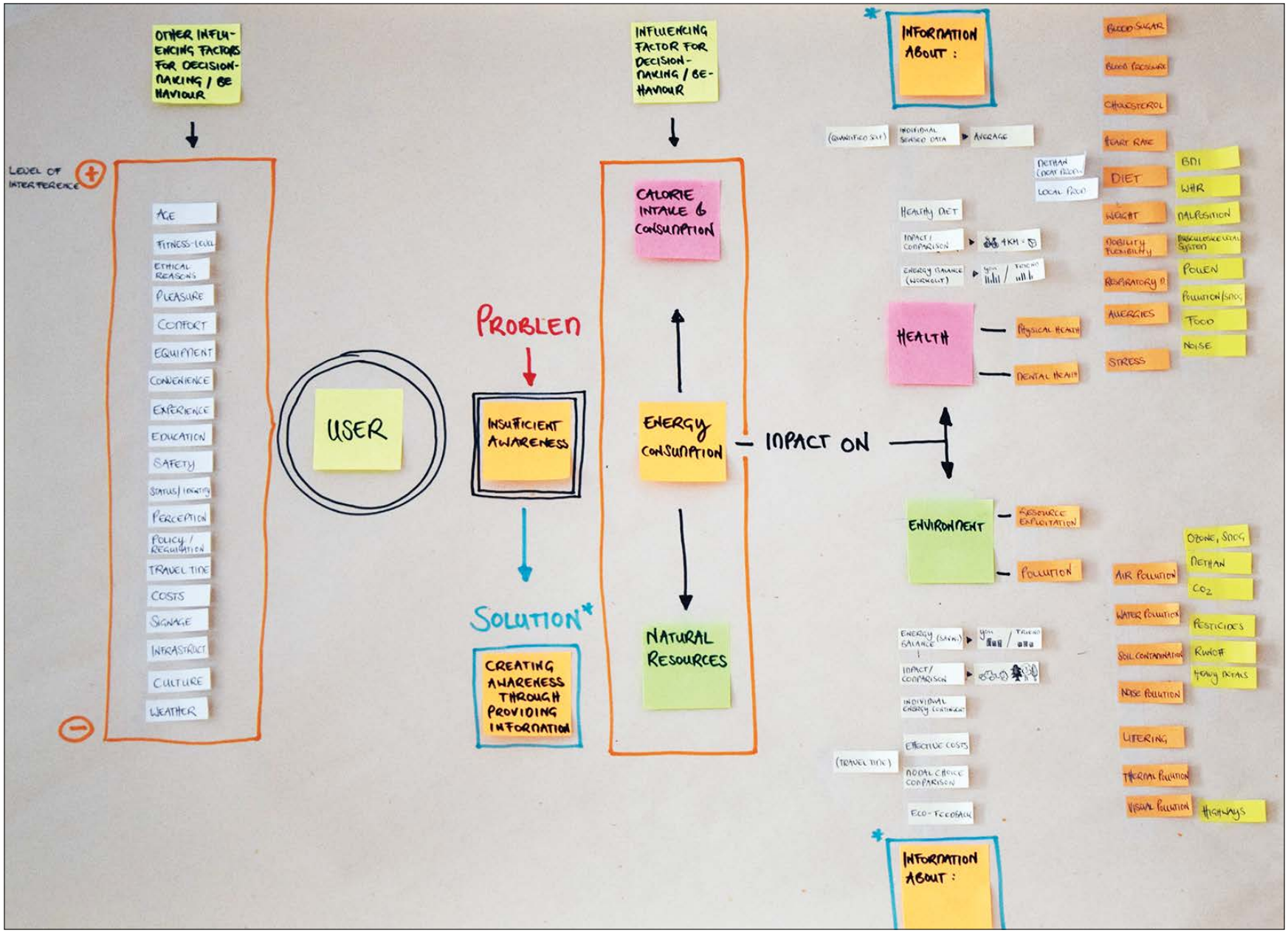


Figure 33: Brainstorming sheet with Post-Its

7.2 Results of the affinity-diagram method

The illustrations below present which categories I decided to use as indicators of great importance for personalized health information: on the left I list the categories, and on the right the explanation, why it is a pre-requisite for user-specific facts. Similar to the categories under personal health other categories were developed as necessary for personalized information in regard to one's impact on the environment.

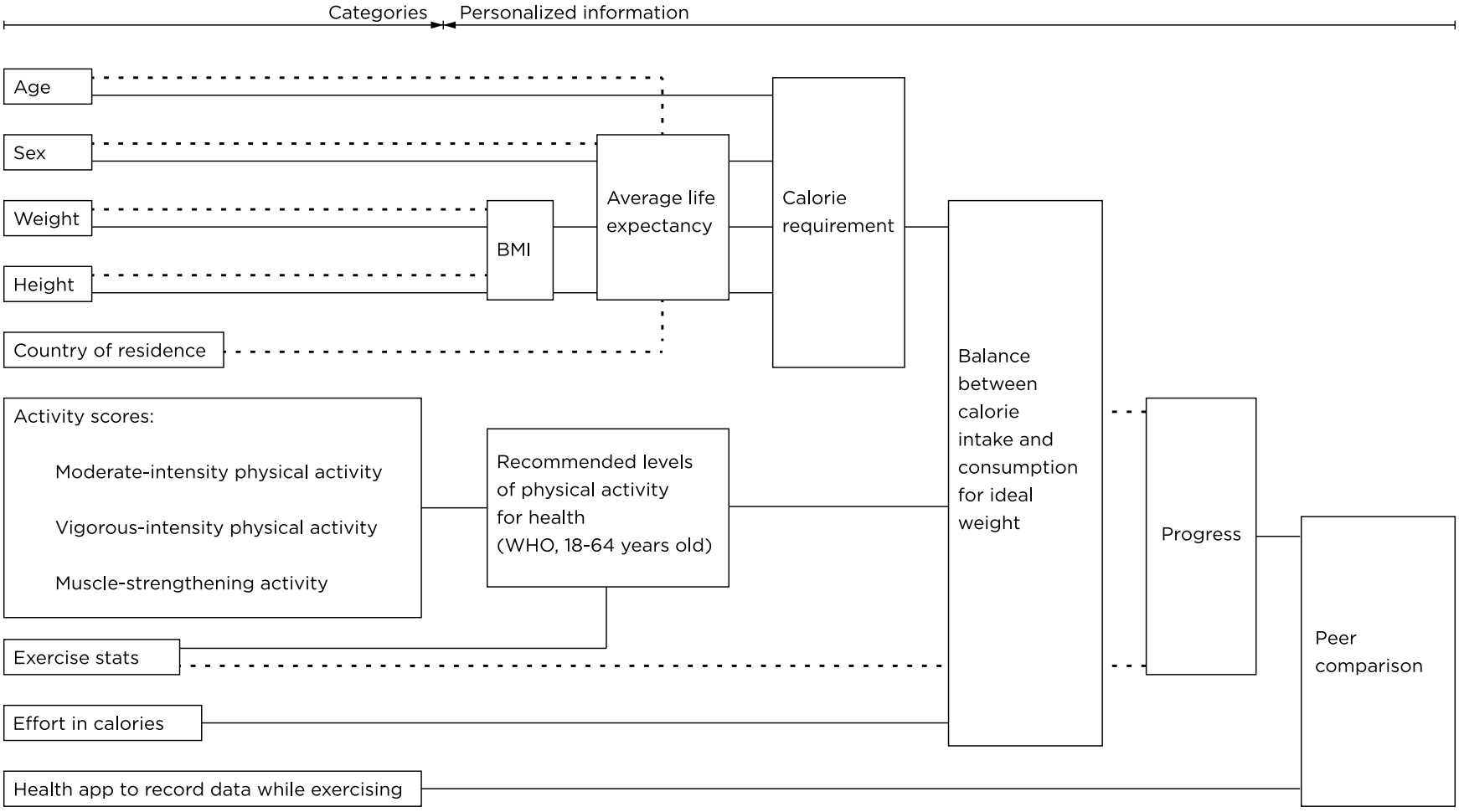


Figure 34: Categories health

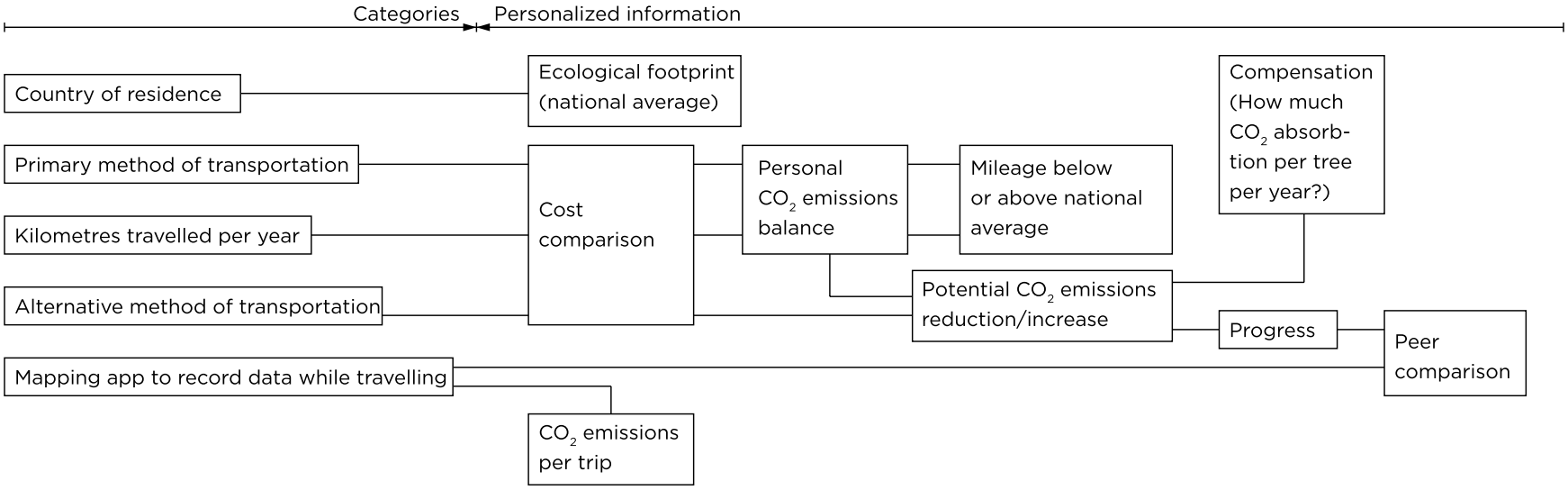


Figure 35: Categories environment

In order to simplify the affinity diagrams, a division of three categories, namely basic, intermediate, and advanced, helped to organize which information was required and on what level. The objective of the division was to accommodate users' different levels of interest and interaction. The illustrations below show how those stages evolved.

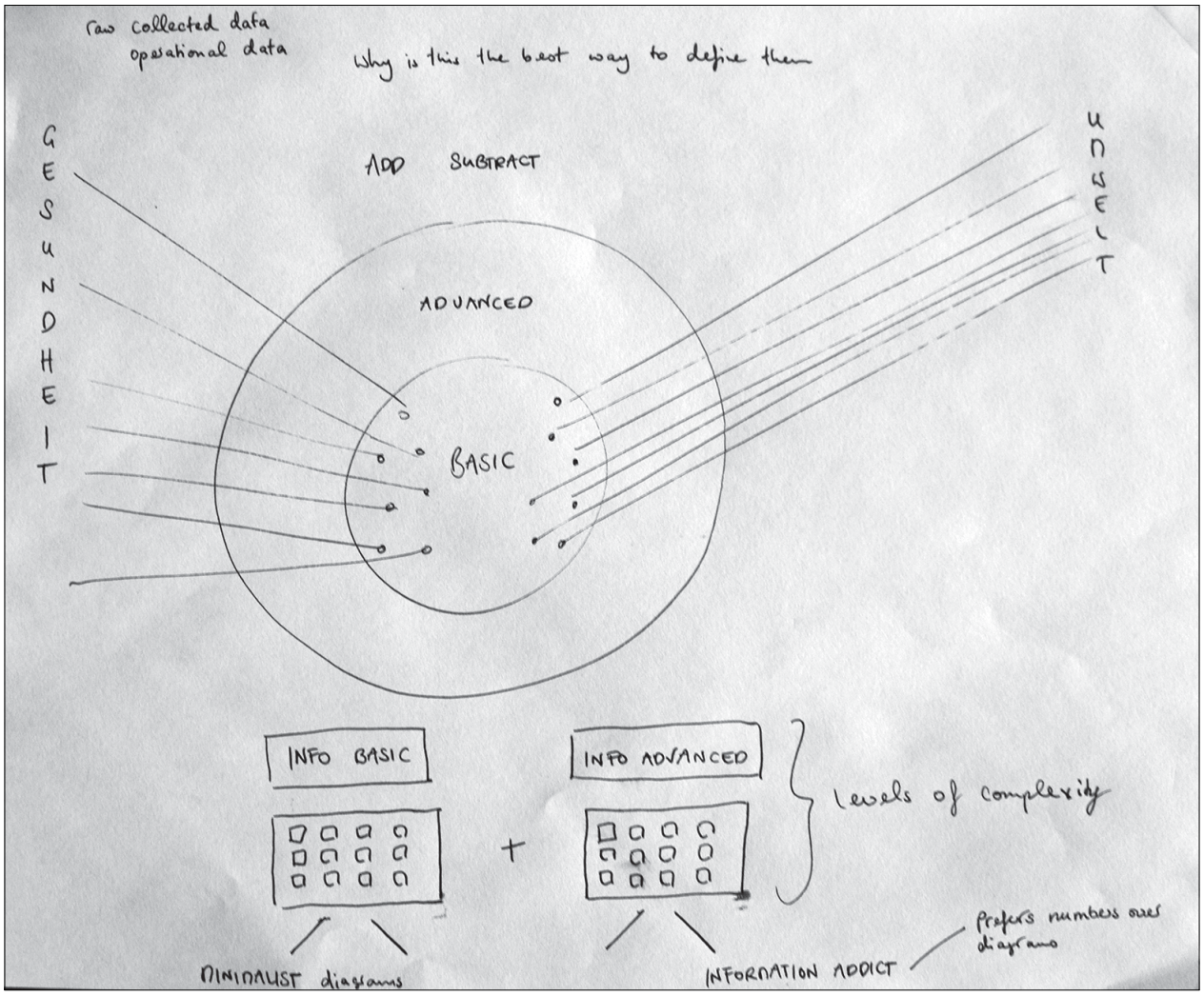


Figure 36: Brainstorming 1, wizard

The three categories (i.e., basic, intermediate, advanced) later determined in the steps the wizard would use to guide a user through the information entry process.

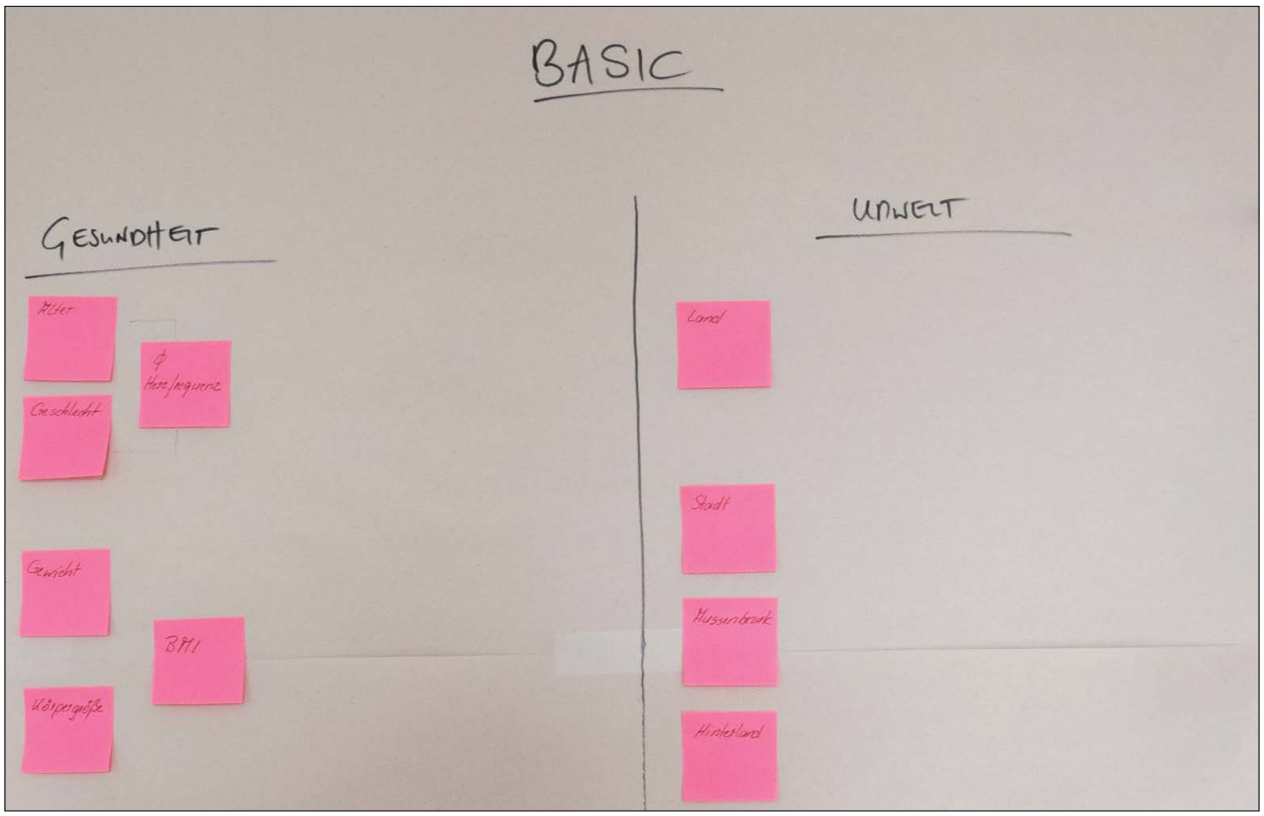


Figure 37: Brainstorming 2, wizard

Under the category of personal health, step one would collect information about the user's age, sex, height, and weight. Under the category of ecological health, the user would be asked to enter his or her country of residence. With this information, the body mass index (BMI), average life expectancy, and average daily calorie requirement could be calculated. Similar to step one, step two inquired about personal activity scores and travel behaviour patterns. The information collected through those questions allowed for recommendations to be suggested regarding workout styles and times and their influence on calorie intake.

A cost comparison, one's personal CO_2 emissions balance, and a comparison with national average kilometres driven resulted from answering step two under the environment category. Step three — designed to accommodate a group of advanced users in terms of interest and interaction — allowed data exchange from a tracking and/or fitness device to produce more precise customized data for both categories, e.g., progress (fitness and/or sustainable travel behaviour) and CO_2 emissions per trip.

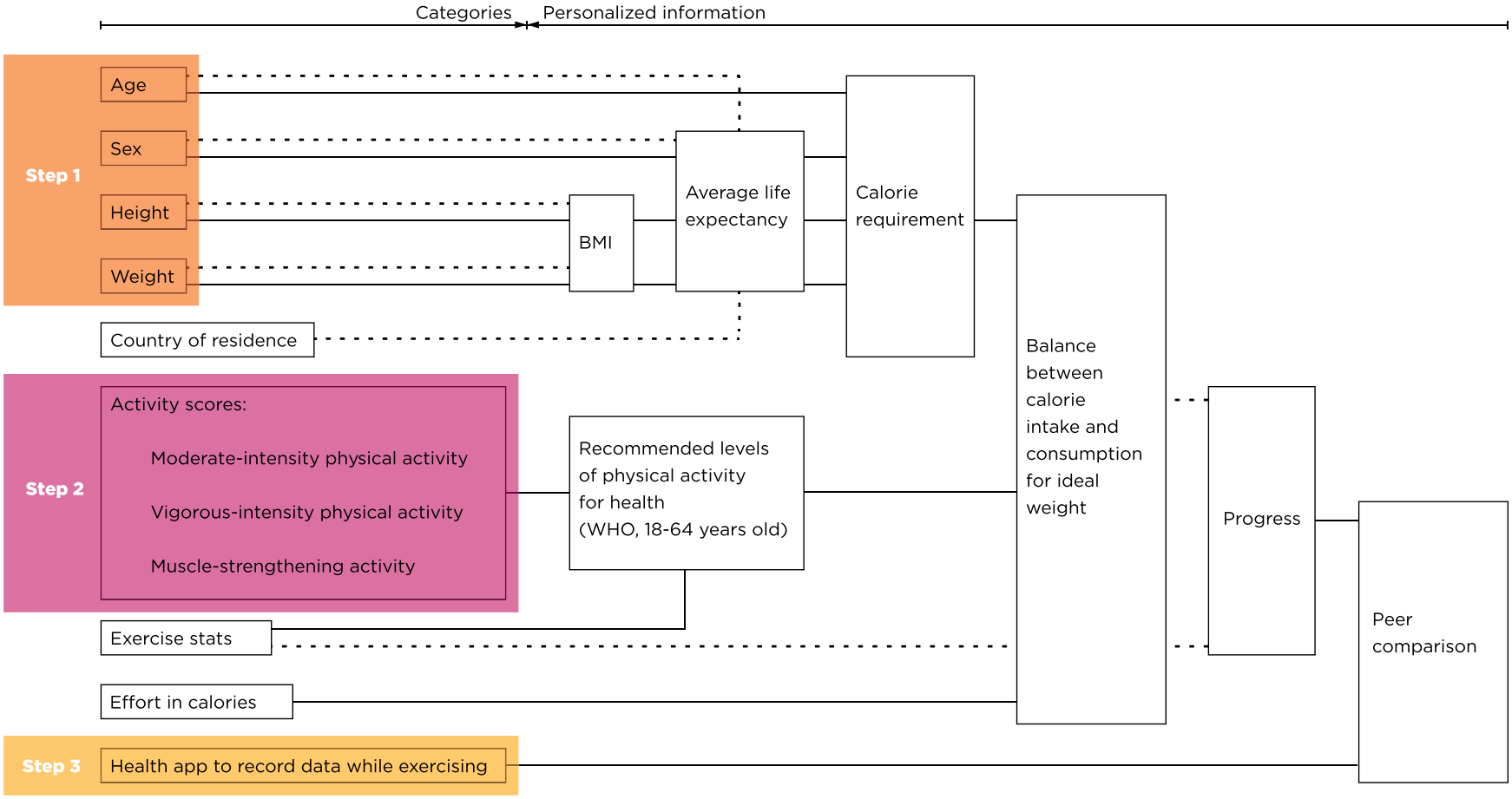


Figure 38: Steps in wizard under category health

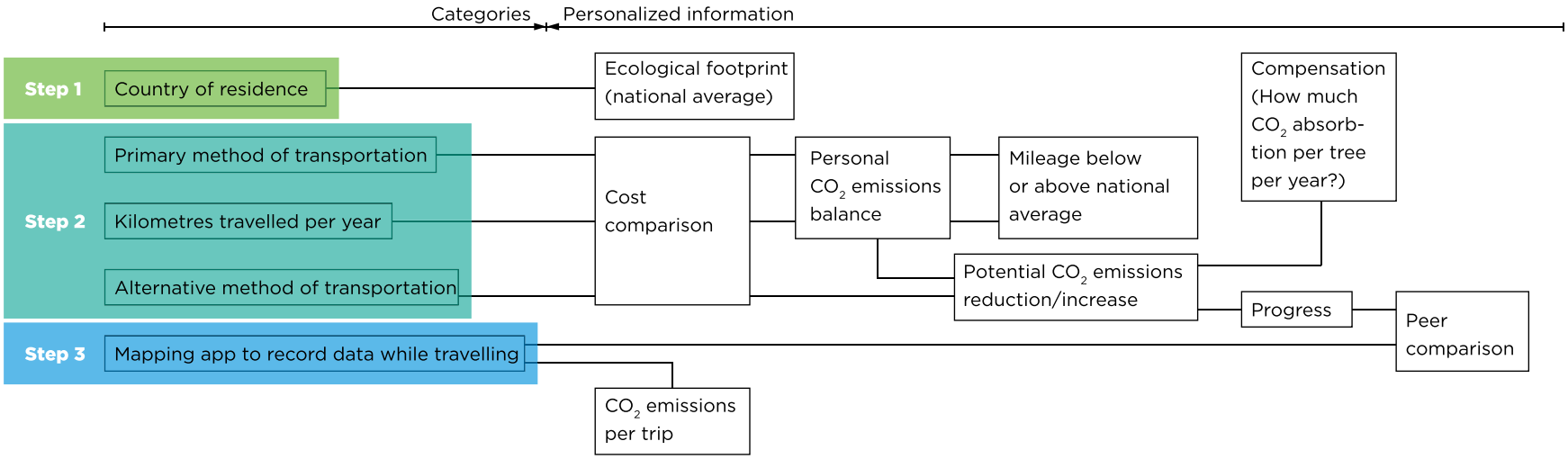


Figure 39: Steps in wizard under category environment

The transformation of these outcomes into a Google-style desktop application required that the researcher became familiar with Google's corporate identity guidelines. Google's corporate identity guidelines are called Material Design, which are available in an online handbook where Google provides software developer and designer with elaborate descriptions of the dos and don'ts when using a Google product as a basis for further build-up. Material Design was published in 2014, and is used for the design of their own applications as well as for designs of third-party developers. It can be described as a visual language that discusses the topic of user interaction (UI) with an electronic device, or more precisely, the software that is operated through the device. As in spoken language grammar rules instruct how to combine single elements in order to create meaning, the rules to design in accordance to a brand CI ensure recoginition and comprehension. (Google, 2014, Retrieved from http://www.google.com/design/spec/material-design/introduction.html

In the next section I will address how the application of the guidelines for the development of the wizard were implemented, and present parts of the resulting mock-up that simulates where users can create their own profile in order to receive customized information based on their circumstances, needs, and interests.

7.3 Results of the wizard method

The design of the wizard mock-up is conceived as a desktop version of a Google software. I decided to use this format, as I wanted to use the mobile format for the smart phone app that would track users' methods of transportation.

At the time I developed the wizard I used the project title 'Footprint tracker' for the software mock-up. As I progressed in my research I moved away from this name, as I got the impression the connotation to ecology is too strong and I did not want to continue with a product name that could be biased. As this is also part of the design process — realizing that a previous

idea must be reconsidered, I decided consciously not to change the designs for their publication in my thesis, however, I wanted to point out that from a more recent point of view I chose not naming the project at all.

Before discussing the content of the screens, an explanation about the general layout design is required. As it can be seen at the example of a page about 'Additional information', the Google Material layout I applied consists of a constant app bar (A) with a floating action button (B). The horizontal app bar presented the user information about page navigation while the floating action button indicated that something can be done, its position is always on the top layer. The vertical side navigation menu (C) gave an overview of the complete wizard menu and allowed a user to move directly from one step to another. The bottom bar (D) also served as a navigating tool, however, compared to the side bar it was designed to "walk" the user through the process step by step. The three-dimensionality in the centre of the page was presented through a background layer, and cards (E) in the front to organize content. In my design the background layer was divided horizontally to create room in the upper part for a page header (F).

To indicate which card is "active" the card size increased, simulating the effect of moving toward the user. Scrolling up and down had the effect of flipping through active cards. In the example above an active card was scaled in its size at the centre of the screen, whereas an inactive card underneath gave the impression of being positioned at a deeper level.

The overall structure of the wizard (footprint tracker) was divided into six parts, namely, (1) introduction, (2) basic information, (3) additional information, (4) advanced information, (5) customized information, and (6) results.

The following illustrations display examples of the six parts the user is guided through the wizard.

