# Sustainable Personal Mobility

**How active modalities and the reduction of mobility can contribute to pro-environmental pratice among commuters.**

**by Jelle-Jacob Kuiper, 2020**

TU Delft

*This report is executed within*
***The Seamless Personal Mobility Lab***
*of The Delft University of Technology*

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***Project partners***

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source: Dronist

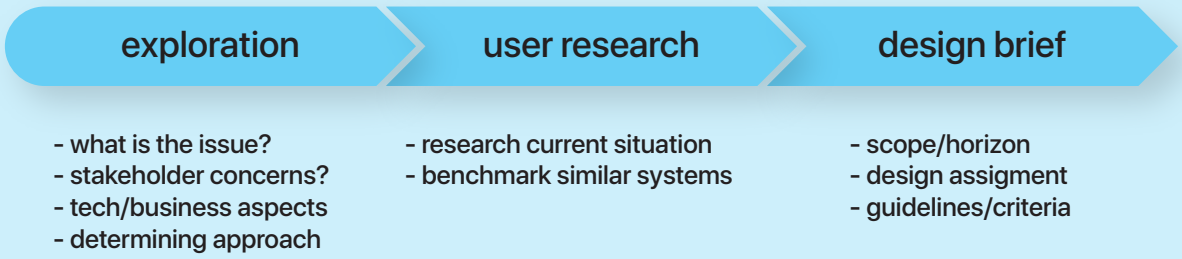
# 1.0 Project base

In this section, we will discuss the base of this project. After a concise introduction, an overview of the setup will be given, then the project background will be reviewed which will be followed by the problem definition and relevance of the project. Lastly, the goal of the project will be discussed followed by the general approach of this project.

## 1.1 Introduction

In the last couple of years, integration of services have been a focus in many industries. In the personal mobility industry, this movement has manifested as so-called MaaS. Mobility as a Service (MaaS) is a flexible, multimodal mobility service that enables users to plan, pay, book and modify their journey in real-time in a one-stop-shop fashion. Possible positive effects are a better spread of public transport and traffic, an increase of sustainability in personal mobility and wider accessibility of hard-to-reach regions. Therefore, the Dutch ministry and operators within the personal mobility industry are looking into MaaS and its benefits as a solution for the future of mobility in the Netherlands.

More specifically, Mobility as a Service is an opportunity to form a breeding ground for sustainable commuting solutions and increase environmental awareness amongst travellers. In this project, we will explore MaaS further and identify opportunities for future MaaS solutions.



## 1.2 Project Setup

As seen in figure 1, the main body of this project will consist of two phases. The first phase (Kuiper, 2020) will consist of an analysis phase and the second phase will consist of a design phase.

More specifically, the first phase will be of an exploratory nature which focuses on getting a well-founded understanding of what Mobility as a Service entails and what this means for the travel experience of the end-user. Furthermore, as this is a user-centred project usability issues will be collected, analysed and concluded. This data will be collected by a series of explorative benchmarking studies conducted in Vienna, Berlin and Helsinki. These cities were selected as they claim to currently deliver Mobility as a Service solutions to its citizens.

The second phase will focus on translating the insights from the analysis phase into viable product-service systems that are desired by travellers. The product-service systems will be tested and evaluated in an iterative manner and finalized into a user-friendly personal mobility concept for the Netherlands.

This document will dive deeper into the details of the design phase, exploring potential solutions, prototyping these solutions and evaluating them with users and stakeholders (figure 1). Furthermore, this report will end with considerations for future progressions.

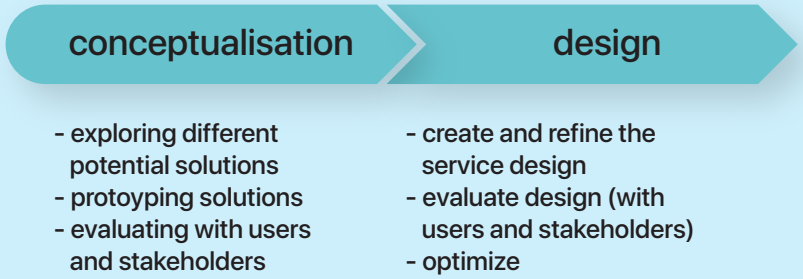



*Figure 1: Project setup*

## 1.3 Seamless PErsonal Mobility Lab

This project is initiated by The Seamless Personal Mobility Lab situated within the faculty of Industrial Design Engineering. Previously, the lab focussed on payment interactions within public transport and how payment options could be designed in a user-centred fashion. Currently, the scope of the lab broadens from merely public transport to personal mobility in general but stays true to its user-centred roots by researching and designing solutions for personal mobility needs.

Moreover, the Seamless Mobility Lab focus lies in the realms of TRIP-platforms and corresponding service systems. As stated by Veeneman et al. (2020), TRIP-platforms can be summarized as platforms that deal with Transaction, Reservation, Information, and Planning within their service. Additionally, the lab aims to explore problems and opportunities that users experience in current mobility systems and optimise them by working together with the users themselves and with company stakeholders. The goal of the lab is to contribute to solving current and future mobility issues in the Netherlands and neighbouring countries.


source: J.J. Kuiper

## 1.4 Project Partners

During this project, collaboration will take place within the Seamless mobility lab and between eight project partners. This relationship will work both ways and interchangeably across the different projects mentioned in section 1.3.

Delft University of Technology

It goes without saying that the faculty of Industrial Design Engineering (IDE) of the Delft University of Technology is the biggest contributor within this project. The IDE faculty facilitates all student activities and all activities within the Seamless Personal Mobility Lab.

CROW is a non-profit foundation, with the main function to provide knowledge to partners. This is done through large programs like Kennisplatform Verkeer en Vervoer (KpVV) (Kennisplatform CROW, 2019). Since 2009 KpVV is part of CROW, CROW-KpVV answers questions about traffic and transportation for the decentralized authorities (Kennisplatform CROW, 2019).

The RET is the main public transport provider in the Rotterdam and surroundings. The RET has been providing transportation to the public for over 150 years and has been operating as a privatized company since 2007 (RET, 2018). Each year they transport about 185,7 million travellers in this area.

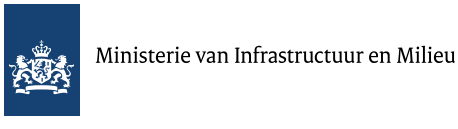
Established in 1991, 9292's aims to provide reliable travel information to its travellers. Having more than 25 years of experience, 9292 understands the changing needs of the traveller and actively work to keep their system up-to-date. In 2016, 700 million travel suggestions were provided by 9292 (9292, n.d.).


Founded in 1971 by Frans van de Poel, Rover represents the travellers using the Dutch public transport system. This travel association focuses on the needs of the travellers and ensures that the operators, authorities and media are updated with this information. Rover has legal advisory rights, which makes them unique in the Netherlands (Rover, n.d.).


The GVB is the public transport provider in Amsterdam and surroundings. The company is 119 years old and provides transportation for around 875.000 travellers each day. Their fleets consist of buses, trams, metros and ferries (GVB, 2019).


Translink is a company that is founded by all mobility operators in the Netherlands. The transport system in the Netherlands is quite unique, there is no other country where travellers can travel within the entire country with different public transport providers using only one transportation card. Each year, Translink processes over 2,6 billion transactions for all public transportation providers (Translink, 2019).


Within DOVA the decentralized OV-authorities work together to improve public transport. There are 15 decentralized OV-authorities including the 12 provinces, Metropoolregio Rotterdam Den Haag, OV bureau Groningen Drenthe and Vervoerregio Amsterdam. (DOVA, n.d.)




The Ministry of Infrastructure and Water Management focuses on a liveable, accessible, clean and safe environment. The ministry aims to manifest strong connections by road, rail, water and air, and to protect the country against flooding whilst ensuring good the quality of air and water (Rijksoverheid, n.d.).

## 1.5 Problem Statement

We live in challenging times, with the exhaustion of our planet just around the corner we need to look into sustainable alternatives to construct our future. According to the climate agreement of Paris, in 2030 the Netherlands will have reduced its emissions with 49% compared to its emission in 1990. This goal is ambitious and should be practiced in all industries in order for it to succeed.

All industries, including the personal mobility industry. In thier vision for the future of The Netherlands (KiM, 2020) The Dutch Institute for Transport Policy Analysis state that traffic and transport, excluding international aviation and the shipping industry, are responsible for 20% of the total CO2 emission in the Netherlands. This shows that personal mobility can play a significant role in achieving our societal goals regarding sustainability in 2030.

However, these ambitions collide with what we perceive in our country. The demand for mobility is increasing and the current infrastructure of the Netherlands is over-saturated with public and private transport. The mobility systems have reached a critical point in which congestion and high emissions result in decreasing liveability in urban areas (Ministerie van Infrastructuur en Waterstaat, 2019). This growth in mobility underlines an opportunity and urge to create sustainable mobility alternatives to facilitate people in travelling more sustainably.

At the same time, when looking at technology new innovations are upon us. During the exploration of novel mobility solutions such as MaaS (Kuiper, 2020), great potential has been identified for Mobility as a Service to play a role in realizing a positive impact on our environment. As stated by Durand et al. (2018), Mobility as a Service (MaaS) is a flexible, multi-modal mobility service that enables users to plan, pay, book and modify their journey in real-time. Possible positive effects are a better spread of private and public transport, an increase of sustainability in personal mobility and wider accessibility of hard-to-reach regions. Therefore, the Dutch ministry and said partners in section 1.4 are looking into MaaS and its benefits as a solution for the future of mobility in the Netherlands.

MaaS could have the potential to change things around for the better. If we look at the main learnings of the OV-chipcard launch however, we see that successfully introducing a new product-service system is not merely dependant on technological and corporate drivers (Meijdam commission, 2011). Van Kuijk (2014) stated that a successful implementation of any product-service system covers human drivers and holds societal relevance as well (figure 3). We've established that MaaS holds societal relevance, this means that in order for a MaaS service to be successful it needs to be adopted by the people using it.

When exploring existing MaaS solutions (Kuiper, 2020), we see that users have no or little interest in using current MaaS services. Evidence shows, that as current MaaS solutions are merely focussed on technological drivers (see chapter 2.3). However, if we take a step back and look at MaaS from a user perspective we see that MaaS is not merely about getting from one place to another. It is about how you do so, about what set of values are represented in your trip. This will be discussed in more detail in chapter 2.3.

This project will explore what a MaaS solution would look like if it focuses on the needs of the end-user and when designing with a value driven approach.

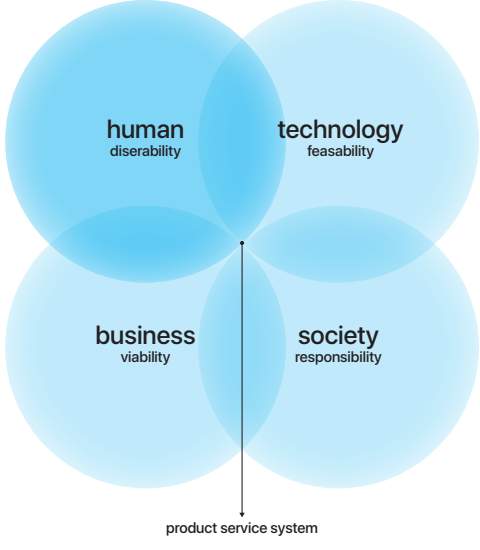



*Figure 3: model of innovation, by van Kuijk (2014)*

## 1.6 Project Relevance

Since the earliest of days, society has been fuelled by our ability to move around. Fast forward until this present-day and mobility still manifests as a basic human need. Public and private transport enables us to live our daily lives, reach our goals and grow as individuals and as a society. As discussed in chapter 1.5, mass mobility also has its drawbacks. Mobility has taken over much of our living space and we are also seeing its negative impacts on the environment. To form a clear understanding of what mobility should look like in the future, the Dutch government created a vision to improve the liveability of the Dutch citizens based on five domains by 2040 (Ministerie van Waterstaat, 2019) seen in figure 4.

In this project, special attention will be given to sustainability as it I personally see this as the biggest challenge to overcome in the next 10 to 20 years. I believe all help regarding this topic is needed and welcome for a prosperous future.

## 1.7 Project Goal

The goal of this project is to reduce CO2 emissions during commutes. To reach this goal knowledge gathered when exploring existing MaaS solutions (Kuiper, 2020) will be used when needed. Furthermore, when additional knowledge is required research activities will be conducted to achieve said goals.


*Figure 4: five domains of improvement*

## 1.8 Research Approach

Traditionally, a design process includes an analysis of the problem, a generation of ideas, a simulation of the possibilities, an evaluation of the ideas based on a set of fixed criteria, implementation and finally an evaluation (Roozenburg & Eekels, 2003). Although this process is thorough and applicable to most design situations, it might not be suitable for problems with complex and dynamic contexts. In this project, a more dynamic approach is needed as it includes a lot of uncertainties and a rapidly changing context. What could be of essence today, might be redundant tomorrow. Therefore, it is key to form a good understanding of the context, background and users within the project whilst foreseeing future scenario's, user-needs and business opportunities. As pinned down by Ideo in 2000, a good design is desirable by the user, feasible within the current resources and contains a viable business model. These three aspects will be considered throughout this project.

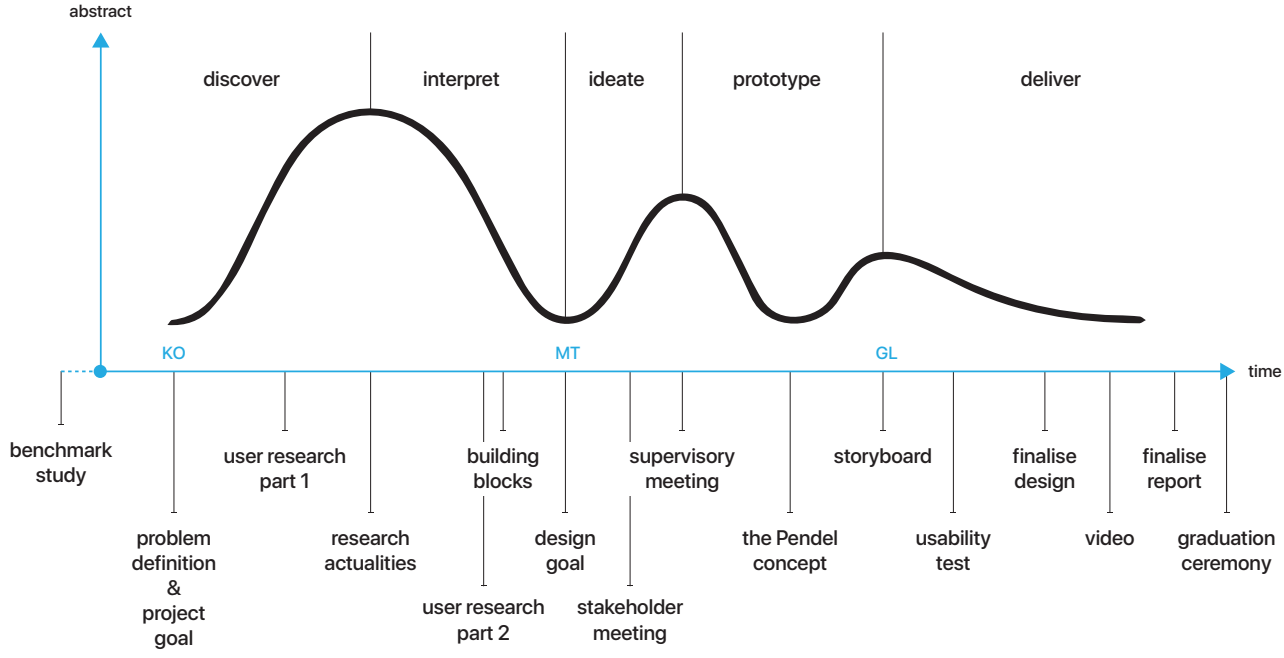



*Figure 5: process during this project*


*source: S. Beyazkaya*


source: J. Jacobsson


# 2.0 Mobility as a Service

In this section, we will take a brief look at the results from the first phase of this project (Kuiper, 2020). These results form the cornerstones on which this design phase is built. More specifically, this chapter starts by explaining a few important aspects of MaaS, then gives a summary of previously performed research activities continued by laying out the main takeaways of the study. Finally, it will present an overarching vision which forms the main driver for this design phase.

## 2.1 Defining Mobility as a Service

The concept of MaaS (figure 6) has briefly been discussed in chapter 1 and will be reviewed in more detail in this section. In short, MaaS offers a tailored door-to-door travel experience for selected personal mobility in a one-stop-shop fashion for trip planning, booking, paying and travelling (Kuiper, 2020).

### 2.1.1 The use of TRIP-platforms

To facilitate the interaction between MaaS users and mobility providers a digital service platform is used (Jittrapirom et al. 2017). This platform is usually in the form factor of a mobile application or website. As stated by Veeneman et al. (2020), these platforms can be summarized as TRIP-platforms: Transaction, Reservation, Information, and Planning. First, the platform enables the user to pay his/her trip through the platform. Second, modes of transport can be reserved for a certain amount of time for later use. Third, the platform provides real-time information before, during and after the trip, e.g. this could range from information about departure times to information about crowds in rush hour. And lastly, the platform enables the user to plan the trip in advance and also provide real-time optimizations based on disruptions or delays.

### 2.1.2 The role of public transport

For MaaS to be successful, the integration of public transport systems is essential (Matyas and Kamargianni, 2018). Also Ramboll's analysis "Whimpact" suggests that public transport is the backbone of MaaS. This statement is based on the MaaS provider Whim's own dataset and states that 95% of all Whim trips are made with public transport. Furthermore, Whim estimates that 63% of its user's modal share is used by public transport.

### 2.1.3 The integration of shared mobility

Besides a strong public transport system, the benefit of MaaS is that it provides the user with alternative modes of transport. The use of shared mobility will provide more mobility choices for travellers. Also, shared mobility modes have the potential to cover distances that public transport fails to cover, also known as the first- and last mile distance (Durand et al. 2018). This would enable the traveller to truly plan a trip from door-to-door. These first- and last-mile trips also have the potential to be beneficial to the traveller's health, especially when active modes are used like cycling or walking. Moreover, the use of shared mobility modes can have a positive impact on the environment as well. It has the potential to reduce, emissions, traffic congestion, and needed parking space.

### 2.1.4 From owner-based to acces-based

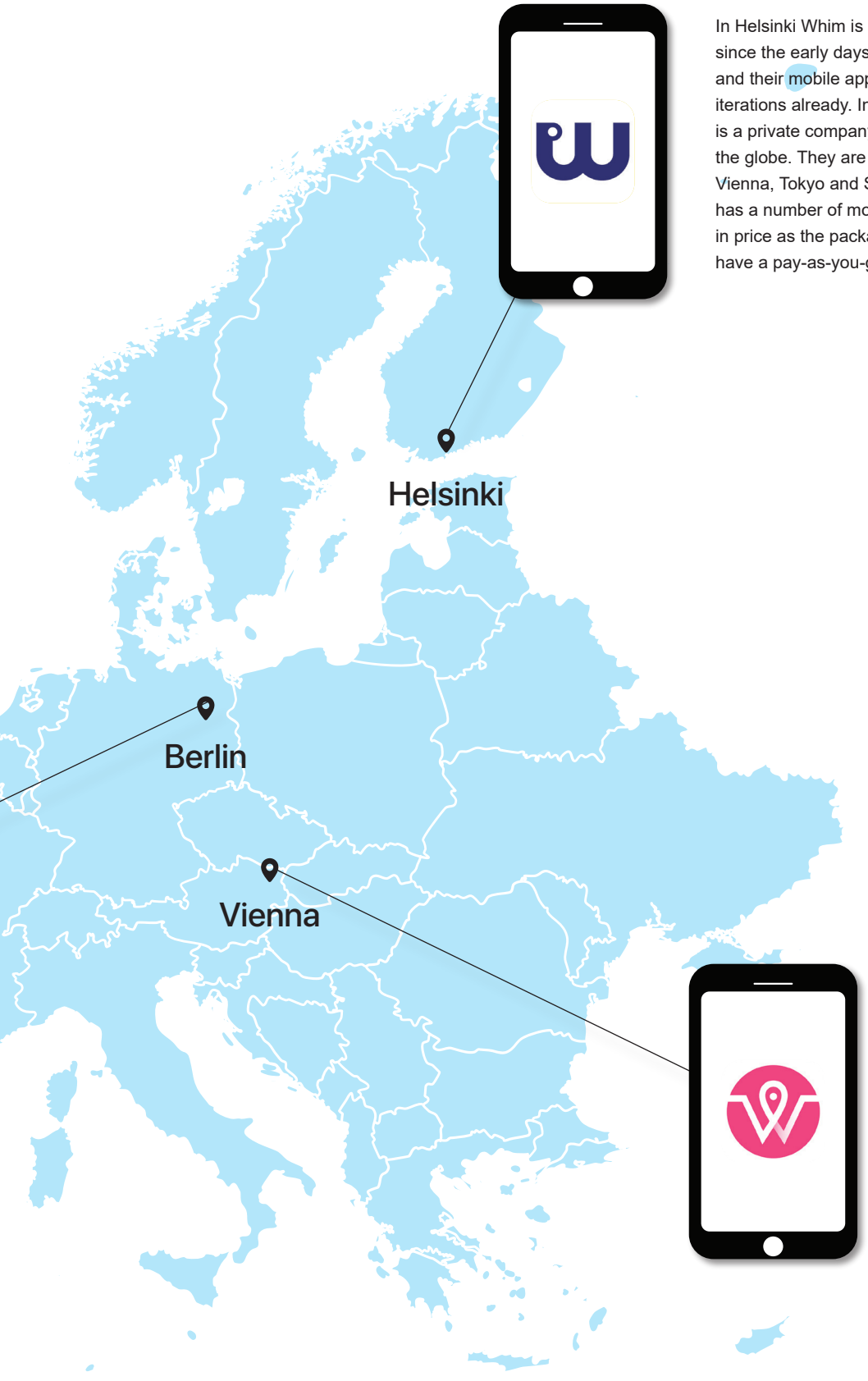
If shared transportation is widely adopted by traveller's we will see a shift from owner-based transport to access-based transport (Durand et al. 2018) (Mulley, 2017). An owner-based mode of transport is privately owned by the traveller, like a bike or a car. Access-based transport, however, is based on services that enable different travellers to use the same vehicle, but independent from one another (Veeneman et al. to be published).

