BIG CYCLIST DATA

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A STUDY ON BICYCLE PRACTICES IN AN URBAN CONTEXT

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Preface

This master thesis completes our two year Master's degree in *Sustainable Cities* at Aalborg University Copenhagen, School of Architecture, Design and Planning. The master thesis is written in the period from February to June 2017.

Our interests in sustainable modes of transport have been inspired in the last two years. The bicycle has been a common interest as this mode of transport has positive effects, such as health, economy and less space demanding than cars. We are both born and raised in Norway, where the bike infrastructure is not as developed as Copenhagen. The opportunity and experience to move and live in a city where almost *everyone* is bicycling made us realise the importance of a well-developed bike infrastructure in future cities all over the world.

Acknowledgements

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We will also like to thank our family and friends for extra motivation when we needed the most. Finally we will dedicate a sincere thank you to the ten voluntary participants in our Mapping Experiment. Without all of you, the substance in our thesis would not have been the same.

Kudos!

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Abstract

Mapping and monitoring of cyclists (Big Cyclist Data) have been absent in the implementation of Intelligent Transport Systems (ITS) in cities. Big data aims to provide information that could support the decision making in urban planning. To ensure that big data provides valuable information in the future sustainable development of cities it is important to define what information the data provides and how it should be utilised. This thesis examines how big cyclist data contribute to urban planning and *to what extent cyclist data provides an understanding of bicycle practices*. The research consists of different methods of data collection. The thesis presents a case study that investigates how big cyclist data have been utilised in Oregon, USA. Additionally, cyclist data for Copenhagen have been examined, where the data represent the bicycle activity for one month in the city of Copenhagen and Greater Copenhagen. The data is received from the IT company Strava Metro, who has developed a smartphone application to collect cyclist data. The users of this application represent the data sample. Finally, conducting an experiment in Copenhagen enabled to collect cyclist data from ten voluntary citizens that mapped their bicycle routes through a smartphone application. The experiment enabled a deeper investigation of to what extent cyclist data gives an understanding of cyclists' practices. In-depth interviews were conducted with each participant, which gave insight into the diverse opinions the cyclists present. By using Shove, Pantzar and Watson's perspective on practice theory, we integrate the elements we believe is elementary for understanding mobility practices.

The research identified that quantitative cyclist data to a large extent highlights the most heavily used routes, and to some extent illustrates where the alternative routes exist. The data enable to form assumptions, which could support the identification of additional research projects. People's bicycle practices tend to be diverse, and the qualitative interviews made it possible to identify different types of common factors that influence cyclists' usage of the infrastructure. Big cyclist data in the form of visualisations on open street maps, numbers on counts, and time of the day profiles are a valuable supplement in urban planning. To achieve a deeper understanding of the practices of urban cyclists, other information sources are necessary such as in-depth interviews. Different methods for collecting cyclist data seems to support decision makers and planners in finding solutions to influence sustainable mobility practices.

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01. Introduction

Sustainable transportation has been a major topic on the agenda for cities around the world in the last decades. The need for more sustainable implementation in the transport sector has been discussed since the Agenda 21 was determined by the United-Nation Earth Summit in Rio de Janeiro in 1992 (SD-UN n.d). The transportation sector is responsible for 25% of the emission of greenhouse gas (GHG) and is a growing industry worldwide (SD-UN n.d). One of the largest redevelopment the transport sector is standing over is the infrastructure system in cities. Most cities have in common that they experience a growth in road traffic, which is a problem as cities at the same time experience higher densities and shortage of space (Gehl 2010). This applies to the road network including rails and bike lanes in a city context (UN 21st Century).

1.1 Intelligent Transport System and Big data

Just like cities have evolved through time, technology has made considerable progress in the past decade. Intelligent Transport Systems (ITS) has been a tool for transport- and urban planners for several years already and is getting more advanced. The ITS is a complex system that includes a broad range of technologies such as communication, information and electronic who all collaborate for a more efficiently, secure and user-friendly system for transportation (Jun et al. 2014.). In this paper, ITS is referred to transport in an urban context which in recent years has grown more than ever. If the implementation of an ITS of road traffic succeeds in terms of accurate data collection and implementation, it could contribute to environmentally friendly and sustainable cities in the future, and reduce congestion, traffic delays, air pollution and noise (Zheng et al. 2016).

ITS and Big Data is a socio-technical complex with an enormous size. Big data is a collection of enormous data sets from traditional and digital sources (Elgendy 2014) and has been used over a longer period for vehicles and public transportation. ITS and Big Data have been important tools that have collaborated in the development of improved traffic flow in existing infrastructure, further also for a better user experience for the citizen. Big Data related to the citizen's transportation behaviour has become a useful tool in recent years, especially in Megacities in

Asia (Zheng et al. 2016). It can be used in the policy-making and decision-making process, as well as it can help urban planners to understand the citizens travelling behaviour to establishing e.g. a more complex intelligent transport system in cities (Zheng et al 2016).