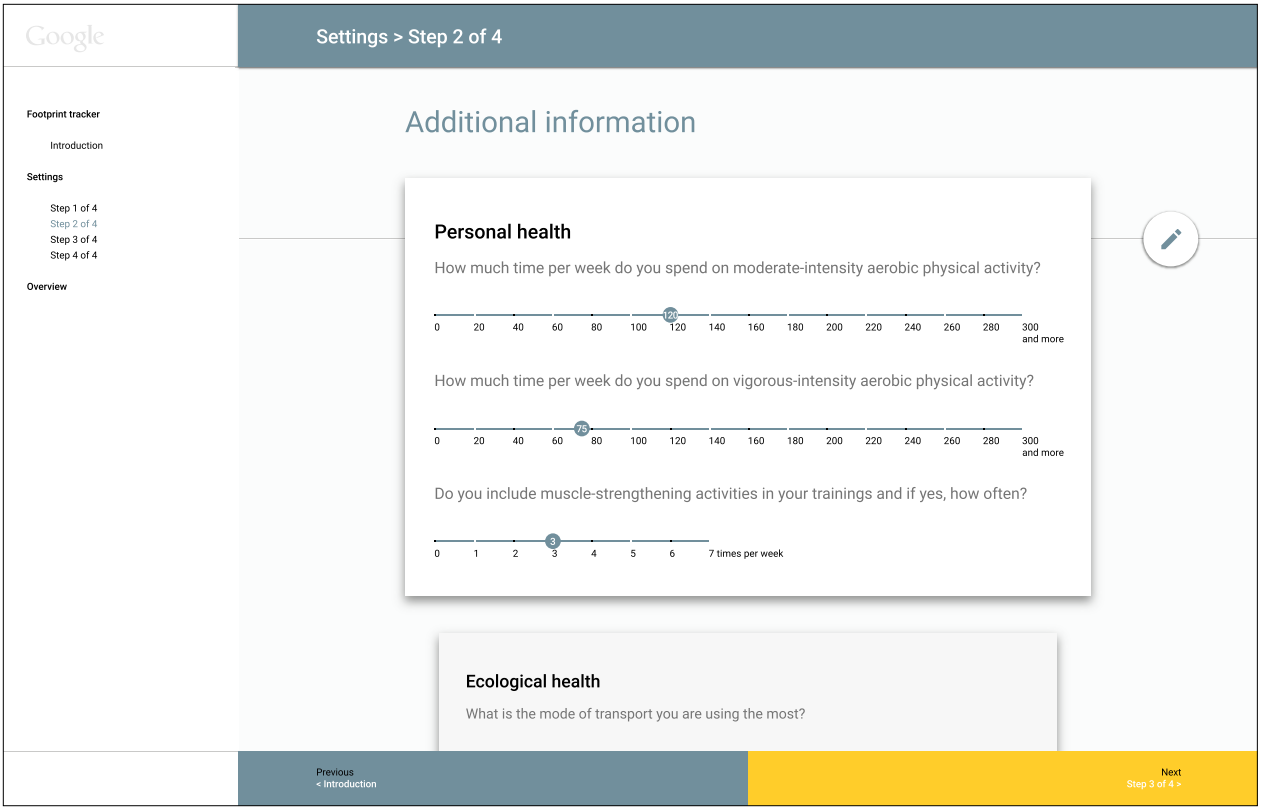


Figure 40: Applied layout design for the wizard mock-up Additional information health

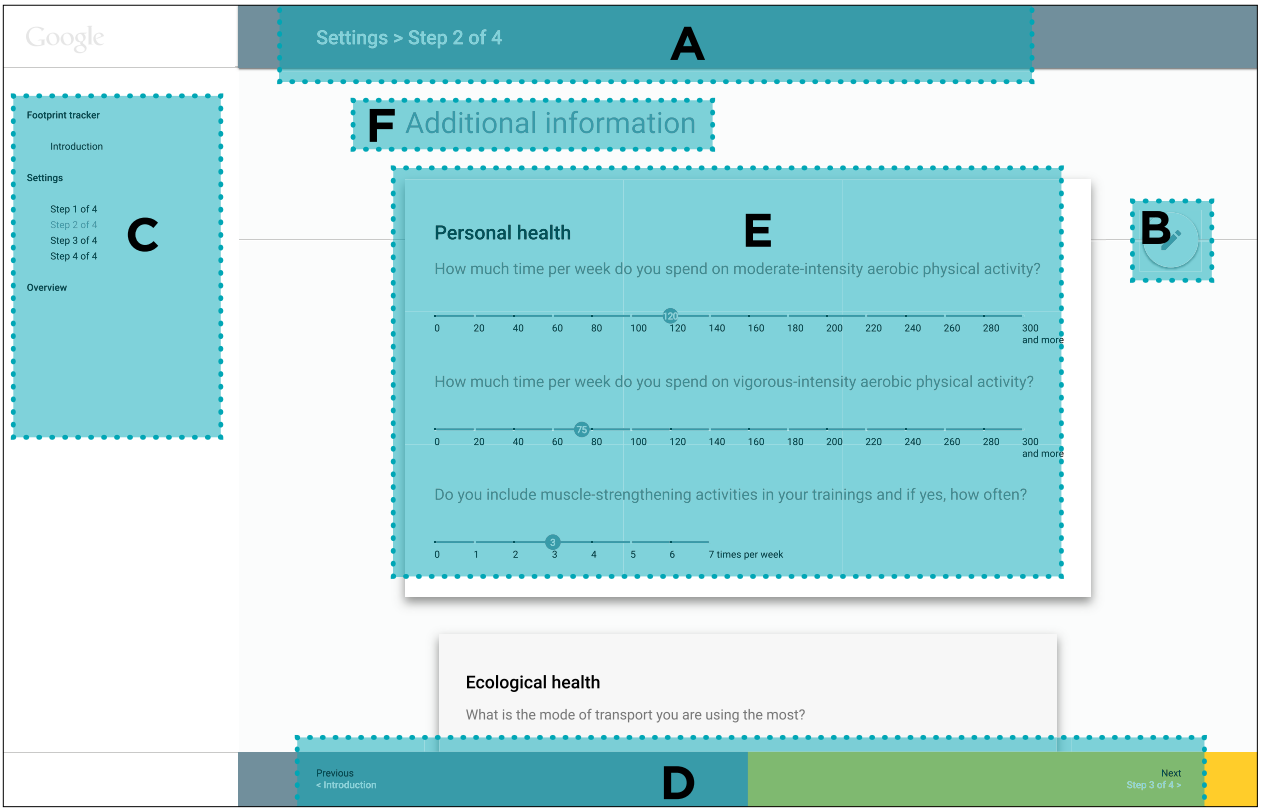


Figure 41: Applied layout design for the wizard mock-up Additional information health: highlighted areas

Part 1: Introduction

The introduction page of the wizard informs the user about the general idea of the application and what the user must do in order to receive customized information about how chosen methods of transportation affect personal and ecological health.

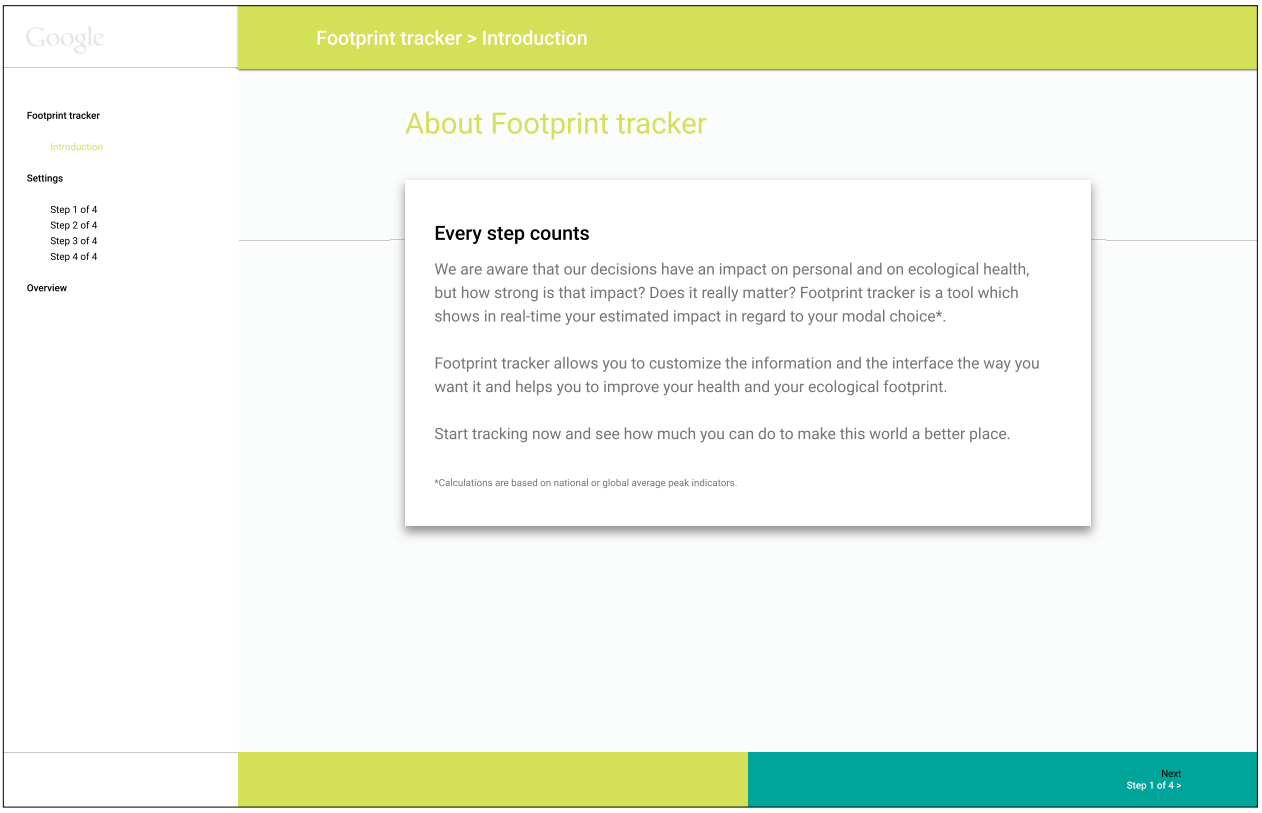


Figure 42: Applied layout design for the wizard mock-up: About Footprint tracker

Part 2: Basic information

The illustrated page about basic information shows how a user could fill in personal data as age, sex, height, and weight. For the design I decided to use a scroll bar instead of a numerical entry option, as I wanted to try a way to present information differently as well as to give the user the experience of interaction with the software in a visualized way. The button on the right presented either a pencil or a check-mark, indicating that information can be entered or that all information required on that page has been given.

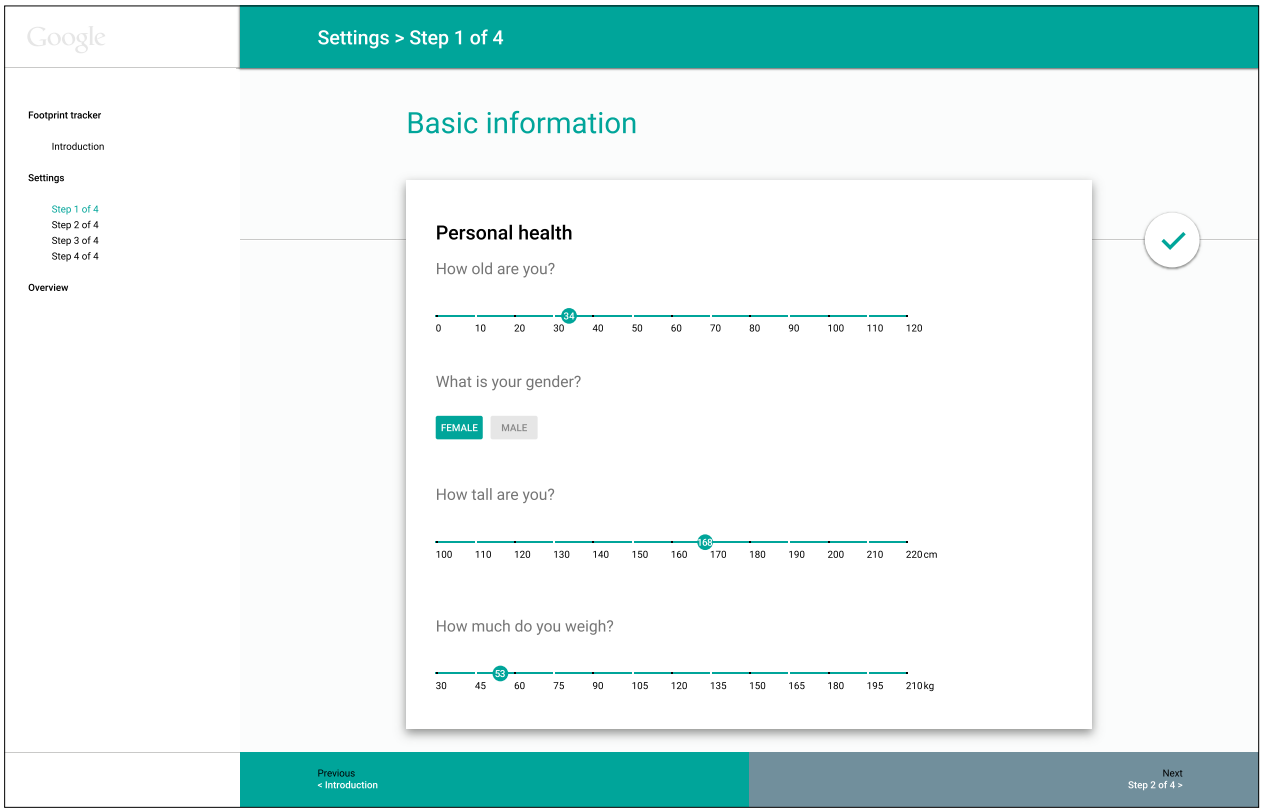


Figure 43: Applied layout design for the wizard mock-up: Basic information

Part 3: Additional information

Additional information in this example is about a user's primary and secondary method of transportation. The question about kilometres driven gives insight when comparing with national average mileage and allows more precise calculation of actual driving expenses, taking into account operating, ownership, and driving costs. The pictograms in the illustrations are available from Google. They can be downloaded as .svg files and implemented in software developments.

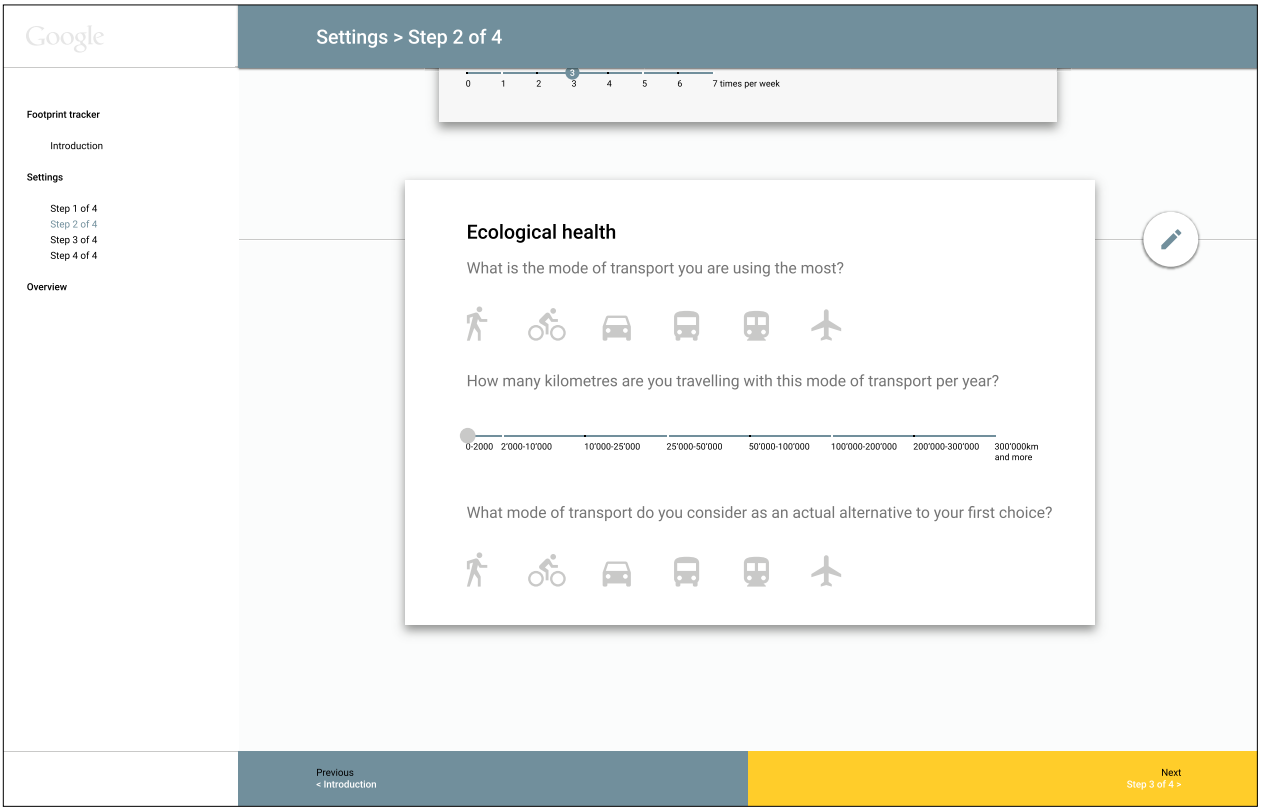


Figure 44: Applied layout design for the wizard mock-up: Additional information environment

Part 4: Advanced information

This example shows the option for a user's choice to allow data synchronisation between another health-related or movement-tracking app/device with the software mock-up. If an advanced user is already collecting fitness or trajectory data with a fitness device, or uses a navigation device in his car, the data could be exchanged and improve the customized calculations.

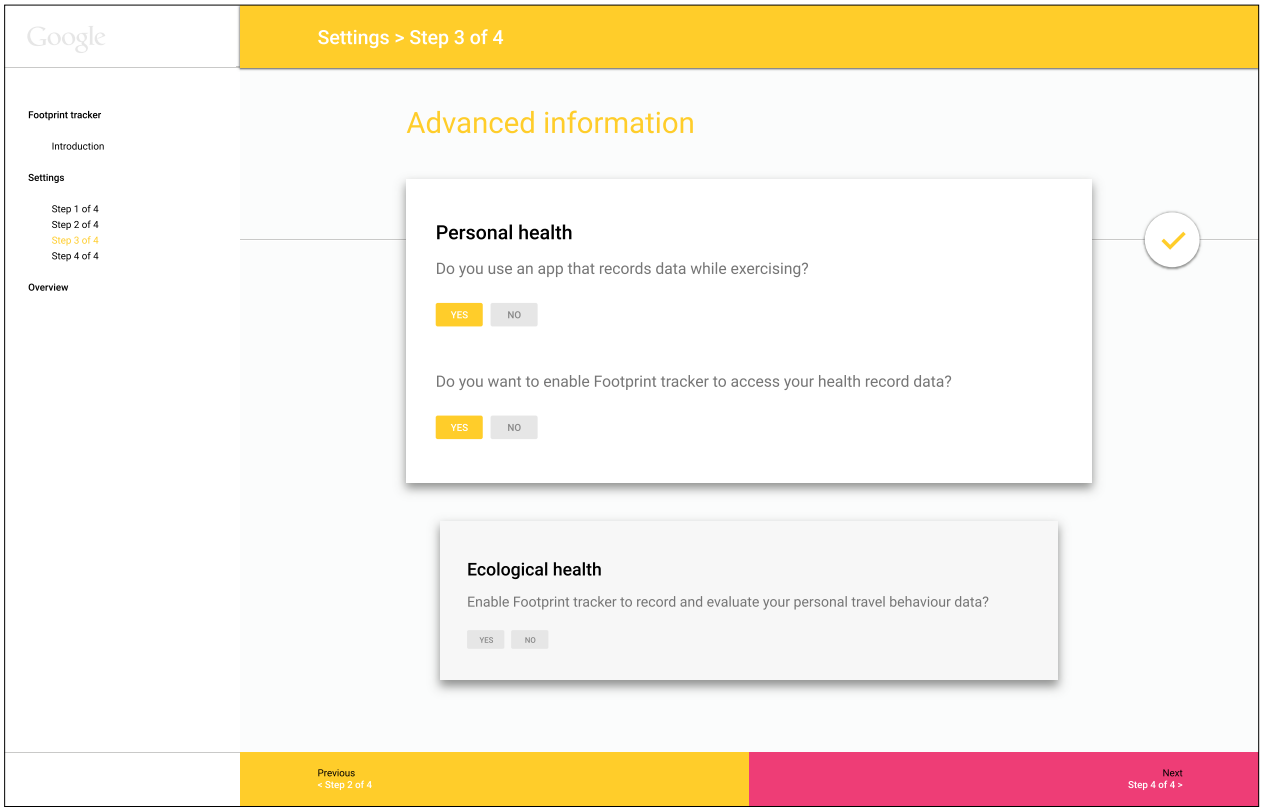


Figure 45: Applied layout design for the wizard mock-up: Advanced information

Part 5: Customized information

The preferred presentation style of information could be defined in this page.

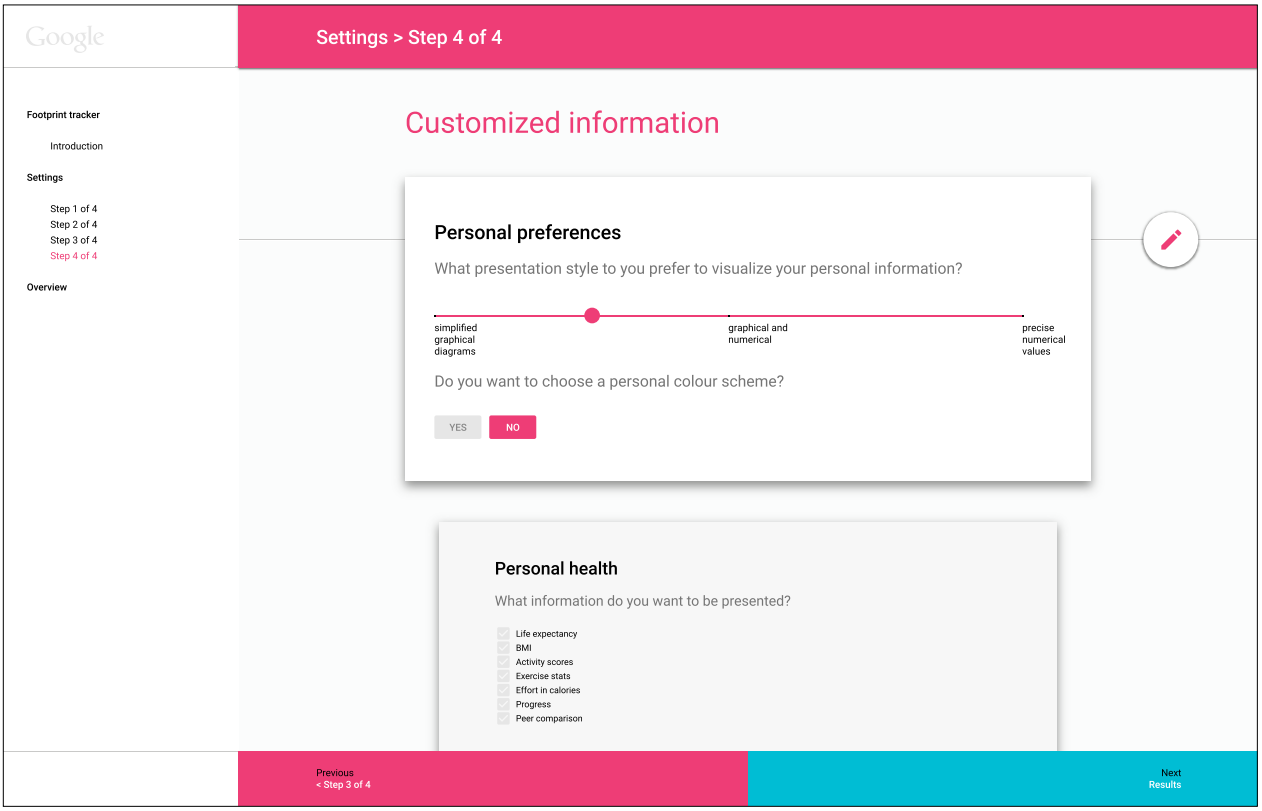


Figure 46: Applied layout design for the wizard mock-up: Customized information

Part 6: Results

After completing the wizard a user would first get results of the information provided. From this point on travel behaviours could be tracked and customized information would be retrievable. In this example the results are based on calculations made using the values the user has entered throughout the previous pages. A potential user would receive the information that her current lifestyle is not sustainable, it exploits limited resources of the planet. Providing this information the hope is to create awareness about a user's current resource consumption, with the objective to guide and improve future decisions.

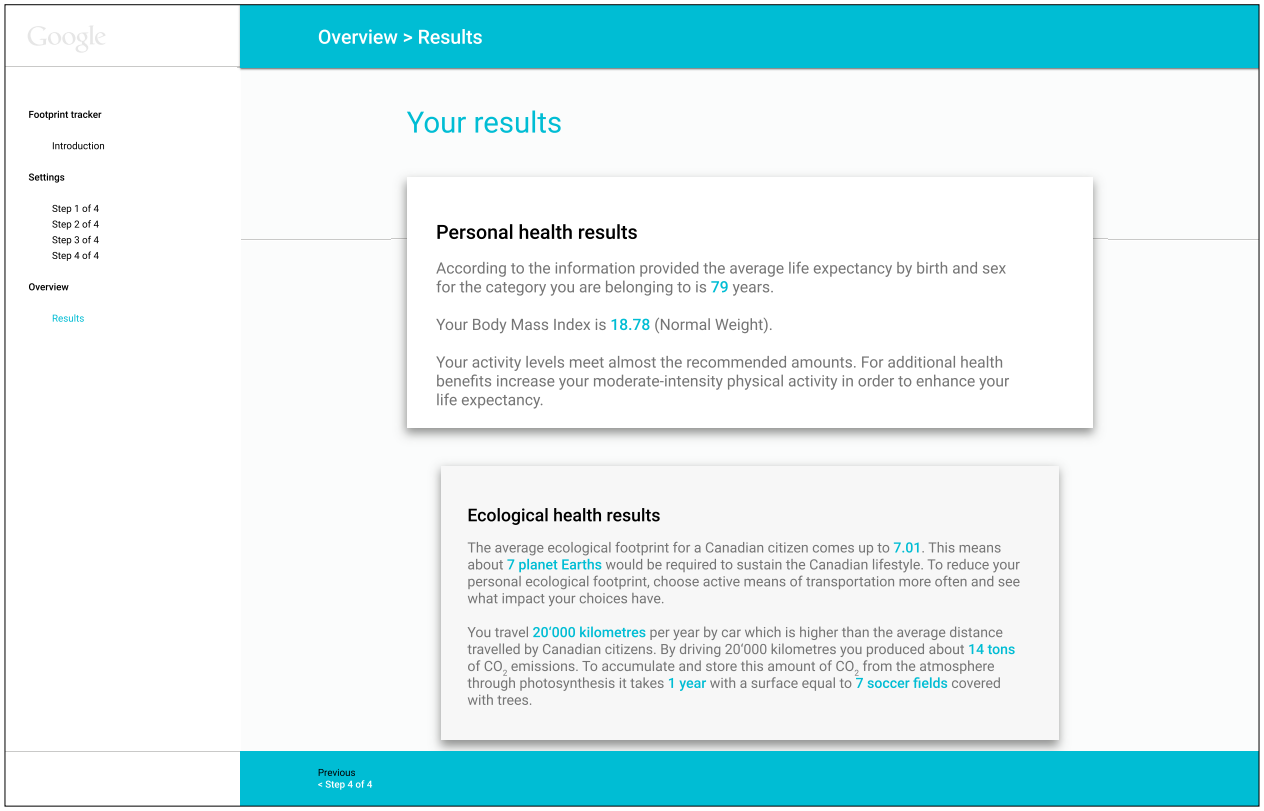


Figure 47: Applied layout design for the wizard mock-up: Results

For further investigation a complete sequence of the wizard is to be found under the appendices.

7.4 Results of the pictogram-development method

"I think that the day of 'eye-consciousness' is rapidly approaching. Communication of knowledge through pictures will play an increasingly large part in the future" (Neurath, Eve, & Burke, 2010 p. 5). More than 70 years ago Otto Neurath (1943) made this statement. We currently live in the future he described back then. Our daily lives are permeated with pictures. The screens of smart phones, tablets, computers and TVs are omnipresent in modern societies. Most people use their phone as an alarm, and their first point of focus of the day is directed to a screen that is also a window to our connected world. Globalization is linking citizens all over the world and a pictorial common language can bridge language borders of communication. New technology demands symbolic language, firstly to increase adaptability and understanding worldwide, secondly to present information in a simplified way. Pictures or more precisely pictograms — if designed well — increase readability and can result in accelerated information transfer. Moreover, organizing the growing amount of information into comprehensible units will improve every day life.