*Figure 6: The principle of MaaS*

## 2.2 Exploring MaaS solutions

Now that we've established the main principles of MaaS concepts we can explore existing MaaS services in the field. In November 2019, I set out to explore various existing MaaS solutions. The goal was to get an understanding of what it means to make a multimodal trip, of how these services work in real life and what the opinions are of travellers towards these services. After comparing all the various options I reviewed three services: Wegfinder in Vienna, Jelbi in Berlin and Whim in Helsinki. However, each city was chosen with the following intent.

Jebli in Berlin is selected as they are a collaboration between a private and a public company. In contrast to Wegfinder, they solely focus on Berlin alone. Jelbi also implemented two mobility hubs in the outskirts of the city. These hubs combine different modes of transport with parking space, WIFI connection and public transport stops close by. Jelbi offers a pay-as-you-go solution to its users, they do however plan to review subscriptions in the future.




In Helsinki Whim is selected as they are pioneering MaaS since the early days. They have grown into a big company and their mobile application has experienced several iterations already. In contrast to Wegfinder and Jelbi, Whim is a private company and is situated in several cities around the globe. They are currently live in Helsinki, Birmingham, Vienna, Tokyo and Singapore. Regarding ticketing, Whim has a number of mobility packages available that increase in price as the package expands. For novice users, they have a pay-as-you-go solution.

In Vienna, Wegfinder is selected as they offer over 75 different mobility providers with their service. They aim to connect the whole of Austria and they are a public company as they are part of railway provider OBB. Ticketing wise, Wegfinder offers a pay-as-you-go system to its users.

### 2.2.1 Benchmark study takeaways

In this section, key insights gathered from the benchmark study are presented. First we the modal trip will be explained, then the specifics regarding MaaS applications and lastly user insights will be discussed.

2.2.1.1 Making a multimodal trip

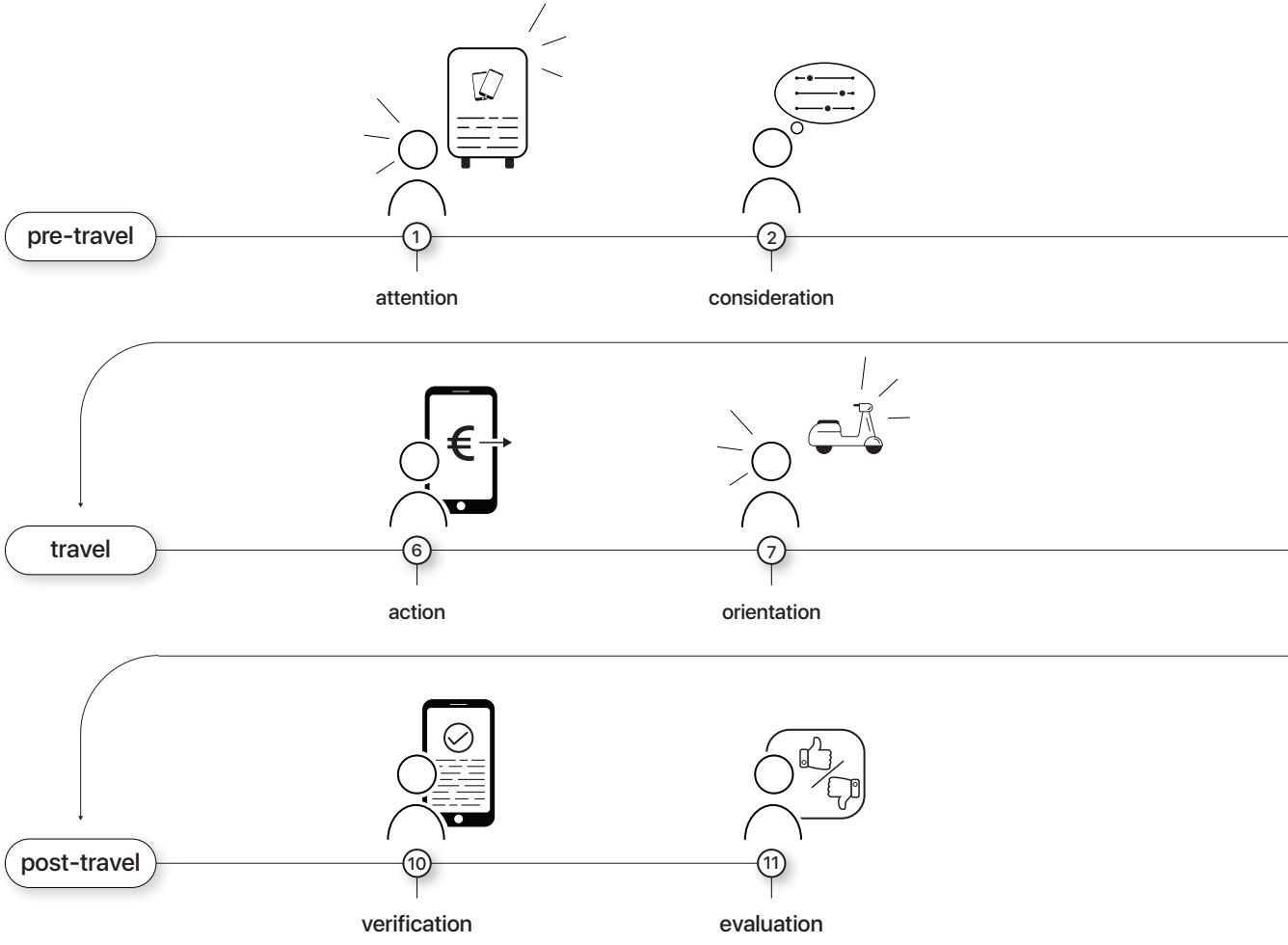
The core of each MaaS concept is that it enables travellers to make a multimodal trip (Durand et al. 2018). A multimodal trip is when various modes of transport are utilised within one trip. For example, this would mean that you would first take the bike to the train station, hop on a train, and afterwards rent a bike to reach your final destination. One main insight of the study has shed new light on the travel stages identified by Joppien, Niermeijer, and Niks (2013). A reasonable amount of time has passed and multiple innovations in the mobility landscape have been established since 2013, therefore changes have been made to the stages to make it compatible with the current mobility spectrum, as seen in figure 7.

The experience starts with attention. In this stage service providers grab the travellers attention by means of advertisement and aim to show the travellers that it is possible to use the service.

After that, a consideration stage kicks in. Travellers ask themselves if they need or want the service, and if the costs are in balance with the benefits.

In the installation stage, the traveller decides to install the application, this process also includes the authentication process of the application.

In the motivation stage, the traveller sets a goal or



destination that he/she want to achieve using the service. It could be as simple as going to a friend or getting groceries.

In the preparation stage, preparation is needed to achieve the set goal. In this stage, journey planning and route considerations are at play.

After preparation, it is time for action. The traveller makes a choice and books tickets and makes reservations if needed.

Once a plan is set, it is time to orientate. In the orientation stage, the traveller scans the surroundings and decides where to go to reach the selected travel mode of choice within reservation times if applicable.
In the execution stage, the traveller onboards the mode and operates it if needed.

After execution, the traveller enters the completion/transition stage. In this stage, the traveller disembarks the mode and locks the mode if needed to complete the trip. If switching modes is needed this stage is also called the transition stage and travellers go back to the orientation stage of the next mode.

When a trip is completed travellers enter the verification stage. In this stage, the traveller checks if everything went according to plan. Travellers check the payment of the trip, the time of arrival and if they reached the desired location.

Lastly, in the evaluation stage travellers evaluate the experience, this stage impacts the consideration stage as a good experience is likely for travellers to use this way of travelling again and a bad experience can keep them from future engagement.

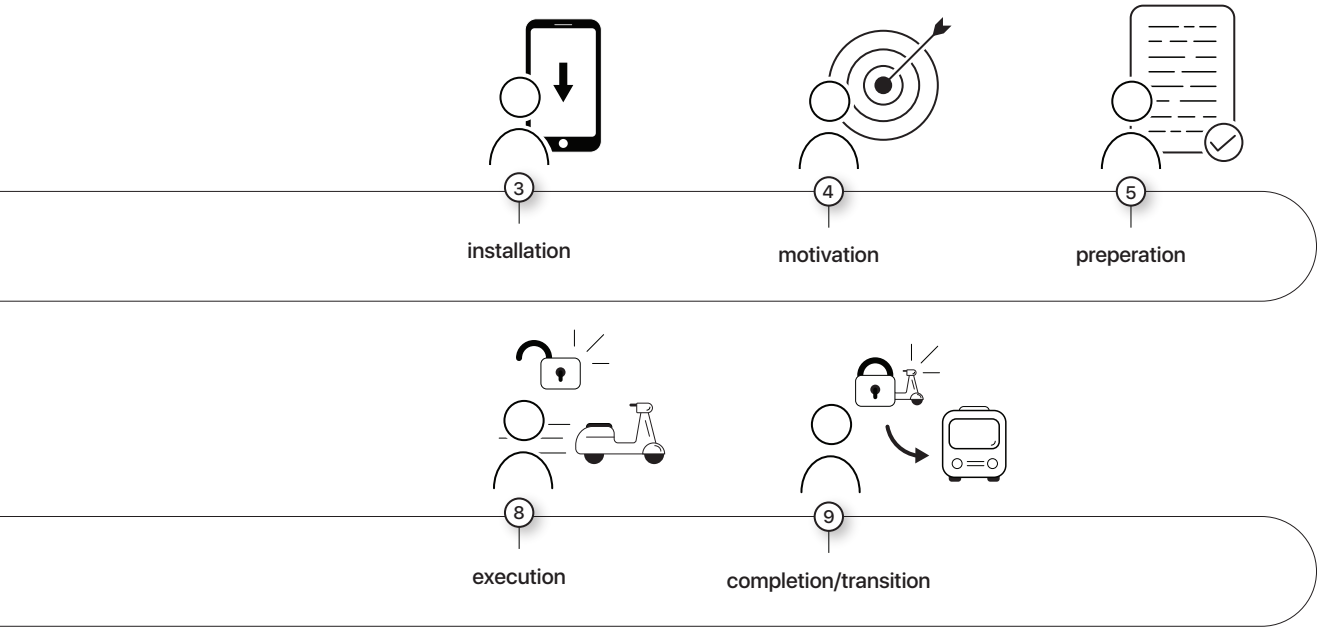



*Figure 7: Multimodal travel stages*

2.2.1.2 Experiencing MaaS Applications

To make a trip with a MaaS service the travellers interact with a mobile application that is provided by the service provider. One of the key insights from the study is these applications contain the following elements:

1. Authentication Process

After installation, the authentication process is the first touchpoint the user experiences with the application. The authentication process should be fairly quick and most of all transparent. Users should be informed why sensitive data such as personal documents or payment details are needed by the MaaS service and what happens with this data. For example, if a third party for verification services is used this should be communicated.

2. Customizable Functionality

When the user has successfully finalized the authentication process, he/she will likely explore the application. Presumably, the first version of the application will not be heavily packed with features. However, as the apps rolls out more functionality it should be presented to the user in a simplistic manner. A MaaS application that is heavily feature-packed is not automatically a good application. Users enjoy feature freedom but are put off by an overload of functionality. As one of the main features of MaaS services is customization (Jittrapirom et al, 2017), special attention should be given to what features make sense from a user perspective. For example, when one does not own a driving license it would not make sense to suggest options that include car-sharing. This inconsistency could be experienced as off-putting as it is not connected to the user's personal needs.

3. Demand for information

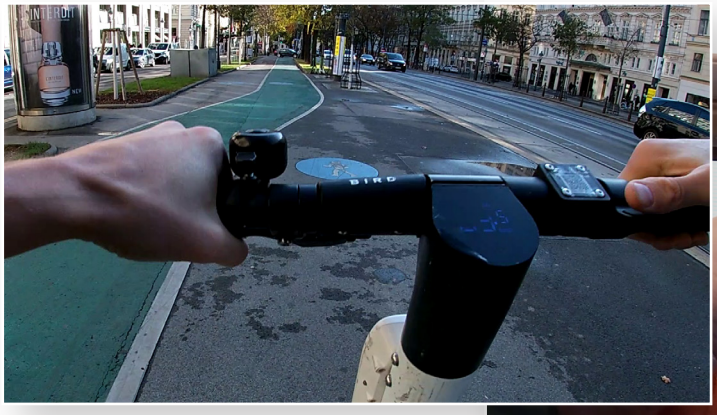
It is important that the travel behaviour, patterns and preferences of users should be taken into account. Special attention should be given to the information that is presented to the user after searching for a route and how it is presented. Again, an overload of information is not desirable the same goes for presenting too little information. For example, when a user is only concerned with going from A to B as easy, fast and comfortable way. This means that the app interface during travel planning should be as simple and straightforward as possible, free of clutter and distractions. Additionally, if the user has covered a particular trip countless times due to commuting or other activities, strategies should be designed to complement this behaviour.

4. Palette of modal choice

MaaS service designers should contemplate how to present the modes that are present in the app. For example, it should be possible to access an E-scooter in the app, even when no trip was planned. And on the flip side, it should be possible to choose a mix of modes when planning a trip. Perhaps the users prefers to walk, take an e-scooter or grab a shared bike before continuing the trip in the train. These options should be configurable in an effortless way and should empower the users need to be able to personalize his/her own trip planning.

5. Payment and ticketing

Lastly, payment and ticketing should not be overlooked, to ensure to exclude certain groups of users multiple forms of payment should be implemented. For example, older generations possibly don't own PayPal accounts as younger generations don't possess credit cards. Furthermore, ticketing should be designed in a user-friendly manner. There are several options for implementation of ticketing with pay-as-you-go being the most simple to implement. A pay-as-you-go ticketing scheme characterizes itself by debiting each trip made in the MaaS app individually. Another option could be designing subscription packages. These packages require a periodically payment from the user and are usually bundles of several modes and their units (i.e. km or hour).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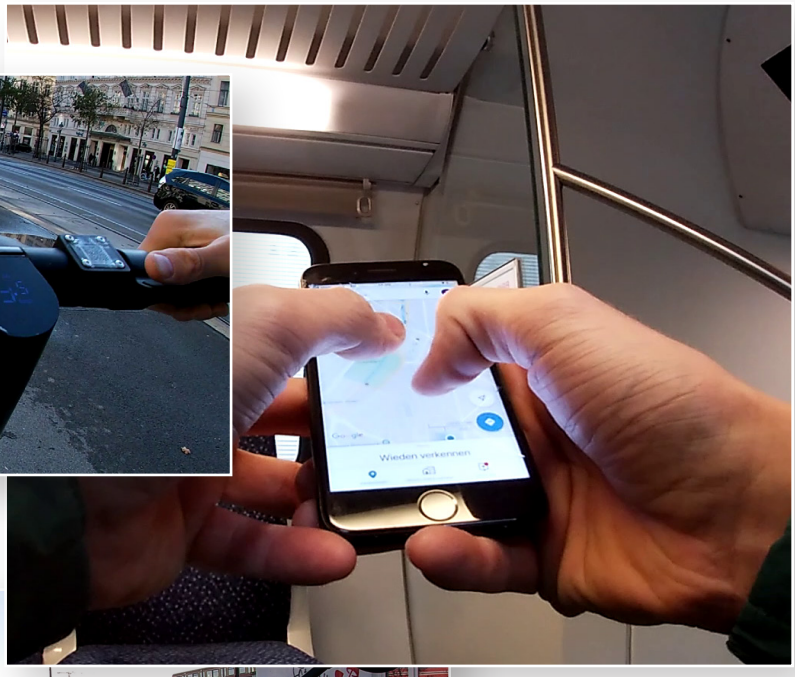
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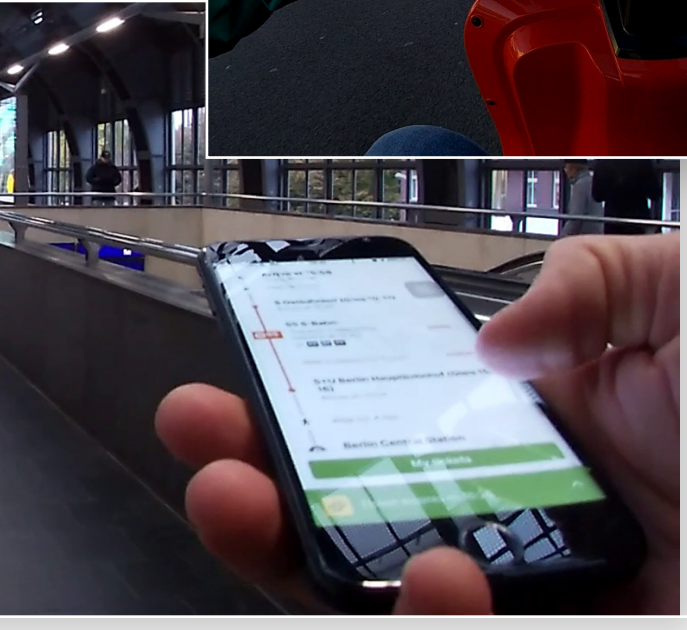
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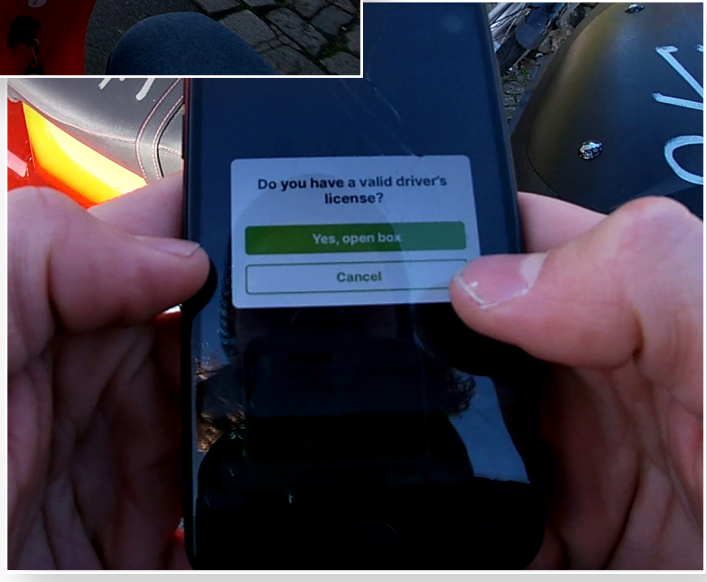
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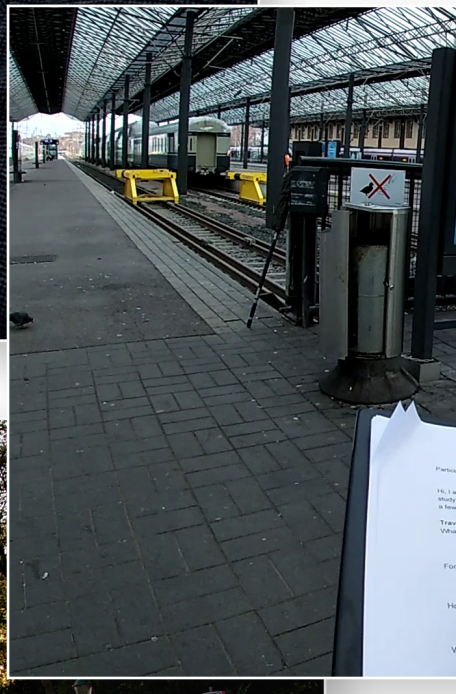
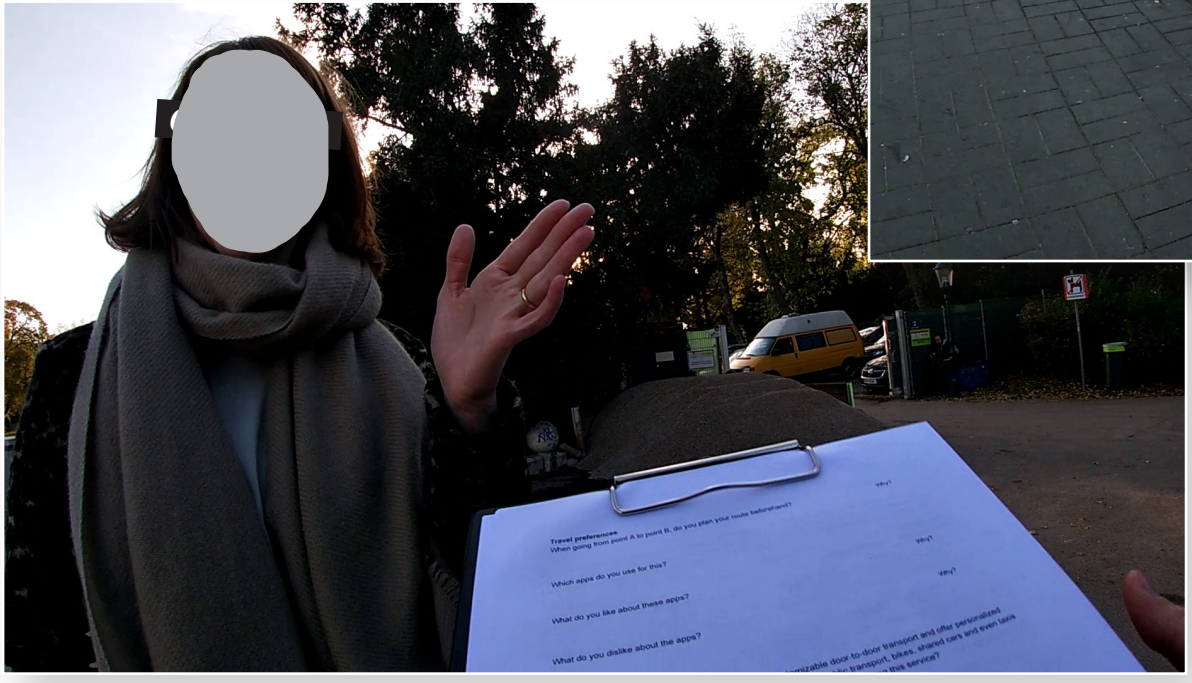



Travel preferences
When going from point A to point B, do you plan your route beforehand?
Which apps do you use for this?
What do you like about these apps?
What do you dislike about the apps?