1.2 Big Cyclist Data

Big cyclist data has been an absent element in the implementation of the development of intelligent transport system in cities (Romanillos et al. 2016). Research about big data in conjunction with cycling goes back approximately ten years (Romanillos et al. 2016). With new markets and innovation, big data for cycling has motivated engineers and computer scientists to assess more available data to actors in policy and governance. Open data for actors, government and private use are still restricted access because of strict rules on privacy.

It is possible to collect cyclist data by *GPS data*, *Live point data* and *Journey data*. Common characteristics are volume and velocity which suggest different problem domains and generate different analysis approaches by following different patterns (Romanillos et al. 2016). Collection of cyclist data from bike share programs (BSP) has existed for almost 50 years. In recent years it has been an increase in bicyclists in cities around the world and the BSP allow citizens or tourists to rent bikes in the city for a small payment. The technology for BSP allow scheme operators to track the cycling movement from one dock station placed in the city to another, but information on the specific route has been missing since the BSP rental bike not often come with a global positioning system (GPS) tracker (Froehlich et al 2009).

GPS data can easily be collected via a tracker in e. g. a smartphone or a sports watch. A GPS tracker in a smartphone are usually for private use and are usually used in conjunction with leisure, health and fitness applications. In some cases, it can be helpful to use a GPS smartphone *application* for specific studies and research to get an understanding of people's travel practices. The user of the application can in some cases share their routes in real time when cycling if the application allows it. Previous research shows that it is common to share a bicycle route after finishing the journey, and this type of data goes under the category of historical data. The historical data provide a high level of precise data density, and with the data sampled every three to five seconds, it is nowadays possible to do detailed research on GPS studies (Hood et al 2011).

Leisure and fitness application like Strava and Endomondo and other social media application that have over a million users have an enormous amount of historical data of its user's walk/run/cycling routes (Endomondo 2013). Strava is an application that tracks running and cycling activities, where the user get information about distance, time, average speed, maximum speed and a map where the route from start to finish is mapped out. Strava also relates to other social media applications and allow you to share and take part in a group or team for sharing and motivation (Strava 2017 b). Challenges who often arise when working with GPS data are the data for accuracy and volume. GPS is still one of the main data sources for mapping and monitoring of journeys. The revolution of smartphones in 2007 has been an important part of the development and opportunity to use GPS data for private use (Schuessler & Axhausen 2009).

Live point data is data which is sampled at a location where there is a traffic light, docking station for BSP, counting station or similar (Froehlich et al. 2009). Live point data can count the amount of cyclist on particular bike lines in an hour, day, month or year. It will be smaller in volume since it is point data and not located everywhere, but the availability who exist will allow urban planners to have some insights in where the cyclist is located in the city.

Journey data register the origin and destination of a route, but have not detailed information about the exact route choice or speed. It can be compared with the data that bike share programs (BSP) provide (Zaltz et al. 2013). Journey data can be used when the government are doing national travel surveys. The sampled data from journey data can be studied over a long time, a year or more, and normally is the data not official to the public before it is collected and organised e.g. for use in statistics, analysis, and maps.

1.3 Research on Big Cyclist Data

The innovation of smartphone technology in 2007 and the increasing amount of smartphone applications has shown to become a marked available for everyone. The mapping, tracking and location functionalities have also become a daily tool for many smartphone users (Romanillos et al. 2016). In 2007 did South Minneapolis conduct the first analysis on cyclist mobility through GPS data. They collected trips from 51 participants and studied the cyclist's behaviour and route choice. They used the data to map the routes in existing bike facilities to understand the bike infrastructure in different neighbourhoods in South Minneapolis (Schuessler & Axhausen, 2009). More recent studies are usually on a larger scale, where up to a thousand of cyclists can participate.

Today nearly 46 million smartphone owners in the USA use a fitness application. The large number presents mainly young and healthy people who often are in activity and are interested in personal sports progression (Mitesh et al. 2015). The personal interest of using the application could decrease after some months and cause that the application is stopped in being used. Selections of fitness application with GPS data tracking have become widespread, and the Strava application with its user-friendliness has around 2.5 million GPS tracked routes uploaded every week (Strava 2017 b).