Pictograms are visual images, usually in the form of abstract graphic symbols that convey information to viewers. They can often be found in the context of orientation systems or the internet. Pictograms seldom contain letters, and are thus frequently employed in order to communicate a certain idea, instruction, or process across national and linguistic barriers. That said, it must be noted that even the simplest of visual images are subject to cultural connotations; many pictograms are not automatically understood and need to be learned (Erlhoff & Marshall, 2008).

From an early point in my design education I became sensitized to the fields of semiotics and semantics. As an alumnus of the hfg Schwäbisch Gmünd which after the closure of the Ulm school of design (hfg Ulm) continued their famous educational concept, my studies in Germany were characterized by a strong focus on pictorial language. Furthermore, as a student under a former hfg Ulm student and professor, Dr. Martin Krampen, I feel fortunate having

had the chance to learn from such a recognized expert in this field. In collaboration with Otl Aicher, co-founder of the Ulm school of design and graphic designer of the pictograms for the Olympic Summer games in Munich in 1972 which were also used for the Olympic games in Montreal in 1976, Krampen (1977) published in "Zeichensysteme der visuellen Kommunikation" (Sign systems of visual communication) an extensive collection of origin, development, and application of pictograms. Among multiple sign systems it discusses the grid system Aicher (1967-1972) established for his world-famous series of pictograms.

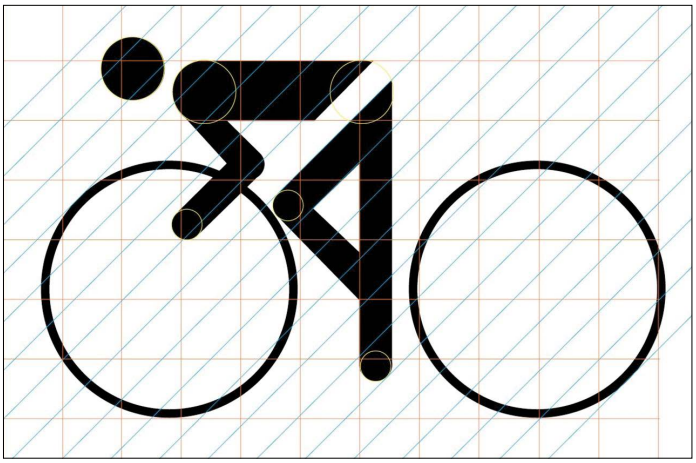


Figure 48: Aicher pictogram, grid system, cycling, Retrieved January 3, 2014, from http://building-blocks.tumblr.com/post/1305764128/grid

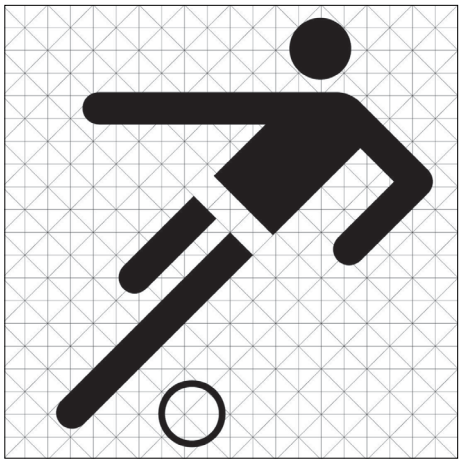


Figure 49: Aicher pictogram, grid system, soccer, Retrieved April 20, 2015, from https://s-media-cache-ak0.pinimg.com/originals/a6/e6/9b/a6e-69b36742e315837edd5785339fc2e.jpg

Similar to Aicher (1967-1972)'s system Google's guidelines for pictogram development are also based on a grid system.

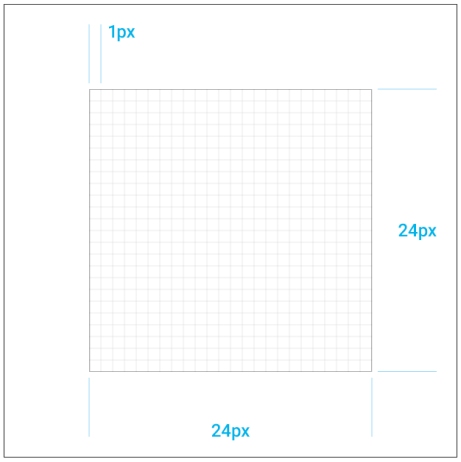


Figure 50: Google pictogram, grid system, basic, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

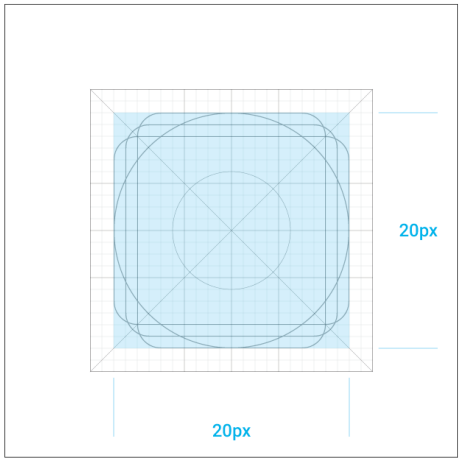


Figure 51: Google pictogram, grid system, keylines, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

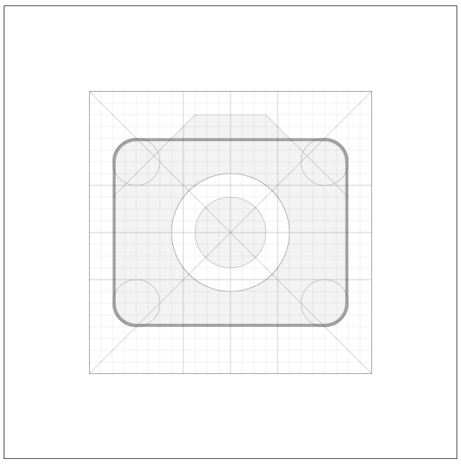


Figure 52: Google pictogram, grid system, camera design, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

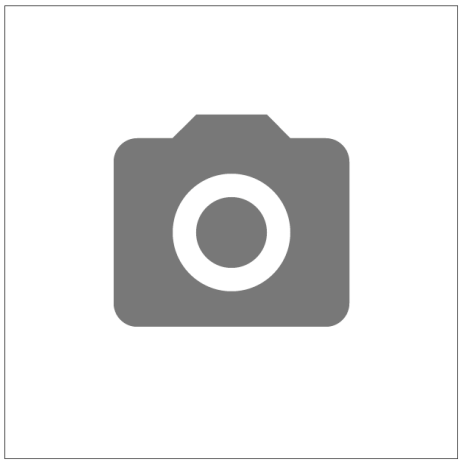


Figure 53: Google pictogram, grid system, camera icon, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

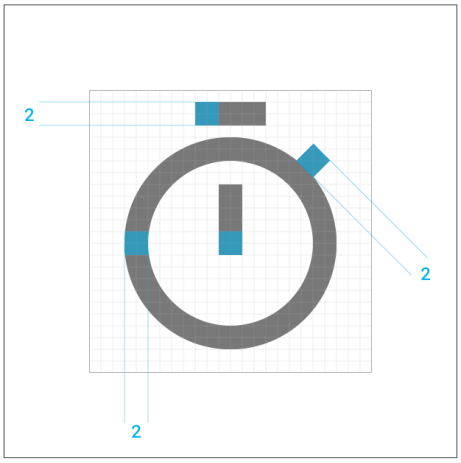


Figure 54: Google pictogram, grid system, timer design, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

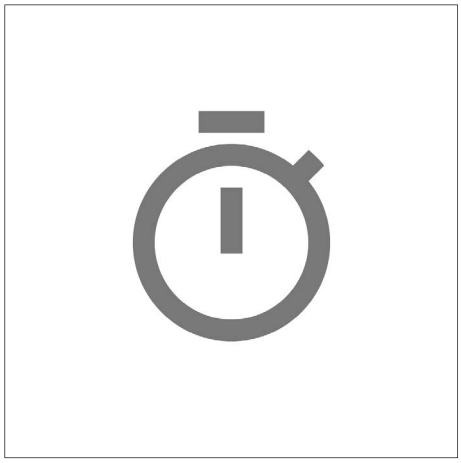


Figure 55: Google pictogram, grid system, timer icon, Retrieved April 20, 2015, from http://www.google.com/design/spec/style/icons.html#icons-product-icons

To develop pictograms that would match Google's design guidelines I studied their grid system by downloading the .svg templates and putting them on a 24 x 24 pixel raster. Doing this helped to develop some "Google-style" pictograms presenting health or environmental information.

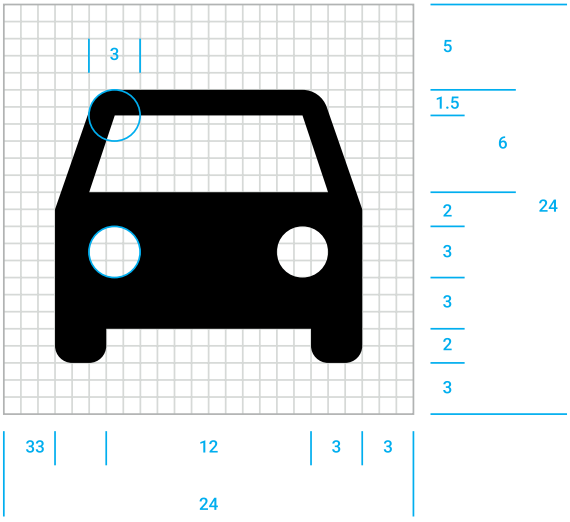


Figure 56: Google pictogram examination, grid system, car

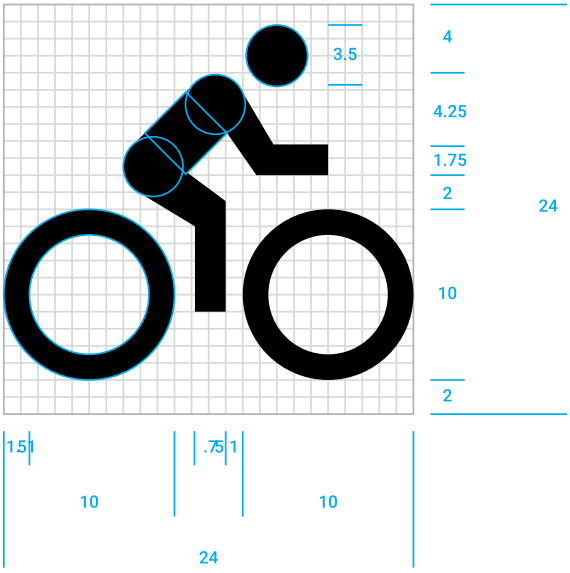


Figure 57: Google pictogram examination, grid system, cyclist

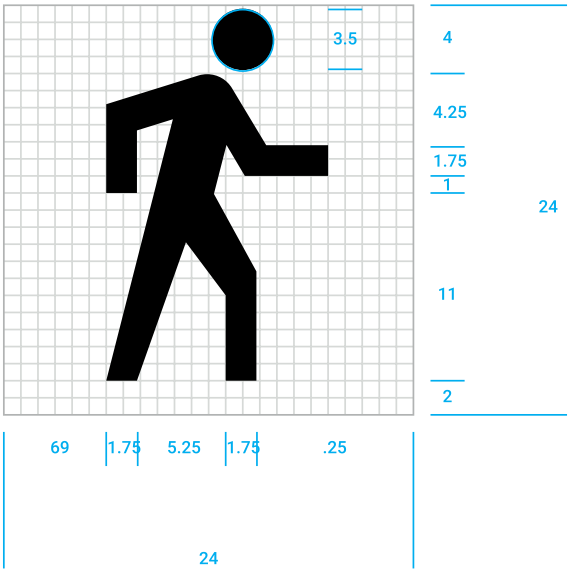


Figure 58: Google pictogram examination, grid system, pedestrian

Another reason for studying the grid system was to become familiar with the process of distinguishing what information was needed to be depicted and what information was required to be left out to improve for comprehensibility. In other words the study of the systems helped me to become familiar with the level of detail the pictograms required to be designed. To explain the process I here present some of the pictograms that were developed. A collection of all pictograms is found under the appendices.

Based on the pictogram of the pedestrian I made adjustments to create a pictogram displaying physical activity in the form of a runner. The upper body was kept unchanged, but the legs were put at a different angle to create the effect of a person running.

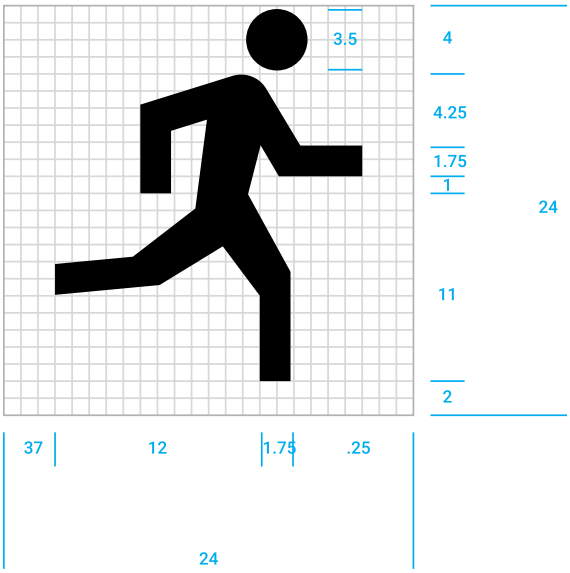


Figure 59: Pictogram development: runner

To visualize CO_2 emissions I drew the molecular structure of the gas, with the carbon atom illustrated as a solid object in black whereas the two oxygen atoms with their outlined shape symbolize the light weight of said atom. The stroke thickness is one pixel, and trials with thinner or thicker strokes ended up with decreased readability when scaled down to fit a mobile phone screen. The weight of the CO_2 emission is indicated in the upper right-hand corner, to give precise information about the amount of the harmful gas actually emitted in a trip. At a later point in time, the CO_2 pictogram was substituted with written information in all templates. None of the presented designs in the survey showed the molecular structure, because over time I came to the realization that in this case written information is easier to understand than deciphering a symbol.

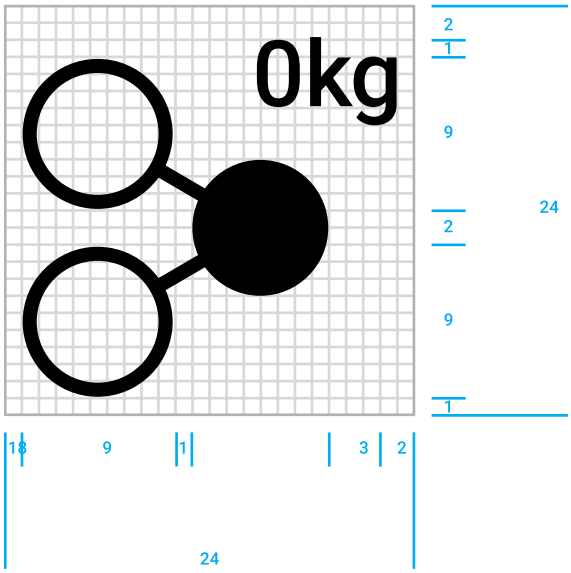


Figure 60: Pictogram development: CO_2 molecule

The only template Google provided for human beings is that of the pedestrian (see above). During the design process however I realized that an application that aims to offer customized information at least would need to be able to present the user's sex. Since the template provided by Google was genderless other pictograms were required. To develop an equivalent pictogram for a female, I added feminine features to the male version. For example, the height of the person was decreased by one pixel, a waistline was created, and the extremities were refined to be more delicate. Moreover, presenting one's height and weight in relation to a corporal reference was more accurate.

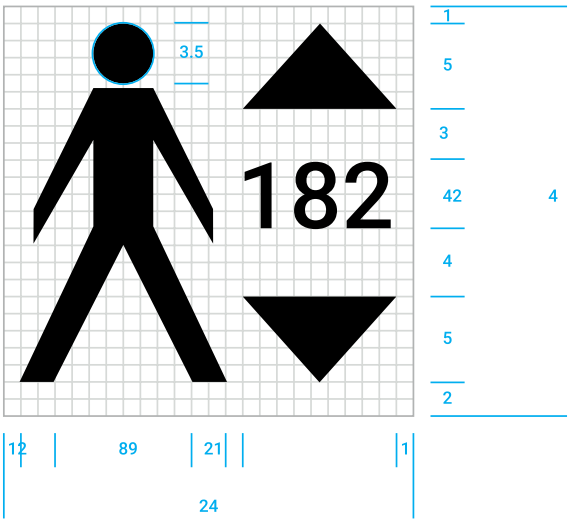


Figure 61: Pictogram development, male plus height

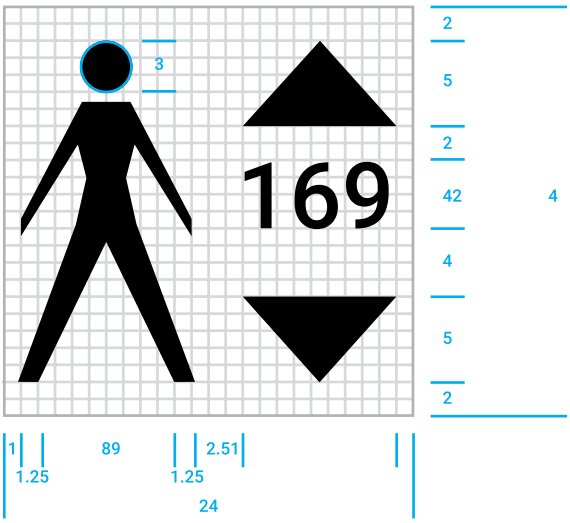


Figure 62: Pictogram development, female plus height

Though these first drafts met the bold Google style with broad sharp corners at the arms and legs, the drafts did not meet my expectations, as those edges seemed too unnatural. Therefore, out of curiosity and despite knowing that moving away from a Google style would be incoherent, a further development resulted in more appropriate designs where I rounded down the corners.

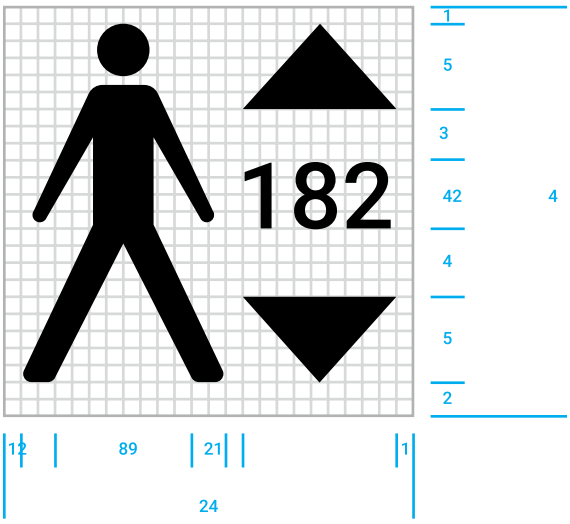


Figure 63: Pictogram development 2, male plus height

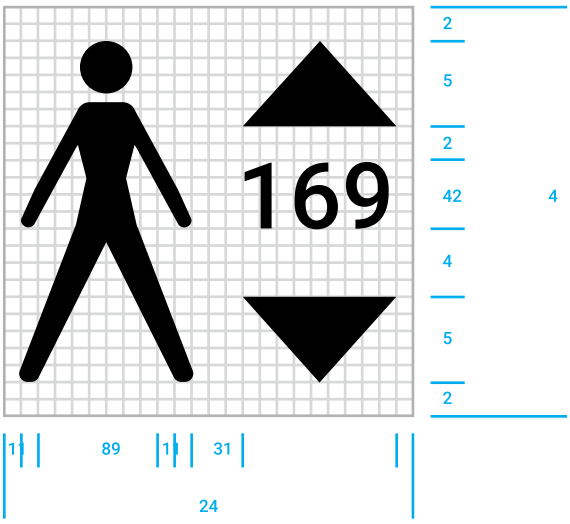


Figure 64: Pictogram development 2, female plus height

While addressing this issue I also worked on different ways in which height or weight could be displayed.

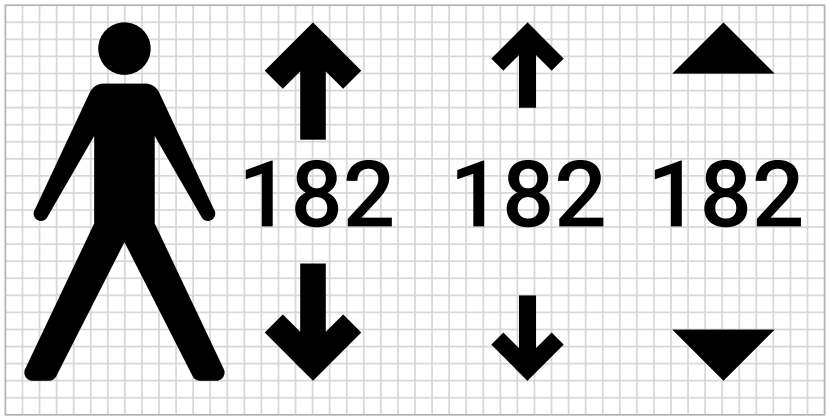


Figure 65: Pictogram development, height variations

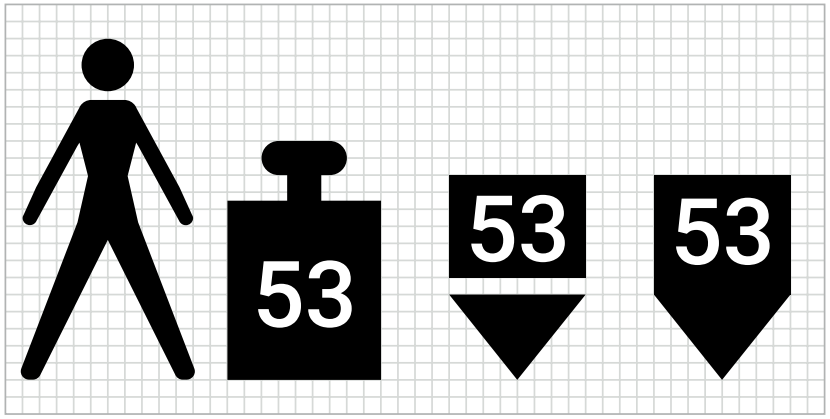


Figure 66: Pictogram development, weight variations

An attempt how to display time spent e.g. travel time, time for exercising or progress respectively effort, resulted in these pictograms. Although the pictogram on the left works well for time spent when the time frame is within one hour, the pictogram on the right is difficult to understand. A further explanation of what a solid or an outlined unit symbolizes would be necessary.

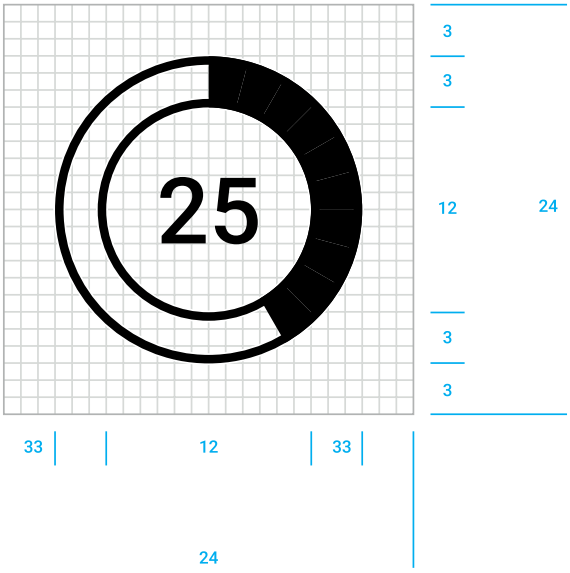


Figure 67: Pictogram development, time

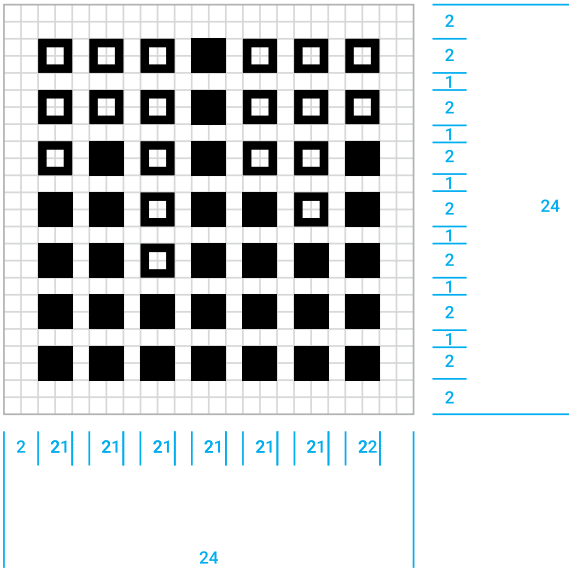


Figure 68: Pictogram development, progress or effort

7.5 Summary of the observations made during the pictogram development process

The pictogram development process was already a time-consuming task, but to improve the pictograms' comprehensibility and readability, separate testing prior to the survey would have been required. According to Tijus, Barcenilla, de Lavalette, and Meunier (2007), "a pictogram's effectiveness should be measured primarily in terms of people's ability to understand it" (p. 18). Due to the length, scope, and purpose of this study (namely, a general interest in a system that provides customizable information about travel decisions), I chose to present pictograms without prior testing. However, for the development process, I followed Tijus et al.'s (2007) proposed guidelines for pictogram design:

a) "appropriate levels of complexity and detail to maximise visibility and comprehension",
b) "a good pictogram should contain little detail and should be easily distinguishable",
c) "excessive representations of reality should not be used",
d) "shading and nuances of color should not be used with thin or flat objects",
e) "new symbol designs must be consistent with existing pictograms which are well understood",
f) "an effective symbol must be easily distinguishable compared with others",
g) "the size of elements and their separators, the levels of contrast between elements, and also content familiarity facilitate legibility and comprehension", and h)
"an appropriate level of complexity and detail will depend on how the pictogram is to be used". (p.18).

Although an earlier study found that the highest level of compliance of information occurred for combined pictorial language and written language (Otsubo, 1988), in this study word-based, pictogram-based, and combined versions were developed. This was the approach used,

as the main concern was not to find out what pictogram would best serve the purpose. Rather the main concern was the overall idea of what style would transmit the message and be perceived favourably. Moreover, it is to be noted that there are plenty of opportunity to independently research pictogram development.

7.6 Results of the mobile application mock-up development simulating a Google-style

With the first series of pictograms I was then able to simulate how the application mock-up I suggested as my research topic would look like. To do so, I took screenshots of the current display of a Google Maps trajectory. As proposed the application would be an installation for mostly everyday commuting, I chose trajectories with an average distance for each method of transportation available. Based on these files I added the option of the "Footprint Tracker". As mentioned previously, in an earlier stage of my thesis the working title of the application mock-up used was Footprint Tracker. Later I decided that the term was misleading, as it could provoke negative connotations. For the following three reasons, I deliberately decided to keep the project unnamed: firstly, the project is a research study (the considerations have not been implemented in a working prototype or product) and, in my opinion, naming should occur during an implementation phase. Secondly, the project was a research project and I did not want to create a name that would evoke negative connotations or affect the final outcome. In this sense an artificially created name might have served best, however, and third, the complexity of a naming process is not to be underestimated, as a chosen name needs to be reviewed by a number of people for potential connotations, and in our globalized world a cultural-linguistic check (which also implies a pronunciation check) is also inevitable. Therefore, in order to not shift the focus of my study, the project remained unnamed.

Figures 69-72 and 73-76 contrast the current appearance with a simulated look of the added function of customized information.