2.2.1.3 Interviewing MaaS Users

Alongside testing and evaluating Wegfinder, Jelbi and Whim user interviews were carried out with people in Vienna, Berlin and Helsinki. Each interview took about 5-10 minutes and all interviewees where scouted in public spaces such as train stations, parks and squares. The main objective was to explore people's experience with multimodal travelling, their opinion on MaaS and their experience with shared forms of transport. All these research questions boiled down into one overarching unexpected insight.

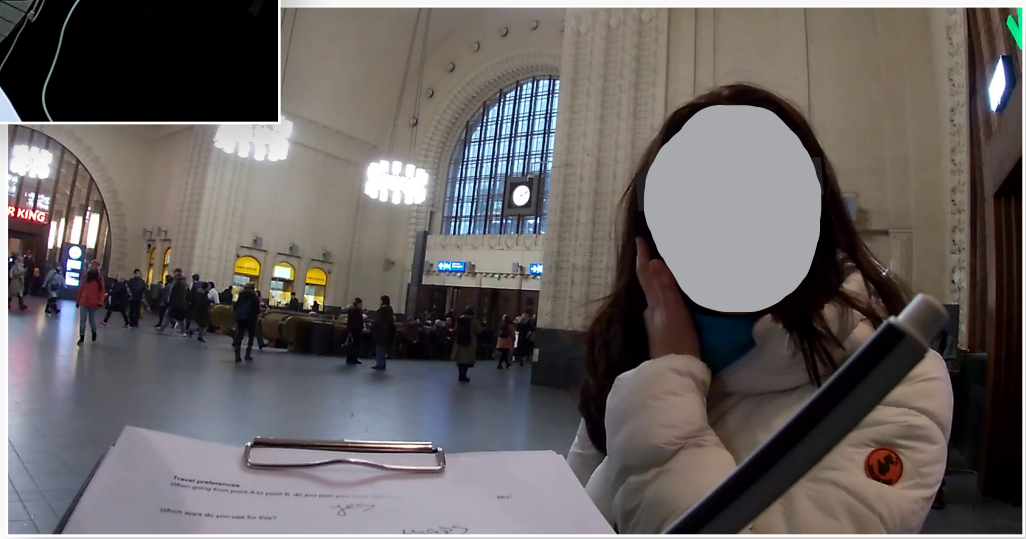
The biggest insights is that within the 75 interviewed participants only 2 participants ever made use of a MaaS service. There are four factors that play a role here.

Firstly, all MaaS services focus solely on quantifiable qualities of the trip like, time, efficiency, speed and costs.

Second, user demands are extremely high. If you promise the fastest, cheapest and most comfortable solution end-users will expect it consistently. In reality however, travelling by public transport simply has its drawbacks such as delays, crowds and sharing public spaces with other people.

Third, traveling is a routine, most participants don't even consider alternative routes. This is also confirmed by Kitamura et al. 2000.

Lastly, simply linking all modalities together is not going to solve these issues. Better yet it adds a layer of complexity, not only for the user but also for the service provider.



## 2.3 Vision on Mobility as a Service

In this chapter, we've talked a lot about MaaS. We've discussed its purpose and potentials and we've recapped the main results from the previous stage shedding light on various issues that might hinder MaaS adoption. These results have led to the following vision on MaaS, it will form the groundwork for this design phase.

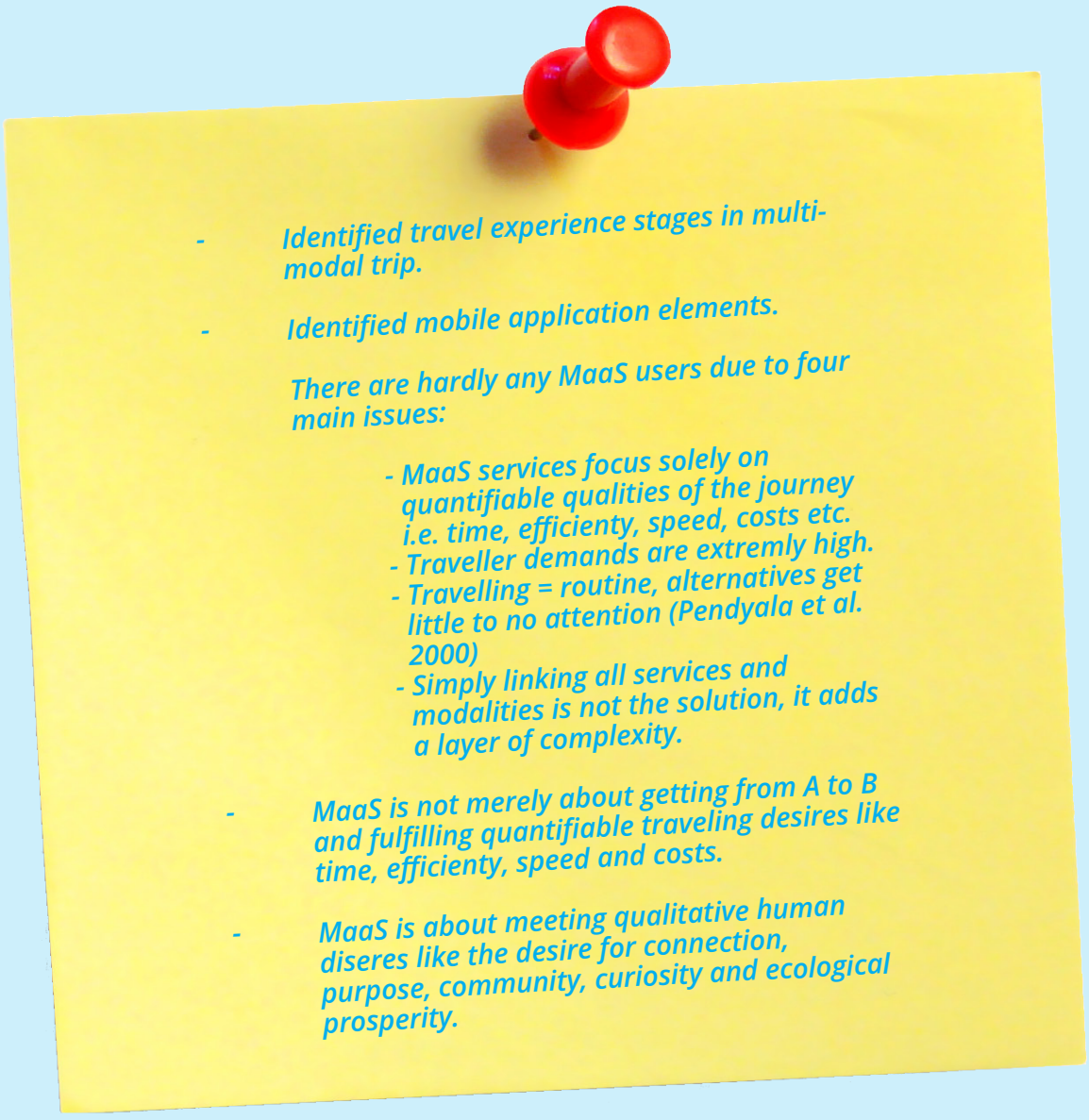
There is great potential in MaaS and the idea of connecting all mobility in an area to make it easier for the user to get around. However, after interviewing travellers and experiencing existing MaaS services it is apparent that MaaS is not merely about mobility itself. The issue with MaaS is that it solely focuses on qualitative aspects of the journey and how these aspects are executed. In short, getting from A to B in the best way possible. This means that the user wants to travel to their destination in a fast, flexible and comfortable manner while keeping the costs at a minimum and not being bothered by crowds. It is believed that this travel utopia is the foundation of how the journey will then positively be experienced by the user. In reality, the quantifiable wishes of the end-user are so close to perfection that it disables us to see the bigger picture.

If we take a step back, zoom out and ask ourselves what MaaS could bring to the table, we see that MaaS is not merely about getting from A to B, MaaS is about meeting qualitative human desires. Desires for connection, purpose, community, tranquillity, curiosity, idealism and so on. Getting around is not merely about getting from one spot to another in the fastest way possible. It is about doing so with your personal values upfront. In practice, this means that several MaaS services should be able to coexist, all specializing in a specific set of values tailored to the need of their users. If so, MaaS services would not merely compete on a technological level, but rather compete with services that cater a similar set, or a variation, of values in mobility.

## 2.4 Design for Sustainability

MaaS has great potential but that it can only reach its full potential if it is designed with a specific set of values in mind. In this project, I will put this idea the test and specifically design for the value of sustainability by reducing CO2 emissions during the daily commute.

## What we learned in Chapter 2



- *Identified travel experience stages in multi-modal trip.*
- *Identified mobile application elements.*
- *There are hardly any MaaS users due to four main issues:*
  - *MaaS services focus solely on quantifiable qualities of the journey i.e. time, efficienty, speed, costs etc.*
  - *Traveller demands are extremly high.*
  - *Travelling = routine, alternatives get little to no attention (Pendyala et al. 2000)*
  - *Simply linking all services and modalities is not the solution, it adds a layer of complexity.*
- *MaaS is not merely about getting from A to B and fulfilling quantifiable traveling desires like time, efficienty, speed and costs.*
- *MaaS is about meeting qualitative human diseres like the desire for connection, purpose, community, curiosity and ecological prosperity.*

source: J. Limcaco


source: M. Spieke


# 3.0 Defining Sustainable Mobility

In order to design for sustainability, we need to understand what sustainability specifically means. Furthermore, we need to get an understanding of what sustainability means in the field of personal mobility. We should become aware of the principles and mechanisms that make current personal mobility unsustainable.

## 3.1 Research Approach

This section will discuss in which fashion research was conducted to gain more insight into sustainable mobility. The research aim, research questions, research methods and insights will be presented below.

### 3.1.1 Research Aim

The aim of this research is to uncover what sustainable mobility is and why is important to pursue.

### 3.1.2. Research Questions

To achieve the stated aim of this research, the following research questions have been formulated.

A. What is sustainable mobility?
B. Why is sustainable mobility important?
C. How do we achieve sustainable mobility?

### 3.1.3. Research Methods

To be able to answer the research questions of this research existing literature will be reviewed.

*source: C. Parker*

## 3.2 Defining Sustainable Mobility

The word “sustainability” is clouded with ambiguity. As there are around 300 definitions of sustainability floating around (Johnston et al., 2007), it’s hard to pin down the true meaning of the term. In this section, we take a closer look at sustainability and it’s most accepted definitions in order to come to a consensus of its true meaning. One definition that is quite common is formulated by Brundtland, in 1987 which goes as follows:

*“Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs.”*

This definition distinguishes itself by presenting a relation between the present and future needs of people. In other words, in the present, one must take future generations into consideration before taking action. Although this definition is easy to understand and to communicate with others, it does not specifically tell us what to do or how to achieve it. On the flip side, there is another widely accepted definition that takes a more scientific approach. It was formulated in 1989 by Karl-Henrik Robert. He figured that by gathering a group of 50 scientists he could come to an understanding of the word sustainability by discussing it through a lens of science and thermodynamics. Consequently, by understanding the definition of sustainability he could uncover the root cause of unsustainability. He came to the following conclusion:

*“Sustainability is the capacity of human society to continue indefinitely within the earth natural cycles.”*

Unlike Bruntlands definition, this definition does not solely take inspiration of human present and future needs. It takes the entire earth, and it’s ecosystems, in consideration as well giving a more profound sense of what it means to act sustainably. Furthermore, the definition also includes society as a whole and is not merely focused on individual needs.

Additionally, sustainability is often referred to as having three pillars: economic, environmental and social. This concept is

known as the “triple bottom line” and is often referred to as the people, planet and profit concept that is coined by John Elkington in 1999. This concept builds on the environmental and social aspect of the previous two definitions and adds a business layer. Although these three pillars are all important the triple bottom line concept presents them as equal. However, when we consider that all things come from nature, and we take a closer look, we can distinguish a hierarchy. For instance, society exists within the environment and in its turn, the economy is a consequence of society. Therefore it would be better to present the three pillars as three nested circles rather than overlapping ones as suggested by Alexandre Magnin.

Now that we’ve established a better understanding of what it means to practice sustainably we can dive deeper and ask ourselves what this means for personal mobility. Although mobility can refer to several meanings, e.g. in terms of biological systems, in this report we refer to mobility as moving from one place to another. If we are talking about sustainable mobility one of the most accepted definitions originates from the EU council in 2001, saying:

*“Sustainable mobility allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;*

*It is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development;*

*It limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise.”*

Basically what this definition tells us is that the negative effects of mobility on people and the environment should be avoided and that mobility should be offered in a fair, efficient and open system that should be accessible to all citizens. Reviewing chapter 2.1, we can see how MaaS offers a promising solution to sustainable mobility.

For this project and the design for sustainable mobility, we come to the following conclusions. First of all, the design has to be created in such a way that people will like it so that it will be used. Second, the service has to be designed in a way that it reduces the burden on natural systems. And lastly, the service has to be designed in a way that it can form a platform for future investments.

## 3.3 The Importance of Sustainable mobility

If we take a look at history, there has always been a relation between the growth of the economy and the degradation of the environment. In other words, when a group of people develops and grows, the environment faces the consequences. Over time, communities have grown and villages have turned into cities. In parallel, the burden on our environment has grown too.

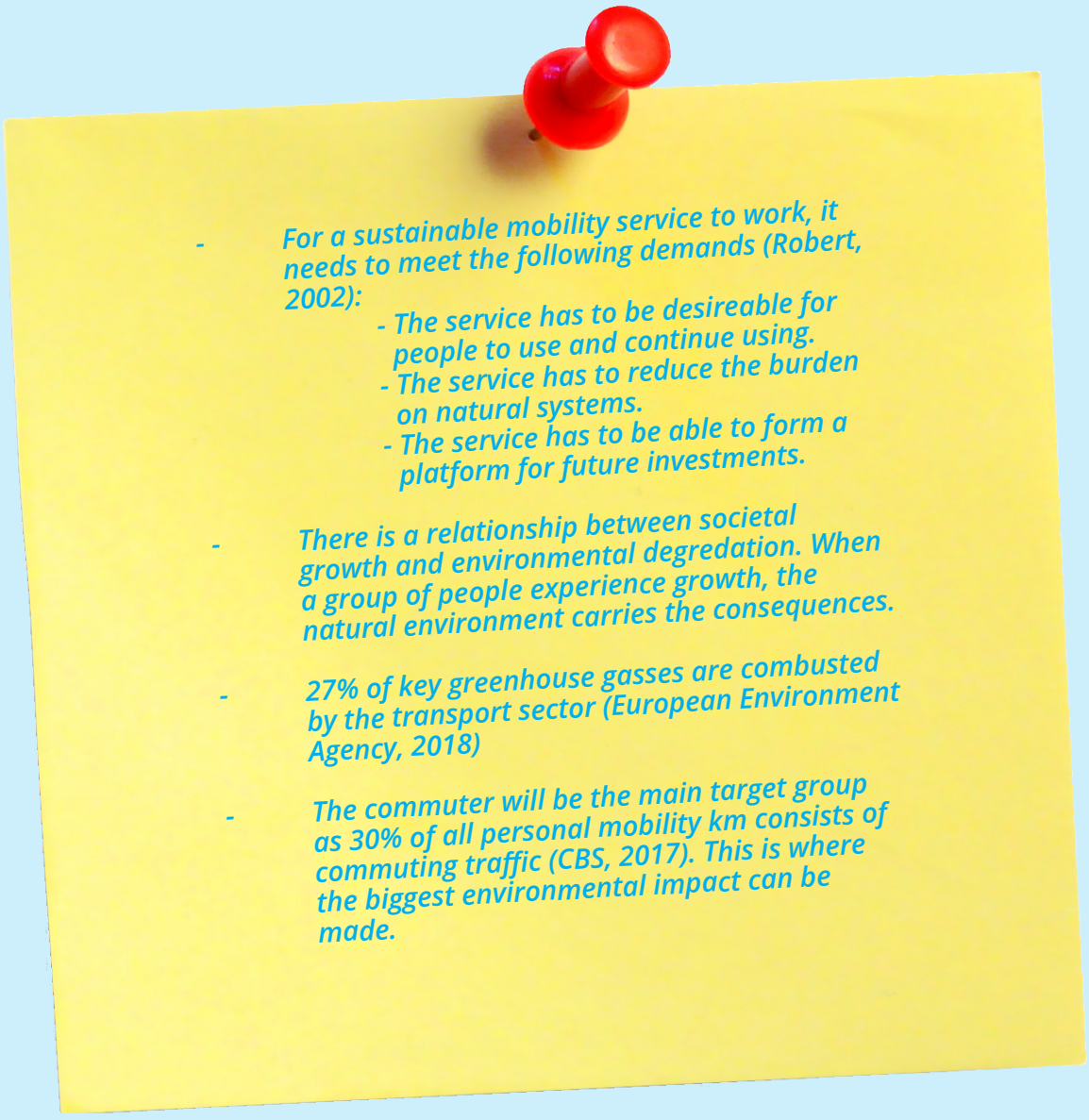
When specifically looking at mobility there are a few issues that need to be addressed. One of the most discussed negative effects of mobility is climate change. The earth has always experienced changes in its climate. However, in the last hundred years, human activity caused significant changes in the climate over a short period of time (Karl and Trenberth, 2003). Global warming is a term that has been widely used in the last decennia and refers to the rise of the earth's average temperature. This phenomenon is caused by a build-up of key greenhouse gases in the atmosphere which accumulated by continual combustion of fossil fuels. When we look at mobility we see that 27% of these greenhouse gasses are combusted by the transport sector (European Environment Agency, 2018).

Furthermore, these gasses are the main contributors to air pollution. There is even a risk for these gasses to cause permanent grey skies (Chan et al. 2009). The most dangerous effect of air pollution, however, is the impact on health. Air pollution can cause a variety of diseases like bronchitis, leukaemia and asthma (Banister, 2008). In fact, according to Lipfert (2004), thousands of deaths are caused by the transport sectors emissions each year.

## 3.4 Achieving Sustainable Mobility

Sustainable mobility can be achieved in a variety of ways. Transport modes can be built with renewable resources and cycled, new forms of fuels could be used like electricity or hydrogen and innovative technologies can be designed to deal with emissions. However, there lies beauty in simpler, more effective and down to earth solutions. People could make use of more active modalities such as cycling or walking. These methods don't combust any fumes in use and contribute to the health of its user. Furthermore, as this project has a background in MaaS and in the traveller behaviour, patterns and preferences in particular, the focus will lie on a specific group of travellers. The commuter is chosen as 30% of all personal mobility kilometres made in the Netherlands consist of commuting traffic (CBS, 2015). This shows an opportunity that the biggest positive impact is to be made within trips between work and home, hence my focus for this project. Together with the use of active modes, the goal of this project is to reduce CO2 emissions during these commutes.