In 2014, Strava developed Strava Metro, which is a GPS program with open street data for cyclists who use the Strava application. It was designed with the primary objective to provide and sell cyclist data to governments, research institutions and agencies with interest in cyclist data for a particular city or region (Strava Metro 2017). The Oregon Department of Transportation (ODOT), USA, was the first agency that collaborated with Strava Metro. The OpenStreetMap (OSM) with over 400 000 individual bicycle journeys had an economic cost of $20 000 USD for one and a half year with cyclist data for Oregon (Romanillos et al. 2016). Cities around the world, e.g. London in UK and Brisbane in Australia have also purchased cyclist data from Strava Metro for use in urban transport planning.

The data from the Strava application for cyclists give transportation planners detailed models for understanding the infrastructure in cities. Point data or journey data cannot provide the same amount of data that the GPS data provides for analysis of the bike infrastructure in details. It is a high density of GPS trackings in the OSM, and it is possible to look back on different days or time frames to see the historical data. Furthermore, it also gives access to see the monthly evolution over a year. With this opportunity, planners can also do seasonal analysis (Romanillos et al. 2016).

1.4 Previously Research

Studies on GPS tracking have been conducted in conjunction with training performance. Average speed, duration of journey and heart rate of 30 000 cyclists were studied by Cintia, Pappalardo, and Pedreschi (2013). Another study conducted by Wamsley (2014) researched travel times and investigated speed on different routes. Clarke and Steele (2011) used the cyclist data to research the architecture of the data collection and investigated the management and methodologies to analyse how the cyclist data behave. Studies about bicycle motivation and experiences of cyclist applications have been conducted by Smith (2014). A missing point in this research context is the analysis of what information a smartphone application can and cannot provide. Research does also lack on how the analysis of information can improve urban transport planning (Clark & Steele 2011). Research conducted in Reykjavik has investigated how cyclist data can be used in transport planning. Strava enabled them to track cyclists and to analyse the routes and a heat map to improve planning (Jonasson et al. 2013).

1.5 Limitations and Challengers

Every innovation comes with limits and challenges, which also has been experienced in the collection of big data for cyclists. As mentioned above, studies have been conducted on smartphone applications and big data for cyclists, but more research in this field are needed. Cities differ in size, political government, topography, climate, etc. and for example does the winter climate in Reykjavik present different needs in the transport planning than for example a city in South Europe (Jonasson et al. 2013).

A second limitation is that the tracking of people involves concerns about privacy and has strict guidelines. Because of this, it is not allowed to track individual bicycle routes without agreement. This limits the possibilities that researchers have to analyse personal purposes of routes and choices of specific cyclist route. The information lacks basic information like age-rand and gender. This limits the amount of information on individual cyclist practices. However, this information can be important for urban transport planning as it provides knowledge on citizens' cyclist practices, which can contribute to efficient developments of bike cities in the future (Romanillos et al. 2016).

GPS data collected by application producers are not as representative as the GPS data used for research in large population studies, for example national or regional travel surveys. This also represents the limitation that the data collection of cyclists needs to address. Application companies risk that the sample that represent the data mainly are people with interest in personal progression in the sport. This data can result in a self-selective sample (Romanillos et al. 2016). The major users of Strava will be classified as cycling enthusiasts, and the lack of cyclists with different interests, geographical location and socio-demographics will lead to monotonous data samples (Dill and McNeil 2013).

Finally, it is a challenge to encourage the users of GPS applications to use their smartphone application for everyday rides. The limited battery time on smartphones can present a barrier to encourage more people to use a GPS application. As the GPS application can contribute to lower battery time would cyclists with less interest in tracking bicycle routes most likely not use the application if the battery on their smartphone already is low (Romanillos et al. 2016).

1.6 Problem Field

Copenhagen, the capital of Denmark, is one of the major bicycle cities in Europe, and the amount of cyclist are increasing each year. In the Bicycle Strategy 2011-2025 (City of Copenhagen 2011) the municipality has established a goal of increasing the trips to work or education by bike with 50% by 2025. The numbers presented in 2011 for trips to work or education was 23% by bike, 29% for cars, 28% for public transportation and 7% for walk. As mentioned before, the capacity in many cities is already pushed to the limits when it comes to the availability of space of transportation. In Copenhagen, the demand for capacity is predicted to almost double from 2012 to 2025 (City of Copenhagen 2011). On main roads and with popular places during peak hours can the space for cyclists on the bike lanes be limited. It is expected that traffic management systems and ITS will be an important tool in the development of transport planning about capacity problems in the future. In the Climate Plan, the main goal is to achieve a CO2 neutral Copenhagen by 2025, which then requires that a larger amount of the citizens choose to bike by 2025 (City of Copenhagen 2011).

In February 2017, the Municipality of Copenhagen in collaboration with the organisation Climate KIC arranged a workshop about ´Bicycle Big Data needs and challenges in the City of Copenhagen´ (City of Copenhagen 2017 a). The aim of the workshop was to create a proposal on how Copenhagen can integrate travel time and route data for cyclists in the already well developed ITS. Public transport and floating car data are already implemented and are working as a helpful tool for transport planners in the city (City of Copenhagen 2017 a). Cyclist data in the city is limited and are until now mainly based on manual countings and the countings from the docking stations located on a few places in the city that sample live point data (City of Copenhagen 2017 a).