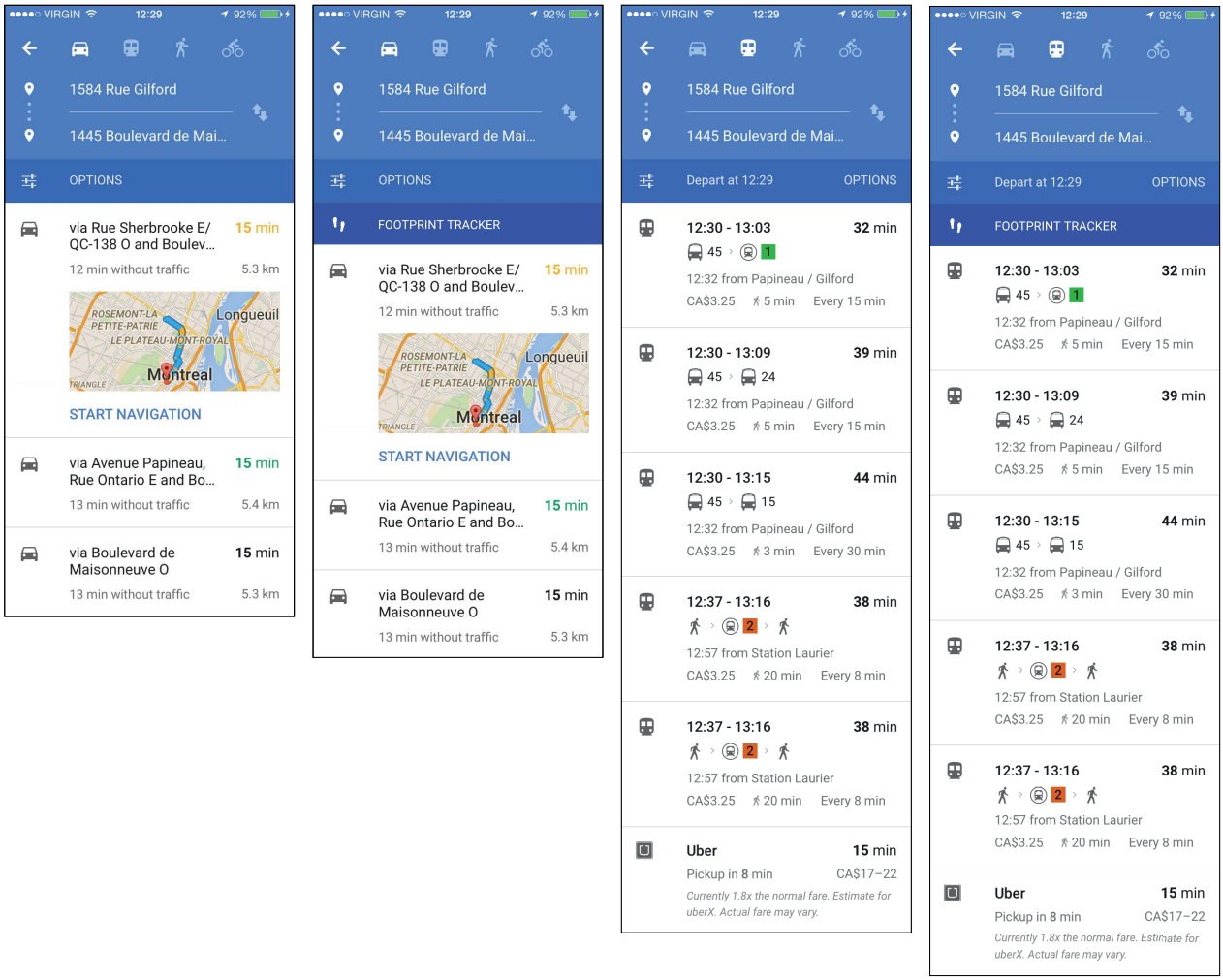


Figure 69-72: Google style mobile application mock-up with Footprint Tracker added, directions for car, connections for public transportation

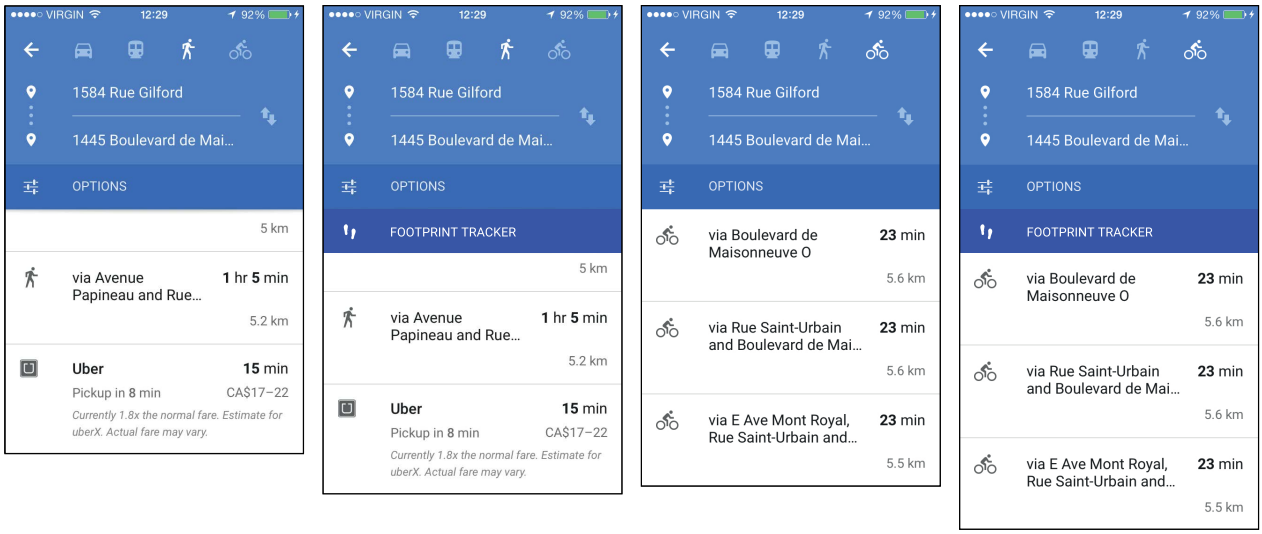


Figure 73-76: Google style mobile application mock-up with Footprint Tracker added, trip details for walking, cycling

The outcome of the first series of pictograms applied in an application mock-up for mobile platforms is illustrated below, demonstrating the change and growth of the development. The simulated screens show what a user would see if he or she would tap on the Footprint Tracker button. The version on the left responds to the category of users that would indicate a preference of simplified graphical information presentation, according to this, the illustration on the right depicts information in a precise numerical manner.

Figure 77: Mock-up with Footprint Tracker simplified information

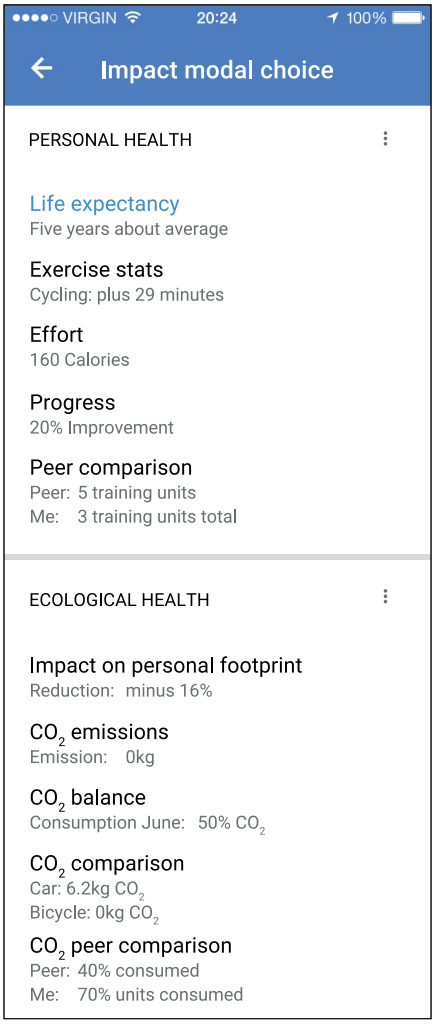


Figure 78: Mock-up with Footprint Tracker precise information

In both designs one category is highlighted, on the left it is *CO_2 balance*, on the right it is *Life expectancy*. The idea behind highlighted links was that a user could access more detailed information by tapping on the category's title. For the examples in the illustrations this is how a sub-menu would look like.

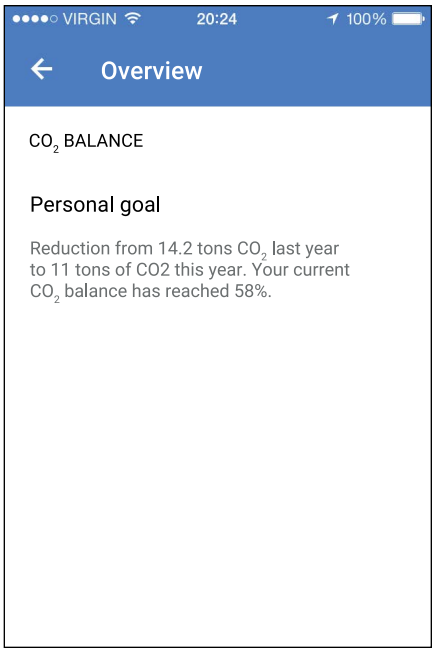


Figure 79: Mock-up with Footprint Tracker detailed formation

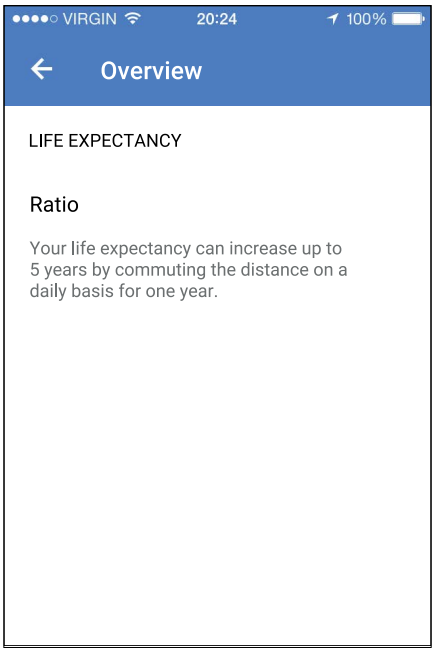


Figure 80: Mock-up with Footprint Tracker detailed formation

When I finished my work on those designs I was not as satisfied as I had hoped in the beginning. First of all I realized that not all of the pictograms conveyed the message without further explanation. Second, some information was easier to understand when it was in a written form than in pictograms. Third, I felt the overall appearance was not very effective, it looked very technical and I did not believe that the design would have a motivational effect in terms of user interaction. During discussions with my supervisors this impression was confirmed. Moreover, following my research proposal which involved a survey to collect people's opinion on how they think additional information about transport decisions would alter their behaviour, I recognized that in order to collect unbiased information I had to move away from

a Google style and focus on developing different styles of pictograms and knowledge visualizations, aiming to reach a broader audience and a wider spectrum of personal tastes.

7.7.1 Results of independent knowledge visualization designs for mobile app mock-ups

The next research-through-design project was focussed on variation in appearance. At the beginning of this phase I struggled, as my working mode was literally still caught up in the grid I applied when developing pictograms that simulated the Google style. To free myself from these constraints I began this new phase from scratch. I conducted a brainstorming session, and consulted literature on the topic. A reflection of existing apps also helped me to open up my mind for another creative process. The brainstorming included a consideration of a development of different persona that would represent target groups for which I had designed knowledge visualizations. A Sinus-Milieu diagram was applied and five fictitious people were placed in the diagram to determine different user types. However, I did not continue with this approach, as I did not want and did not have influence in choosing participants that would match those criteria when evaluating the outcome in a survey at a later point in time.

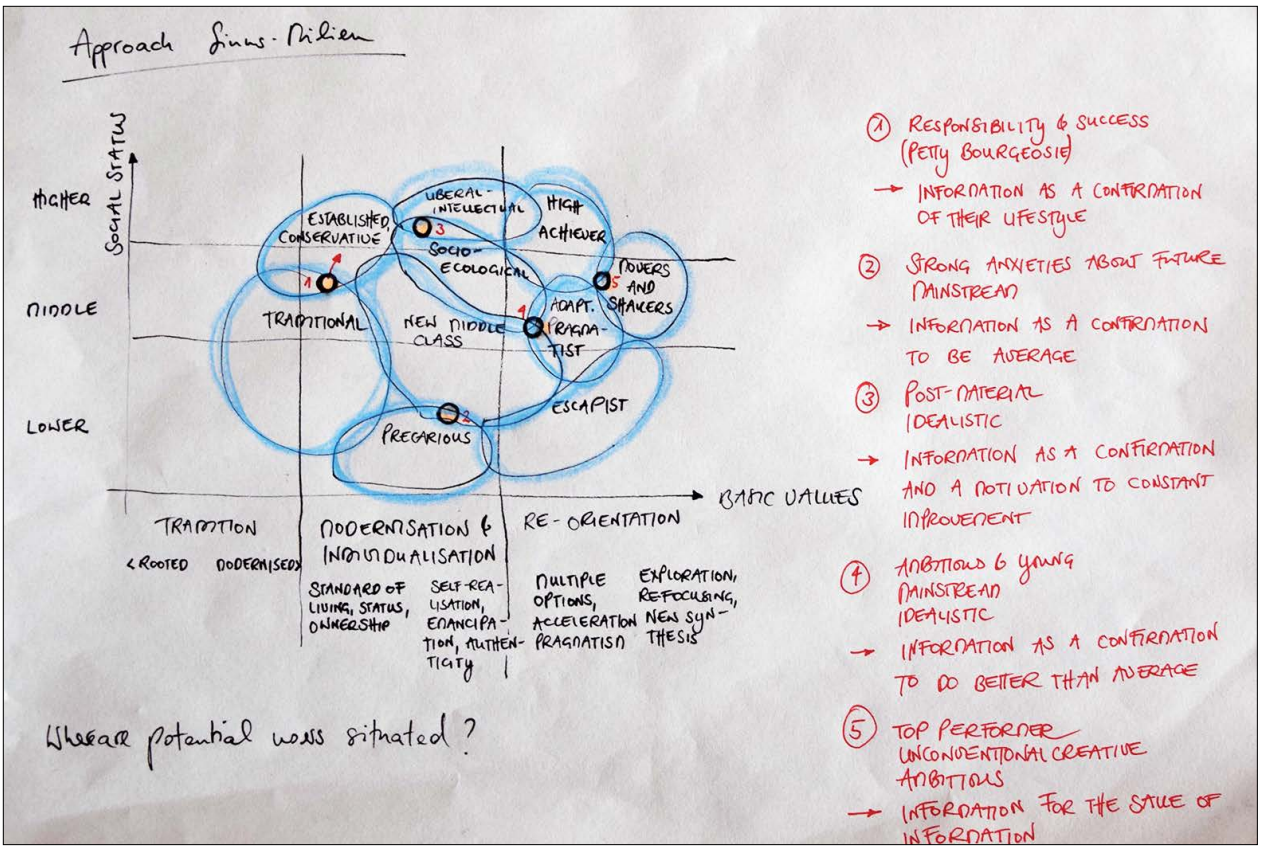


Figure 81: Approach Sinus-Milieu

As previously mentioned, the design of the different knowledge visualizations then followed the idea of developing three different pictogram styles, and one or two text-based versions. Another important consideration for the development of the knowledge visualizations was the outlook of developing a survey in which I would not have the chance to explain in detail the objective of the study or the actual meaning of a pictogram. This idea assisted me in aiming my attention toward the essentials of what my app should be. At first I decided that the new templates would only compare two different methods of transportation at once. The reason for this decision was not only to simplify the design, but also to accommodate users' habits. By this I mean most users have a primary method of transportation. It is the method they evaluate as the most appropriate for their purposes. This does not imply that it is the most convenient, but if compared with other options the advantages may outweigh disadvantages. In this sense, I decided that for the survey — and therefore for the designs — people require a comparison of their primary and secondary method of transportation. Reducing the options

also resulted in avoiding an information overload and improved readability, acknowledging the limited space of a smart phone screen. Last but not least, the reduction was another step toward customization, as it deliberately left out information of minor importance.

7.7.2 Results knowledge visualization template I

In contrast to the first knowledge visualization where I attempted to simulate a Google style, the next visualization I developed, I decided to make colourful. I had in mind icons that would invite someone to use the app. I had envisioned a playful and friendly appearance, presenting the context of health improvement in a positive rather than neutral way. From the left to the right the illustrations below show the development of the pictograms.

The rounded corners, the use of colour, and presenting information in pictures instead of words supported the overall idea of a friendly appearance. However, if someone was not familiar with the category, the pictograms may not be self-explanatory. In addition, in the beginning for example the pictogram for public transportation (a commuter train or metro) evoked in some viewers a symbol for a desktop computer screen, the pedestrian seemed to run, and the pictogram symbolizing costs was associated with a calculator instead of money. Yet, I maintain that the dollar sign is not a final solution either, as the currency is not a worldwide instrument of payment.

Category	First draft	Improvement	Final design
Directions		unmodified	
Transportation method			
Workout		unmodified	
Calories		unmodified	
CO_2 emissions			
Travel costs			
Travel time		unmodified	
Traffic conditions		unmodified	
Weather conditions			

Table 2: Stages of development pictograms first knowledge visualization template I

7.7.3 Results knowledge visualization template II

This design completely went without pictorial language; it is an idea that used words for each category. For this design no stages of a development process occurred. After the first layout I decided not to continue with this idea. The initial concept did not work out, it divided the screen diagonally, presenting information to each method of transportation in one of the resulting corners. The first draft was designed using a colour scheme consisting of black, white, and blue. Customizability in this idea was also provided through the option of changing the colour scheme or adding personal photographs. The layout design did not support comprehensibility and readability, therefore I decided not continue with its development.

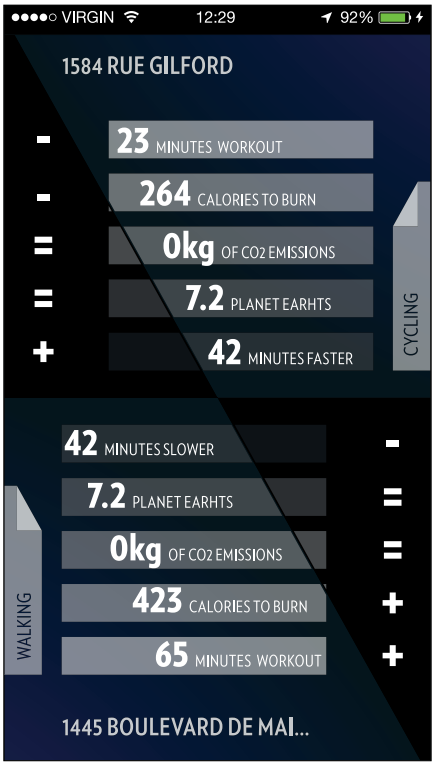


Figure 82: Template II, black/white/blue, design not continued

Figure 83: Template II, personalized background picture, design not continued

7.7.4 Results knowledge visualization template III

The goal of this template's appearance was to be a clear and simple one. My approach was to develop a reduced design without any distracting elements. Firstly, I deliberately resigned from the use of colour in this version. The pictograms consisted of plain line drawings, the font I chose is Univers 47 light condensed, a slim typeface of the Univers sans-serif type family, underlining the targeted sophisticated simplicity.

Category	First draft	Improvement	Final design
Directions		unmodified	
Transportation method		BIKE / BUS	BIKE / BUS
Workout		unmodified	
Calories		unmodified	
CO_2 emissions		unmodified	CO_2
Travel costs		unmodified	
Travel time		unmodified	
Traffic conditions		unmodified	
Weather conditions			

Table 3: Stages of development pictograms third knowledge visualization template III

7.7.5 Results knowledge visualization template IV

The inspiration for template IV came from my work as a watch designer for Porsche Design in 2006 and 2007. As a watch designer one becomes very sensitized to perception of information and readability. A watch face must satisfy diverse needs. First the main purpose of the watch is to display the time, but with many functions of movement types, brand identity, social status and the taste of its bearer, the limited space of a watch face is a challenging project for a designer. Time, speed, altitude — among other dimensions — are perceived well if displayed in a circle. Many designs of dashboards for planes and cars are examples where this principle is applied. Emanating from displaying information in a ring-like layout, for the designs in this template I attempted another approach of information presentation. For instance, assuming the visualization of 100 percent corresponds to a solid circular shape, than a hundreth — or a 3.6 angled section of this shape is the equivalent of one percent. In this sense I decided to write out in words the categories, but present the numerical values in circular shapes. Also, for the initial draft of this template I inversed the colour scheme by using a black background combined with white text and highlighted information in yellow.

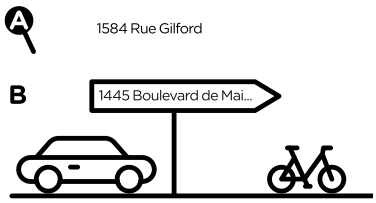
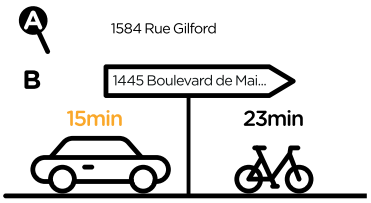
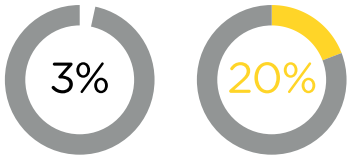
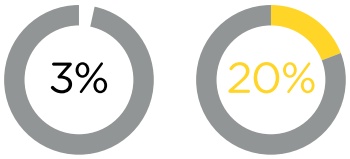
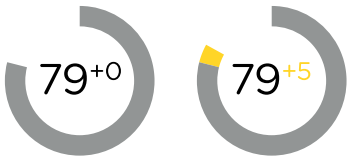
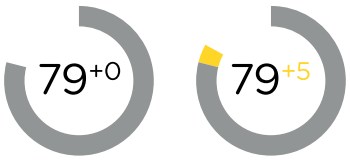
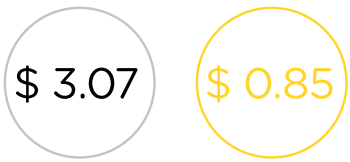
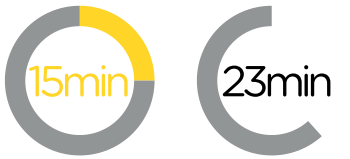
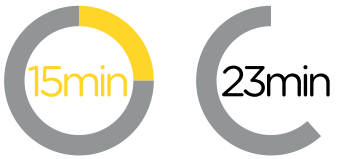
Category	First draft	Final design
Directions and Transportation method		
Workout		
Life expectancy		
CO_2 emissions		
Travel costs		
Travel time		

Table 4: Stages of development pictograms fourth knowledge visualization template IV

7.7.6 Results knowledge visualization template V

With the experiences I acquired especially from designing knowledge visualization templates II and IV — with the first attempt that did not work out and the second that required applying another way of information presentation, I decided to develop a fifth template using bars to indicate numerical values. Bar diagrams are a common method to present data, therefore I decided to create a group of different knowledge visualization templates that I included to give participants of the survey one more option to choose from. This was also the only design where I left out any numerical information, only the size of the bars served as an indicator for corresponding values in reality. In contrast to earlier drafts, in this version I did not highlight advantages or disadvantages, I kept the data raw. For the font I used Hoefler & Frère's Knock-out Welterweight 50, a sans-serif typeface that is part of a font family developed with a focus on readability up to very small font sizes and screen display.

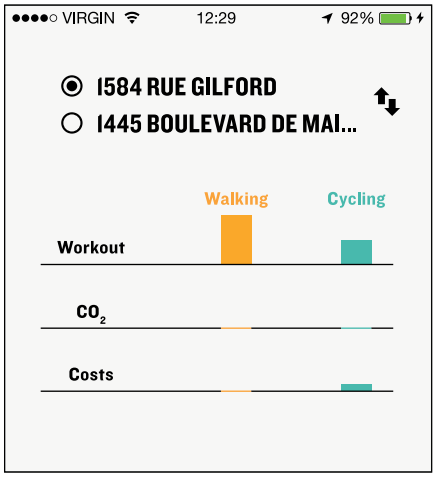


Figure 84: Mock-up design template V

7.8.1 Presentation of the five application mock-ups

Figure 85: Mock-up design template I

Figure 86: Mock-up design template II

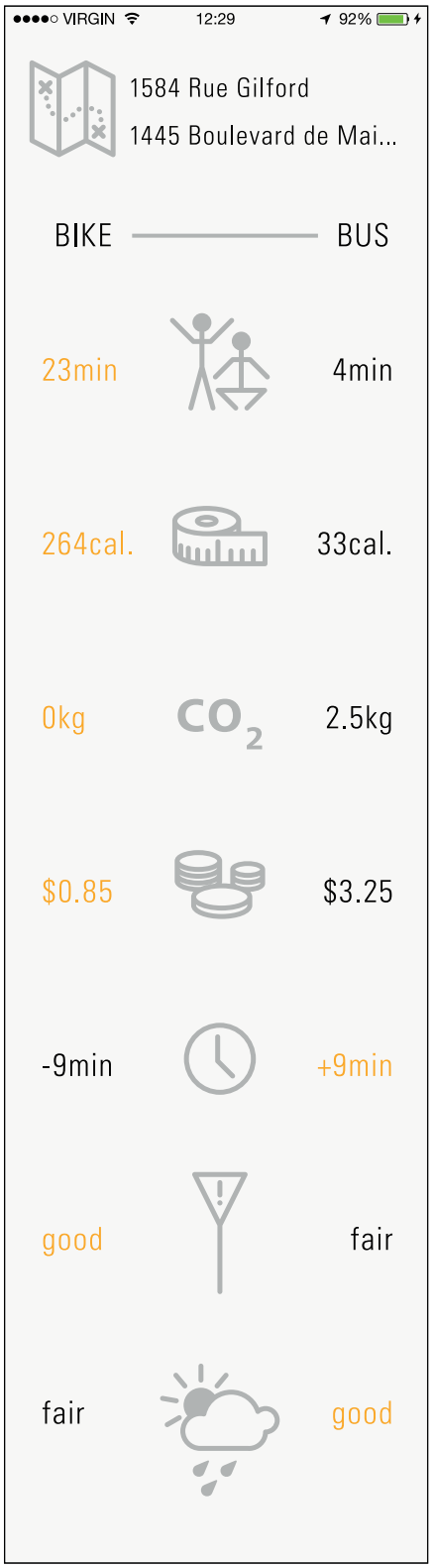


Figure 87: Mock-up design template III

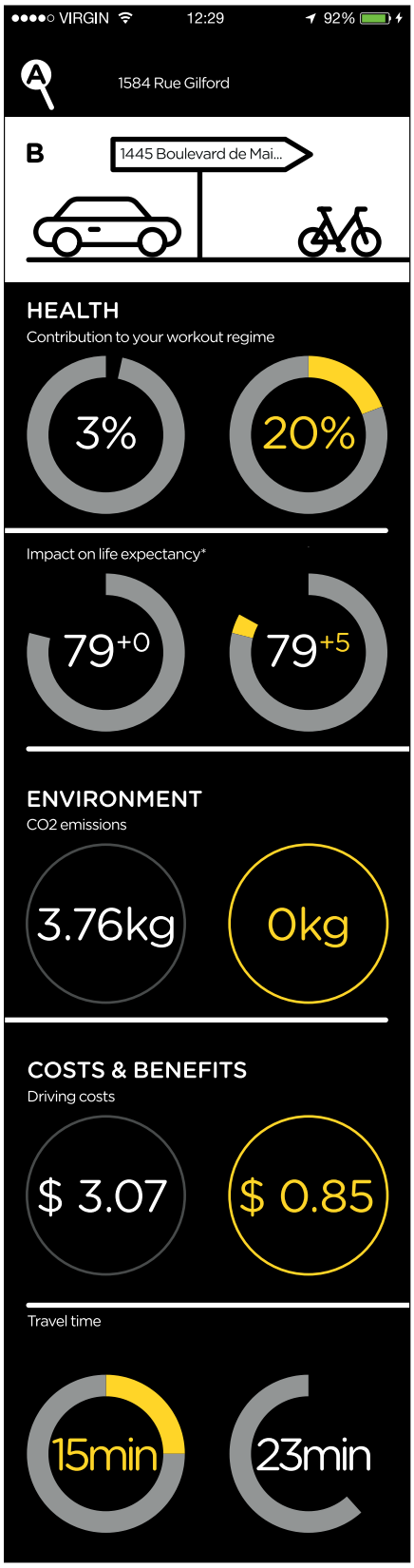


Figure 88: Mock-up design template IV

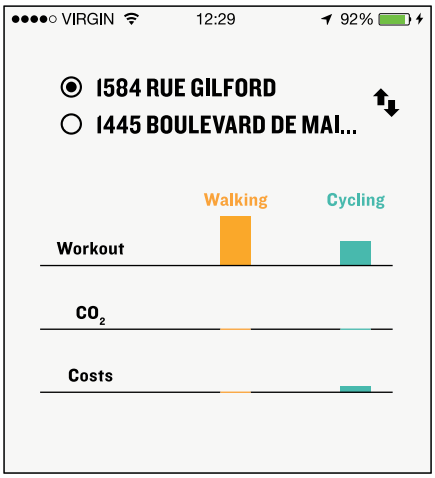


Figure 89: Mock-up design template V

7.8.2 Reduction of the templates for improved comparability

With all templates designed I realized that the presentation in their current state evoked uncertainty and therefore gave a distorted picture of the results. Participants should be offered templates that would differ in their design, but not in their content. To reduce information I defined that under each category, namely health, environment, and costs and benefits one piece of information would be displayed. Moreover, in order to avoid distraction caused by too many design features, I chose to depict all templates with a white background. To add a reference option, I decided to present template I with pictograms and, based on this template, a text-based version, referred to as template C. The final versions as presented in the survey are displayed below.