## What we learned in Chapter 3



- *For a sustainable mobility service to work, it needs to meet the following demands (Robert, 2002):*
  - *The service has to be desireable for people to use and continue using.*
  - *The service has to reduce the burden on natural systems.*
  - *The service has to be able to form a platform for future investments.*
- *There is a relationship between societal growth and environmental degredation. When a group of people experience growth, the natural environment carries the consequences.*
- *27% of key greenhouse gasses are combusted by the transport sector (European Environment Agency, 2018)*
- *The commuter will be the main target group as 30% of all personal mobility km consists of commuting traffic (CBS, 2017). This is where the biggest environmental impact can be made.*

*source: T. Weinhold*

*source: K. Bewik*

# 4.0 The Commuter

As discussed in chapter 3.4, the commuter is chosen as the main target group of this project. The most important reason to design for the commuter is that commuters are responsible for 30% of all personal mobility kilometres in the Netherlands (CBS, 2015). This underlines an opportunity, making the biggest positive impact on the environment by reaching out to this group of users. In this chapter, further insight on the commuter will be given. First, a recap of insights regarding travel patterns, behaviours and preferences will be given that stem from the benchmark study discussed in chapter 2.2. Second, the main results of a dual user insight generation study will be discussed and lastly, a conclusion of this chapter will be given.

## 4.1 Desk research

This study is conducted to gain more insight into the commuter. The research aim, research questions, research methods and the results will be presented below.

### 4.1.1 Research aim

The aim of this research is to get a better understanding of the users that I will be designing for during this project. More specifically, the aim is to found a valid reason as to why the commuter is the right target group for this project.

### 4.1.2. Research questions

To achieve the stated aim of this questionnaire, the following research questions have been formulated.

- *Why is the commuter the right target group for this project?*

### 4.1.3. Research methods

During this study literature will be reviewed to answer the research question.

### 4.1.4. Results

One of the most striking pieces of evidens is shown in figure 8. In this figure we can clearly see that the biggest motif for people to travel in the Netherlands is work. We can see that the amount of distance travelled is the highest within the commute and the same goes for the larges amount of time people spend travelling.

### 4.1.5. Conclusion

As seen in the image below, the commuter is the most promising target group as traveling from home to work makes up the biggest distance, displacements and time.

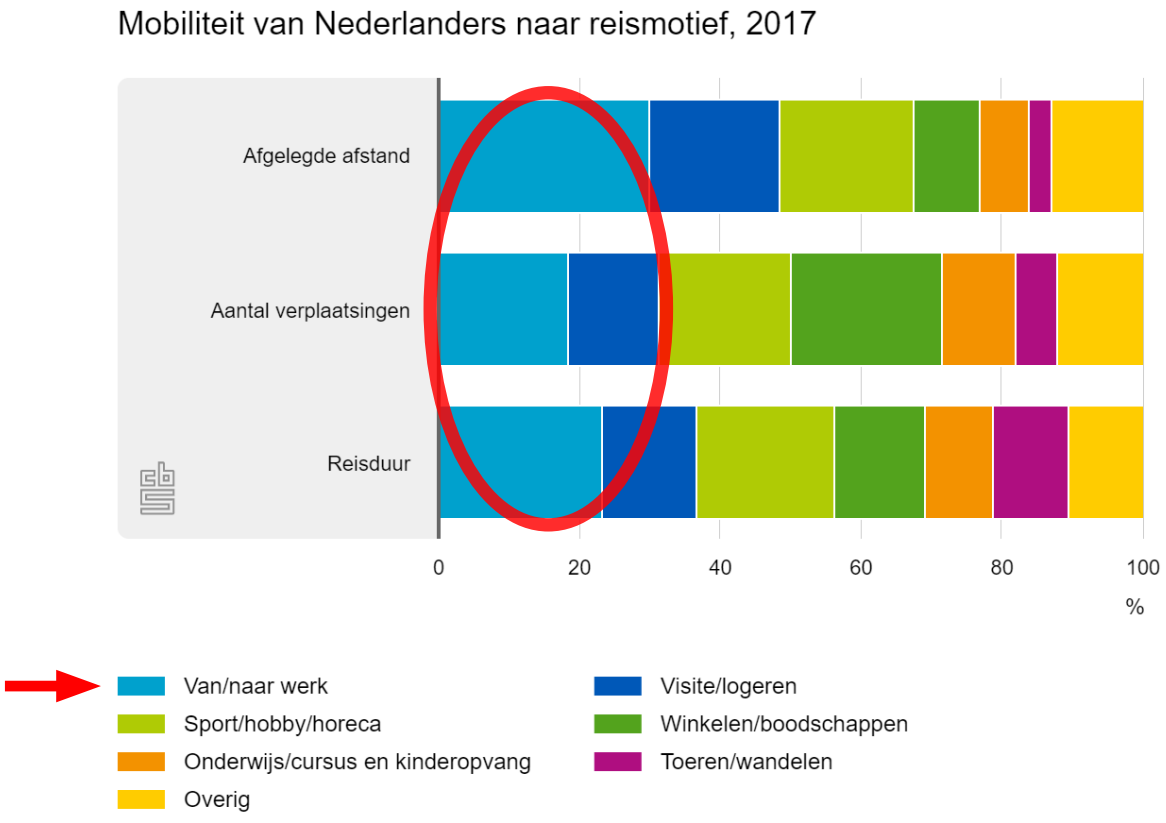



*Figure 8: travelling motif in the Netherlands, 2017 (CBS,2017)*

## 4.2 Online survey

This study is the first in a series of two studies conducted to gain more insight into the commuter. The research aim, research questions, research methods and the results will be presented below.

### 4.2.1 Research aim

The aim of this research is to get a better understanding of the users that I will be designing for during this project. More specifically, the aim is to find a link between high sustainable willingness and the user's demographics, travel behaviour and travel patterns.

### 4.2.2. Research questions

To achieve the stated aim of this questionnaire, the following research questions have been formulated.

- *What is the link between sustainable willingness and commuting properties?*
- *What does this say about the sustainable commuter?*

### 4.2.3. Research methods

Due to the COVID-19 virus, the number of viable research methods is limited. This means that all research and design activities must be carried out online. Therefore, in this research, a questionnaire will be used. The questionnaire was chosen as questionnaires offer an objective means of collecting information about people's knowledge, beliefs, attitudes, and behaviour (Opperheim, 2000). Additionally, the questionnaire fits the aim of this research as it is will be done in a quick fashion.

The setup of the questionnaire can be found in appendix X. The questionnaire was spread via numerous friends, colleagues and family who in their turn were asked to send the questionnaire to their own friends and colleagues. The only sample criteria were that the participants had to travel from home to work on a weekly basis.

### 4.2.4. Results

All in all, we see that most (n=37) participants (80%) travel to work 4-5 times a week which confirms what we've learned in chapter 4.1. Furthermore, we see that the travel time and work location have no direct relationship with wanting or not wanting to commute more sustainably. However, people who do want to commute more sustainably are not only more concerned with the wellbeing of the environment but also with their own wellbeing as they show higher appreciation for safety and activeness during their commute. Further details regarding this study can be found in appendix.

### 4.2.5. Conclusion

There is no promising link between sustainable willingness and certain properties of the commute. However a relation between concern for personal wellbeing and a concern for environment and sustainabilite has been found. This could be a promising lead to further this research.

## 4.3 Online interviews

This study is the second in a series of two studies conducted to gain more insight into the commuter. The research aim, research questions, research methods and the results will be presented below.

### 4.3.1 Research aim

The aim of this research is to uncover what future commuting scenarios are preferred by the sustainable commuter when travelling restrictions loosen up. This will be done by reviewing his/ her travelling and working experience in times of quarantine whilst reflecting on previous commuting behaviour before quarantine.

### 4.3.2. Research questions

To achieve the stated aim of this research, the following research questions and sub-questions have been formulated.

- *In what way has the participants commute been affected by the COVID-19 virus?*
- *How has quarantine affected your daily travel experience?*
- *How do participants experience working remotely?*
- *What reflections do participants have on previous commuting behaviour?*
- *What commuting/working scenarion would the prefer in the future?*

### 4.3.3. Research methods

Due to the COVID-19 virus, the number of viable research methods is limited. This means that all research and design activities must be carried out online. In this case, qualitative research is utilized, namely remote interviews, as it enables the researcher to dive deep into the experiences of the interviewee and emphasize with the underlying needs and motives of their actions (Kvale, 1983).

The questions in the interview guide have been set up in a semi-structured fashion. Their purpose is mostly to guide the interviewee through the main structure of the interview and should not be experienced as leading. Therefore, it is possible to venture into uncharted territory and probe further into relevant experiences. The interview guides of this research can be found in appendix X.

Moreover, the interviews are carried out via an application called Zoom. This application enables the researcher to record the interview if consent is given by the participants. Recording enables the researcher to fully focus on the conversation without being obstructed by the hassle of taking notes. Furthermore, the recording can then later be transcribed into statements which can then be processed further if needed.

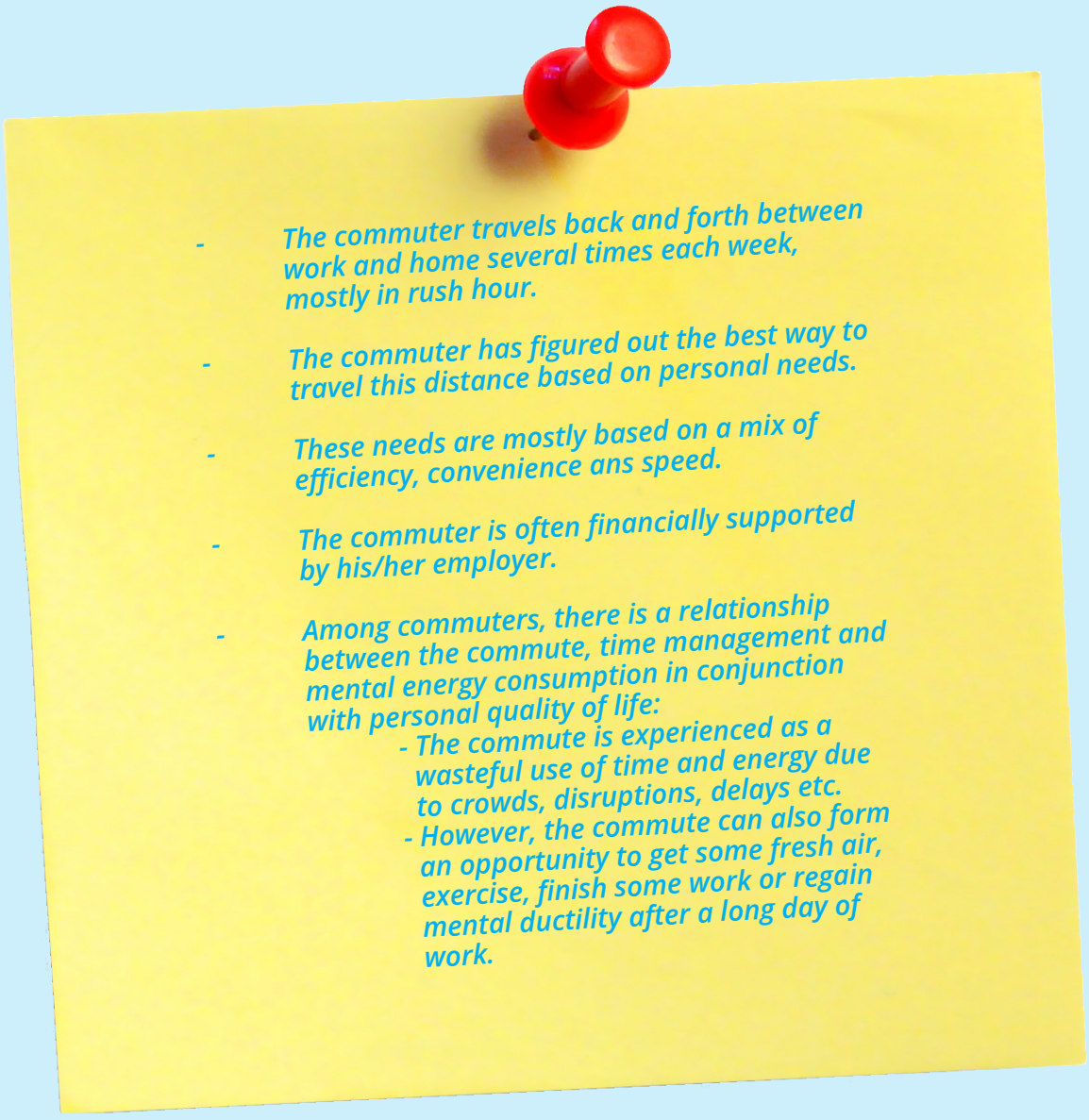
### 4.3.4. Results

The main insight obtained from this study is that among commuters (n=6), there is a relationship between the commute, time management and mental energy consumption in conjunction with personal quality of life. In other words, the commute is experienced as a wasteful use of time and energy due to crowds, disruptions and delays. On the flip side, however, the commute can also form an opportunity to get some fresh air, exercise, finish some work or regain mental ductility after a long day of work.

### 4.3.5. Conclusion

The COVID-19 virus has greatly impacted the commute. All participants work from home and to not travel. As a result the travel experience has greatly been affected as it is non-existant. Most participants however, do welcome wokring remotely. They experience less fatigue and stress, however leisure and work does have the tendency to overlap in some cases. Participants look back at the commute as exhausting and a waste of time, they feel they have more time in a day.

## What we learned in Chapter 4



- *The commuter travels back and forth between work and home several times each week, mostly in rush hour.*
- *The commuter has figured out the best way to travel this distance based on personal needs.*
- *These needs are mostly based on a mix of efficiency, convenience ans speed.*
- *The commuter is often financially supported by his/her employer.*
- *Among commuters, there is a relationship between the commute, time management and mental energy consumption in conjunction with personal quality of life:*
  - *The commute is experienced as a wasteful use of time and energy due to crowds, disruptions, delays etc.*
  - *However, the commute can also form an opportunity to get some fresh air, exercise, finish some work or regain mental ductility after a long day of work.*

*source: A. Anton*

*source: D. Coffman*

# 5.0 The World in Quarantine

We've established that the commuter is the most promising group to target within the realms of this project. Due to current events however, the commuter experiences a great shift in behaviour due to the pandemic that has hit the world in the winter and spring of 2020. As explained in this topic, mobility patterns, behaviours and preferences are vastly effected by the virus and thus need to be researched in order to design in a holistic fashion.

## 5.1 The Rise of the COVID-19 Virus

In the second half of February 2020, the COVID-19 virus disruptively came into our lives that only a handful of people had foreseen. Although the severeness of the situation wasn't apparent in the first few days, governments quickly realised that action had to be taken. In the course of a few days, entire nations started strategizing how to get a grip on this vastly fast-spreading decease.

Besides the countless casualties inflicted by this virus, the corona crisis has a profound impact on society as we know it. As a reaction to the pandemic, lockdowns and social-distancing are the new norms that citizens have to respect in order to secure the wellbeing of their neighbours. It is safe to say that only a few individuals were able to foresee what drastic changes the rise of the COVID-19 virus would have on our daily lives. Though after a few weeks in quarantine, we unwantedly all became experts on this subject.

As in the rest of the world, social-distancing and quarantines is currently the Dutch way of life. We work at home, we meet our friends and colleagues through our favourite teleconferencing applications and try to minimise our physical displacement as much as possible. This is what we must do to keep the spread of COVID-19 to a minimum. It is almost unbelievable that such a massive behavioural shift is possible and yet, it has happened.

## 5.2 The Possible Effects on Society

Dutch anthropologist Jistke Kramer recognized that such a massive shift in behaviour is comparable with the stages of culture shock. As stated by Furnham (2010) culture shock is seen as a loss of one's culture, a marker of moving from one culture to another, and as socialisation in another culture. Culture shock is usually experienced by a single individual that is situated in a different culture for a certain amount of time. This individual then undergoes changes due to the conflicts that arise from this experience (Furnham, 2010). Jitske Kamer states that the current changes in the world due to the Coronavirus can be seen as a collective culture shock. She has adapted previous culture shock models to give guidance to our current struggle with uncertainty in our society (figure 9). The model consists of four phases describing our moral capacity in each phase whilst continuing in time.

### 5.2.1 The running-up phase

This phase only lasts a few days and nobody knew what was going to happen. Some people had to work extremely hard in hospitals or were directly affected by the virus and others did nothing, hoarded toilet paper or purchased extra deep freezers to store extra food. There was a lot of confusion as at the time the danger was still invisible to most of us. In the Netherlands, the biggest pivot-point was when we all collectively had the goal to flatten the curve. This was a story we could all understand and act upon. The story changed from, "I'm not going outside because I don't want to get sick" to "I'm staying inside because I don't want to infect the people around me".

### 5.2.2 The honeymoon phase

This phase is characterized by action. The running up phase is has taken its course and slowly turns into questions. How should I arrange my home office, can I see my parents or grandchildren and what does this mean for my business? The questions are hard to answer and do not have a straight answer. The inconvenience builds and that is when you hit the first culture shock.

### 5.2.3 The transistion phase

In the first culture shock, you need to change your basic behaviour. You need to find new ways to the stores, find alternatives to public transport and need to change the way you live your household. It's messy and it is stressful but things simply need to be adjusted. When the basic adjustments are done, the situation feels better and you are building a set of new behaviours. When the situation continues, you slowly start to realize that it won't blow over tomorrow. It's going to take a lot longer than you thought. Upon this realisation the second culture shock hits. Unlike the first culture shock that is based on your behaviours, the second culture shock targets your values. This is the place where a significant change can be made as you have a different set of values than when you started. It's not simply a crisis that we have to sit out, no, this is something we need to act upon. Debates arise whether it is more important to focus on the economy or on health care systems. The outcome of this second culture shock is a change in culture as you've been able to challenge and change your values due to the situation.

### 5.2.4 The coming down phase

The last phase is when restrictions loosen up and people are allowed to have physical contact again. It is possible to go back to how things were before the Corona crisis. You feel energised and thankful that it is over. However, then the inevitable happens. You realise that not everything before the crisis was as good as you remember. You remember the cars in the city, the kilometres of traffic jams and crowded trains in rush hour. You don't want these elements back and this is what's called the fallback shock. It's like coming back home from living abroad, you have changed and the environment you come back to has changed. Yet again you have to adjust, and balance that what has changed your, your new set of values, with your changed environment.