Copenhagen has been a well-developed bike city for many years, and more than the half of the citizens who live in Copenhagen own a bike and ride the bike each day (City of Copenhagen 2017 a). With this starting point, Copenhagen will be the ideal city for doing research on citizens' cyclist practices. Regarding the diversity of the bike infrastructure in Copenhagen, which will increases every year, could it be important for urban planners to understand the citizen's bicyclist practices more detailed before doing decision making on new bike infrastructure or upgrading of existing infrastructure (City of Copenhagen 2017 b.). In order to gain understanding of individual route choices and behaviour does practice theory emphasize that the elements that creates a practice needs to be understood. The elements needs to be understood in relation to each other. Knowledge about the relations that connect them could contribute to the understanding of how practices arise and vanish and could further support decision makers in finding solutions for how to invite and attract people to use the bike infrastructure. Copenhagen says they want to implement big cyclist data to manage further development of a more efficient and holistic traffic management system in the city (City of Copenhagen 2017 a).

1.7 Research Question and Methodology

Big data for cyclists is a new research field that in the recent years have become more relevant. Innovative and fast developing technology presents possibilities for collecting this type of data, which further would provide large amounts of information that could be analysed and used for supporting decision making and the planning process. Based on the lack of research on big data for cyclists in an urban context, we want to study what information big cyclist data can add to the urban planning process and the transport infrastructure development. We will use Shove, Pantzar and Watson's (2012) perspective on practice theory to integrate the elements we believe is elementary for understanding mobility practices. The main research question to be answered is as follows:

"To what extent can Big Cyclist Data give an understanding of bicycle practices in an urban planning context?"

To find answers to the research question, we will make an attempt on gaining knowledge on what information cyclist data provides planners and decision makers by investigating the following sub-questions:

1. ***Case study of Oregon Department of Transportation, USA***.
   What information did the Big Cyclist Data from Strava Metro give the planners in Oregon (USA), and to what extent does it provide an understanding of cyclists' practices?

2. ***Strava Metro Data In the Context of Copenhagen.***
   To what extent are the data provided by Strava Metro in compliance with the information collected by the in-depth interviews conducted during the Mapping Experiment in Copenhagen?

3. **The *Mapping Experiment in Copenhagen.***
   To what extent does in-depth interviews of cyclists in Copenhagen supplement big cyclist data in terms of the elements of competence, material and meaning?

By having three sub-questions, we will hopefully manage to get an understanding of to what extent the different information sources present cyclist data. With this chapter, we have presented the challenges regarding big data, opportunities in research and the importance of investigating big data for cyclists. Our research question and its answer will hopefully address and facilitate a current problem field that can benefit the City of Copenhagen and other bicycle cities.

The reader will get an understanding of Shove, Pantzar and Watson's perspective on practice theory in *Chapter 2. Theory*, where the elements of material, meaning and competence that form a practice are carefully described. The theory has supported the development of the interviews that are a part of the empirical data, and the analysis and discussion of our findings.

The methods used to structure our master thesis are presented in *Chapter 3. Methods*. The empirical data consists of both interviews with Oregon Department of Transportation in the Unites States of America, qualitative in-depth interviews with cyclists in Copenhagen and data on cyclists in Copenhagen that have been accessed through Strava Metro. A variation of empirical data is necessary in this research to understand the limitations and possibilities different information sources present.

The analysis is structured in three different parts, and is presented in *Chapter 4*. *Analysis*. The analysis present findings on to what extent bicycle practices are understood within the data collection, which further leads to *Chapter 5. Discussion*. The interview with the Oregon Department of Transportation is used to answer the first sub-question through a discussion on to what extent the Strava data gave an understanding of bicycle practices. The analysis of the cyclist data in Copenhagen is used to reflect upon the second sub-question through discussions on to what extent the data could be in compliance with qualitative information. The in-depth interviews conducted with the participants in the mapping experiment are used to answer the third sub-question and discusses the information the interviews provided.

In *Chapter 6. Conclusion*, we will attempt to conclude the investigation of to what extent bicycle practices are understood in big cyclist data. Proposals on future research projects in this field to find methods on how big cyclist data can contribute to an increase of bicyclists in an urban context are presented in *Chapter 7. Perspective.* The factors that limited our research are also presented in this section, and *Chapter 8. References* contains a complete list of the references.