Author's note: The order of the templates presented in this document is not coherent with the numeration presented in the survey. For this reason, the researcher chose to numerate the design templates while in a working stage with Roman numbers (templates I to V) and the design templates presented in the survey with letters (A to E).

7.8.3 Final designs as presented in the online survey

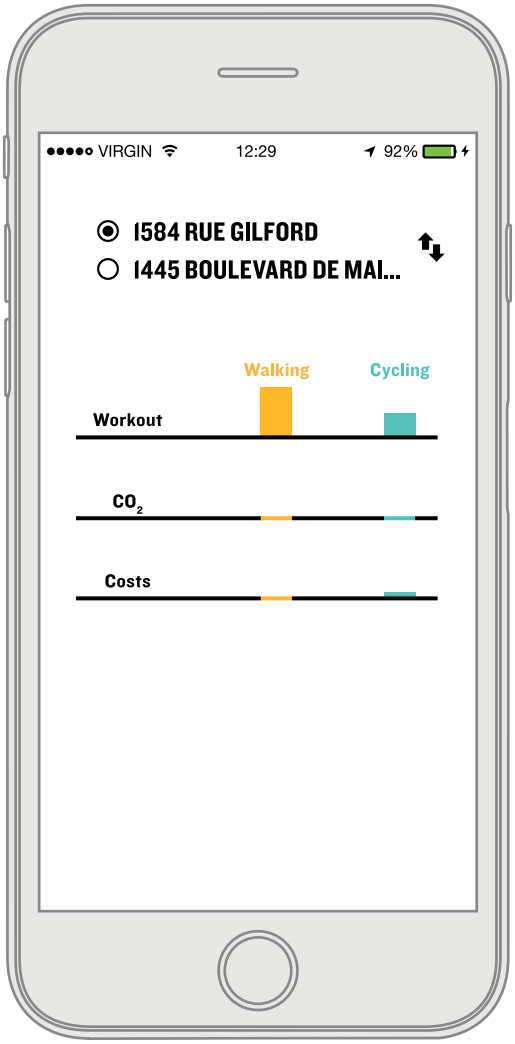


Figure 90: Mock-up design template A

Figure 91: Mock-up design template B

Key design elements of design template A:

- no usage of pictograms
- text-based template
- size of bars symbolize value
- no numerical information presentation

Key design elements of design template B:

- no usage of text
- pictogram-based template
- text colour indicates better choice
- numerical information presentation

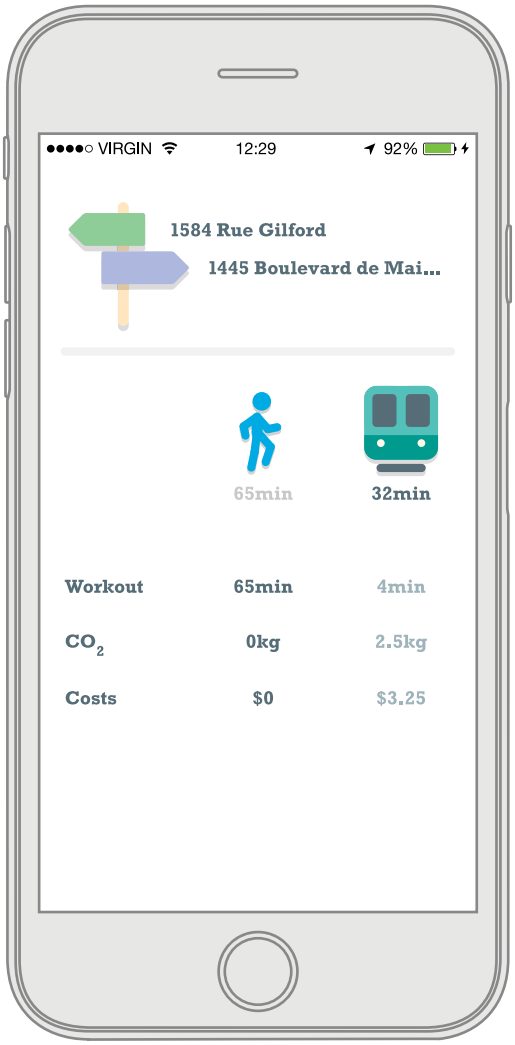


Figure 92: Mock-up design template C

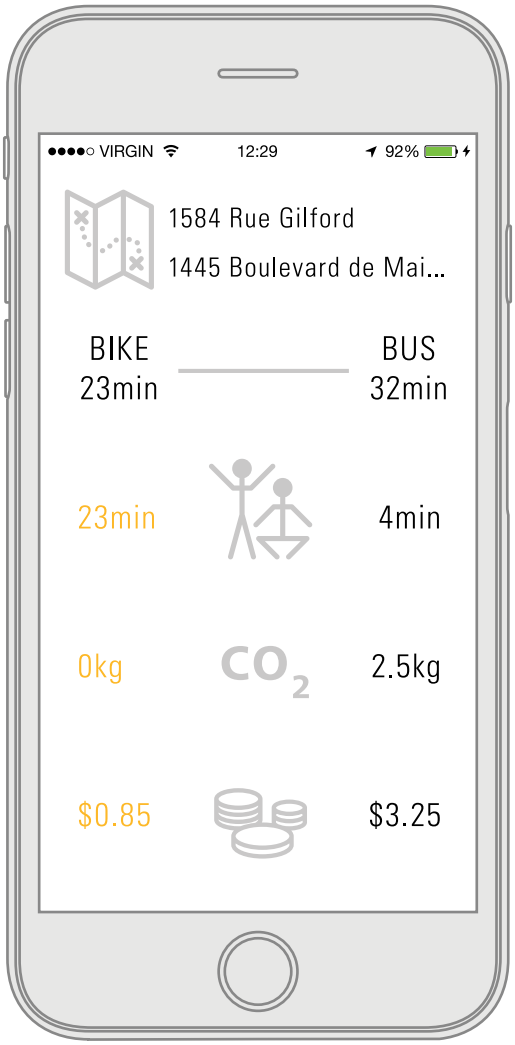


Figure 93: Mock-up design template D

Key design elements of design template C:

- combined usage of pictograms and text
- sampling to compare with template B
- text colour indicates better choice
- numerical information presentation

Key design elements of design template D:

- no usage of text
- pictogram-based template
- text colour indicates better choice
- numerical information presentation

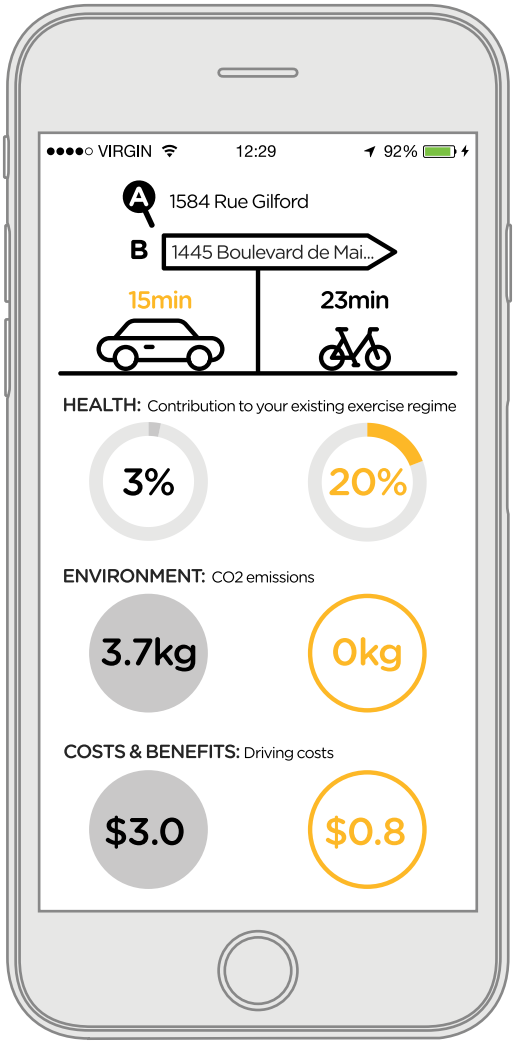


Figure 94: Mock-up design template E

Key design elements of design template E:

- combined usage of pictograms and text
- text-based template
- size, surface, and stroke symbolize value
- colour indicates better choice

Author's note: the values presented in the knowledge visualizations are based on calculations using material from recognized research institutions or national statistical databases.

However, for a realistic implementation and precise customized representation of personal data, a more refined method must be developed and applied.

Chapter 8: Reflection on the action-reflection approach

8.1 Experiences from the design process

Though the thesis proposal I prepared guided me through the actual research period, I realized during this time that in fact the practical part of my research did not always follow the theoretical map I had outlined in advance. I experienced through self-reflection, but also through presentations and conversations with my supervisors that the paths I went down did not always led to the point I expected. One of the difficulties I faced was what is so distinctive for design practice: problem solving is not a process flow of a linear order. On the way new problems evolved, but also new ideas and possible solutions emerged.

My thesis topic overlaps with and borders on several no less interesting research areas and it was tempting to investigate further in other directions. I think of designers and design researchers as explorers and the pleasure that come with seeking new lands can also be dangerous. As in my case I had to be careful that I did not lose orientation. Creativity in this context can result in self-provided obstacles as well. Indeterminate problems could be approached from different angles and producing ideas could convey an impression of productivity, but it is the execution of an idea or of a selection of ideas that finally brings results.

In retrospect, I remember I struggled the most in the beginning of the practical part of my research. This makes sense as I experienced the paradox of choice. Defining the categories and subsequently the three steps a user would have to go through when providing basic information to produce customized data was the most challenging task. At this stage I staked out the field I was about to plough up and once this was done I felt much more comfortable investigating in this well-defined area. I then had created a setting I knew very well from experience as a design practitioner. I had a briefing and I saw in which direction my next step would lead me.

Investigating in Google's design guidelines was a pre-requisite as in any design project. For example when the design task is to create a new toy for children, the designer needs to examine purpose of the product, physical and mental abilities of the target group, material specifications, and so on. In this sense familiarizing myself with Google's design guidelines finally led to first scribbles, sketches, and then to final drafts. Later analysis, synthesis, and evaluation helped me to orientate myself again.

After having developed the wizard it was clear that the next task was to work out the mock-up for the mobile application: slipping from the role of the researcher back into the role of the designer. Though this transition was not always easy, I was surprised how much I enjoyed both sides of the process. For each decision I made I had to deal with the consequences, and sometimes this felt as if I were bargaining with myself. I experienced this especially after I had finished the Google-styled design for the mobile application, as in the beginning I did not foresee designs independent from Google's CI. Moving away from these constraints however had a freeing effect. Although I enjoyed working in this "safe" area of 24 x 24 pixels, it was more interesting to experience trial and error based on regulations I set for myself.

The time limit of this study was essential in terms of staying focussed. The inquiry was extremely rewarding and in fact when I had to choose the designs to be presented I felt the design process was not completed. The designer in me still wanted to produce more designs, try out other ways of information presentation, and the researcher in me was eager to approach the problem from other points of view. This being said I considered the survey rather as another stopover for re-orientation, and I hope that future research in this field will continue.

8.2 Development and distribution of the online survey

With full-coverage internet in modern societies online surveys have gained more popularity as well as credibility. (Wright, 2005). Concerns of representativeness are less strong than in the past as for example in the U.S. internet access distribution has reached a share of 57 percent by people in the age class of 65 years and older, 88 percent by people from 50 to 64, 93 percent between the ages of 30 and 49, and 97 percent for people between 18 and 29 years. (Statista, 2014). Online surveys offer a number of advantages, and regarding the context and the purpose of the research, those can outweigh the disadvantages.

The development of a survey is a task that needs to be thought through in advance. Questions that do not serve the purpose of the survey are useless and must be avoided. The researcher must consider that the interviewee is possibly not familiar with the topic, therefore the questions being asked needed to be in understandable language, refraining from using technical terms. Information about the survey needed to be provided at the beginning of the survey, participants also needed to understand the purpose of the survey, realize who the person responsible for the survey and what was the institution the person was affiliated with. In this sense, the briefing needed to be be short and easy to comprehend. To create trust, participants needed to know immediately how data security was handled and if anonymity was ensured. Meeting these requirements I decided to put all the information necessary on the introduction page, personally addressing the potential participant — in contrast to general formulations — and concluding with a request for the participant's consent which led to the next section of the survey.

The total survey consisted of seven steps, with four questions in regard to demographic data under the first section. The participants were asked about their sex, age, country of residence, and if they live in an urban, suburban or rural environment. As I had mentioned before, I designed a survey in which skipping questions was not possible, answering the presented questions per page directly led to the next section. After I had collected personal information

my interest focussed on methods of transport available, as well as travel preferences. Subsequently the participant was asked if he or she would be interested in additional information about their modal choice. A yes/no option for answering was combined with a page logic I created for the survey. If the participant chose "yes" they were guided to a sub-question that investigated the health category more deeply. A "no" moved directly to the next category, namely environment. Similar to the prior procedure, a "yes" or "no" option was provided. I applied this page logic one more time, under the category for costs and benefits in relation to modal choice. At any of the sub-questions I had an additional field where the participant was given the option to fill in information of personal interest if not already given. After completion of the four initial steps about people's general opinion of additional data for customization, the next section I applied a question matrix or Likert scale, investigating the extent of importance about the style of information presentation. Also, I asked about the participant's preference of either a simplified graphical or precise numerical presentation style. With these questions being asked the subsequent section presented the five knowledge visualization templates I created. The participant was asked to choose a favourite as well as give an explanation for the choice. After having presented those designs the concluding questions, explored the participant's opinion of increased usage of the software and the influence of customized information on his or her travel behaviours. To indicate that the participant has answered all questions, a 'thank-you' page appeared once the last response had been given.

The survey was online for seven days with a total number of 126 participants. To distribute the survey I applied active and passive recruitment methods. An active recruitment method is when the interviewee contacts potential participants personally. To do so I sent out an email to people of my personal and professional network. I invited people to take part in my survey, but I also directly included the option for passive recruitment, asking people if they were willing to share the link to the survey within their networks. To increase the number of addressees I also used web 2.0 options that allowed me to post the link on different platforms, in particular Facebook and Twitter.

8.3 Results of the online survey

Within one week 126 participants completed the survey. After cleaning the data, e.g. deleting entries of people that stopped filling out before completion, a total of 102 valid responses remained. Of those 102 people, 58 respondents were male and 44 female. The geographical distribution of the participants was 50 people from North America, 46 from Europe, and 6 from Australia, Asia, and South America. The distribution in the age classes was as follows: 18 to 27 years: 19 percent, 28 to 37 years: 30 percent, 38 to 47 years: 26 percent, 48 to 57 years: 19 percent, and 58 to 67 years: 6 percent. 80 percent indicated to live in a city, 15 percent in suburban areas, and the remaining five percent in the countryside.

Regarding questions about travel behaviours, 16 percent stated that their primary method of transport is walking, whereas 34 percent cycle, 24 percent take their car, and 26 percent use public transportation. The results between respondents from North America compared to participants from Europe however differ greatly. A closer look at the survey evaluation reveals that personalized motorized traffic has the highest share in North America with more than one third indicating the car as the primary transport method. In comparison, only nine percent of people from Europe chose the car as their primary method of transportation. On the other hand, only 11 percent of Europeans stated that walking is their first choice to get around, when in fact 1/5 of North Americans indicated that walking was their primary transportation method. Bike percentage numbers vary considerably as well. In North America 22 percent indicated cycling as their primary method of transportation whereas Europeans reported more than twice that, namely 50 percent of Europeans prefer the bicycle over other transportation methods.

Of all respondents, more than two thirds (65 percent) are generally interested in additional information about the impacts of their travel behaviours on health, environment, and costs versus benefits. Almost half of the respondents (48 percent) stated that the way in which information was presented would likely affect how they make use of information. Another 31

percent thought that it is very likely that the information presentation would have an impact on them. Regarding different presentation styles, 44 percent preferred a precise numerical representation, and 56 percent preferred a simplified graphical.

Almost half of the participants also thought that customized knowledge visualizations had a strong influence on the frequency of the use of mapping software, and another 13 percent thought it had a very strong influence.

The distribution of the favoured knowledge visualizations is as follows: design A: 13 percent, design B: 7 percent, design C: 21 percent, design D: 12 percent, and design E: 47 percent. What is most interesting about this division is that the majority of people preferred the template with a combination of written information about the category, and graphical presentation of the numerical value.

One participant for example explained he chose design E because of “exact values shown, clear descriptions”. Another who favoured design E said “graphical and interactive, easy to understand and compare, giving percentage for health is more tangible”, and a third opinion on the design was that provided “exercise motivation and visually pleasing”.

This general direction of how people evaluated the designs is backed up through the numbers of votes the two similar design templates B and C received. Where design B illustrated pictograms to present the categories, and C described those in words, B was chosen by only 7 percent whereas C was favoured of 21 percent of the people.

Category

Total number participants	126				
Cleared data	102				
Sex	Female 44	Male 58			
Age	18-27 19%	28-37 30%	38-47 26%	48-57 19%	58-67 6%
Origin	North America 50	South America 1	Europe 46	Asia 2	Australia 3
Home	City 80%	Suburbs 15%	Country 5%		
	Walk (%)	Cycle (%)	Car (%)	Publ.T. (%)	
Primary transport method	16	34	24	26	
Secondary transport method	18	28	16	40	
	Walk (%)	Cycle (%)	Car (%)	P.T. (%)	
Primary method North America	20	22	36	22	
Primary method Europe	11	50	9	30	
Primary method Others	17	17	33	33	
General interest in additional information about	Yes	No			
Health	65%	35%			
Environment	77%	23%			
Costs/benefits	82%	18%			
Preferred presentation style:	Simplified graphical 56%	Precise numerical 44%			
Favoured KV template	A  13%	B  7%	C  21%	D  12%	E  47%
Information presentation affects use of information	Very unlikely 3%	Unlikely 3%	Neutral 15%	Likely 48%	Very likely 31%
Customized information affects frequency of use	4%	8%	30%	45%	13%
Customized information affects transportation method	10%	9%	23%	49%	9%

Table 5: Major results of the survey

Chapter 9: Design research outcome: discussion

Through the literature review, I descried the lacking research in the overlapping fields of behavioural psychology, human-computer interaction, and customization. Moreover, during a discourse review of additional media, such as blogs, magazines, and tweets, I realized the timeliness of the topic. Despite the extensive literature and specifically discourse reviews I examined, I was unable to find anything that corresponded to the research design and framework I considered most appropriate for knowledge contribution. With the application of a research-through-design approach, I delved even deeper into the field, as this way of unique enquiry — combining knowledge and experience from design practice and design research — offered a more holistic examination of topic.

In her paper "No Guru, no Method", Carol Gray (1996) considered practice-led research as seminal in the way in which the application of new investigative methods is required and supports knowledge contribution. She defined practice-led research as:

> "Research which is initiated in practice, where questions, problems, challenges are identified and formed by the needs of the practice and practitioners; and ... [where] the research strategy is carried out through practice, using predominantly methodologies and specific methods familiar to us as practitioners". (Gray, 1996, p. 3).

Since new methods and new combinations of methods can come with unpredictable difficulties, the application and implementation, but even more the capability of dealing and overcoming the uncertainty of said, could be regarded as a contribution to knowledge.

In any scientific discipline, research should be done in an inquisitive and informed manner. The process has to be methodical, and the results need to be communicable. (Cross, 2007). However, most importantly, research must be undertaken for a purpose. Cross (2007) explained it as follows:

> "The whole point of doing research is to extract reliable knowledge from either the natural or artificial world, and to make that knowledge available to others in re-usable form. This does not mean that works of design practice must be wholly excluded from design research, but it does mean that, to qualify research, there must be reflection by the practitioner on the work, and the communication of some re-usable results from that reflection" (p. 102).

I am confident that my examinations and developments can be reused, either by choosing another inquisitive direction or by building upon the existing results. Also, a reflection on the work from another point of view—researchers with other backgrounds, other skill sets, or just different priorities—would help to improve the existing work.

Cross (2007) further explained in *Designerly Ways of Knowing* that sought knowledge is to be found in people, processes, and products. More specifically, knowledge lies in the analysis of observation of how people design, in the design methodology, and in the embodied information of the designed artifact. In this way, the reflection on my research activity and the observation of what I did give answers to epistemological developments. The picture an outsider would get upon reflecting on my work would differ from what I experienced during the process of recognition and therefore the knowledge that lies within the work would be perceived differently. Following Cross' (2007) characterisation of design, I can say the study's "design is opportunistic". By considering changing conditions or additional information, I was able to make adjustments in the theoretical as well in the practical research phases. This allowed me to act and react while solutions and problems emerged during the process. For example, the idea of independently designed knowledge visualization mock-ups only came up when I realized that the "Google-style" mock-ups did not serve the purpose of investigating people's opinions when provided with personalized information. The study's "design is abductive", as I presented a solution that corresponds to the hypothesis I proposed in the beginning of the thesis. The study's "design is emergent" as it points out where a knowledge gap has been bridged and where further research is needed. The study's "design is rhetorical": the results

of the online survey reveal participants showed a great interest in the proposed system of customized information regarding personal behaviour patterns and impacts of different transportation methods. Furthermore, the "design is risky", as the concepts presented do not and cannot meet expectations of different points of view. However, the "sketches are there to be criticised, not admired; and they are part of the activity of discovery, of exploration". (Cross, 2007, p. 36). For example, I would have liked to spend more time developing and trying pictograms upon their quality of information presentation, but in order to produce results, I decided to go with what I had, knowing that any decision I would make would influence the outcome. Last but not least, the study's "design is exploratory" in the way in which I designed a unique methodology to explore the topic. Other designers might apply different methods or develop different results with the same methods; however as long as the goal remains the same — namely suggesting approaches that can improve people's health — the body of knowledge would increase. Marples (1960) argued:

> The nature of the problem can only be found by examining it through proposed solutions, and it seems likely that its examination through one, and only one, proposal gives a very biased view. It seems probable that at least two radically different solutions need to be attempted in the order to get through comparisons of sub-problems, a clear picture of the "real nature" of the problem. (As cited by Cross, 2007, p. 17).

My hope is that other design researchers will help to broaden understandings in this field, as the more approaches there are, the better the chances to respond to the problem and broaden the existing knowledge.

Chapter 10: Conclusion

While I was preparing to write the conclusion my editor sent me an email with copy-edited texts from earlier chapters. In one sentence she commented on my work and said "you must have really loved the work you did", which made me think. Though it is common knowledge that design is a process and not a moment, when we designers start a new project we are all-over excited about the wonderful opportunities and possible solutions, but we easily like to forget that struggles will be on our way as well. From where I am standing now I can honestly say I did really love the work I completed, however, though I am looking forward to graduation I feel there is still so much left to discover that it is hard to put an end on something that certainly needs to be studied further. Nonetheless, this research has contributed to a better understanding to what extent increased awareness of the implications of transport decisions directly influence intention, which in turn translates into action, and increases the use of sustainable modes of transportation.

10.1 Addressing initial objectives

The initial objective of this research was to develop an approach that can help to reduce health issues related to sedentary lifestyles and automobile emissions. As the research problem is a result of many unknown variables, a design perspective that takes into account this indefiniteness offers plenty of opportunities to tackle such a problem. The researcher in this case chose to assess the topic from psychological and philosophical points of view and situated the research under the umbrella terms of health and sustainability. The psychological aspects of the study focussed on awareness creation, motivation, decision-making, and the intention-behaviour-gap theory. The philosophical aspect of the study was concerned with people's values and moral obligations; it follows Kant's concept of the categorical imperative which is regarded as a basic ethical concept where one is expected to evaluate his or her action on the premise that a decision should be made while considering the consequences of said

decision on each potential object that might be affected by its implications. It was expected that if one's awareness about transport decisions increase, the effects of future considerations on health and the environment would be influenced. The method that was chosen to increase awareness was the simulation of the provision of a mobile-technology-based system that would inform people in real-time about personal implications, based on their transport decisions. To make sure that information provision would not lose its relevance over time — and therefore result in a decline in the users' interest in the information — the objective was to design a system that adapted to users' personal needs and allowed active user interaction. The option of customization combined with user involvement seemed promising to help users bridge the intention-behaviour gap until they formed a new, more sustainable habit.

10.2 Addressing the research question

Access to different designs of a mobile application was simulated. The application mock-ups provided users with comparative information on ecological and health impacts of various transportation options. An online survey was applied to evaluate the idea of the mobile application in general and the role of design in particular. A majority of participants indicated an interest in additional and customizable information on impacts of modal choice on health aspects. The main focus of this study was how design can initiate and/or support behaviour change. The role of design therefore is to create awareness, enable and motivate to action, and reinforce new behaviours. Design must not be authoritative, rather it should invite people to reflect critically and decide consciously. Though it is in the human nature to strive for improvement, we have to acknowledge that perfection will not be reached. Therefore design should simplify the process of improvement or make the process an enjoyable experience. Good designers do not create for the sake of creation. Good designers take their social responsibility seriously and consider how their work can help to move from a current to a desired state.

With this study my goal was to shed light on how the design of a mobile application can contribute to influence decision-making (short-term) and habit formation (long-term). Psychological aspects of behaviour change, motivation, perception, and mindful design were taken into account when different strategies were developed for the designs to be tested. One strategy was to present information word-based, pictogram-based, and combined versions. Another strategy was to present the pros and cons of various transportation methods without giving judgement. While people's reception on the different strategies showed a spectrum of preferences, it became clear that the most favoured designs were the ones that were regarded as most informative, understandable, and motivating. Moreover, the objective information presentation corresponds to my belief that design should neither evaluate nor dictate behaviour, but empower to critical and reflective thinking and acting.

10.3 Major findings

According to the results of the survey, a majority of the participants (65 percent) indicated an interest in such a system and a great majority (79 percent) stated that access to such information would affect their usage. The major findings therefore indicate a general interest in increased information volume and improved information content and presentation. Enhanced information results in greater awareness and supports decision-making. The knowledge visualization template (E), which was favoured by the largest group of participants (47 percent), was a design that combined written information with visualized numerical values. An earlier study done by Otsubo (1988) had a similar result: participants complied best when information was presented in a "words plus pictogram" style. The design of the favoured template (E) was designed in accordance with dashboard designs, presenting values as a partition of a circular shape that symbolized the whole unit. On the contrary, in the least favoured design (B, chosen by seven percent) the personalized information was illustrated in plain text. Another design that was unpopular (A) was done without any numerical information. This finding leads to the assumption that a combination of written and illustrated information best serves

the purpose of improved information and awareness. Though the study has offered new links to approach sedentary-caused health issues, the study has limitations and challenges.

10.4 Limits of the work

Firstly, though in recent years the number of health-related devices and applications has increased significantly, those applications mainly focus on information related to physical health. In a similar way, eco-feedback information largely emphasises saving money on energy. We might expect that a device combining eco-feedback and health-related information would encourage responsible behaviour even more, since it connects an individual's choices to their impacts on their health and the environment. In an individual driven by self-interest and moral values, such an increase in awareness would improve satisfaction with the system, and as a result, the individual's physical and mental health would improve as his or her ecological footprint recedes. However, there are many factors that influence one's choices and behaviours, and even if we assume that most of them are known, an evaluation of the known does not subsequently result in rational decision-making.

Secondly, if change begins with oneself, then attempts to face an epidemic of lifestyle related diseases and environmental contamination must shift from general to individualized solutions. Customization or individualization is a recent trend that stems not only from the desire to stand out in a crowd flooded by mass-produced artifacts, but also from the desire to adjust products to their users' individual requirements (as opposed to the user adjusting to the product specifications). The customization movement can fulfil a user's desire to express their identity and personal style, and will foster an emotional connection to the product itself, but it is also a fact that people deliberately choose mass-products. Be it due to group affiliation, for example wearing yoga clothes to show others about mind-set and workout preferences, or status related choices such as having a $2000 Louis Vuitton handbag, or due to avoiding to

having to deal with a possibly time-consuming task of finding personal preferences as opposed to accepting a rough fitting mass-product.