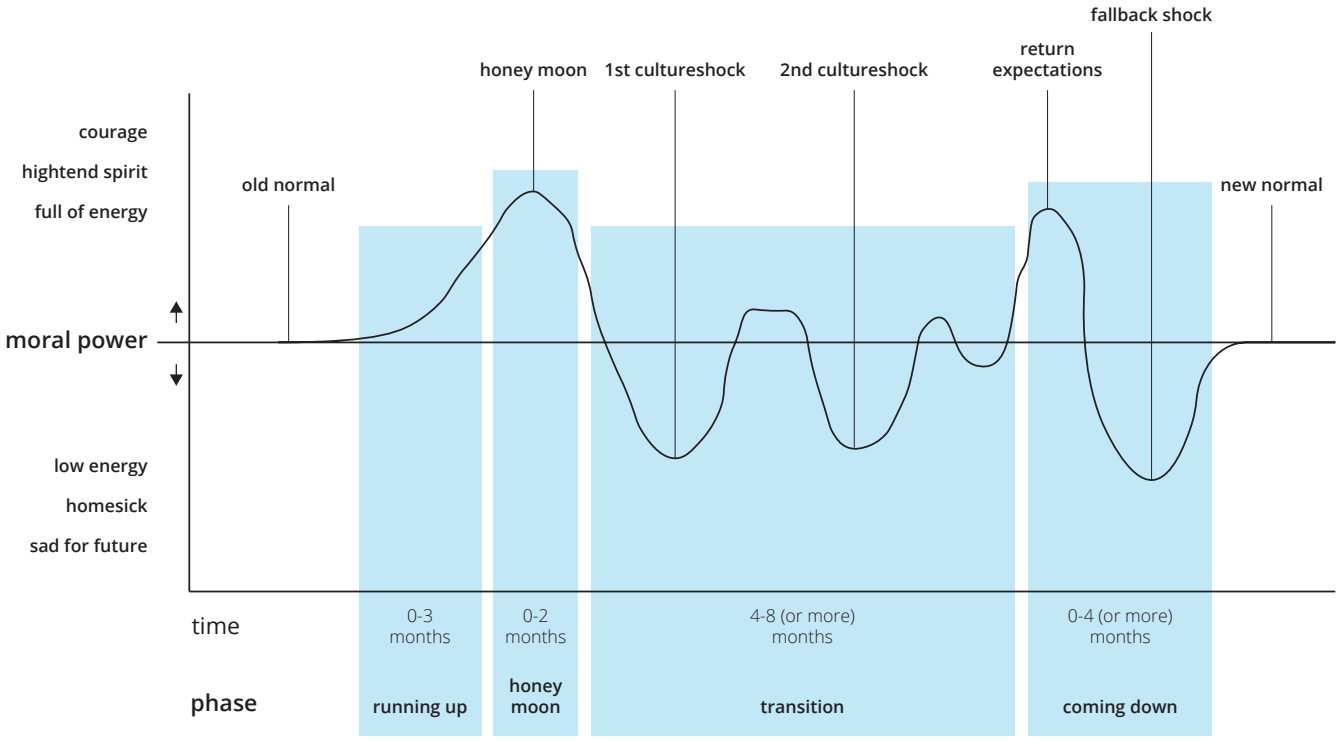



*Figure 9: the phases of culture shock*

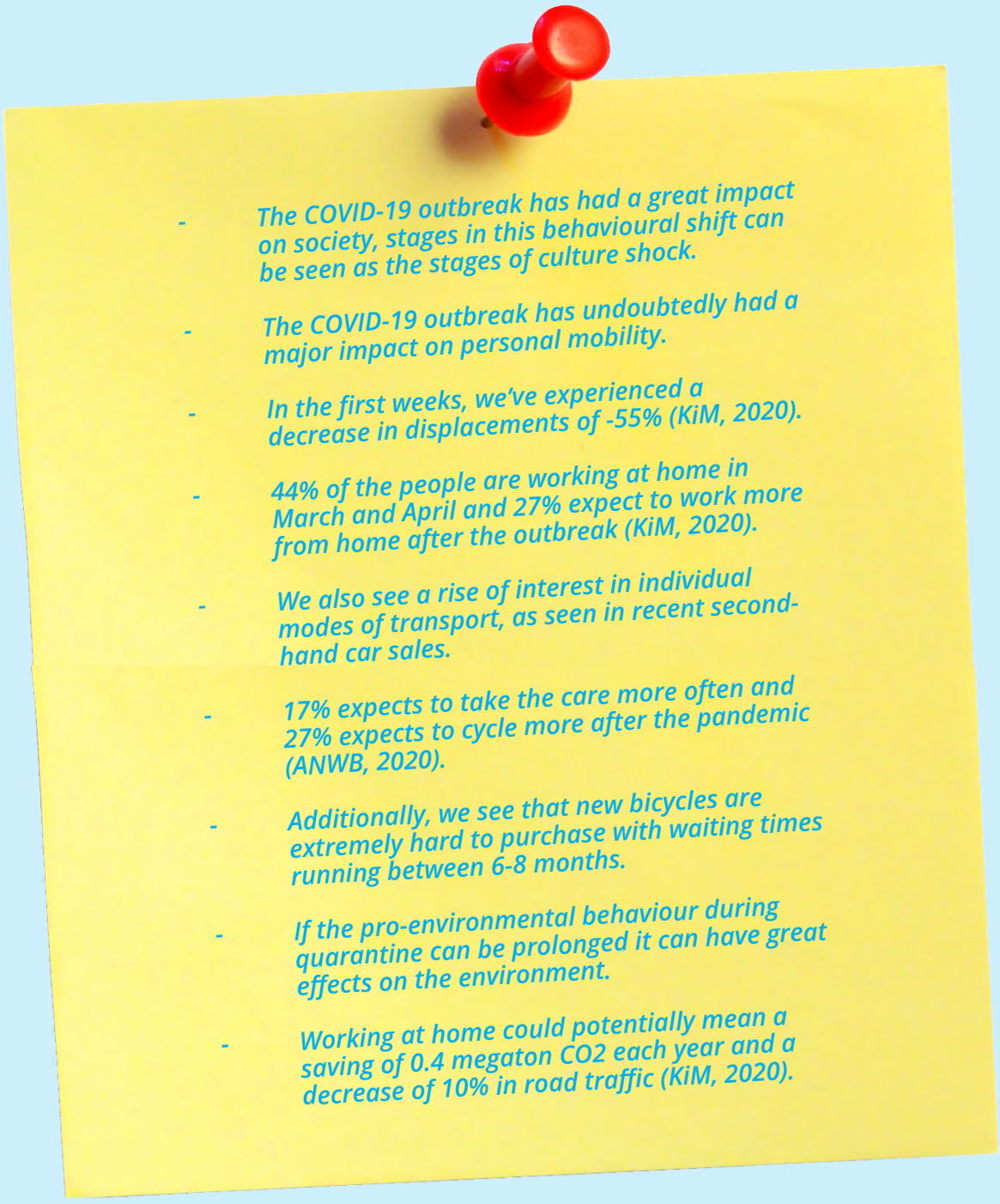
## 5.3 The Effects on Personal Mobility

The corona crisis has undoubtedly had a major impact on our society. In the light of this project however, the first question that comes to mind is what mark the corona crisis will leave on the personal mobility industry. Imaginably, the routines and behaviours that we display in quarantine, won't be forgotten overnight. But surely, as a social species that is driven by habits, routines, comfort and what we are used to we will to some extent fall back in our pre-corona lifestyles.

## 5.4 The Effects on Sustainable Mobility

Due to restrictions we all work from home which decreases our displacements drastically by -55% (KiM, 2020). In particular, public transport systems have had a major decrease in use as people have negative associations with it due to a high probability of infection (KiM, 2020). In return, there is a rise in interest in individual modes of transport. Additionally, 44% of the Dutch population has been working from home in the months of March and April 2020 and 27% expect to work from home more often after the outbreak has cooled down (KiM, 2020).

## What we learned in Chapter 5



- *The COVID-19 outbreak has had a great impact on society, stages in this behavioural shift can be seen as the stages of culture shock.*
- *The COVID-19 outbreak has undoubtedly had a major impact on personal mobility.*
- *In the first weeks, we've experienced a decrease in displacements of -55% (KiM, 2020).*
- *44% of the people are working at home in March and April and 27% expect to work more from home after the outbreak (KiM, 2020).*
- *We also see a rise of interest in individual modes of transport, as seen in recent second-hand car sales.*
- *17% expects to take the care more often and 27% expects to cycle more after the pandemic (ANWB, 2020).*
- *Additionally, we see that new bicycles are extremely hard to purchase with waiting times running between 6-8 months.*
- *If the pro-environmental behaviour during quarantine can be prolonged it can have great effects on the environment.*
- *Working at home could potentially mean a saving of 0.4 megaton CO2 each year and a decrease of 10% in road traffic (KiM, 2020).*

*source. A. Porpaei*


Follow the RIVM guidelines
Please follow the RIVM guidelines on COVID-19 prevention.
• Keep, as much as possible 1,5-meter distance from each other
• Cough and sneeze on the inside of your elbow
• Use paper tissues.
htm.nl | twitter.com/HTM_Reisinfo | facebook.com/HTMPersonenvervoer | 0900 486 46 36
HTM | kom verder!


*source: L. Dirks*

# 6.0 Mechanisms for Environmental Behaviour Change

In order to design a sustainable solution for commuters, it is key to understand that the current behaviour of commuters. However, this behavioural display might not be the desired set of behaviour. In other words, the design might need to stimulate commuters towards the realms of pro-environmental behaviour. According to Ones et al. (2015), pro-environmental behaviour is referred to as “individual behaviour that contributes to environmental sustainability”. Such behaviour is usually stimulated by norms, beliefs, personal commitment and positive utilitarian outcomes (Stern, 2000). In this chapter theories and principles will be presented that could potentially be used in the design to simulate pro-environmental behaviour among commuters. Specifically, the quantified self-movement and the self-determination theory will be looked at.

## 6.1 The Quantified Self Movement

Since 2000 technology has influenced our daily lives in ways that we would have never imagined. The use of digital devices has skyrocketed and it's hard to remember the days we lived without. Accompanied by our mobile devices, almost everything imaginable is just a few finger tabs away. As the use of digital devices continues to grow, so does the utilisation of various sensors and other data-producing constructions to make technology even smarter and more efficient.

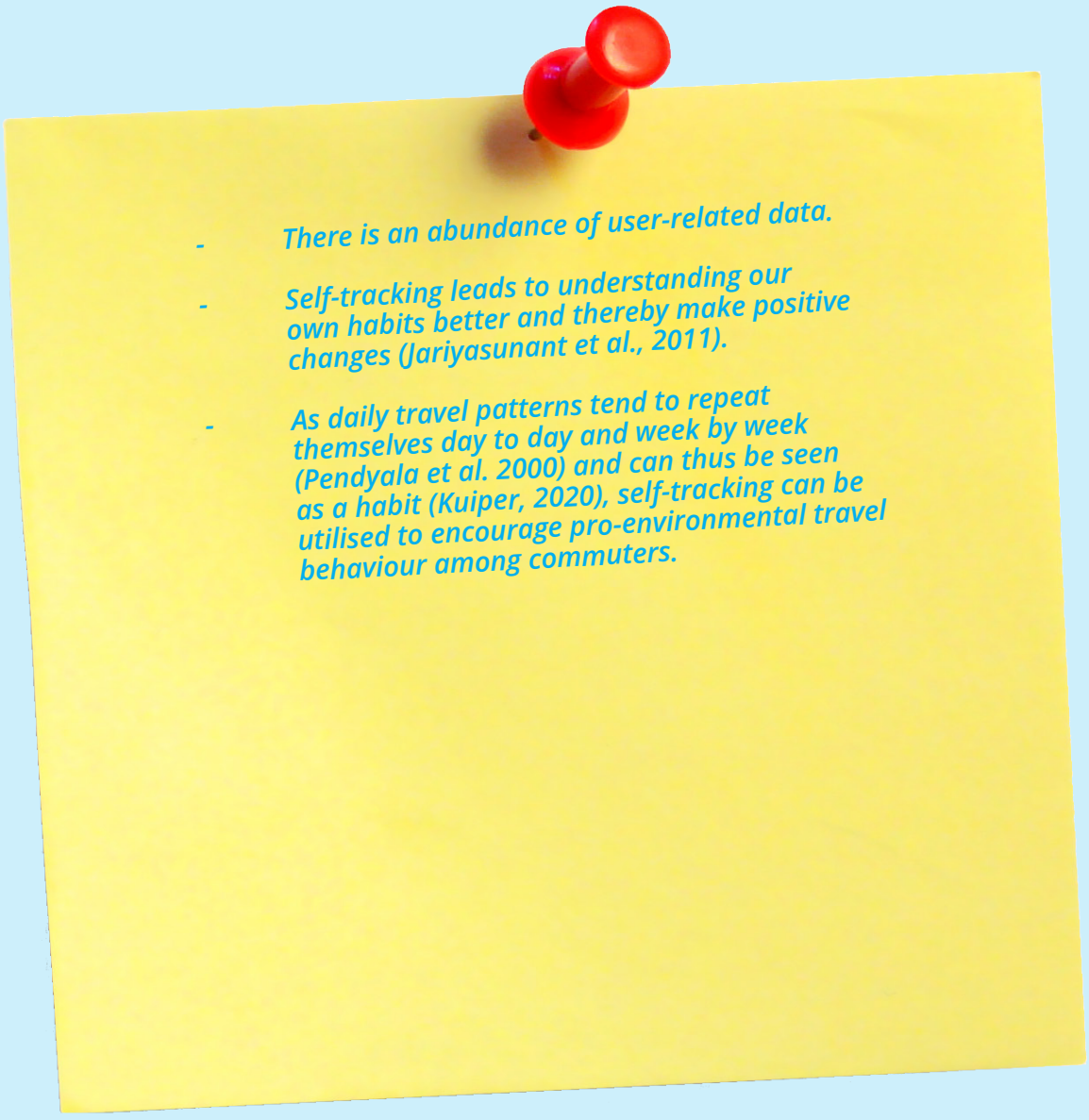
This increase of available information has also lead to an abundance of detailed data that has become available to the end-user. A group of people recognised this trend as an opportunity resulting in an interest in self-tracking and self-knowledge. These people call themselves "The Quantified Self" movement. According to Jariyasunant et al. (2011), "the core idea is to track and quantify one's behaviour and calculate personal metrics allowing to better understand own habits and routines, this enables people to improve their quality of life by making positive changes". Examples that make use of collected data for personal reflection are, monitoring sleep patterns, social media attention, evaluating time usage and productivity, evaluating personal finance, evaluating personal health, and much more.

However, we do not see much use of the quantified self-movement in the personal mobility industry. Admittedly, there are some apps that provide user-insights and feedback on their usage like the Volkswagen app or Google Maps, but the full potential has yet to be utilized in journey planning and multi-modal transport usage. Even though the quantified self-movement is not apparent in the field, there have been publications drawing a line between the quantified self and sustainable travel behaviour. According to Jariyasunant et al. (2011) "the self-tracking movement has the potential to induce travel behaviour change by tracking travel behaviour and data and feeding this information back to the user". Such motivational feedback can increase user benefit and continued use (Hassan et al., 2019).

## 6.2 The Self-Determination Theory

Coined by Ryan and Deci in 2000, the self-determination theory describes human motivation and personality development. The theory is based on the assumption that individuals are driven and seek out personal growth and self-organisation. This is done by cultivating needs, desires, interests and by connecting with the outside world (Deci & Ryan, 2012). In contrast, the theory also states that the natural tendency to individual growth and self-organisation should not be assumed and that on the flip side people can become controlled, fragmented and alienated if their basic phycological needs for autonomy, competence and relatedness are not met. In fact, the theory is built on the idea that the individual is in constant interaction with the social world. As a result of this interaction people can become engaged, curious, connected and whole and on the other hand become demotivated, ineffective and detached.

## What we learned in Chapter 6



- *There is an abundance of user-related data.*
- *Self-tracking leads to understanding our own habits better and thereby make positive changes (Jariyasunant et al., 2011).*
- *As daily travel patterns tend to repeat themselves day to day and week by week (Pendyala et al. 2000) and can thus be seen as a habit (Kuiper, 2020), self-tracking can be utilised to encourage pro-environmental travel behaviour among commuters.*

*source: G. Carstens*

*source: J. Ying*

# 7.0 Design Framework

Now that we have discussed all project building blocks in-depth, it is time to translate that knowledge into design. Therefore in this chapter, the design brief will be defined using all gathered knowledge from previous studies and activities. First, the design goal will be reiterated. Then, an overview of all gathered knowledge will be given. And lastly, and overview of the design process will be given.

## 7.1 Defining the Desing Goal

To steer the design process a design goal is formulated. In this section the design goal will be presented together with its details.

***"To design an active multimodal public transport experience that showcases the beauty of an ordinary commute to commuters."***

1 2 3

## 1 What?

An active multimodal public transport experience can provide a strong mobility triangle between walking for small distances, cycling for langer distances and train for intercity distances. As mobility patterns are based on habits and routines and environmentally aware commuters prefer to travel in an active manner active modes can be a viable green way to travel when combined with the train. In the Netherlands, this combination is already widely adopted. However, this practice of mobility does not get as much positive attention from commuters as most attention is spent towards negatively charged discomforts like delays and crowds. (based on chapter 2, 3 and 4)

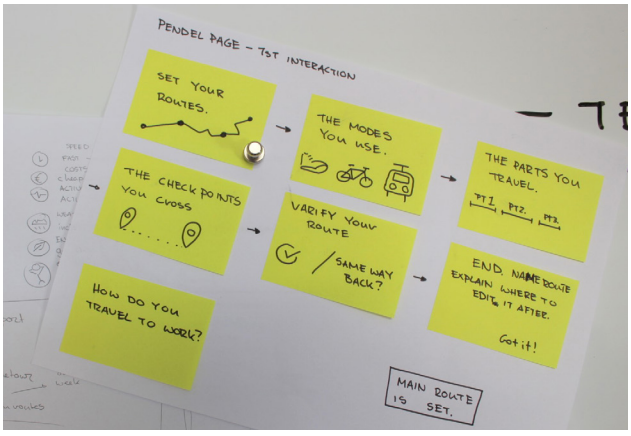
## 2 How?

With the rise of technology and user-related data, we have grown more and more concerned with values such as efficiency, speed and costs. Everything is calculated and performed in such a way for the most optimal solution. However, when we translate this to mobility, we see that this makes travellers focus solely on the destination of the journey and how to get there in the most optimal way. This process drains the commuters positive experiences as in the real world, travelling always comes with unpredictabilities. So, this design will explore how to bring more beauty and quality into the commuting experience. (based on chapter 2, 4, 5 and 6

## 3 Who?

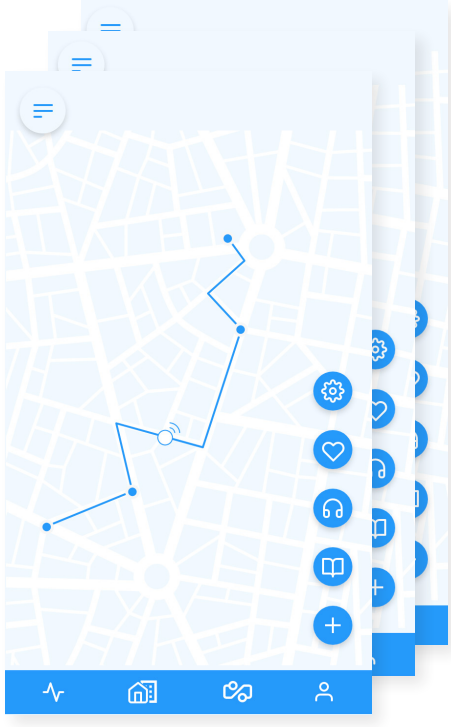
Commuters are responsible for a large chunk of the kilometres made in the Netherlands. Commuters also have to deal with commuting on a daily basis, if this experience can be improved that is a great step forward in making public transport more enjoyable. (based on chapter 4)

## 7.2 Design Process



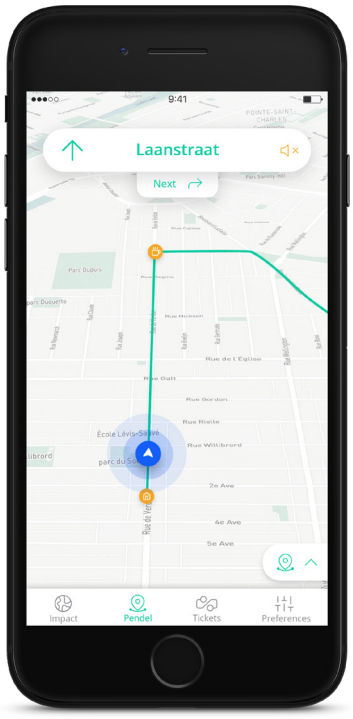

After the stakeholder meeting halfway the project the design work started. First, basic interactions, functions and features where ideated with use of post-its and simple drawings.

After this phase the first wireframes of the app where designed digitally. At this stage all design work is purely functional. It's about the interactions and the flow of the experience rather than a polished look.



After the first wireframes where made, all the screens off the app were linked to form a working prototype. This prototype was presented during the Seamless Mobility Lab meeting for initial thoughts on the concept.

Finally, after a few iterations the prototype got an updated user interface making it pleasant to look at for a professional look and a pleasant experience.The professional look was gained after several iterations and comparing various mobility apps on the market. Making the app a more pleasant experience was achieved by countless of personal testing, making the transitions between screens more natural and fluent.



*source: J. Ying*

*source: B. Garret*

# 8.0 Pendel App

In this chapter, we will take a closer look at the chosen design concept. First, a short introduction to the concept is given. Second, the Pendel Concept will be explained in more detail. Furthermore, the user experience and user interface will be discussed. And lastly, an overview of the most common use case scenario will be given.

## 8.1 Introducing Pendel

Pendel is a digital application that enables commuters to plan out their entire mobility pattern throughout the day. Where regular trip planners are concerned about getting you from one destination to another, Pendel takes a holistic approach by chaining all your mobility patterns together and encouraging users to adjust these patterns on the fly. Hence, why multidestination planning is not an issue for Pendel users. Furthermore, Pendel encourages users to be more active by promoting active modes such as walking and cycling, ensuring users to stay healthy and act sustainably in tandem. Additionally, Pendel encourages users to partake in pro-environmental behaviour by enabling users to explore remote working spots close to their home.


9:41
Laanstraat
Next
Parc Dupuis
parc Duquette
Rue Hickson
Rue de l'Église
Rue Gordon
Rue Rielle
Rue Willibrord
2e Ave
4e Ave
5e Ave
Impact
Pendel
Tickets
Preferences

## 8.2 The Pendel Concept

Pendel consists of four menu structures, the Impact menu, the Pendel menu, the Tickets menu and the Preferences menu. In this section, all menus will be discussed to illustrate Pendel's feature architecture.