2.0 Theory

In order to gain an understanding of to what extent big cyclist data gives knowledge about people's practices, we will use Shove, Pantzar and Watson perspective of practice theory and the respective 'three elements model'. To explain our understanding of the theory do we first introduce the theory with a focus on how this theory relates to mobility practices. Using Shove, Pantzar and Watson's book *The Dynamics of Social Practice* (2012) have enabled us to gain an understanding of the theory, where we have mostly used chapter two *'Making and breaking links'* and chapter eight *'Promoting transitions in practice'.* To underline other important points, we have referred to relevant literature in the form of articles and books written by researchers with interest in this field of sociology and research.

2.1 The Development of Practice Theory

Research on sociology and everyday life, and the idea that it is shaped by the dynamics of human practices led to the development of practice theory in the late 1970s and early 1980s. Pierre Bourdieu, a French social theorist, developed a new generation of thinking because of his original approach to social science (Harker et al. 1990). Bourdieu wanted to find the relationship between structure and agency (the ability to act for making a change), and his fieldwork resulted in an observation of individual's practices being embedded in the interaction of habitus and field. The 'habitus' can be described as what guides a person's behaviour and thinking, and could in one way be seen as personal stories. The 'field' can be described as the arena where people act and get involved with rules, values and institutions (ibid).

Also, Anthony Giddens (born 1938), another social theorist and British sociologist, had an interest in how social life was formed and structured (Postill 2010). He introduced the dual relationship between individuals and the structure that forms them. He contributed to the development of practice theory by arguing that structure form individual, which in turn, is also formed by them (Postill 2010). This relationship illustrates that reproduction is essential in the formation and keeping of practices in social life (Nicolini 2012).

Elizabeth Shove is an English sociologist and a professor at Lancaster University, who through her career have focused on theories of practice, environment and everyday life (Lancaster University N.d.). Elizabeth Shove has been inspired by social philosophers such as Andreas Reckwitz and Theodor Schatzki, which all have contributed to versions of understanding the social practice. Several understand attitude, behaviour and change as something embedded in the individual human body, but Shove criticises this by emphasising that practices and social structure are more complex than several others express themselves to believe. There are essential elements beyond the individual body and mind that have the influence on humans practices (Shove 2009). Her aim to correct the common understanding of how practices are understood strengthened the development of her version of practice theory. The book 'The Dynamics of Social Science' is written in a collaboration between Shove, Pantzar and Watson, and aims to understand practices and how they are formed, rather than focusing on individual's attitude, behaviour and choice.

Instead of locating problems as a matter of individual behaviour, can practice theory contribute to understanding where more sustainable ways might take hold, and where the options and possibilities are, and should be structured (Shove et al. 2012). The theory also helps the understanding of how to potentially shape the range of practices of which contemporary society is formed. Shove, Pantzar and Watson's perspective on practice theory form the basis on how we involve the theory in our research and fieldwork.

2.2 The Elements of Practice

A Practice is defined by Loorbach and Rotmans (2010) as a form of doing, a routine, a habit. Practices is not formed by the individual itself, but is rather formed by multiple factors that works together in an interdependent relationship (Shove et al. 2012). These factors are referred to as the elements of practice, which are the material, competence and meaning. These elements are what a practice consists of. If one of the elements or the link between them is missing, the practice does not exist (figure 2.1). First of all, practices are connected to things. This is because of that practices are dependent on the material itself, for example objects (e.g. a bicycle), infrastructure (e.g. the bike path network), buildings, hardware, tools and the body itself (Shove et al. 2007; 2012).

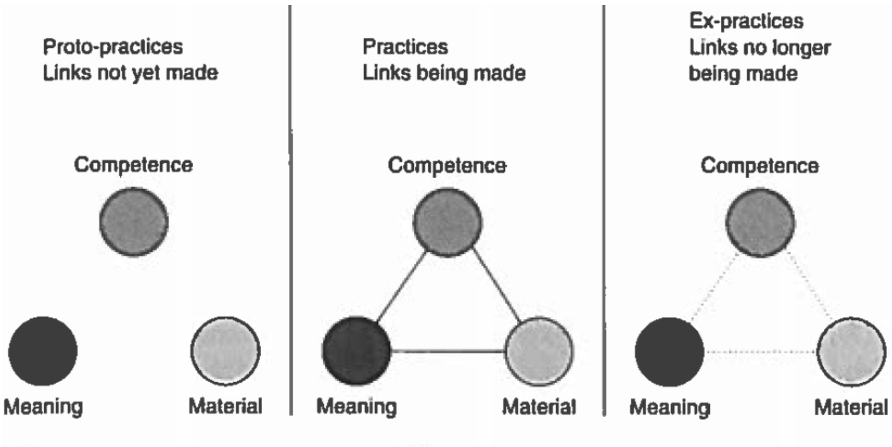


Figure 2.1. Proto-practices, Practices and Ex-practices (Shove et al. 2012, p. 25)