Thirdly, although 79 percent of the participants indicated that they expected enhanced information to affect usage, the study did not take place over a long period of time, therefore the results are based on people's opinions instead of actions. Due to the limited time period of the study and the resources available to the researcher, it was not possible to develop a software prototype that would have implemented the ideas and functions that were presented in this study as a simulation. Moreover, due to the constraints of a mock-up, the evaluation method did not allow for the testing of user interaction, customizability, and application of the system in general. Also, as the mock-up was not translated into a working prototype, the option for a long-term study that would reveal users' usage patterns and their influence on decision-making, habit formation, and ultimately health was not given.

Finally, research in the field of knowledge visualization is still in its infancy. Technological developments outrace mans' capacity to deal with new devices, applications, and the amount of data that is produced. Because of this, it is even more difficult to research the effects and the effectiveness of knowledge visualizations on people's every day lives. However, this certainly should not discourage attempts to investigate, in fact it should call for a greater group of researchers in order to cover more of this highly interesting and forward-looking field.

10.5 New research possibilities

A long-term study would be necessary to reveal the actual effectiveness of the proposed system. Likewise, a long-term study could help to shed light on to what extent customizable information helps to overcome the declining use of software past the novelty phase, which is an important factor in regard to bridging the intention-behaviour gap until a new and more sustainable habit is formed. To execute a long-term study, a working prototype of the software

would be required. This means the research would need to be developed further in a number of ways. For example, desktop and web-based software needs to be programmed such that user profiles can be created and accessed. The information provided needs to be translated into meaningful outcomes, using calculations that are based on current scientific findings. Such a software prototype would overcome the obstacle of the simulation of this study, which did not provide customizability. In addition, new knowledge visualization templates need to be designed, considering the findings of this study. An evaluation method needs to be developed and a greater number of participants, a real-world setting, and a sample group would improve the validity of results and give direction for future implementation.

10.6 Future research approaches

This research could be moved to the next level by resolving the current limitations. Another way to investigate the related issues further is by changing the perspective and focus. As the current study was concerned with people's general interest and perception about customizable information in regard to travel decisions, future studies could examine in more detail which information (content) has the strongest impact on awareness creation and decision-making and what information (presentation) has the most convincing appearance. The outcome of such studies depends greatly on the researcher's background and objectives, for example an interaction designer might be mostly concerned with improving the human-computer experience, whereas a graphic designer might aim to perfect pictograms and knowledge visualizations, and a behavioural scientist might want to find out how personal habits are actually altered through customized information. This being said, future research questions might be:

- How can an information system that provides customized information and supports sustainable behaviour be distributed among a large number of people?

- How can collected information be used for other purposes, e.g., health care cost modelling, transportation planning, urban design, etc.?
- How can the idea of customized information be developed further and applied in other fields, e.g., product purchases and the resources being used for production, waste management and estimated energy/time required for recycling, resource exploitation and its unequal distribution? and
- How can the discipline of design improve customizable knowledge visualizations resulting in solutions that address a broad range of societal needs?

It was Niels Bohr who once said:

> "An expert is a person who has found out by his own painful experience all the mistakes that one can make in a very narrow field". (as cited in Coughlan, 1954, p.62).

I am far from claiming to be an expert, but I hope that the mistakes I made will help to create expertise in a field that certainly needs to be studied further.

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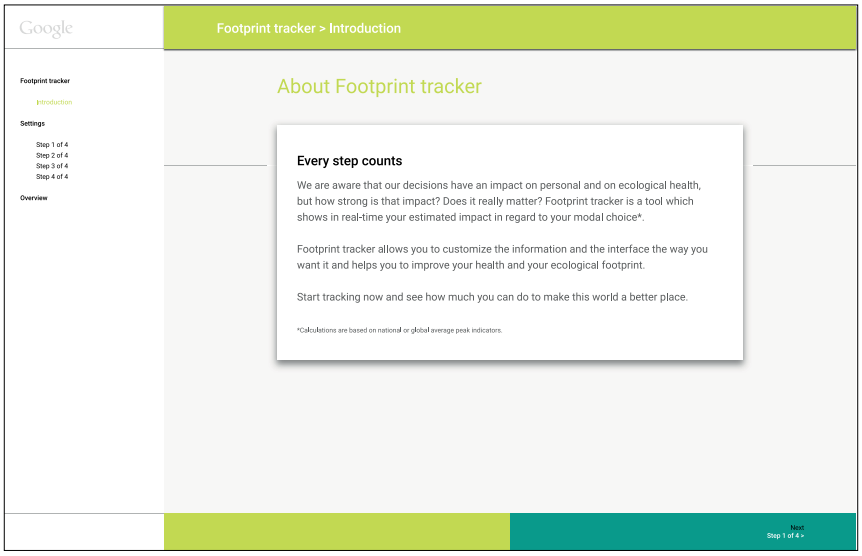
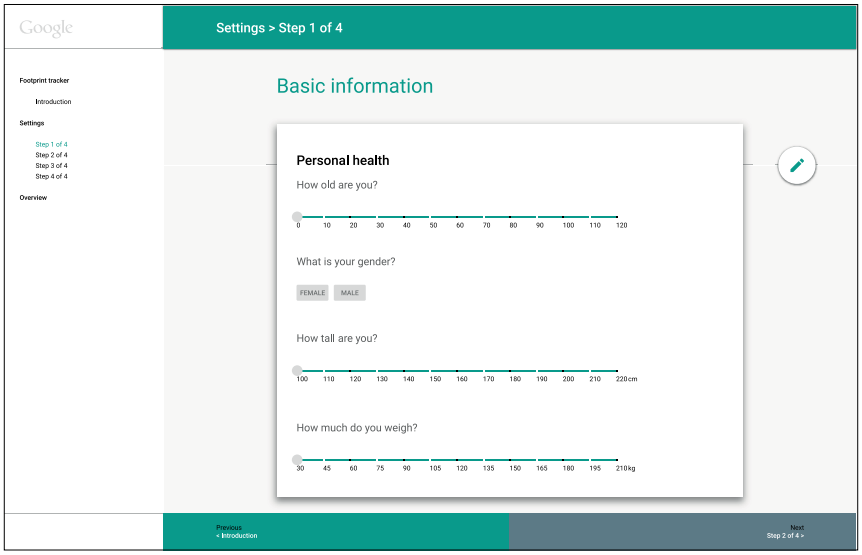
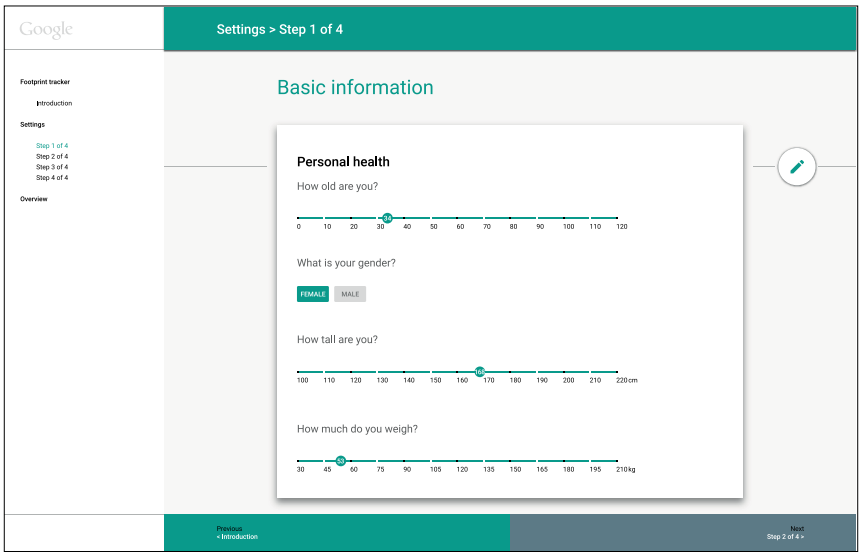
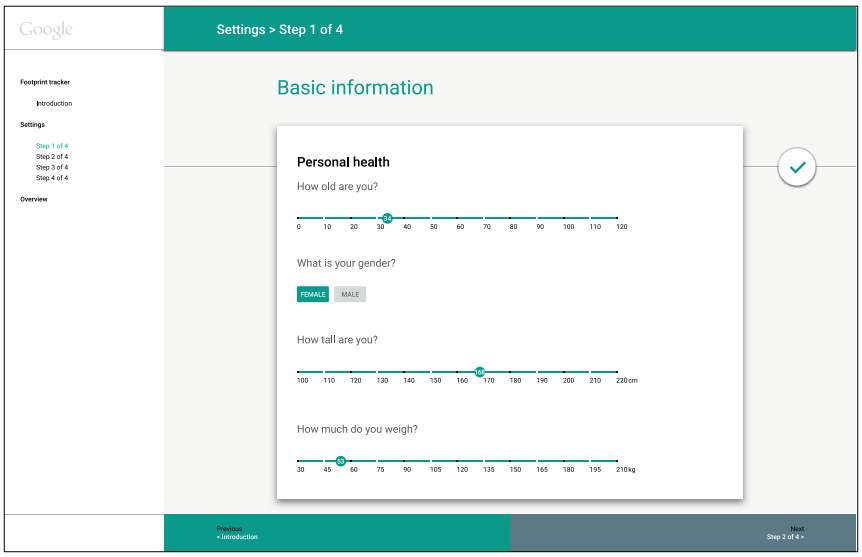
APPENDICES

Appendix 1: Wizard






Google
Settings > Step 1 of 4
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Basic information
Personal health
How old are you?
0 10 20 30 40 50 60 70 80 90 100 110 120
What is your gender?
FEMALE
MALE
How tall are you?
100 110 120 130 140 150 160 170 180 190 200 210 220cm
How much do you weigh?
30 45 60 75 90 105 120 135 150 165 180 195 210kg
Previous
< Introduction
Next
Step 2 of 4 >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Footprint tracker
Introduction
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Overview
Basic information
Personal health
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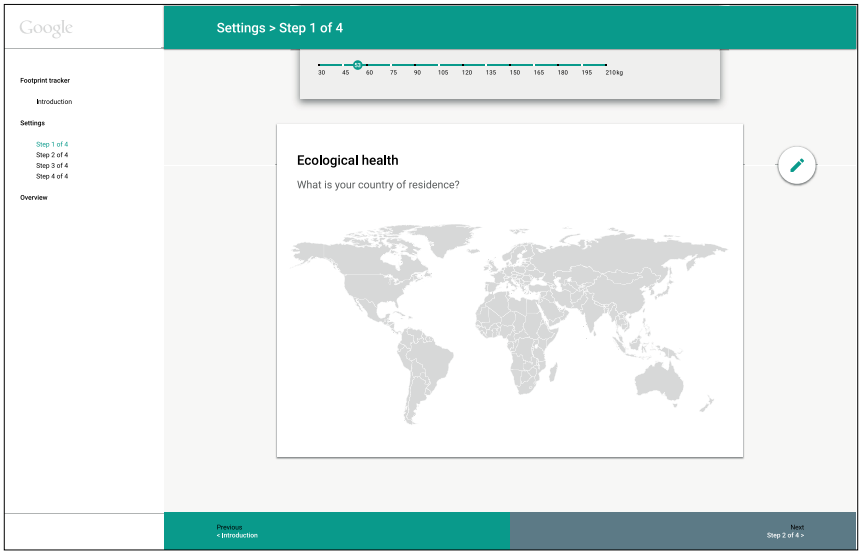
Next
Step 2 of 4 >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30 45 60 75 90 105 120 135 150 165 180 195 210kg
Footprint tracker
Introduction
Settings
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Overview
Ecological health
What is your country of residence?
Previous
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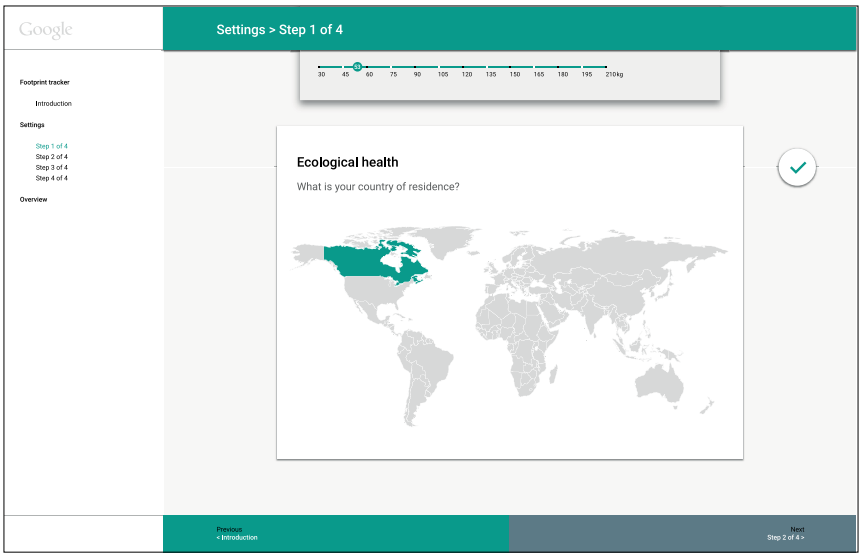
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Overview
30 45 60 75 90 105 120 135 150 165 180 195 210kg
Ecological health
What is your country of residence?
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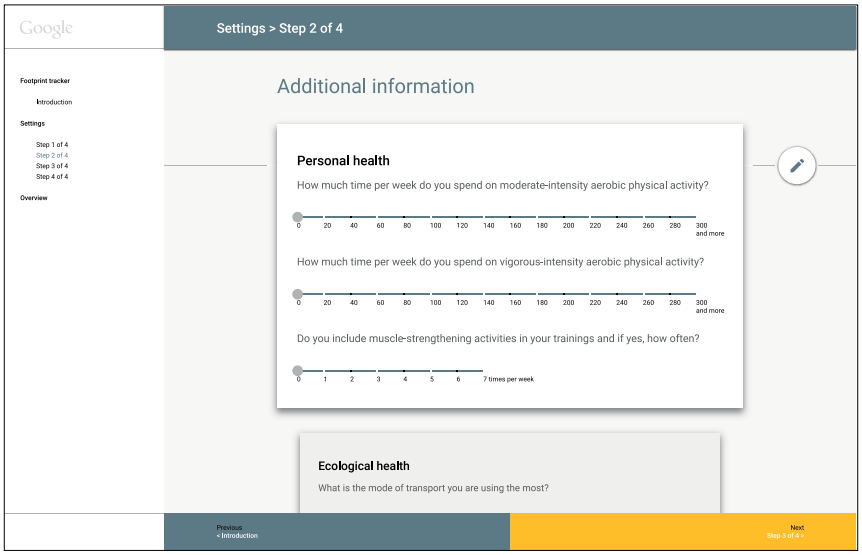
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Settings > Step 2 of 4
Footprint tracker
Introduction
Settings
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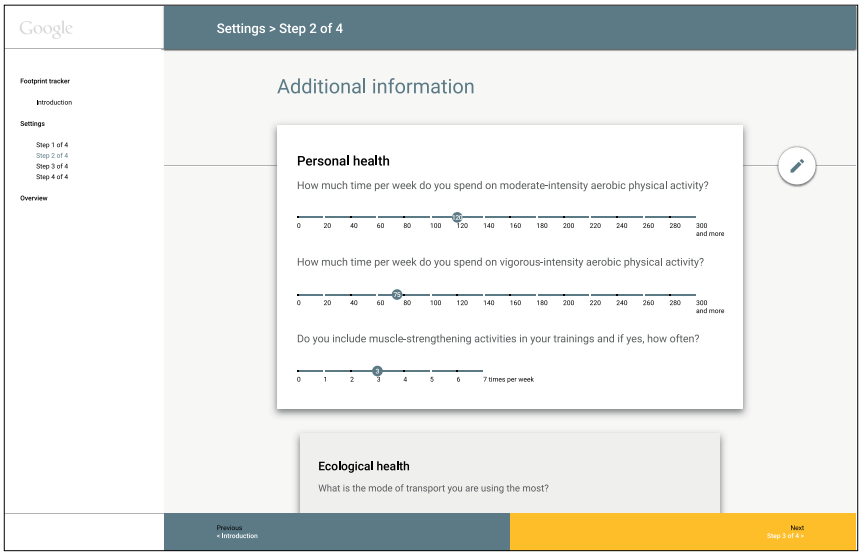
Overview
Additional information
Personal health
How much time per week do you spend on moderate-intensity aerobic physical activity?
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 and more
How much time per week do you spend on vigorous-intensity aerobic physical activity?
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 and more
Do you include muscle-strengthening activities in your trainings and if yes, how often?
0 1 2 3 4 5 6 7 times per week
Ecological health
What is the mode of transport you are using the most?
Previous
< Introduction
Next
Step 3 of 4 >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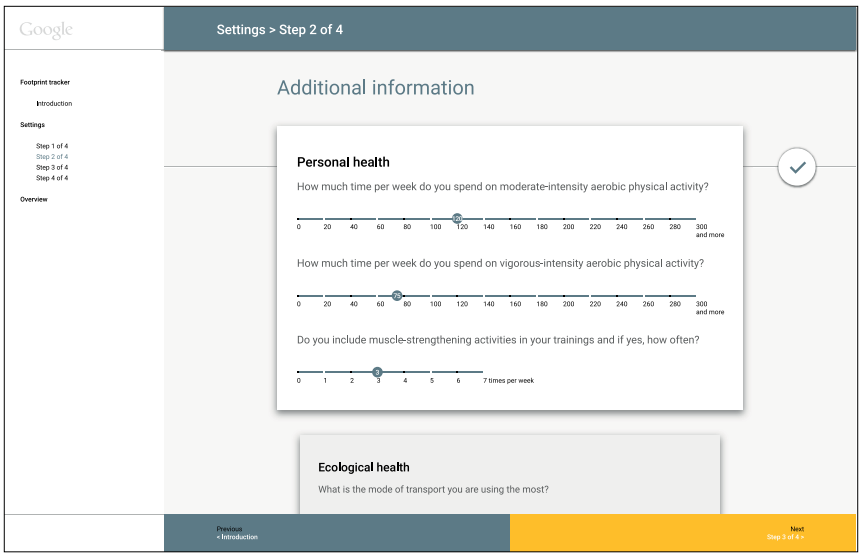
Step 3 of 4 >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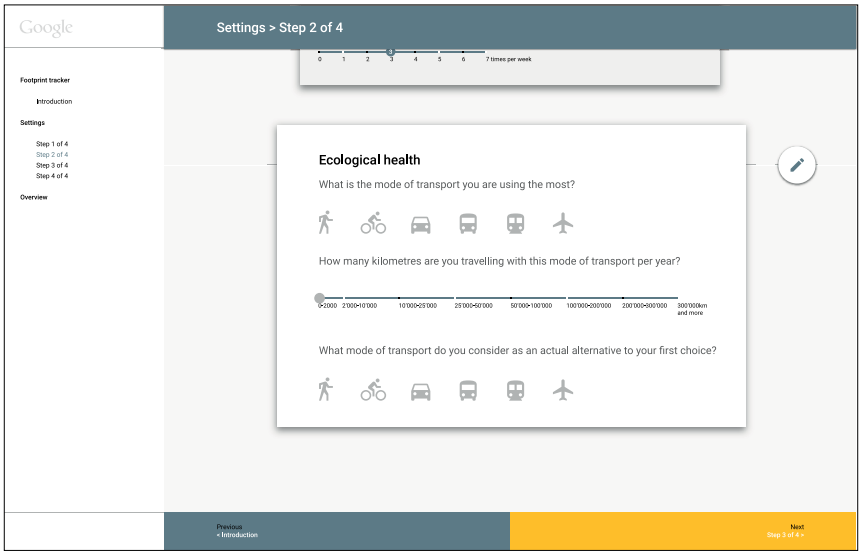
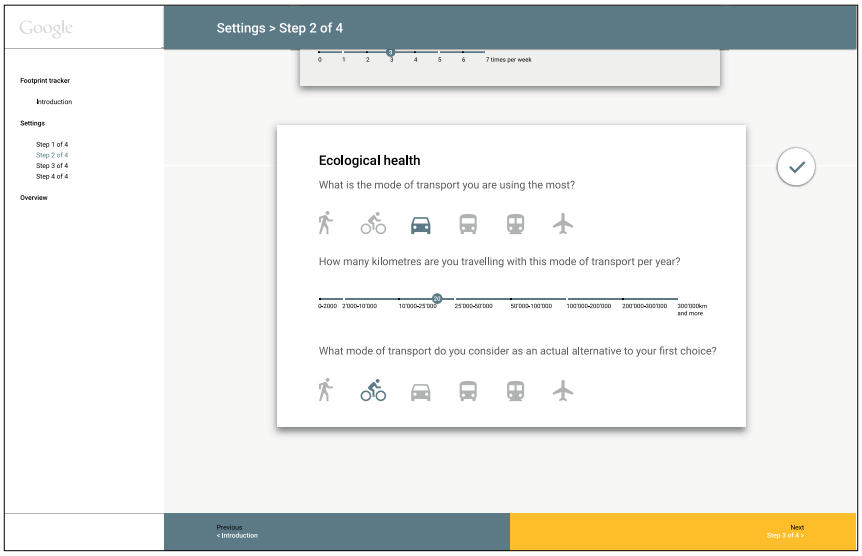
What is the mode of transport you are using the most?
Previous
< Introduction
Next
Step 3 of 4 >