### 8.2.1 Pendel menu

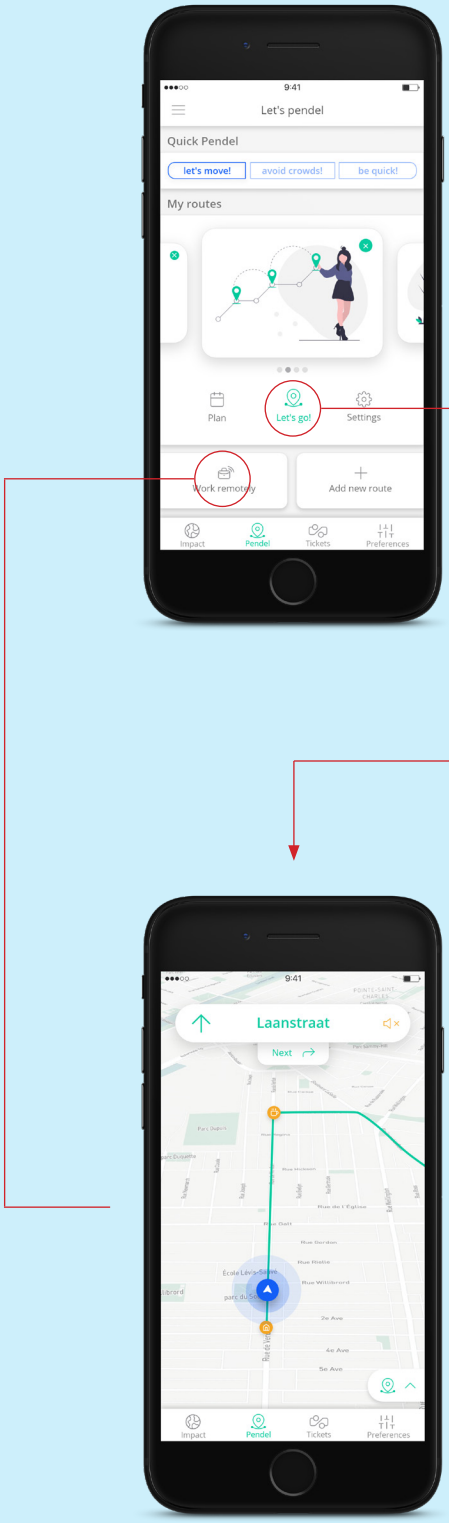
On the right, the main menu structure of the application, the Pendel menu, is shown. In this page, users can choose a trip by selecting between their personal set of routes. When selecting a route, the user gets feedback on whether the route has delays, is crowded or will be influenced by rain.

Each route is tailor-made by the user and forms a baseline route for the day. The main routes are often simple in nature and consist of a "from a to b" structure. Users can export a route to their agenda for another day, execute a route, and edit a route. Furthermore, users can add a new route and work remotely, more on this later.

With the main route of the day in place, users can add and subtract destinations by interacting with the timeline by placing detours. Here, users can tap the section of the timeline they would like to add a detour to and are prompted with their personal places and with Pendels suggestions. When a place is added Pendel will recalculate the route and add the place to the timeline.

Personal places are the places that the user has added to their preferences. This will be discussed in more detail in the next section. Suggested places, however, are places that Pendel suggests based on the user's usage and are often utilities like, supermarkets, coffee places, shops and restaurants.

Additionally, the Pendel menu also gives the user access to the remote working feature. When pressed, the user is asked which mode of transportation is preferred and how long the user would like to walk or cycle. When a selection is made, the user can choose one of their own saved workspaces or choose to engage in one of Pendel's suggestions. Workspaces provide some basic information about the space, info can be pressed for more information. Furthermore, workspaces can be shared between colleagues and planned in the user's agenda.



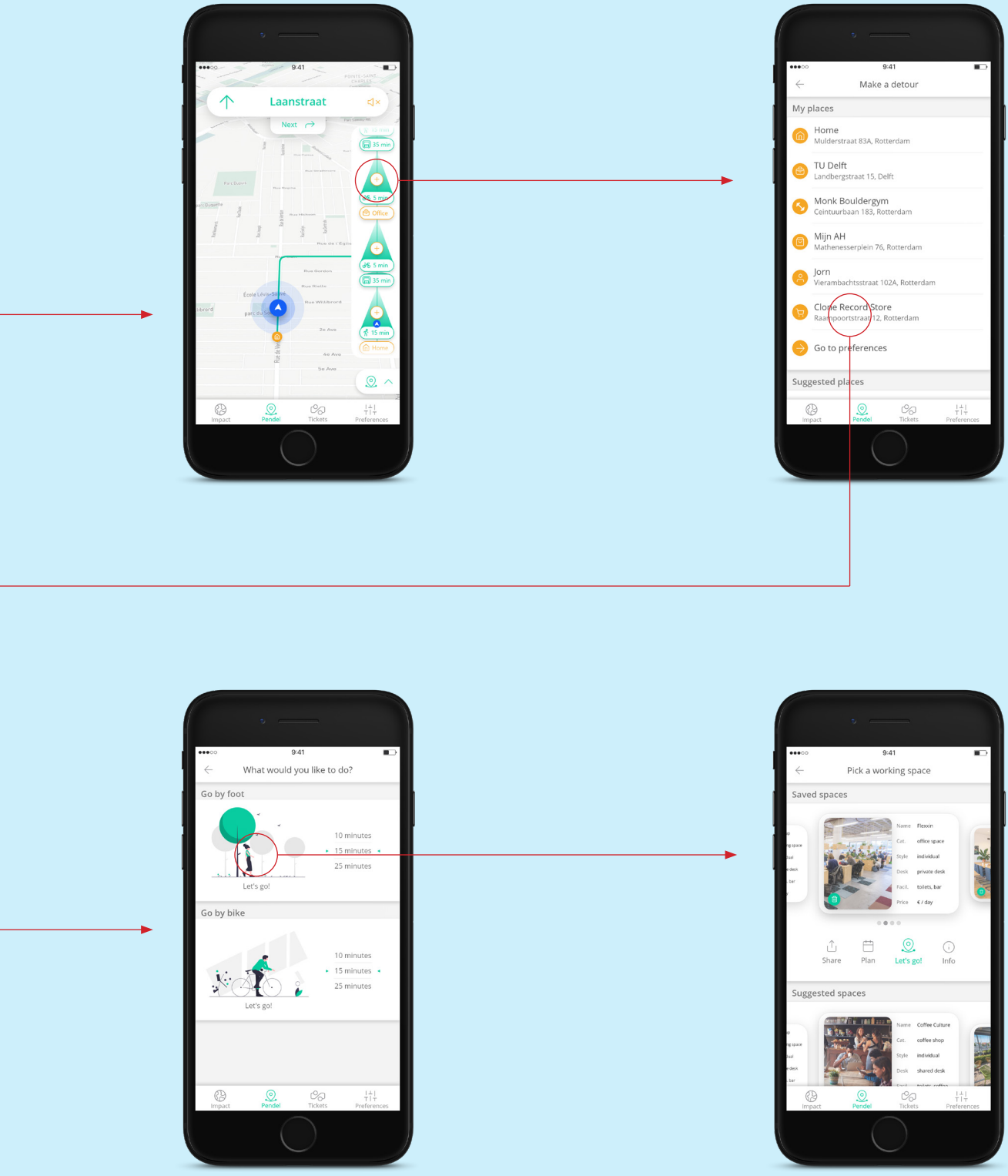



*Figure 10: Pendel menu*

### 8.2.2 Preferences menu

Pendel rests heavily on the idea of customization and personalization. As established in chapter 2.2 and 4, tailoring the application to the user's needs is of utmost importance for a positive experience for commuters. The preference menu consists of three main elements: The user's modes of transport, the user's personal places, and the user's values. The user's transport and the user's places are both editable. The user's values have a different approach, here users can select which travel values they value the most.

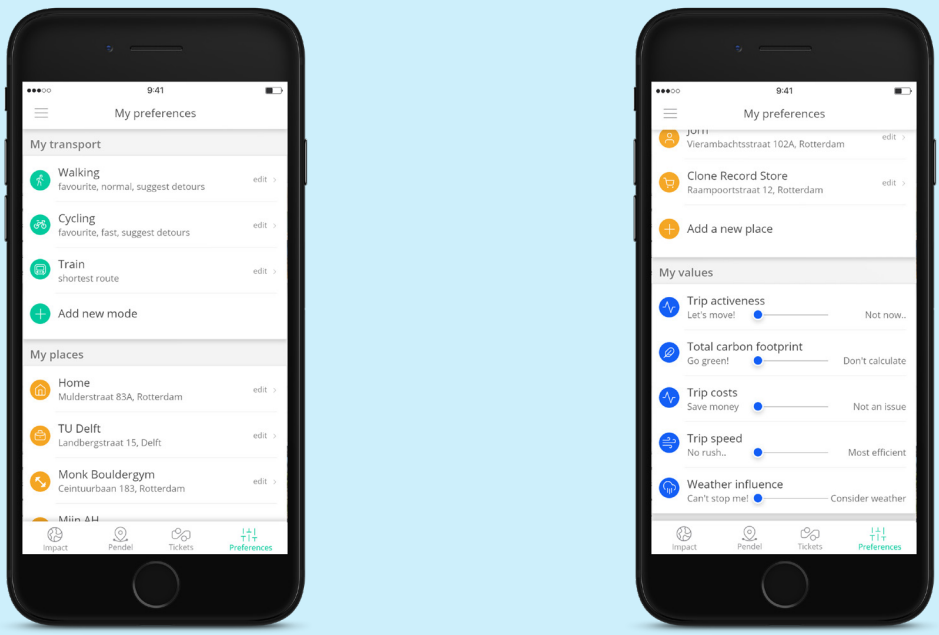



*Figure 11: Preferences menu*

### 8.2.3 Impact menu

As discussed in chapter 6, Jariyasunant et al. (2011) described that "The self-tracking movement has the potential to induce travel behaviour change by tracking travel behaviour and data and feeding this information back to the user". This is what the impact menu aims to achieve. Feedback will be given, which can increase user benefit and continued use (Hassan et al., 2019).

### 8.2.4 Tickets menu

The tickets menu is a menu that enables users to identify themselves to the public transport driver with just a single click. In this menu, users can add multiple OV-cards and specify each card accordingly. For example, you could have a business card set up whilst having your personal card set up as well.

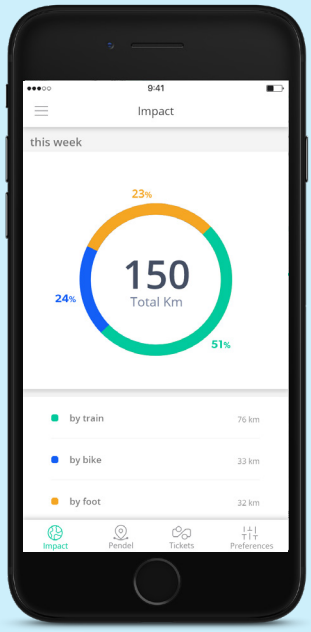



*Figure 12: Impact menu*

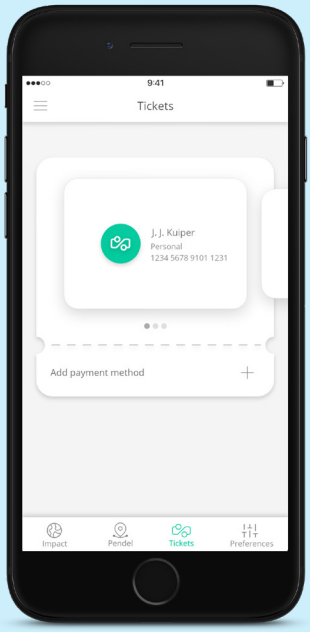
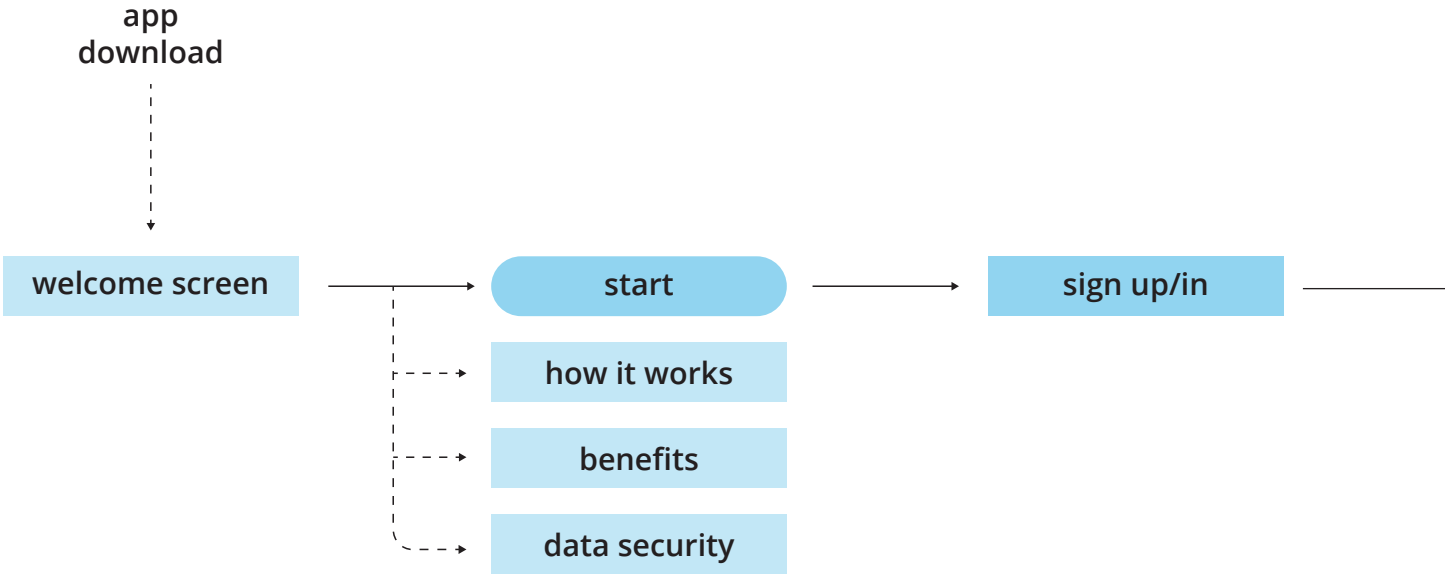



*Figure 13: Tickets menu*

## 8.3 Use Flow

In figure 14, the overall Use Flow of Pendel is illustrated. This figure illustrated that after downloading the application the user first interacts with the landing page. On this page, the application is described, including how it works, what the benefits of using it are and what happens with the user-related data. Afterwards, the user enters the onboarding phase. In this phase, the user authenticates his/her self by creating an account. Consequently, the user is now ready for first-time use. Furthermore, the main embodiment of the design consists of four menu structures, the Impact menu, the Pendel menu, the Tickets menu and the preferences menu.



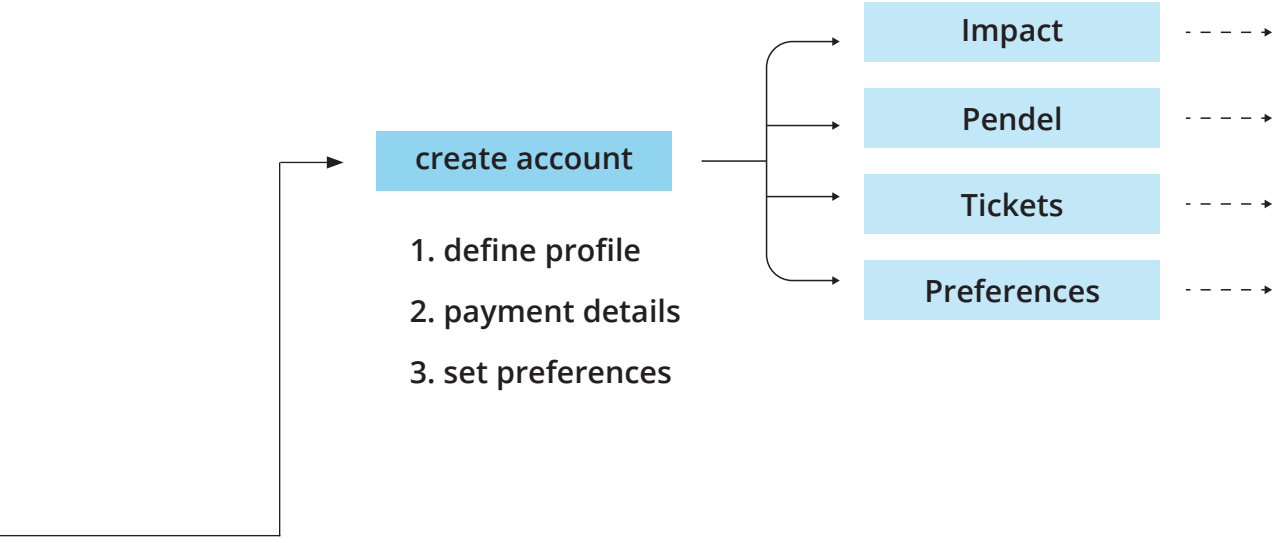
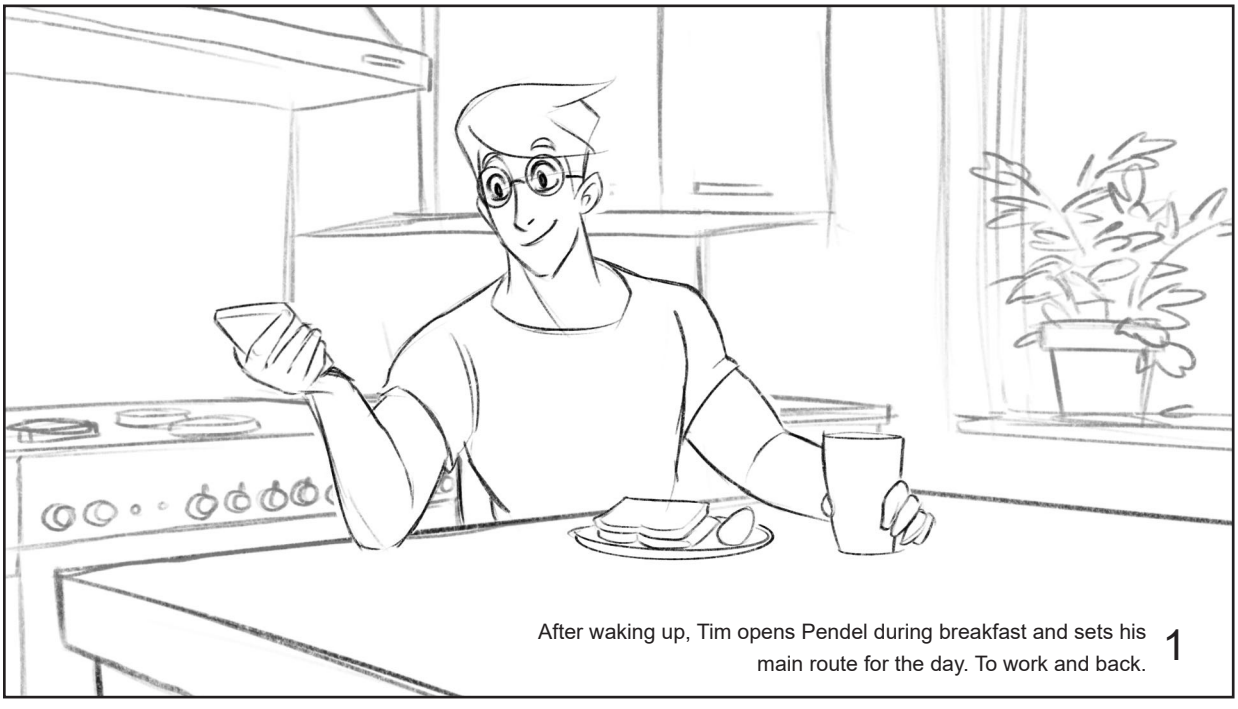