2.2.1 Material

Material influence bicycling as a practice because material is essential for carrying out the practice. If the material is not provided, the practice can not be conducted even if the two other elements are present. However, investment in for example bicycle infrastructure does not guarantee to create more practitioners itself, but it does shape the distribution of necessary elements in a practice (Shove et al. 2012). *"(...) the design and operation of infrastructures (...) reflect and structure inequalities of access and hence the social distribution of different practices"* (Shove et al. 2012 p. 47). Different practices can also mean different variations of a specific practice. Cycling as a practice differs between individuals, depending on several factors such as the elements. Different variations of practice take place within an infrastructure, where for example a transportation network could facilitate different variations of practice. The access to the materials is crucial for whether a practice is conducted or not, for which purpose it is conducted and how often. How the location and access to the material are structured would to a large extent influence the appearance of practices, the reproduction of a practice and also the disappearance of a practice.

2.2.2 Competence

The second element is referred to as the competence, which is an element related to knowledge of how to use the material such as a bike, infrastructure or a smartphone. Competence is also referred to as knowing how to do things. It is in other words essential to have the skill required to interact with the material (Warde 2005, Shove et al. 2012). Competence can be understood as the precondition for what a person might do next. Here it can be argued that past performances have an influence on exactly what a person might do. Knowledge and competence can be based on what a person used to do in his or her childhood and have an influence on what a person find relevant in his/her daily life. Some competences are allocated with dedicated training, and sometimes even without noticing. Often does a practice begin to emerge when an individual becomes familiar with the qualities of a competence and the circumstances of its use (Shove et al. 2012), which further can contribute to an competence being used in more than one practice. Competence can be able to move beyond the context of where it started, which means that competence can transfer to other practices. For example, could the competence of reading and using a map be transferred to the practice of cycling, where it would benefit the individual in understanding the transportation network and increase its knowledge of where to navigate. However, it can be difficult to convey how a person travels on a cycle path. When driving a car is there clear traffic rules, but what about when riding a bicycle? Rules on how to act as a cyclist in traffic exist, but a cyclist is not as tied as a car driver to follow the transport network, as a cyclist have more freedom to manoeuvre through traffic (Gössling 2013, Marshall et al. 2016). There are to a large extent norms and unwritten rules that have an influence on how cyclists bike in traffic (Gössling 2013, Marshall et al. 2016). Less knowledge about norms and unwritten rules could contribute in making cyclists feel unsafe and result in confusion, misunderstandings and injuries. Knowing about these unwritten rules is an essential competence to have as a cyclist, and differ from city to city depending on the design of the infrastructure and culture. Different levels of cycling competence could contribute in making some cyclists feeling safer than others, and could have an impact on how bicycling is practised. More drastically, different levels in cycling competence could have an influence on whom that chooses to bike, and also on when, how often, and where they bike. The differences in a person's bicycling competence can contribute to different variations of cycling as a practice. The competence of bicycling does not only include knowledge about how to ride a bicycle, but also knowledge about the traffic system, such as being able to understand both written and unwritten traffic rules.

2.2.3 Meaning

Material and competence complement and influence each other, and involves a certain mindset that gives meaning to the practice. A person's actions in everyday life are to a large extent embedded in its perception of what the meaning behind the practice is. In 2016 did we in collaboration with three student colleagues conduct a semester project that studied to what extent the elements of practice formed the mobility practices of the citizens in Ørestad. We identified amongst other things that the choice of riding a bike instead of driving a car is embedded in the meaning of timesavings, freedom and exercise (*Aalborg University Student Report 2016)*. This example indicates that the meaning behind a person's actions influence why a practice occurs. Meaning is treated as an element of practice and not only as a motivating force, which means that it makes up the third element in practice theory. Regarding sustainability and planning, influencing the meaning could to a certain extent contribute to a shift from unsustainable practices towards more sustainable practices. Making private car ownership more expensive, at the same time as bicycling infrastructure is made efficient and safe, could influence people to choose the bike because it could mean that they save money on transportation. The presence of unsustainable practices is to a large extent a consequence of the meaning people gives to the practice (Shove et al. 2012). An understanding of these meanings behind practices could contribute to knowledge on why unsustainable practices are obtained, and again contribute to understanding important factors on how to facilitate a shift to more sustainable practices (ibid.). Social norms and trends that are present in contemporary society, such as concerns about personal health, could interrupt the meaning behind a practice. Connections between transport and health could add new layers to the 'old', unsustainable meanings, and influence a person to choose more sustainable transport modes that also benefit health (ibid.). Changes in life can also contribute to new preferences in type of transportation mode. Being a parent and having young children can influence the choice of transportation mode, and a car ownership could be seen as the most convenient transport mode as it could mean more flexibility. Understanding meanings will give an answer to why certain practices are preferred and why other practices are not.