Google
Settings > Step 2 of 4
0 1 2 3 4 5 6 7 times per week
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Ecological health
What is the mode of transport you are using the most?
How many kilometres are you travelling with this mode of transport per year?
0-2000 2'000-10'000 10'000-25'000 25'000-50'000 50'000-100'000 100'000-200'000 200'000-300'000 300'000km and more
What mode of transport do you consider as an actual alternative to your first choice?
Previous
< Introduction
Next
Step 3 of 4 >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0 1 2 3 4 5 6 7 times per week
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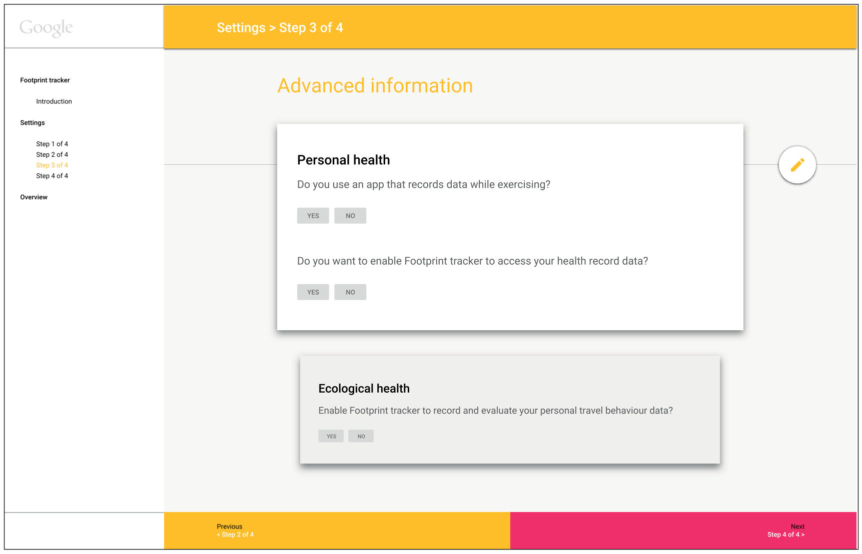
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Footprint tracker
Introduction
Settings
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Overview
Advanced information
Personal health
Do you use an app that records data while exercising?
YES
NO
Do you want to enable Footprint tracker to access your health record data?
YES
NO
Ecological health
Enable Footprint tracker to record and evaluate your personal travel behaviour data?
Previous
< Step 2 of 4
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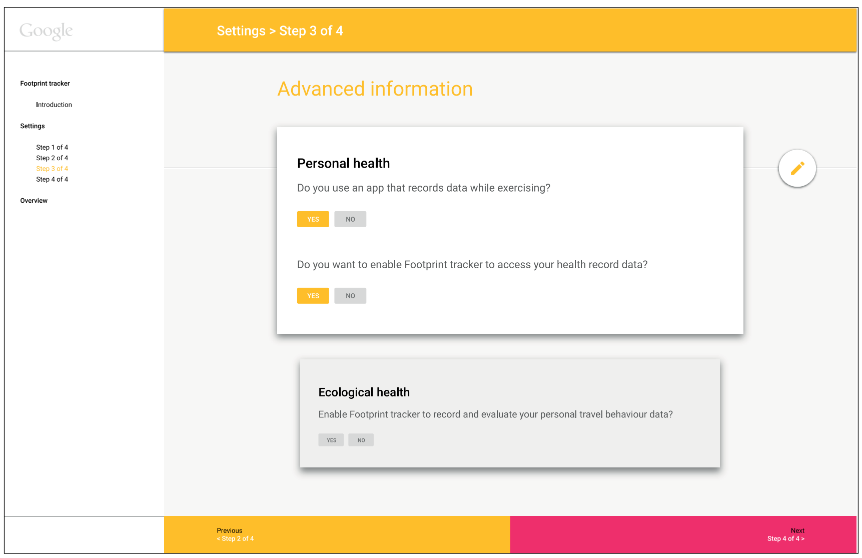
Step 4 of 4 >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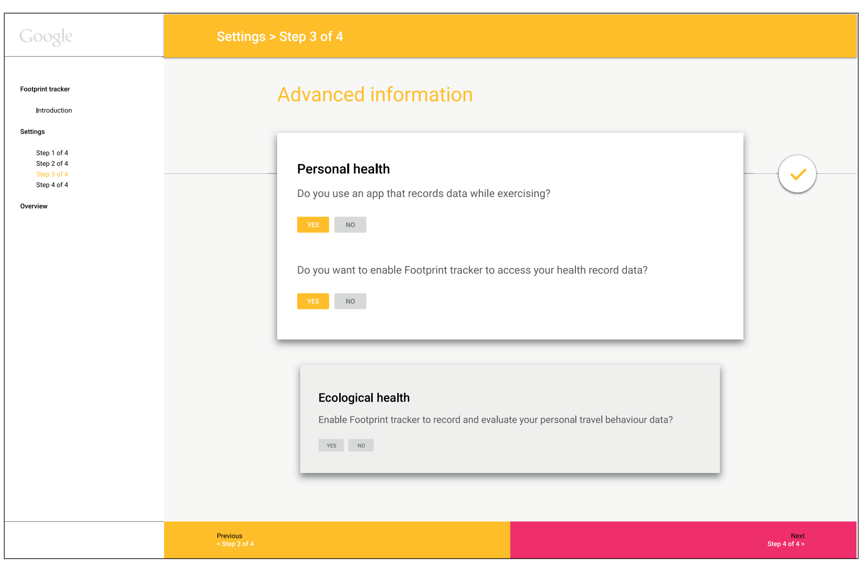
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Footprint tracker
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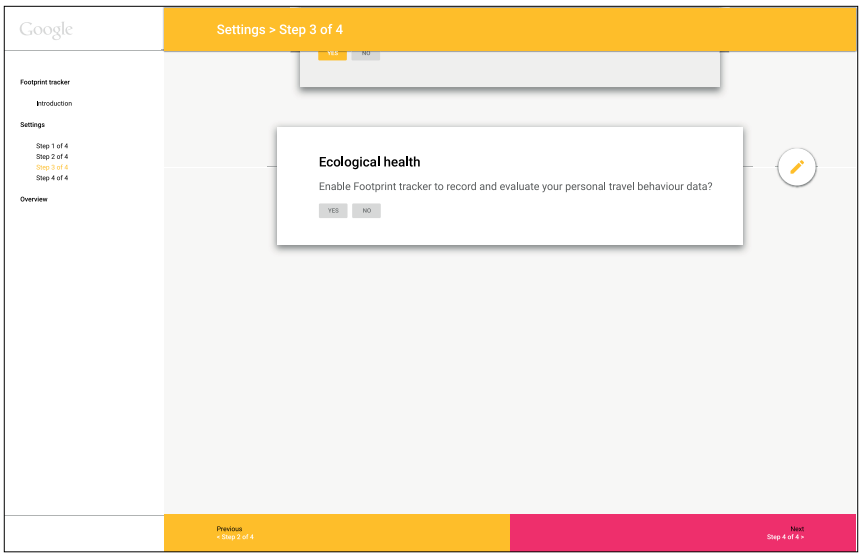
Step 4 of 4 >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Settings
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Ecological health
Enable Footprint tracker to record and evaluate your personal travel behaviour data?
YES
NO
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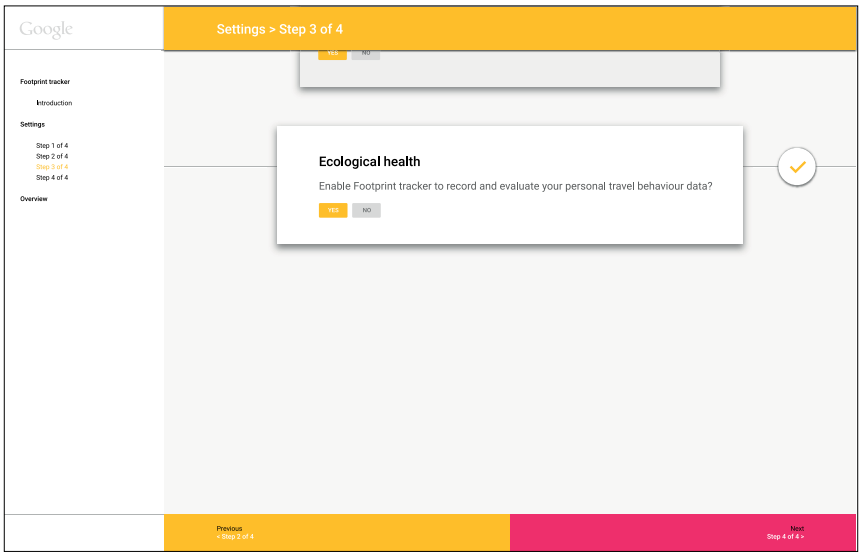
Next
Step 4 of 4 >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Introduction
Settings
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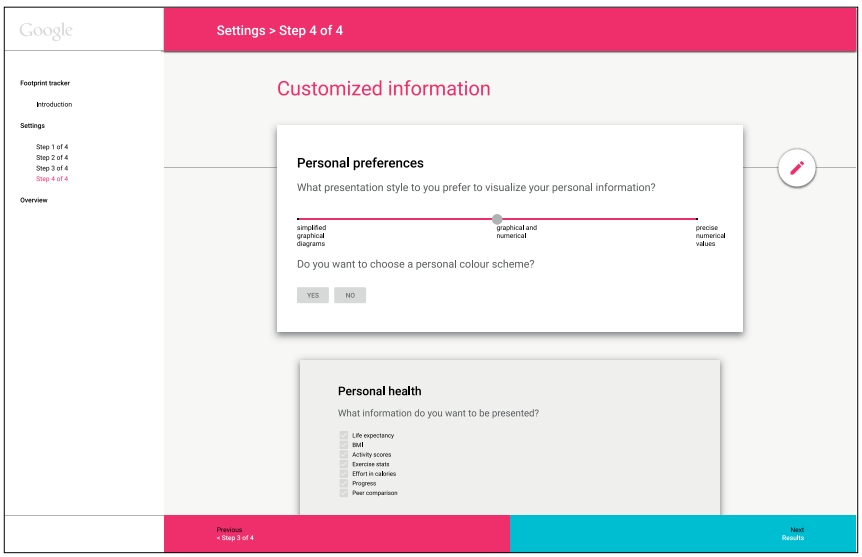
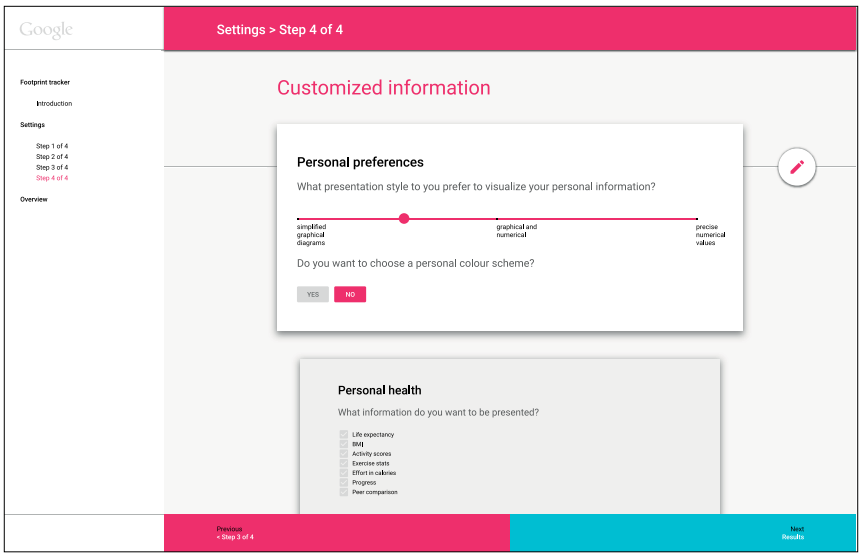
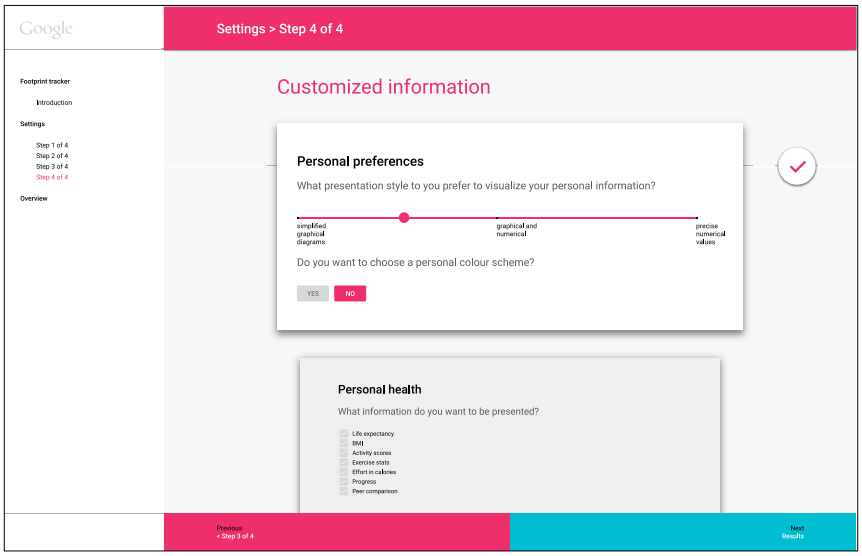
Step 3 of 4
Step 4 of 4
Overview
Ecological health
Enable Footprint tracker to record and evaluate your personal travel behaviour data?
YES
NO
Previous
< Step 2 of 4
Next
Step 4 of 4 >


Google
Settings > Step 4 of 4
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Customized information
Personal preferences
What presentation style to you prefer to visualize your personal information?
simplified graphical diagrams
graphical and numerical
precise numerical values
Do you want to choose a personal colour scheme?
YES
NO
Personal health
What information do you want to be presented?
Life expectancy
BMI
Activity scores
Exercise stats
Effort in calories
Progress
Peer comparison
Previous
< Step 3 of 4
Next
Results


Google
Settings > Step 4 of 4
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Customized information
Personal preferences
What presentation style to you prefer to visualize your personal information?
simplified graphical diagrams
graphical and numerical
precise numerical values
Do you want to choose a personal colour scheme?
YES
NO
Personal health
What information do you want to be presented?
Life expectancy
BMI
Activity scores
Exercise stats
Effort in calories
Progress
Peer comparison
Previous
< Step 3 of 4
Next
Results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Footprint tracker
Introduction
Settings
Step 1 of 4
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Overview
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Progress
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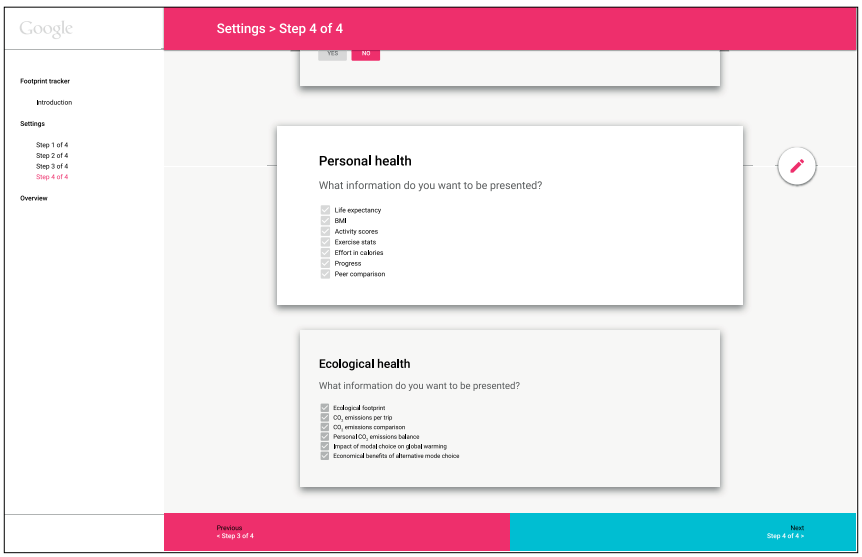
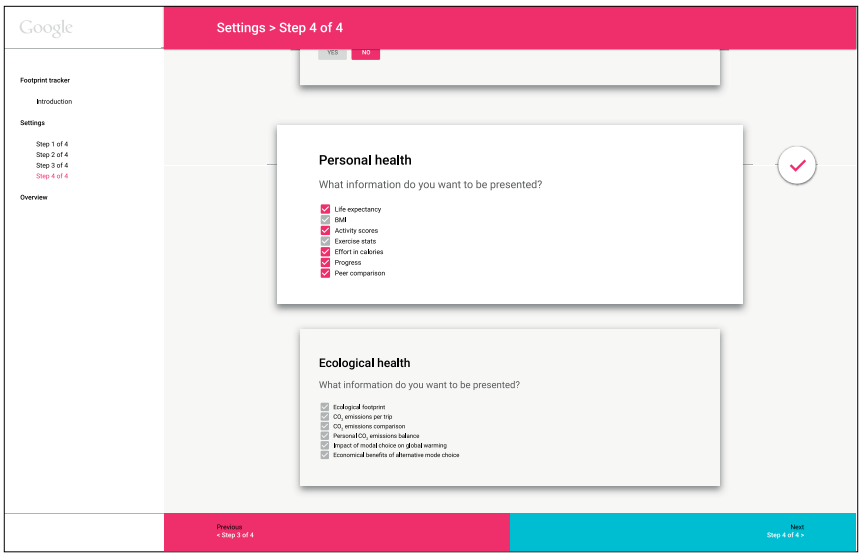
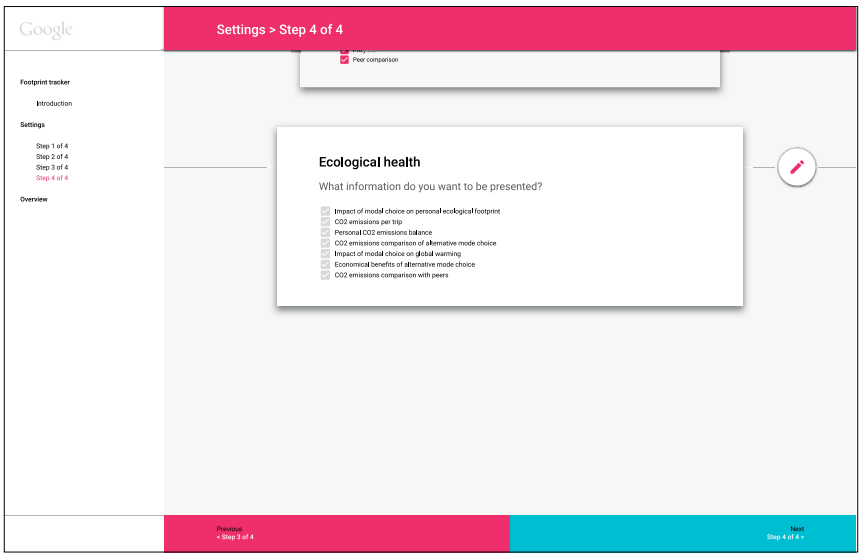
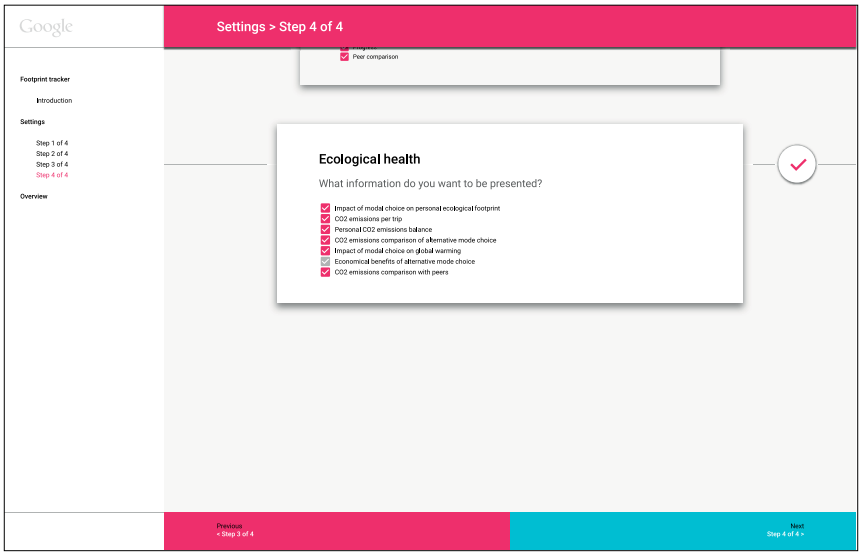

Google
Settings > Step 4 of 4
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Personal health
What information do you want to be presented?
Life expectancy
BMI
Activity scores
Exercise stats
Effort in calories
Progress
Peer comparison
Ecological health
What information do you want to be presented?
Ecological footprint
CO2 emissions per trip
CO2 emissions comparison
Personal CO2 emissions balance
Impact of modal choice on global warming
Economical benefits of alternative mode choice
Previous
< Step 3 of 4
Next
Step 4 of 4 >


Google
Settings > Step 4 of 4
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Personal health
What information do you want to be presented?
Life expectancy
BMI
Activity scores
Exercise stats
Effort in calories
Progress
Peer comparison
Ecological health
What information do you want to be presented?
Ecological footprint
CO2 emissions per trip
CO2 emissions comparison
Personal CO2 emissions balance
Impact of modal choice on global warming
Economical benefits of alternative mode choice
Previous
< Step 3 of 4
Next
Step 4 of 4 >


Google
Settings > Step 4 of 4
Peer comparison
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Ecological health
What information do you want to be presented?
Impact of modal choice on personal ecological footprint
CO2 emissions per trip
Personal CO2 emissions balance
CO2 emissions comparison of alternative mode choice
Impact of modal choice on global warming
Economical benefits of alternative mode choice
CO2 emissions comparison with peers
Previous
< Step 3 of 4
Next
Step 4 of 4 >


Google
Settings > Step 4 of 4
Peer comparison
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Ecological health
What information do you want to be presented?
Impact of modal choice on personal ecological footprint
CO2 emissions per trip
Personal CO2 emissions balance
CO2 emissions comparison of alternative mode choice
Impact of modal choice on global warming
Economical benefits of alternative mode choice
CO2 emissions comparison with peers
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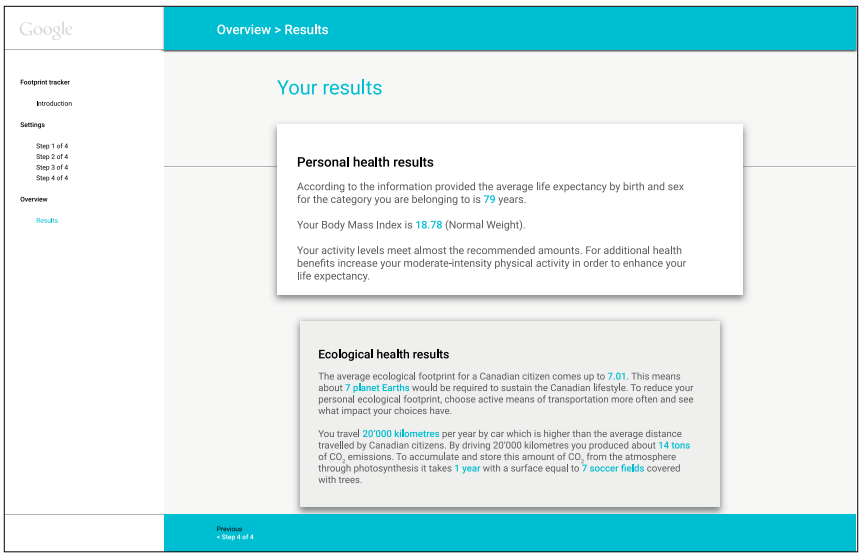
Google
Overview > Results
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
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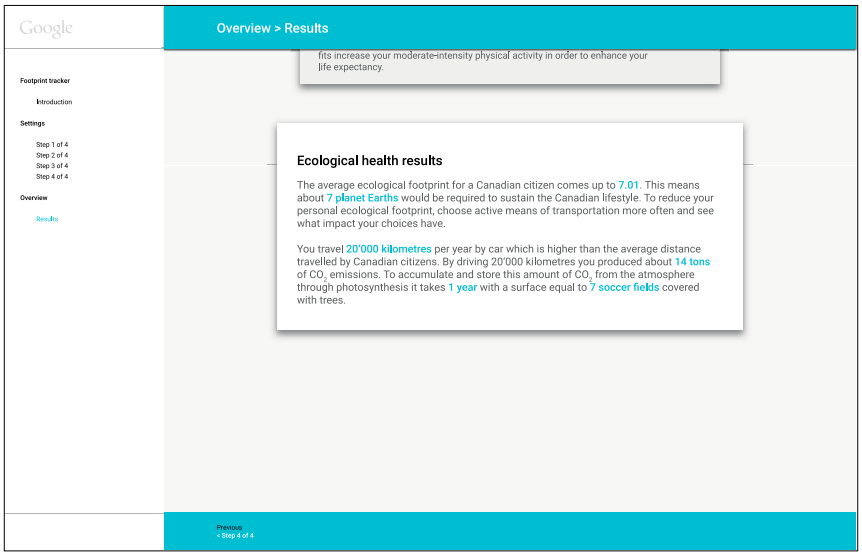
Step 4 of 4
Overview
Results
Your results
Personal health results
According to the information provided the average life expectancy by birth and sex for the category you are belonging to is 79 years.
Your Body Mass Index is 18.78 (Normal Weight).
Your activity levels meet almost the recommended amounts. For additional health benefits increase your moderate-intensity physical activity in order to enhance your life expectancy.
Ecological health results
The average ecological footprint for a Canadian citizen comes up to 7.01. This means about 7 planet Earths would be required to sustain the Canadian lifestyle. To reduce your personal ecological footprint, choose active means of transportation more often and see what impact your choices have.
You travel 20'000 kilometres per year by car which is higher than the average distance travelled by Canadian citizens. By driving 20'000 kilometres you produced about 14 tons of CO_2 emissions. To accumulate and store this amount of CO_2 from the atmosphere through photosynthesis it takes 1 year with a surface equal to 7 soccer fields covered with trees.
Previous
< Step 4 of 4


Google
Overview > Results
fits increase your moderate-intensity physical activity in order to enhance your life expectancy.
Footprint tracker
Introduction
Settings
Step 1 of 4
Step 2 of 4
Step 3 of 4
Step 4 of 4
Overview
Results
Ecological health results
The average ecological footprint for a Canadian citizen comes up to 7.01. This means about 7 planet Earths would be required to sustain the Canadian lifestyle. To reduce your personal ecological footprint, choose active means of transportation more often and see what impact your choices have.
You travel 20'000 kilometres per year by car which is higher than the average distance travelled by Canadian citizens. By driving 20'000 kilometres you produced about 14 tons of CO_2 emissions. To accumulate and store this amount of CO_2 from the atmosphere through photosynthesis it takes 1 year with a surface equal to 7 soccer fields covered with trees.
Previous
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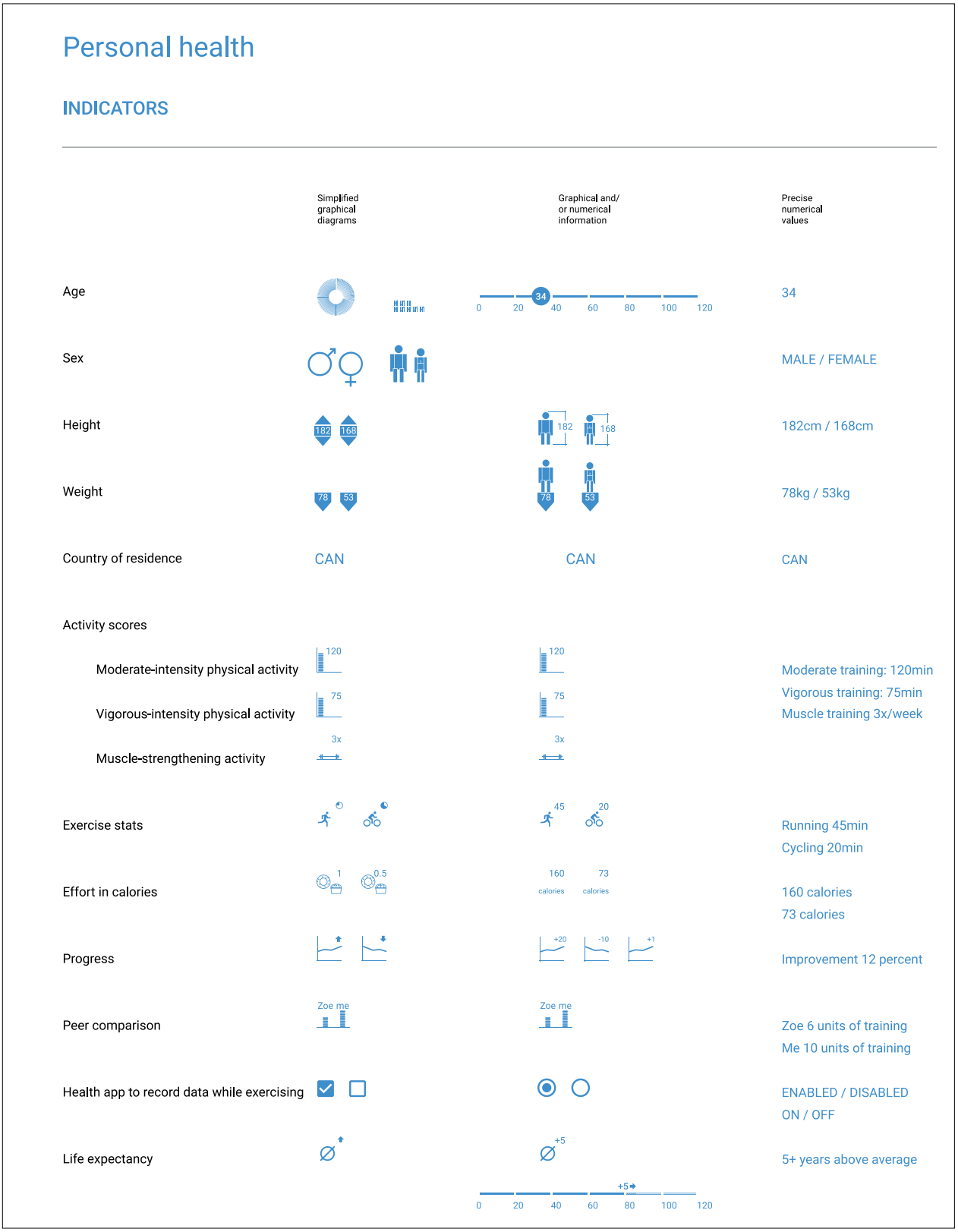
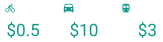
Appendix 2: Pictogram development



Ecological health

INDICATORS

	Simplified graphical diagrams	Graphical and/ or numerical information	Precise numerical values
Ecological footprint			x7
CO2 emissions per trip			6.2kg CO_2
CO2 emissions comparison			0kg, 6.2kg, 1.7kg
Personal CO2 emissions balance			4kg above personal limit
Impact of modal choice on global warming			Temperature rise
Economical benefits of alternative mode choice			$0.5, $10, $3
Compensation			per kg CO2 approx. 1 tree photosynthesis for one year

Appendix 3: Structure online survey

This survey seeks to find out: At what level do you think your method of transportation would be influenced if you were provided with personalized information about the impacts of your mobility behaviours on your health and on the environment? Your participation in the survey helps me to fulfil a part of my Master's thesis requirement. Thanks for your time.

CONSENT TO PARTICIPATE IN: Collecting Transportationrelated Behavioural Data to Present Customizable Information with the Objective to Improve Personal and Ecological Health

I understand that I am being asked to participate in a research project conducted by Manuela Hummel, INDI Program, Concordia University, under the supervision of Dr. Martin Racine, Design and Computation Arts Department of Concordia University. This research project is part of a Master's thesis requirement for the researcher.

Manuela Hummel
Email:
m_hummel@live.concordia.ca

A. PURPOSE
I have been informed that the purpose of the research is to collect information about how and at what level users think their method of transportation would be influenced if they were provided with personalized information about the impacts of their mobility behaviours on health and on the environment.

B. PROCEDURES

I understand that:

· My participation in this study will be done through this online survey.

· I will be asked some questions regarding socio-demographic information about me.

C. RISKS AND BENEFITS

I understand that participation in this survey presents no risk to me.

I understand that this research is not intended to benefit me personally.

D. CONDITIONS OF PARTICIPATION

• I understand that I am free to withdraw my consent and discontinue my participation at anytime without any negative consequences.

• I understand that my participation in this study is anonymous (i.e., the researcher will not know my identity)

• I understand that results from analysis of this data may be published, but the data themselves will not be published.

If at any time you have questions about the proposed research, please contact the study's Principal Investigator.

If at any time you have questions about your rights as a research participant, please contact the Research Ethics and Compliance Advisor, Concordia University, (514) 848 2424 x 7481 ethics@alcor.concordia.ca

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT.
I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

What is your gender?

Female

Male

How old are you?

18-27

28-37

38-47

48-57

58-67

68-77

78 and older

What is your country of residence?

Where do you live?

In a city / town

In the suburbs

In the countryside

What methods of transportation are accessible to you?

Walking

Cycling

Car

Public Transportation

What is your primary transportation method?

Walking

Cycling

Car

Public Transportation

What method of transportation would you consider as an alternative to your primary method of transportation?

Walking

Cycling

Car

Public Transportation

Mapping apps such as Google Maps offer trajectories and predicted travel times from point A to B based on a chosen method of transportation. Imagine the image below shows a planned trip of yours or a commute you do on a regular basis. Would you be interested in additional information on how trips can affect your health depending on the method of transportation you choose?

Yes

No

What additional health information would you like to have?

Contribution to your existing exercise regime

Impact of method of transportation on life expectancy

Calories burnt

Other (Please Specify)

Would you be interested in additional information on how trips can affect the environment depending on the method of transportation you choose?

Yes

No

What additional information about impacts on the environment would you like to have?

CO_2 emissions

Personal Ecological Footprint

Other (Please Specify)

Would you be interested in additional information comparing the costs and benefits of your primary and secondary methods of transportation?

Yes

No

What additional information about the costs and benefits would you like to have?

Travel costs / comparison

Tavel time / savings

Impact of traffic conditions

Impact of weather conditions

Other (Please Specify)

Do you think that the way in which information is presented affects how and to what degree you make use of the information?

Very unlikely

Unlikely

Neutral

Likely

Very likely

What presentation style of information would you prefer:

Simplified graphical information

Precise numerical information

Five different knowledge visualization templates are displayed below. Each of them compares two different methods of transportation in regard to their impact on health (e.g. fitness), environment (e.g. CO_2 emissions), and costs and benefits (e.g. trip fare). Assuming Google Maps (or any other mapping software provider) would expand its functions toward customized information which template would you choose?

A

B

C

D

E

Please explain why?

Do you think customized knowledge visualizations would affect your frequency of use of Google Maps (or the like)?

Very unlikely

Unlikely

Neutral

Likely

Very likely

Do you think customized information would influence your method of transportation?