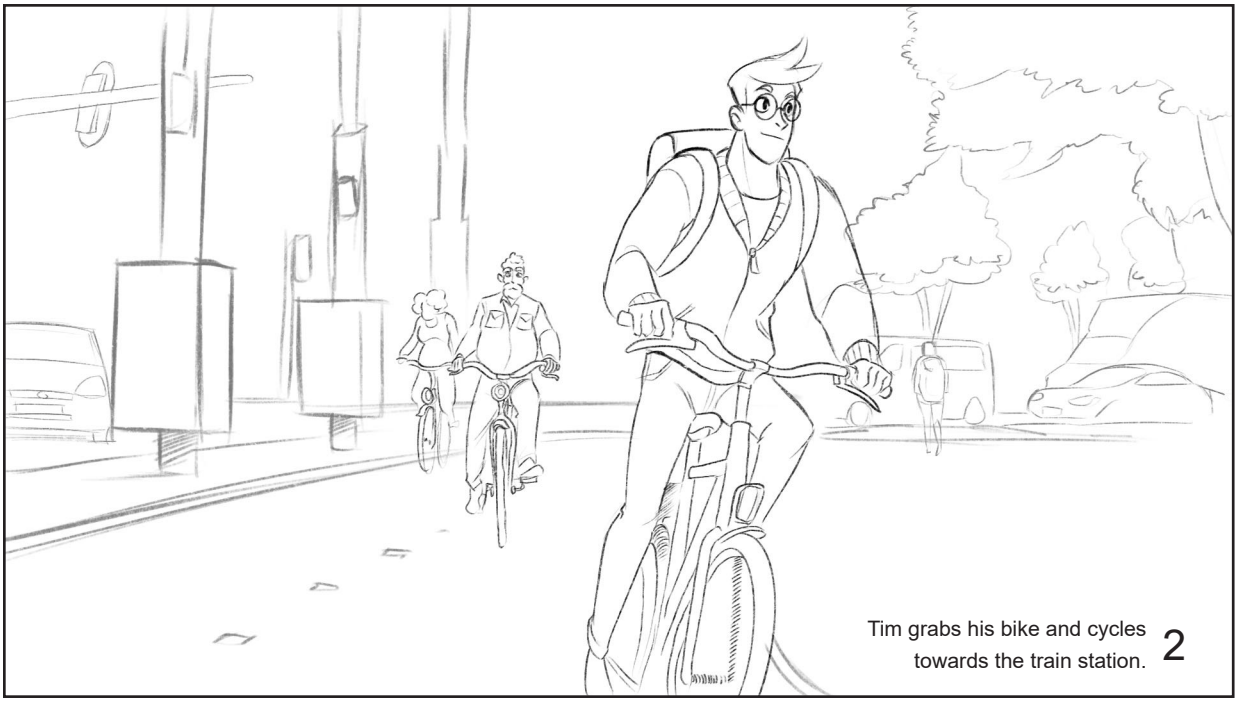

*Figure 14: overall use flow of Pendel*

## 8.4 Scenario in Use

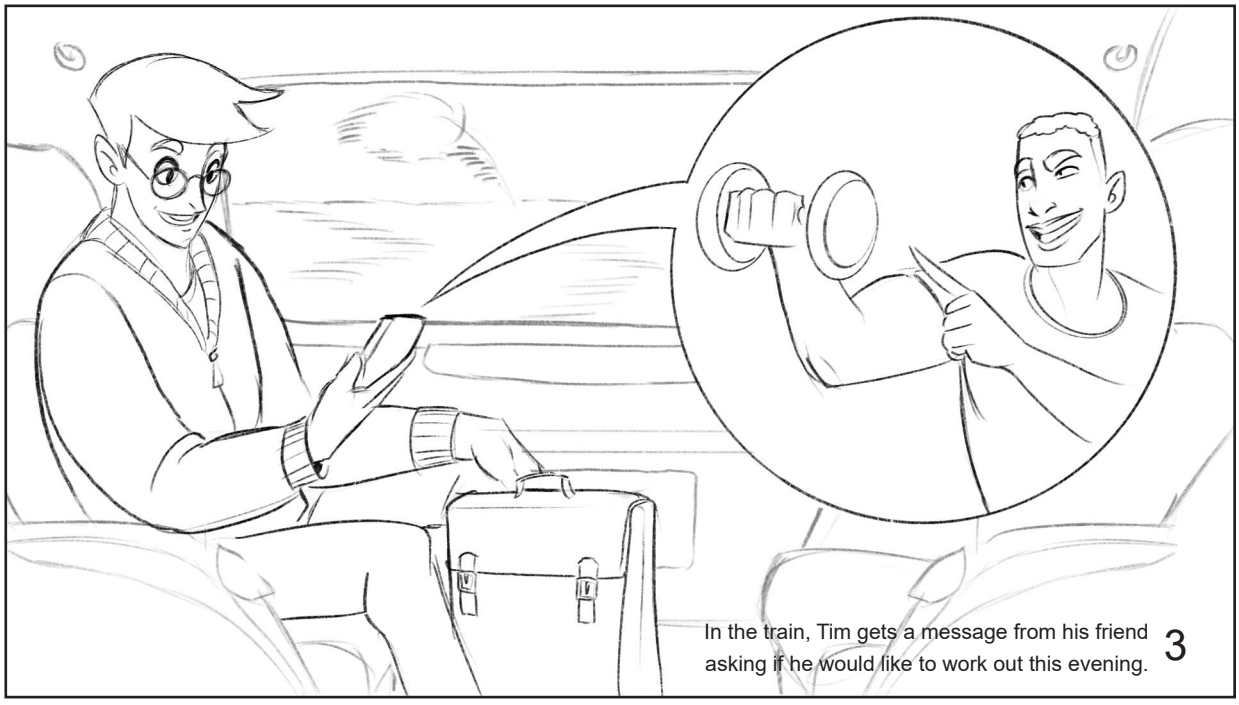
In this section, a typical use case of Pendel will be showcased. Each image will have a short discription explaining each action.



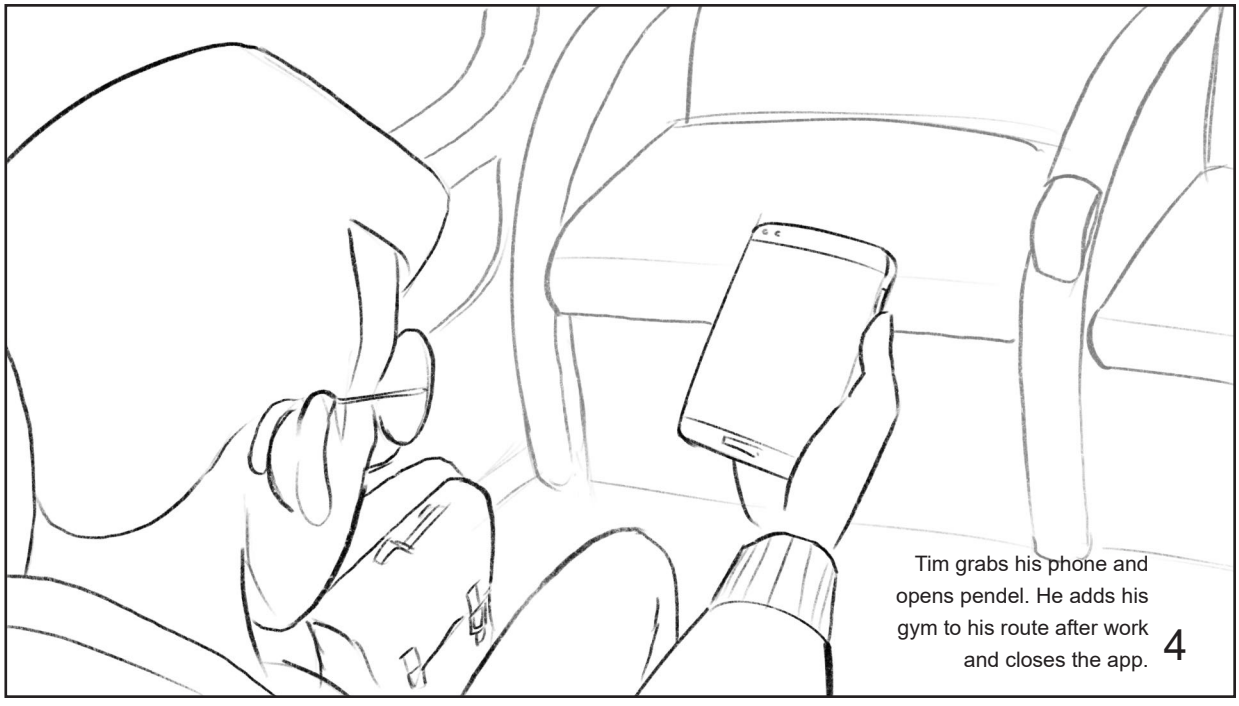
After waking up, Tim opens Pendel during breakfast and sets his main route for the day. To work and back. 1



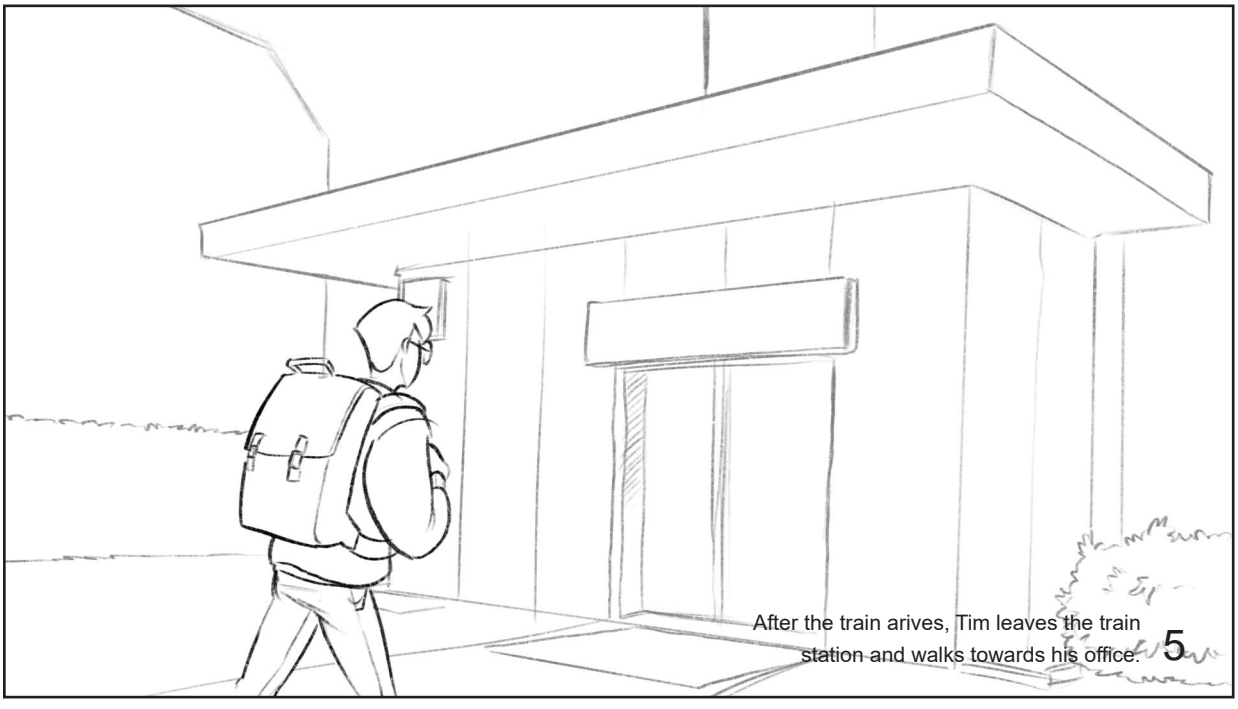
Tim grabs his bike and cycles towards the train station. 2

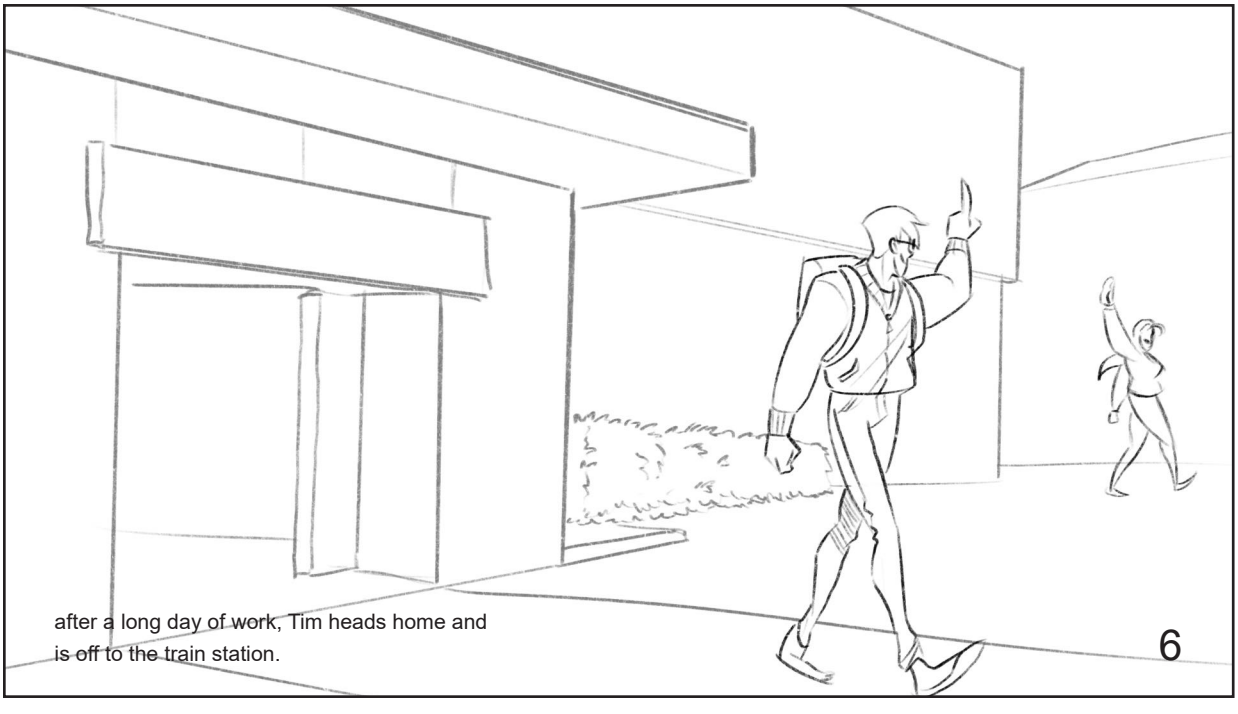


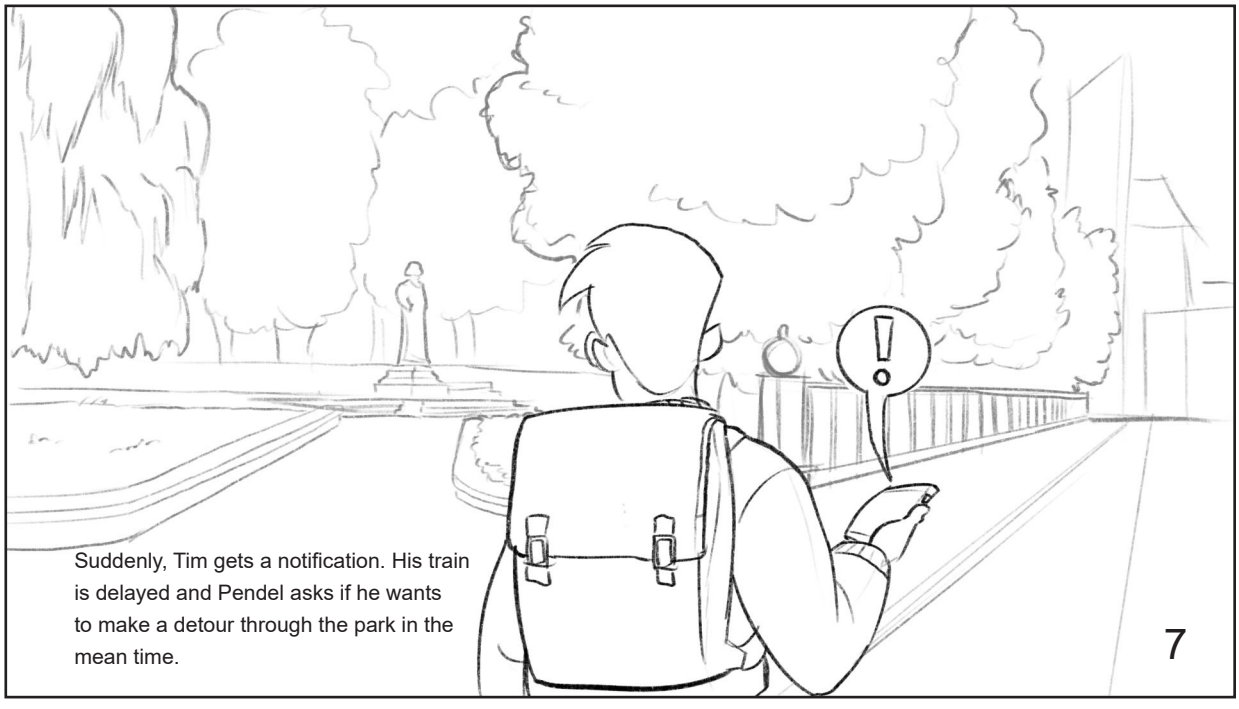
In the train, Tim gets a message from his friend asking if he would like to work out this evening. 3



Tim grabs his phone and opens pendel. He adds his gym to his route after work and closes the app. 4

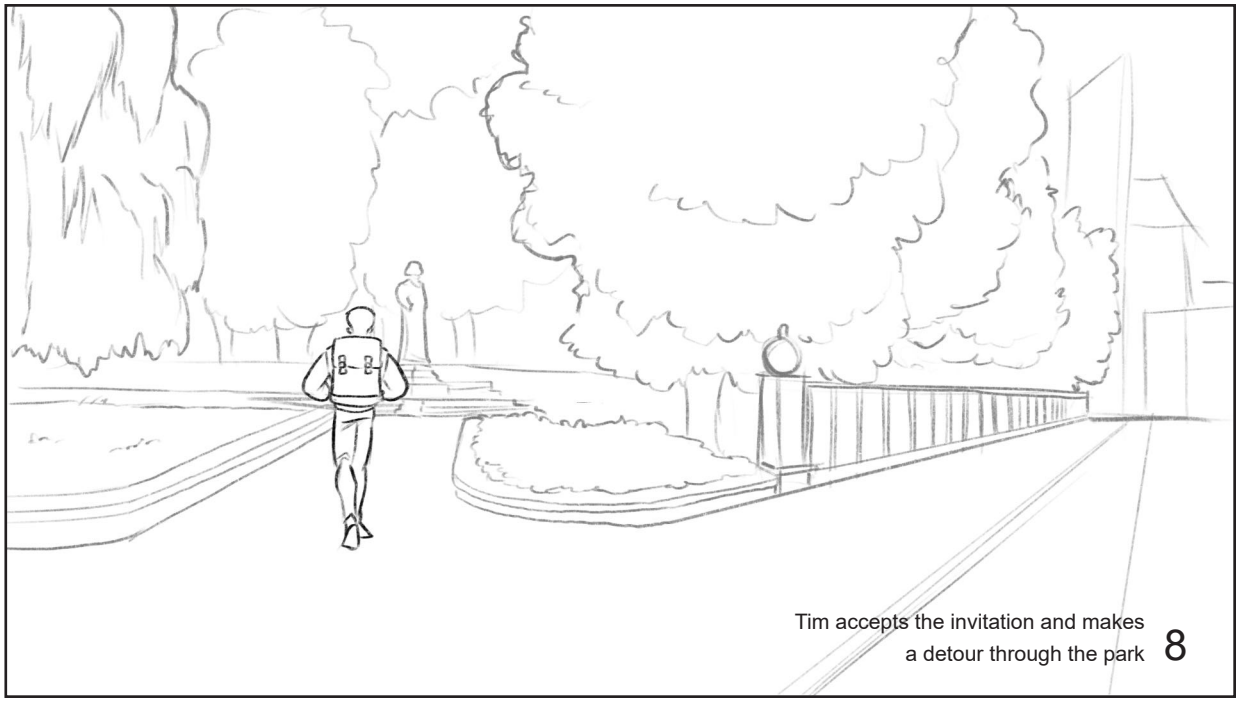

After the train arives, Tim leaves the train station and walks towards his office.
5


after a long day of work, Tim heads home and is off to the train station.
6



Suddenly, Tim gets a notification. His train is delayed and Pendel asks if he wants to make a detour through the park in the mean time.