These elements are interdependent, which means that they are equally dependent on each other in forming a practice. A practice is therefore only formed when the three elements are linked to each other. They can exist by themselves, but elements that exist without being linked with other elements are classified as passive and inactive. As humans are not the drivers of practices, are they seen as the carriers of practices (Shove et al. 2012). Figure 2.1 shows how links between the elements affect the existence of the practice. The relations between the elements will be described further in the next paragraph.

2.3 Linking and De-linking Elements

Practices do not emerge before they are linked to each other in an interdependent relationship. Even though access to material is provided, and the person has the competences for using it, and meaning is given to the practice, does it not necessarily mean that these elements are active in forming a practice. Some practices are competing, and certain elements can have a stronger influence on what an individual choose as a practice. Strongly embedded institutions or norms can weaken other practices and prevent them in emerging, but separate elements (not being linked) could be triggered in being connected if the right force is pushing them to. Elements that potentially can form a practice if being linked to each other are called a proto-practice, a practice that not yet exist but potentially can in the future (Shove et al. 2012).

As the demand for transportation of people in cities is growing, will it regarding sustainability be important that alternative transportation modes such as bicycling are practised by a greater amount of people in the years to come. When bicycling as a practice is conducted, do the elements of the practice connect, and the practice is therefore maintained in a reproduction of linked elements. The links between the elements are therefore accomplished repeatedly when a person do the practice (Shove et al. 2012).

To understand how to increase bicycling as a practice it is necessary to look into how changes in practices occur. Innovations in practice could contribute to some elements being disconnected, but how and when do elements disappear? Shove (2012) says that elements can exist after links are broken, but without being active. Practices can disappear for a while, and after some time it can flourish again. Inactive but present elements can be linked if the right forces are pushing, as could be when changes occur in the landscape. Copenhagen has a long tradition of cycling, but after the car was introduced to society during 1960's and 1970's, the city experienced a downgrading of its bike infrastructure and fewer cyclists, and more private car ownerships (Elle et al. 2014). After some years was bicycling as a practice brought back to life again, partly because of knowledge on the health benefits that bicycling represented and a growing concern about health and the environment (Shove et al. 2012, Elle et al. 2014). Ex-practices can become practices again if the relevant elements still exist, which it did in this case. Passive elements can be active and re-linked to relevant elements again when for example the landscape changes or forces are pushing for action.

There is a possibility that the involved elements in practices exist beyond the practice they are identified in. As an example, the practice of cycling could also relate to concepts of health and leisure. The condition of elements taking part of other concepts beyond a practice is important for understanding individual practices and how a practice emerges. Shove refer to this condition as bridging practices. What do we know about bridging practices of people that bike? Are the elements involved in bicycling taking part in other practices or concepts, and what effect does this have on bicycling as a practice? In other words, we could say that certain factors could contribute to a person's perception of a certain practice. For example, health and environmental consciousness can contribute to the framing of bicycling as something sporty and 'green' to do. As such, bicycling acquire characteristics of awareness, as both things relate to a person's awareness of its body or the environment. Therefore, could awareness provide a point of connection between practices, such as exercising and bicycling (Shove et al. 2012).

It is important to notice that the relationship of bridging practices is not a stable relationship. Links are made and broken not just between the elements that a practice consists of, but also between the different practices that the elements are involved in. The elements circulate in between many practices. The occurrence of new elements can move, accumulate or change place. Practice theory argues that practices are in constantly change and transformation. We might believe that we can change practices, but more correctly do we influence the trajectories (elements) of practices to achieve a new practice or a disappearance of a practice. Decision makers, planners and other actors can influence the circulating elements, they can influence the ways practices relate to each other, and the trajectories of practice as well as the individuals carrying them, but also the reproduction of practices (Shove et al. 2012).

Today there are different types of smartphone applications that can be used for tracking individual routes when a person are out walking, running or bicycling. The application gives GPS information about the activity in the form of numbers on distance, time and speed, and information about the route on a map. To use such applications it does require access to a smartphone. This also requires knowing how to use a smartphone, and how to use the application for tracking routes. These applications are mostly designed for athletes that want to analyse their exercise, which could present persons that already have a certain practice and therefore a reason for why to use the application (Romanillos et al. 2016). The usage of these applications by regular and everyday cyclists is not that widespread (ibid.), but providing incentives could influence people to acquire the competence. If the application influences the meaning behind bicycling as a practice, the competence of using a smartphone would not only be used for phone calls or e-mail but also for bicycling.