Very unlikely

Unlikely

Neutral

Likely

Very likely

Appendix 4: Online survey evaluation

Q1	Q2	Q3	Q4	Q5	Q6-1	Q6-2	Q6-3	Q6-4	Q7	Q8	Q9	Q10-1	Q10-2	Q10-3	Q10-4	Q11	Q12-1	Q12-2
Consent	What is your gender?	How old are you?	What is your country of residence?	Where do you live?	What methods of transportation are accessible to you?				What is your primary transportation method?	What method of transportation would you consider as an alternative to your primary method of transportation?	Would you be interested in additional information on how trips can affect your health depending on the method of transportation you choose?	What additional health information would you like to have?				Would you be interested in additional information on how trips can affect the environment depending on the method of transportation you choose?	What additional information about impacts on the environment would you like to have?	
Yes	Female	28-37	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	Canada	In a city / town	Walking		Car	Public Transportation	Walking	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Walking	Yes		Impact of method of transportation on life expectancy	Calories burnt	Environmental Impact!	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Cycling	Yes			Calories burnt		Yes		Personal Ecological Footprint
Yes	Female	18-27	u.s.	In a city / town			Car		Car	Walking	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	United Kingdom	In a city / town	Walking		Car	Public Transportation	Car	Walking	No					No		
Yes	Female	38-47	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	canada	In the suburbs			Car		Car	Public Transportation	No					No		
Yes	Female	28-37	us	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Walking	No					No		
Yes	Female	48-57	canada	In the suburbs	Walking	Cycling	Car	Public Transportation	Car	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	48-57	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Car	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	18-27	USA	In the suburbs	Walking	Cycling	Car	Public Transportation	Car	Walking	Yes		Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	United States of America	In a city / town			Car		Car	Car	No					Yes		Personal Ecological Footprint
Yes	Male	28-37	Canada	In a city / town	Walking			Public Transportation	Walking	Public Transportation	Yes		Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Canada	In the countryside			Car		Car	Cycling	Yes			Calories burnt		No		
Yes	Female	18-27	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	United States	In a city / town			Car	Public Transportation	Car	Public Transportation	Yes		Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Canada	In a city / town	Walking	Cycling		Public Transportation	Walking	Public Transportation	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	38-47	Switzerland	In the countryside	Walking	Cycling	Car	Public Transportation	Car	Public Transportation	Yes	Contribution to your existing exercise regime				Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Walking	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Switzerland	In a city / town	Walking			Public Transportation	Public Transportation	Cycling	Yes			Calories burnt		Yes	CO2 emissions	
Yes	Female	18-27	England	In the suburbs	Walking			Public Transportation	Public Transportation	Cycling	Yes	Contribution to your existing exercise regime		Calories burnt		Yes		Personal Ecological Footprint
Yes	Female	38-47	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Car	No					No		
Yes	Female	58-67	canada	In the countryside			Car		Car	Public Transportation	No					No		
Yes	Male	48-57	canada	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Cycling	Yes			Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Switzerland	In a city / town	Walking	Cycling	Car	Public Transportation	Walking	Cycling	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	USA	In a city / town	Walking			Public Transportation	Walking	Public Transportation	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	USA	In a city / town	Walking	Cycling		Public Transportation	Walking	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	UK	In a city / town	Walking			Public Transportation	Public Transportation	Walking	No					Yes	CO2 emissions	
Yes	Male	38-47	CH	In the suburbs	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	Yes			Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Switzerland	In a city / town	Walking			Public Transportation	Public Transportation	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	18-27	Switzerland (Winterthur)	In the suburbs	Walking	Cycling		Public Transportation	Public Transportation	Car	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Switzerland	In the suburbs	Walking	Cycling	Car	Public Transportation	Public Transportation	Cycling	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	18-27	Switzerland	In a city / town	Walking	Cycling		Public Transportation	Public Transportation	Cycling	Yes		Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	48-57	Switzerland	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Walking	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	Switzerland	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	No					No		
Yes	Female	28-37	Canada	In the suburbs	Walking	Cycling	Car	Public Transportation	Car	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	38-47	CH	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Walking	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt	Impact on environmental pollution	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Canada	In a city / town	Walking	Cycling		Public Transportation	Walking	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes		Personal Ecological Footprint
Yes	Male	28-37	Switzerland	In a city / town	Walking	Cycling		Public Transportation	Walking	Cycling	Yes	Contribution to your existing exercise regime				Yes		Personal Ecological Footprint
Yes	Male	38-47	canada	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Walking	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Canada	In a city / town	Walking	Cycling		Public Transportation	Public Transportation	Cycling	Yes			Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	18-27	Canada	In a city / town	Walking		Car	Public Transportation	Public Transportation	Car	No					No		
Yes	Male	28-37	switzerland	In the countryside	Walking	Cycling	Car	Public Transportation	Public Transportation	Cycling	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	38-47	Switzerland	In the suburbs	Walking	Cycling	Car	Public Transportation	Car	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes		Personal Ecological Footprint
Yes	Male	38-47	Denmark	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	No					No		
Yes	Female	38-47	Germany	In a city / town	Walking	Cycling		Public Transportation	Walking	Cycling	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	Australia	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Walking	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt	Pollution levels	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Germany	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Car	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	UK	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	No					No		
Yes	Male	38-47	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Walking	No					No		
Yes	Male	38-47	UK	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Walking	No					No		
Yes	Male	28-37	United States	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Car	Yes			Calories burnt		Yes		Personal Ecological Footprint
Yes	Male	28-37	England	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Cycling	Yes			Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	United States of America	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Car	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	France	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes		Personal Ecological Footprint
Yes	Male	38-47	Germany	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Spain	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	korea	In a city / town	Walking	Cycling		Public Transportation	Public Transportation	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt	negative health impact by air pollution (better drive a car with filtered air inside then inhaling deeply on bike)	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	USA	In the suburbs	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy		CO2 emitted	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	48-57	United Kingdom	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy		Impact of method of transport on general population's health	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	United States	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Cycling	Yes		Impact of method of transportation on life expectancy			Yes		Personal Ecological Footprint
Yes	Male	18-27	Slovakia	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes		Personal Ecological Footprint
Yes	Male	58-67	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	58-67	UK	In the countryside	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	58-67	Australia	In a city / town	Walking	Cycling		Public Transportation	Cycling	Walking	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	58-67	Canada	In a city / town	Walking	Cycling		Public Transportation	Walking	Cycling	No					Yes		Personal Ecological Footprint
Yes	Male	18-27	Portugal	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy			Yes	CO2 emissions	
Yes	Female	28-37	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt	environmental issues	Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Spain	In a city / town	Walking		Car	Public Transportation	Walking	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	
Yes	Female	38-47	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Walking	Cycling	Yes		Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	
Yes	Female	38-47	United Kingdom	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	No					Yes	CO2 emissions	
Yes	Female	28-37	usa	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Walking	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	28-37	Latvia	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	Belgium	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes					Yes	CO2 emissions	
Yes	Female	18-27	Canada	In a city / town	Walking	Cycling		Public Transportation	Public Transportation	Cycling	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Female	28-37	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	No					No		
Yes	Male	38-47	Australia	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Cycling	No					No		
Yes	Male	48-57	Canada	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy	Calories burnt	$ saved by public health care by my choice	Yes	CO2 emissions	
Yes	Male	28-37	germany	In the suburbs	Walking	Cycling		Public Transportation	Cycling	Public Transportation	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	Bolivia	In the suburbs	Walking	Cycling	Car	Public Transportation	Car	Cycling	No					No		
Yes	Male	18-27	Austria	In a city / town	Walking	Cycling		Public Transportation	Public Transportation	Cycling	No					Yes		Personal Ecological Footprint
Yes	Female	38-47	Luxembourg	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	Denmark	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy	Calories burnt		No		
Yes	Female	48-57	United kingdom	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Public Transportation	Yes			Calories burnt		Yes	CO2 emissions	
Yes	Male	48-57	Denmark	In a city / town	Walking			Public Transportation	Walking	Public Transportation	No					No		
Yes	Male	48-57	Canada	In a city / town	Walking	Cycling	Car	Public Transportation	Walking	Cycling	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	48-57	Finland	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes		Impact of method of transportation on life expectancy			Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	Poland	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	No					No		
Yes	Male	48-57	Australia	In a city / town	Walking	Cycling	Car	Public Transportation	Walking	Cycling	Yes		Impact of method of transportation on life expectancy			No		
Yes	Male	18-27	Scotland	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Walking	Yes	Contribution to your existing exercise regime	Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	18-27	Denmark	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	Yes	Contribution to your existing exercise regime		Calories burnt		Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	58-67	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Car	Cycling	No					No		
Yes	Female	48-57	USA	In the suburbs	Walking	Cycling	Car		Car	Walking	Yes			Calories burnt		No		
Yes	Male	48-57	Australia	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Car	Yes	Contribution to your existing exercise regime				Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	38-47	USA	In the suburbs	Walking	Cycling	Car	Public Transportation	Cycling	Car	No					No		
Yes	Male	28-37	United Kingdom	In a city / town	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	Yes		Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	
Yes	Female	48-57	USA	In a city / town	Walking	Cycling	Car	Public Transportation	Cycling	Walking	No					Yes	CO2 emissions	Personal Ecological Footprint
Yes	Male	18-27	Canada	In the suburbs	Walking	Cycling	Car	Public Transportation	Public Transportation	Car	No					No		
Yes	Male	28-37	Germany	In a city / town	Walking	Cycling		Public Transportation	Cycling	Public Transportation	No					Yes		
Yes	Female	38-47	Canada	In a city / town	Walking	Cycling		Public Transportation	Walking	Public Transportation	Yes		Impact of method of transportation on life expectancy	Calories burnt		Yes	CO2 emissions	

	Q12-3	Q13	Q14-1	Q14-2	Q14-3	Q14-4	Q14-5	Q15	Q16	Q17	Q18	Q19	Q20				
		Would you be interested in additional information comparing the costs and benefits of your primary and secondary methods of transportation?	What additional information about the costs and benefits would you like to have?					Do you think that the way in which information is presented affects how and to what degree you make use of the information?	What presentation style of information would you prefer:	Assuming Google Maps (or any other mapping software provider) would expand its functions toward customized information which template would you choose?	Please explain why?	Do you think customized knowledge visualizations would affect your frequency of use of Google Maps (or the like)?	Do you think customized information would influence your method of transportation?	Date taken	Country Code	Region Code	
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Precise numerical information	D	Goes with the way my brain processes information.	Likely	Likely	4/18/2015 6:34:00 PM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	E	The graphic is easy to read/see and not too cute	Likely	Likely	4/18/2015 6:54:00 PM	CA	ON	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Simplified graphical information	A	I like graphs, and it seems to be the most straightforward.	Very likely	Very likely	4/18/2015 7:09:00 PM	US	NJ	
	t Number of litres of fuel (not) consumed	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Precise numerical information	C	Side-by-side, precise, easy to compare.	Very likely	Very likely	4/18/2015 7:37:00 PM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	D	Simple and clear	Likely	Likely	4/18/2015 8:06:00 PM	CA	SK	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Precise numerical information	C	It's the most graphically pleasing as well as giving actual numbers.	Very likely	Neutral	4/18/2015 8:22:00 PM	US	OH	
		No						Likely	Simplified graphical information	A	Provides clear visual information, simple easy to understand, with minimum time spent looking at template .	Unlikely	Unlikely	4/18/2015 8:56:00 PM	GB	B7	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	E	I know this contradicts a previous answer, but the detailed template is more interesting. I do prefer the look of template A.	Likely	Likely	4/18/2015 9:32:00 PM	CA	QC	
		Yes	Travel costs / comparison	Tavel time / savings		Impact of weather conditions		Likely	Precise numerical information	C	a lot of the symbols used in other templates are hard to understand	Neutral	Very unlikely	4/18/2015 10:44:00 PM	CA	ON	
		Yes	Travel costs / comparison	Tavel time / savings				Very unlikely	Precise numerical information	D	aesthetically pleasing	Neutral	Neutral	4/18/2015 11:11:00 PM	US	CA	
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	E	Il me convient mieux	Likely	Likely	4/18/2015 11:32:00 PM	CA	QC	
	t	Yes		Tavel time / savings	Impact of traffic conditions			Very likely	Precise numerical information	A	Je n'ai pas à essayer de comprendre.	Likely	Neutral	4/18/2015 11:49:00 PM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	E	Visually appealing while also stating exact numerical values.	Likely	Likely	4/19/2015 12:07:00 AM	US	NH	
	t	No						Neutral	Simplified graphical information	A	Clear and concise	Neutral	Very unlikely	4/19/2015 12:55:00 AM	US	SC	
	t How much money saved by not using a car and/or transite, bike, etc	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Precise numerical information	E	Words and graphics combined make a stronger message	Likely	Very likely	4/19/2015 1:30:00 AM	CA	ON	
		No						Likely	Precise numerical information	C	Easy to understand	Likely	Unlikely	4/19/2015 2:16:00 AM	US	TX	
	t	Yes	Travel costs / comparison			Impact of weather conditions		Likely	Simplified graphical information	C	It is simple, appealing and c'lear	Likely	Likely	4/19/2015 2:31:00 AM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	C	It was the simplest/easiest to understand quickly	Likely	Likely	4/19/2015 2:32:00 AM	US	CA	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	E	Graphical and interactive, easy to understand and compare, giving percentage for Health is more tangible	Very likely	Very likely	4/19/2015 4:01:00 AM	US		
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Simplified graphical information	A	Es ist auf den ersten Blick klar ersichtlich, was für mich die bessere Art des Transports wäre. Würde mir aber wünschen, durch anklicken mehr Informationen zu bekommen.	Likely	Likely	4/19/2015 4:45:00 AM	CH		1
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	E	Easily identifiable information	Likely	Likely	4/19/2015 5:15:00 AM	US		
		Yes	Travel costs / comparison					Neutral	Simplified graphical information	C		Neutral	Likely	4/19/2015 10:02:00 AM	CH		1
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	D	I like that it gives you the precise information, but in a slightly more interesting/visually appealing way than template B and C..	Neutral	Likely	4/19/2015 10:41:00 AM	GB	H7	
		No						Very likely	Precise numerical information	D	nice balance and stats and graphics	Very likely	Unlikely	4/19/2015 1:03:00 PM	CA	QC	
		No						Neutral	Simplified graphical information	E	easier	Neutral	Neutral	4/19/2015 1:29:00 PM	CA	ON	
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	A	Lecture et compréhension plus rapide	Likely	Likely	4/19/2015 4:27:00 PM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	A	Because it's so simple and easy to "understand". The others are too full of signs and stuff	Likely	Neutral	4/19/2015 6:07:00 PM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	B	seems simplest and easiest to read, would need something I can look at fast and not be confused or unsure	Neutral	Likely	4/19/2015 7:16:00 PM	US	MA	
	t	Yes	Travel costs / comparison	Tavel time / savings		Impact of weather conditions		Neutral	Simplified graphical information	D	Information is easily presented. The layout is clean and simple. The layout is easier to follow and understand without any column confusion.	Very likely	Likely	4/19/2015 10:03:00 PM	US	WA	
		No						Very likely	Precise numerical information	C	Simple display, gives full info	Neutral	Very unlikely	4/19/2015 10:53:00 PM	GB	P7	
		Yes	Travel costs / comparison	Tavel time / savings				Neutral	Simplified graphical information	E	Looks best	Likely	Likely	4/20/2015 7:53:00 AM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Precise numerical information	E	Teamplate E	Neutral	Very likely	4/20/2015 8:05:00 AM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings				Neutral	Precise numerical information	B	The visual effect is more preferable there.	Likely	Likely	4/20/2015 8:07:00 AM	CH		25
	t	Yes		Tavel time / savings				Likely	Precise numerical information	E	easiest to understand	Likely	Neutral	4/20/2015 8:17:00 AM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Simplified graphical information	E	it includes nice graphs as well as numbers...	Neutral	Likely	4/20/2015 8:32:00 AM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	C	best overview for me	Likely	Likely	4/20/2015 10:14:00 AM	CH		25
		No						Very unlikely	Precise numerical information	C	I like it most.	Very unlikely	Very unlikely	4/20/2015 10:25:00 AM	U		9
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Simplified graphical information	E	I find E the most visually appealing. the others are a bit 'sterile.' it also offers all information at one glance.	Very likely	Very likely	4/20/2015 12:07:00 PM	CA	QC	
	t Quality of agricultural land in the region I live	Yes		Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	A	Simpler, but missing info which is present on others	Likely	Likely	4/20/2015 12:28:00 PM	CH		25
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Precise numerical information	A	Simpliest to quickly understand.	Likely	Likely	4/20/2015 12:51:00 PM	US		
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Simplified graphical information	E	It's the most appealing and the easiest to understand.	Likely	Likely	4/20/2015 8:15:00 PM	CH		1
	t	Yes		Tavel time / savings				Very likely	Simplified graphical information	E	Well, I like D and E but what swayed the choice towards E is that for Health, I have a point of reference (contribution to regimen). This has also led me to think that a similar point of reference would be good for the other variables.	Unlikely	Neutral	4/20/2015 10:56:00 PM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Simplified graphical information	E	More sipmle and understandable	Very likely	Very likely	4/20/2015 11:41:00 PM	CA	QC	
		Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Neutral	Simplified graphical information	D	It is more user friendly, meaning that it's easy to understand and work with that.	Likely	Likely	4/21/2015 1:20:00 AM	CA	QC	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	C	for me it's the most appealing	Likely	Likely	4/21/2015 7:29:00 AM	CH		25
		Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Neutral	Precise numerical information	C	Easier understanding with the textual description. Good overview with precise informations.	Likely	Neutral	4/22/2015 7:05:00 AM	CH		1
		No						Neutral	Simplified graphical information	E	Nicest graphic. But all I want is distance and travel time. Like most people, I don't care about the rest of the information. Cycling is A to B. Nothing else. People don't ride because of environmental concerns.	Neutral	Very unlikely	4/22/2015 1:23:00 PM	DK		
	t	No						Likely	Precise numerical information	E	Graphics and numerics well integrated.	Likely	Neutral	4/22/2015 1:27:00 PM	DE		10
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	E	More visual/graphic and at-a-glance which I prefer.	Likely	Neutral	4/22/2015 1:27:00 PM	AU		7
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Simplified graphical information	E	Clear and simple.	Likely	Neutral	4/22/2015 1:28:00 PM	DE		
		No						Very likely	Simplified graphical information	E	It was the most clear and easiest to read on my iphone	Very unlikely	Very unlikely	4/22/2015 1:29:00 PM	GB		
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	C	Clarity and simplicity	Likely	Neutral	4/22/2015 1:29:00 PM	CA	ON	
		No						Likely	Simplified graphical information	E	Look better to me	Very unlikely	Very unlikely	4/22/2015 1:29:00 PM	GB	H9	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Precise numerical information	C	Simple yet contains all necessary information without the need of guessing what specific icons mean and it doesn't crowd the screen with unnecessary graphics.	Likely	Likely	4/22/2015 1:30:00 PM	US	MN	
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	E	Easier to read	Likely	Likely	4/22/2015 1:31:00 PM	GB		
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	E	Most understandable combination of stats and graphices	Neutral	Likely	4/22/2015 1:31:00 PM	US	WI	
	t	Yes		Tavel time / savings				Neutral	Precise numerical information	C	clearest	Likely	Neutral	4/22/2015 1:33:00 PM	FR	AB	
	t	Yes			Impact of traffic conditions		Environmental impact	Likely	Precise numerical information	C	Numbers without icons I need to understand first	Neutral	Likely	4/22/2015 1:33:00 PM	DE		2
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Precise numerical information	E	Numbers are the main information, but graphics support it.	Likely	Unlikely	4/22/2015 1:35:00 PM	ES		
	t particulate matter	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	E	clearest informration	Neutral	Likely	4/22/2015 1:37:00 PM	KR		
	t Cost to society (i.e. subsidized roads, health care $, etc.)	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Neutral	Simplified graphical information	E	The "workout" icons are not understandable. Figuring that out will be too big a hump for ppl to get over. E has text but you will read the text once and the images are easily consumable in a glance.	Very likely	Likely	4/22/2015 1:37:00 PM	US	WA	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Precise numerical information	B	I like the graphics and I find the display clearer than the others. My second favourite is E.	Likely	Neutral	4/22/2015 1:40:00 PM	GB	H9	
	t	Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	E	easy to digest the information	Neutral	Neutral	4/22/2015 1:41:00 PM	US	MD	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Simplified graphical information	C	easiest to read	Neutral	Likely	4/22/2015 1:45:00 PM	CH		25
	t	Yes	Travel costs / comparison			Impact of weather conditions		Likely	Simplified graphical information	E	It seems to be the easiest to understand	Likely	Likely	4/22/2015 1:47:00 PM	CA	ON	
	t NO2 emissions, smoke emissions	Yes		Tavel time / savings	Impact of traffic conditions			Neutral	Simplified graphical information	E	Just taste, really.	Likely	Neutral	4/22/2015 1:47:00 PM	US	NY	
	t	Yes					external costs such as health impacts on others through pollution & danger	Likely	Simplified graphical information	A	Can scan it quickly Without putting on my reading glasses.	Likely	Neutral	4/22/2015 1:47:00 PM	HU		
	t	No						Unlikely	Simplified graphical information	D	Time taken is important; for the rest I basically use my bike if the weather is good - public transport otherwise	Unlikely	Unlikely	4/22/2015 1:48:00 PM	CA	QC	
		Yes	Travel costs / comparison	Tavel time / savings				Very likely	Precise numerical information	C	Simple yet effective	Neutral	Neutral	4/22/2015 1:49:00 PM	PT		14
	t Visible impacts on the environment due to transport on my route	Yes	Travel costs / comparison	Tavel time / savings		Impact of weather conditions		Likely	Simplified graphical information	E	I chose E because it gives more perspective, but it would need to be worked out a little. But for datavit purposes, I will got with E. A was interesting too but it seems that that type of data rendering is not good with so small numbers.	Very likely	Very likely	4/22/2015 1:54:00 PM	CA	QC	
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	E	Precise information + attractive design.	Neutral	Likely	4/22/2015 1:55:00 PM	ES		56
	Comparative	Yes	Travel costs / comparison					Neutral	Simplified graphical information	A	B, for instance, is cluttered. Simple graphics (ag histogram) best understood by majority.	Likely	Unlikely	4/22/2015 2:00:00 PM	US	OR	
		Yes	Travel costs / comparison	Tavel time / savings				Very unlikely	Simplified graphical information	A	Clearest to read at a glance.	Unlikely	Unlikely	4/22/2015 2:02:00 PM	GB	H9	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	C	easy to see, read and understand, includes written metrics	Neutral	Likely	4/22/2015 2:03:00 PM	US		
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	E	Easy watch.	Likely	Likely	4/22/2015 2:12:00 PM	LV		25
		No						Likely	Precise numerical information	E	It looks more accessible	Unlikely	Neutral	4/22/2015 2:14:00 PM	BE		11
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	C	easy to read	Likely	Likely	4/22/2015 2:16:00 PM	CA	QC	
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	D	Clean look, easy to read, precise info.	Neutral	Neutral	4/22/2015 2:28:00 PM	US	WA	
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Simplified graphical information	B	Easiest to read at a glance.	Likely	Neutral	4/22/2015 2:28:00 PM	VN		20
	$ saved by other's health (ie lower lung disease) by my choice.	Yes	Travel costs / comparison	Tavel time / savings			my impact on congestion & parking	Likely	Simplified graphical information	E	I like both graphic and precise info together, but I couldn't choose both above.	Very likely	Likely	4/22/2015 2:44:00 PM	CA	SK	
	t Space used	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Very likely	Simplified graphical information	E	Nice graphical representation, relative numbers instead absolute values	Likely	Likely	4/22/2015 2:45:00 PM	DE		2
		No						Very likely	Precise numerical information	E	Instant understanding	Very unlikely	Very unlikely	4/22/2015 3:06:00 PM	BO		8
	t	Yes		Tavel time / savings				Likely	Simplified graphical information	E	Looks the most modern.	Likely	Likely	4/22/2015 3:15:00 PM	AT		9
	t Effect on other factors (e.g. congestion, noise)	No						Neutral	Simplified graphical information	E	Exercise motivation and visually pleasing	Likely	Neutral	4/22/2015 3:25:00 PM	LU		
		No						Very likely	Simplified graphical information	E	Best overview	Likely	Likely	4/22/2015 3:33:00 PM	DK		18
		Yes	Travel costs / comparison	Tavel time / savings				Very likely	Simplified graphical information	B	I found it easiest to take in info quickly. It also made me smile - the stick figures were a bit silly and amusing.	Neutral	Neutral	4/22/2015 3:34:00 PM	GB	I2	
		No						Unlikely	Precise numerical information	B	Easy to read	Neutral	Unlikely	4/22/2015 4:02:00 PM	DE		18
	t PM2.5 NO2	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions	Congestion	Neutral	Precise numerical information	D	Seems to be the clearest but has reasonable graphics too	Neutral	Likely	4/22/2015 5:18:00 PM	CA	QC	
	t	Yes		Tavel time / savings	Impact of traffic conditions			Likely	Simplified graphical information	E	Easy to read and understand.	Likely	Neutral	4/22/2015 5:21:00 PM	FI		13
		Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Precise numerical information	E	Exact values shown, clear descriptions.	Unlikely	Unlikely	4/22/2015 6:23:00 PM	PL		77
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	E	Better design	Neutral	Likely	4/22/2015 6:32:00 PM	AU		4
	t	Yes	Travel costs / comparison	Tavel time / savings				Very likely	Precise numerical information	C	Simple design	Likely	Likely	4/22/2015 6:52:00 PM	GB	U3	
	t	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Very likely	Precise numerical information	E	The clearest to me	Very likely	Likely	4/22/2015 6:59:00 PM	DK		17
		Yes	Travel costs / comparison	Tavel time / savings				Likely	Precise numerical information	E	nice combination of graphics and numerical comparison	Neutral	Very unlikely	4/22/2015 7:37:00 PM	US		
		Yes		Tavel time / savings		Impact of weather conditions		Likely	Simplified graphical information	C	Simple. Easy to interpret.	Unlikely	Neutral	4/22/2015 8:35:00 PM	US	CA	
	t	Yes	Travel costs / comparison		Impact of traffic conditions			Very likely	Simplified graphical information	E	It shows what's important to me in images but also contains more information.	Very likely	Very likely	4/22/2015 9:02:00 PM	AU		
		No						Unlikely	Precise numerical information	C	It's the easiest for me to understand.	Unlikely	Neutral	4/22/2015 10:13:00 PM	US		
	air quality	Yes	Travel costs / comparison					Likely	Simplified graphical information	A	The bar charts provide the easiest means of comparison of options.	Neutral	Likely	4/22/2015 10:18:00 PM	GB	N7	
	t Use of limited natural resources ie metals etc	Yes					Safety	Likely	Precise numerical information	D	Easy to understand comparison	Neutral	Very unlikely	4/22/2015 11:31:00 PM	US		
		Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Simplified graphical information	D	Both intuitive and precise display.	Neutral	Likely	4/23/2015 3:05:00 AM	US		
	Resources compared to cars	Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions			Likely	Simplified graphical information	E	Impact on/costs for society of bikes vs cars is probably most relevant	Likely	Likely	4/23/2015 7:58:00 PM	DE		12
		Yes	Travel costs / comparison	Tavel time / savings	Impact of traffic conditions	Impact of weather conditions		Likely	Simplified graphical information	B	E is a close second choice but I think that B is most appealing due to simplicity. While I enjoy deeper analysis, for an everyday app, I would be more likely to view something like B. Colour helps, too. Shallow, I know.	Neutral	Likely	4/24/2015 6:00:00 AM	CA	BC	

Appendix 5: Ethics approval certification

CERTIFICATION OF ETHICAL ACCEPTABILITY FOR RESEARCH INVOLVING HUMAN SUBJECTS

Name of Applicant: Manuela Hummel

Department: Individualized Program

Agency: N/A

Title of Project: Translating Knowledge into Action: Bridging the Intention-Behaviour Gap with Customizable Information to Improve Personal and Ecological Health

Certification Number: 30004562

Valid From: April 14, 2015 to: April 13, 2016

The members of the University Human Research Ethics Committee have examined the application for a grant to support the above-named project, and consider the experimental procedures, as outlined by the applicant, to be acceptable on ethical grounds for research involving human subjects.

Dr. James Pfaus, Chair, University Human Research Ethics Committee