7



Tim accepts the invitation and makes a detour through the park

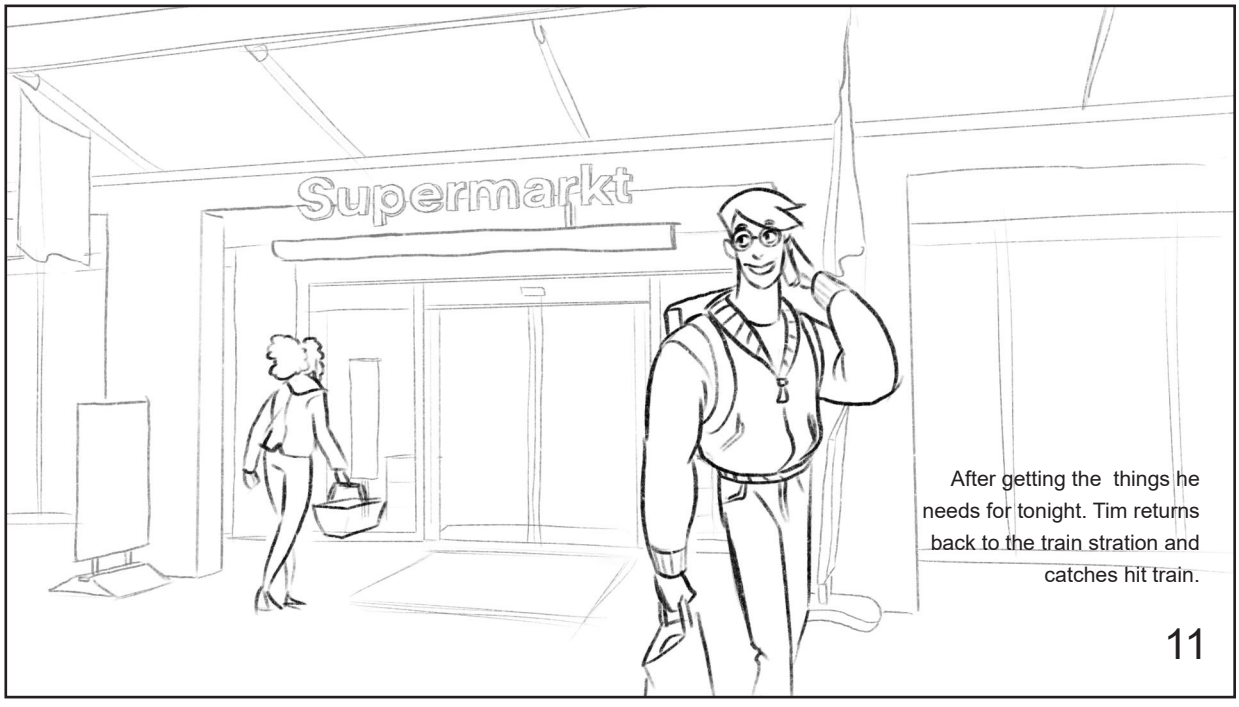
8

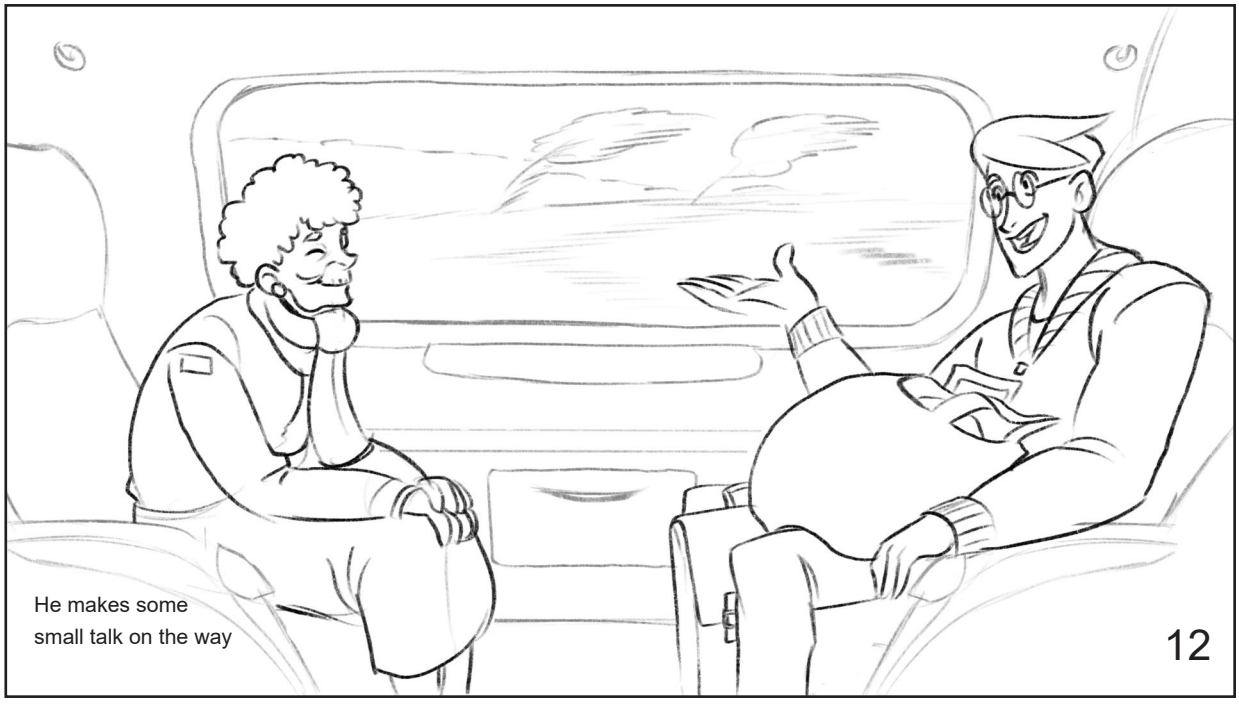
Whilst walking in the park, Tim sees a woman with grocery bags and realises he hasn't got any food for tonight.

9

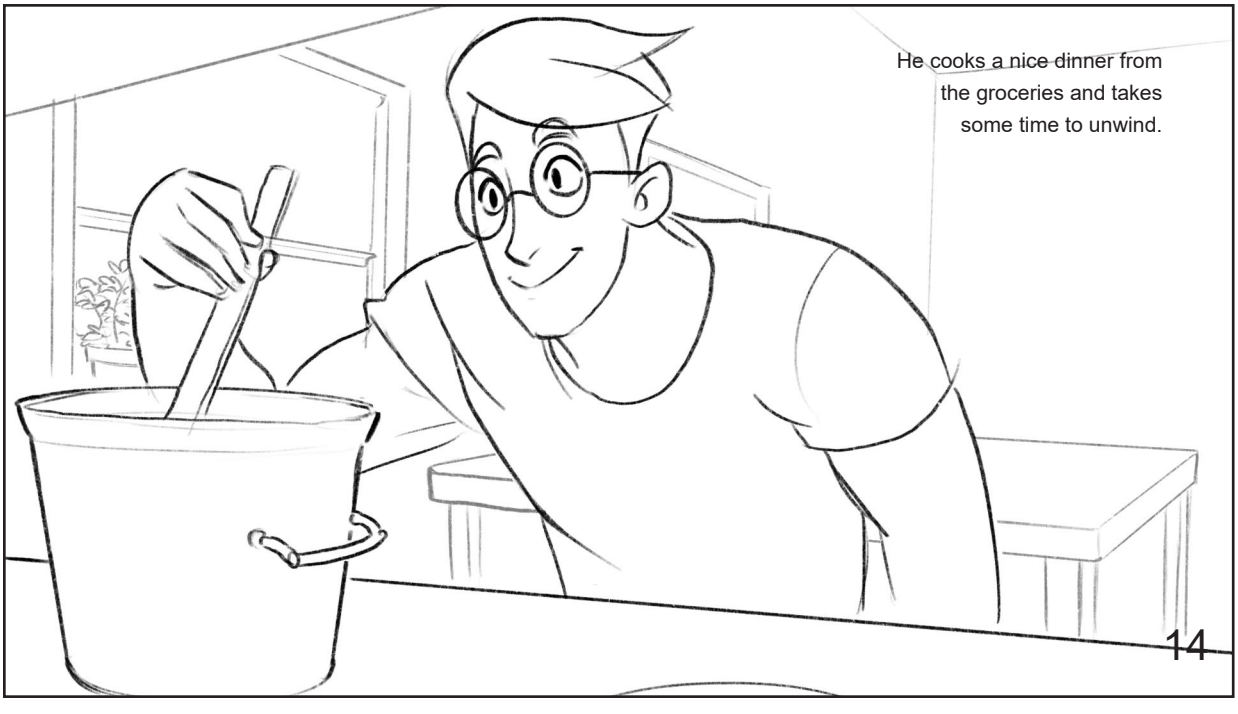
Tim grabs his phone and opens Pendel. He seeks out the nearest grocery store and adds it to his route.

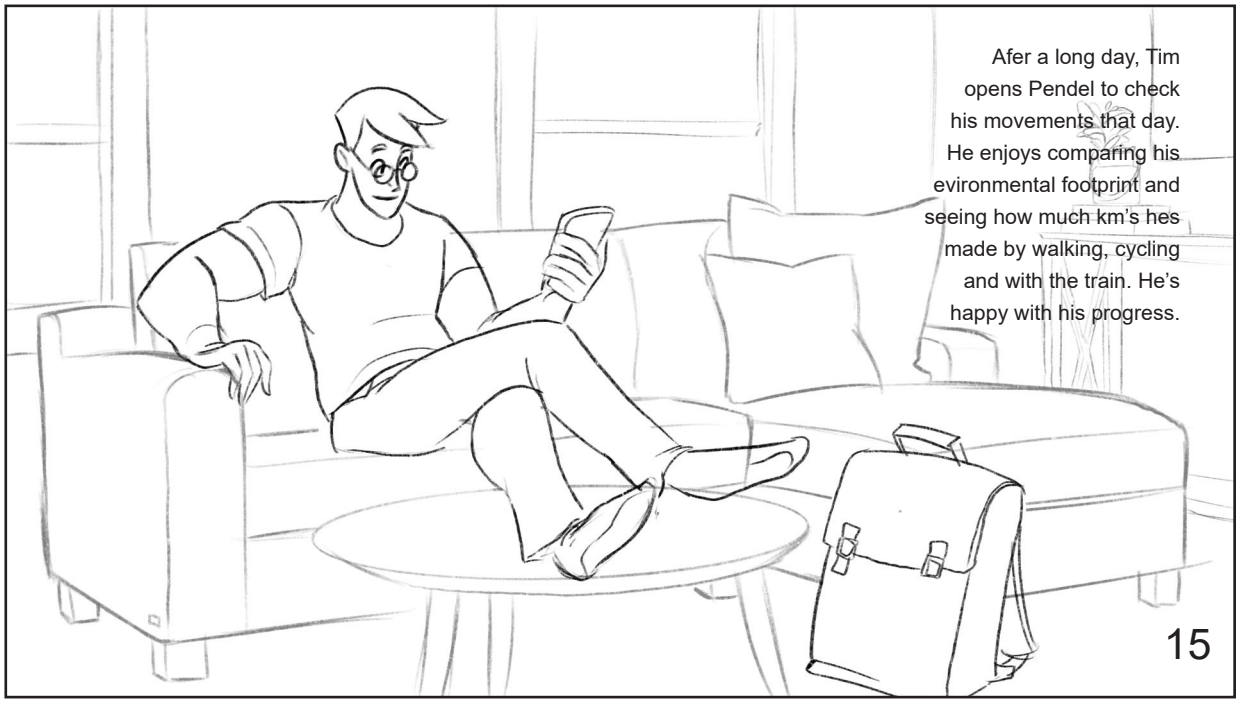
10


Supermarkt
After getting the things he needs for tonight. Tim returns back to the train stration and catches hit train.
11


He makes some small talk on the way
12


Sporthal
Tim meets his friend at the gym and gets some excersize after a long day.
13


He cooks a nice dinner from the groceries and takes some time to unwind.
14


Afer a long day, Tim opens Pendel to check his movements that day. He enjoys comparing his evironmental footprint and seeing how much km's hes made by walking, cycling and with the train. He's happy with his progress.
15

## 8.5 User Evaluation

In this section, the usability test to evaluate Pendel will be shown. The research aim, research questions, research methods and the results will be presented below.

### 8.5.1 Research aim

The aim of this research is to evaluate how people perceive, understand and operate the design. This will be done by observing the efficiency, effectiveness and satisfaction of participants during the tests.

### 8.5.2. Research questions

To achieve the stated aim of this research, the following research questions have been formulated.

- *Which use cues are perceived and encountered during use? (perception of design)*
- *How does the user understand these use cues during use? (cognition of design)*
- *How does the user understand the design and its structure? (cognition of design)*
- *How does the user achieve his/her goal during use?*

### 8.5.3. Research methods

Due to the COVID-19 virus, the number of viable research methods is limited. However, as restrictions loosen up a window of opportunity occurs to conduct some tests in person. This gives an advantage as the setting of the research can be influenced by eliminating distraction objects and by adding decor to immerse the participant into the actual context of use. In this case, qualitative research is utilized as it enables the researcher to dive deep into the experiences of the participants and emphasize with underlying needs and motives of their actions (Kvale, 1983).

During this study, two main items will be used. First, an interactive prototype of the Pendel application will be utilized. Second, the storyboard explained in chapter 8.4 will be used to immerse participants in the storyline and use case. Additionally, sounds, video's or pictures might be used in physical instances of this research to immerse the participant.

The instructions and questions in this research have been set up in a linear fashion, following a specific timeline of events described by the storyboard. Participants will be immersed in the use case and storyline by talking participants through each scenario and prompt them with instructions and questions when interacting with the interactive prototype is needed to progress the storyline. The storyline, questions and instructions can be found in appendix.

Upon testing, all participants will be asked consent to take photos and videos during the test via a participation form. Additionally, some participants will be tested online, these sessions will be carried out via an application called Zoom. This application enables the researcher to record the interview if consent is given by the participants. Recording all remote and physical sessions enables the researcher to fully focus on the participants without being obstructed by the hassle of taking notes. Furthermore, recordings can later be transcribed into statements which can then be processed further if needed.

### 8.5.4. Results

Due to poor health reasons, the user evaluation has not been fully analysed and therefore finished. However, a few insights have been gathered from a zoom recording with my project coordinators shortly after the user evaluation. This recording sheds more light on how Pendel is perceived by users. Firstly, the main insight was that the landing page was not clear, this should be optimised in future revisions. Also, the personalisation of places, modalities and routes should be more intuitive as now setting up a route for the day can be experienced as tedious over time. These quality of life changes aside, the concept and core value of Pendel was clear and inspired most participants to look at their travel habits from a different angle. They could see the benefit of adding more value and quality to their daily commutes.

### 8.5.5. Conclusion

In conclusion, Pendel still needs more fine-tuning to get the aimed user experience. The app does have a few more iterations ahead for it to become a truly valuable tool for users. However, as seen by the enthusiasm of the participants, if done right the Pendel concept can be a useful tool to improve and reflect on their travelling lifestyle. Sadly, the research questions could not be concluded due to poor health.

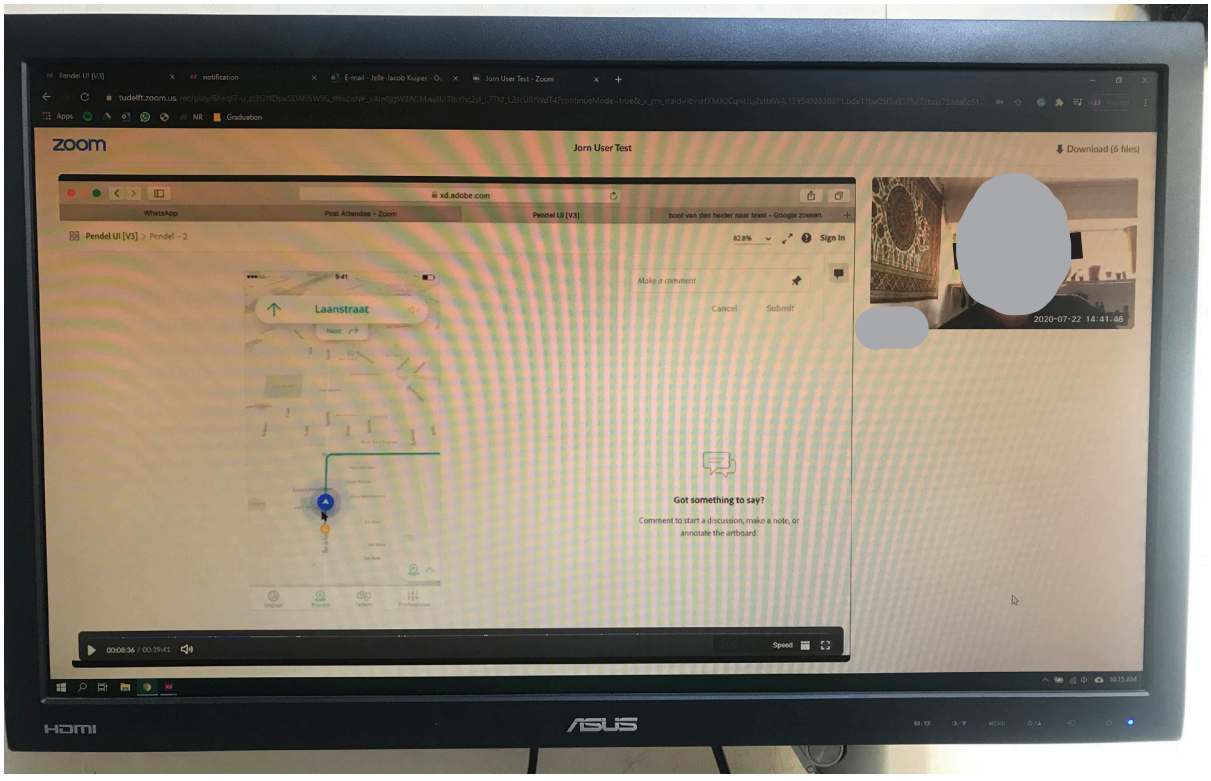



*Figure 15: User test of Pendel*

source: A. Brinkman

*source: J. Ying*

# 9.0 In Conclusion

In this chapter this project will be concluded with final thoughts and recommendations.

## 9.1 Conclusion

The initial goal of this project is to reduce CO2 emission during the commute. More specifically, the project aims to envision future solutions of what such CO2 reducing commutes can look like. However, like any project, little gems of knowledge reveal themself along the way. In this section, we will take a look at these gems and picture them in the entire personal mobility, pro-environmental and societal spectrum.

First off we conclude MaaS. If anything Pendel has shown that a MaaS service can take on many forms and cater to many needs. Ultimately, the only limitation to MaaS is the service providers imagination. Granted, MaaS still needs to operate in a highly competitive market with services all storming towards the next innovation to make travelling cheaper, easier and faster. But if a MaaS service does not solely focus on such quantifiable values and broadens its horizon to serve quality, it enters a vibrant world of possibilities to improve the traveler's experience in a positive manner. It could even directly act on societal and environmental problems. Pendel has shown this, the challenge however is to find the right balance between qualitative values and qualitative values and finding an audience that resonates with the ideals of the service.

When looking at Pendel a few things come to mind. As said, Pendel has shown how the idealism of quality over quantity and the importance of the environment can manifest in a MaaS solution. However, it also shows what service would look like when building upon the expertise of the commuter and not augmenting its routine but rather building upon it. This knowledge could form an inspiration to other services to reiterate which customization options are truly valid to the quality of the journey.

On a societal en pro-environmental level, Pendel shows two main benefits. Firstly, commuters stay healthy by getting sufficient exercise. Second, this green way of travelling reduces the amount of emission during the commute which consequently also forms the second pillar. The core concept of Pendel does align with the goal of this project by reducing the CO2 emission during the commute.

On a final note, let's reiterate the design goal and see if this project reached its goal. The design goal is "to design an active multimodal experience that showcases the beauty of the ordinary commute to commuters". It is safe to safe to say that Pendel is an active multimodal experience, however, little information is known if Pendel showcases the beauty of the commute to commuters. This is due to a lack of results in the final user evaluation. In the next section, we will discuss the limitations that occurred during this project.

## 9.2 Discussion

First off, a few elements formed limitations during this project. The biggest and most prominent limitation was and is the pandemic caused by the COIV-19 virus. This formed a barrier to speak and interact with users, stakeholders and project coordinators and also formed a hurdle to escape the desk and find inspiration and information in the field. Furthermore, in the last four weeks of this project, the author was hospitalised which manifested in a bit of an unorthodox ending of the project, to say the least. In reality, this means unfinished user evaluations and texts that had to be finished months after the fact. Therefore, momentum in the project was last and compromises had to be made. In hindsight, poor health caused friction throughout the entirety of the project, however, we will ignore this for now.

Regarding the stakeholder involved in this project, they could have been consulted more often. Ultimately, a meeting after the final user evaluation would have sufficed. The perspectives and needs of the stakeholders were always taken into account when designing during this project. However, often commitment towards positive users experiences would overrule the needs and wants of stakeholders resulting in a unique perspective on personal mobility and specifically the daily commute. Moreover, the needs and wants of stakeholder regarding MaaS would often be seen as unrealistic and due to confirmation biasses of projecting MaaS as the solution that will solve all problems. In reality however, MaaS adds more complexity and thus more problems.

When zooming out and looking at the future of Pendel many possibilities can be seen. The outcome of this project however turned out to be slightly paradoxical. On the one hand, the idealism and strong moral values during this project have given it a unique perspective on personal mobility and MaaS in particular. On the other hand however, this strength can also be seen as a limitation. It can lead to a worldview that doesn't always rhyme with reality. However, I believe this a decision every designer needs to make at some point in their career. Do we design for a world we live in, or do we design for a world you want to live in?

## 9.3 Recommendation

The research done in this project has been thorough and formed a large chunk of the project's insights. In this section, we will look at future undertakings to make Pendel as complete as possible. First off, the current state of the application might feel a bit too crowded. Certain features like "working in the area" and "Pendel" feature seem to compete for attention in the user's experience. It splits the focus of the application. Furthermore, features aren't balanced out as they should. For instance, the "Impact page" is one of the most important features of Pendel, yet there is little insight on how to optimise this feature. More user research should be done regarding this feature. When looking at the User Interface of the design more optimisation of interactions should be made, the most important one being the landing page. This page was not clear to most participants of the final evaluation. Also, to set a route wasn't as intuitive as initially thought, so this needs more attention.

Pendel's core concept is the feedback loop that makes the user intrinsically want to adjust their habits for the better. This means that using the app should integrate into the users routine, therefore the feedback loop should be interesting enough for them to want to track your mobility patterns. The idea is that users aren't micromanaged by their phone and that they solely set the route at the beginning of the day so the incentive to do that has to be big enough for users to do that. More intuitive and easier ways of tracking should be explored without being too intrusive for the end-user. If so, users can become more aware of their mobility patterns and change for the better. Additionally, this application is not for everyone. Pendel is meant for a specific group of people that feel the need to have more control and say over their mobility patterns, they want insight so they can judge their habits accordingly. This means that the feedback loop also needs to be tailored to what they value as important insight. Again, more user research should be able to reveal more promising solutions.

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