2.4 Practice Theory in a Planning Context

Urban planners are in charge of planning infrastructure, hence the material element of which taking part of the formation of practices. The infrastructure plays an important role, as it could be argued that material is forming the stage where actions take place (Shove et al. 2012). But the infrastructure alone is not enough for achieving a change in people's actions and on how they travel. More sustainable technologies tend to be the focus in climate change policies, instead of the pathway to the breakdown of unsustainable practices or regimes. *"If only the technical components of a system are changed, they may well snap back into their earlier shape like charged particles in a strong electromagnetic field"* (Hughes 1993 (1983): 465). Hughes says that attention should also be paid to the "field", as this is where values, institutions and legislations exist.

Geels explains that histories of driving and bicycling are marked by extensive forms of symbiosis (Geels 2005, Shove et al. 2012). Before the car was developed and accessible for many, was bicycling the main mode of transportation in many cities (Shove et al. 2012). The development of bicycling laid the foundations for many of the elements on which the system of automobility depended, including aspects of infrastructure (road surfaces, production capacity) along with ideas and expectations of personal mobility (Shove et al. 2012). As car driving became accessible for many and not just for few, bicycling headed in the opposite direction (Bertolini 2011). The introduction of the car to society illustrates that innovation at one field can contribute to the disappearance of something else. The theory of practice has identified that practices might compete, such as bicycling and car driving (Shove et al. 2012). This example could suggest that intervening in processes that intersect would benefit the promotion of sustainable practices.

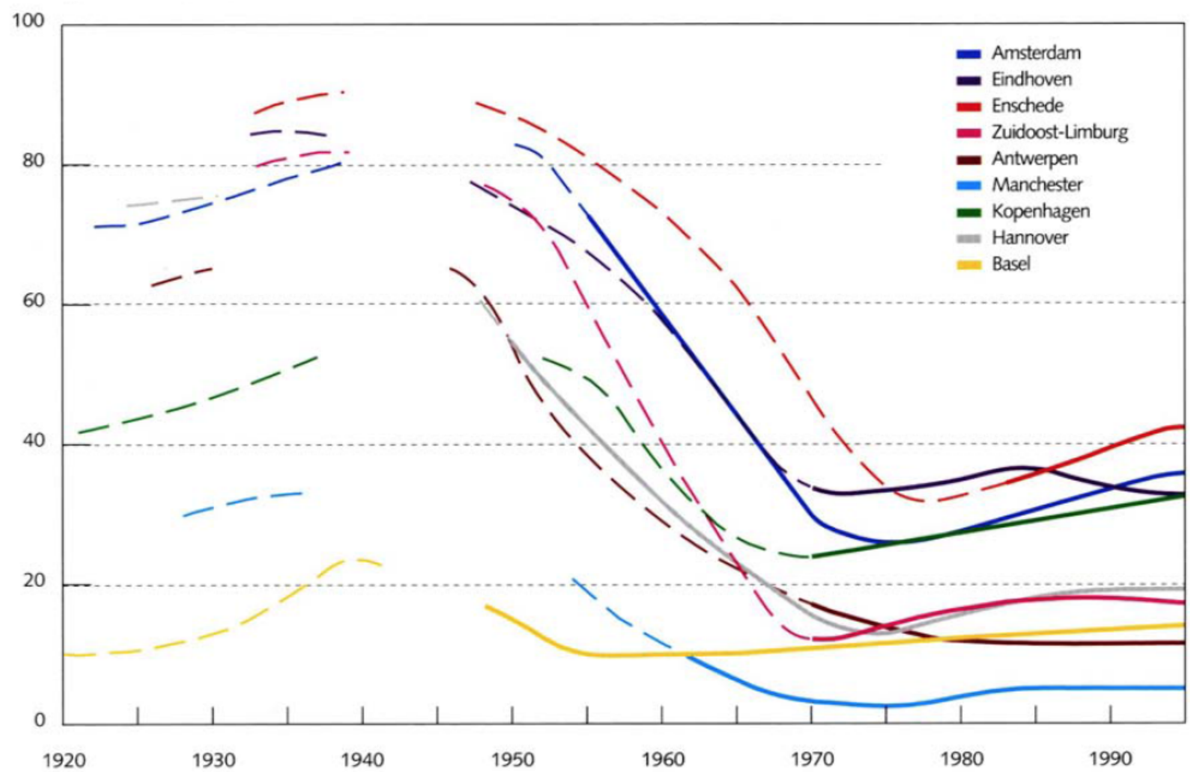


Figure 2.2. The share of bicycling in total of motorized individual transportation and public transportation (walking excluded) in various cities in Europe, 1920 – 1995 (Bruhèze and Veraart 1999, referred in Bertolini 2011).

The introduction of individual motorised transport and an increased focus on road and railway infrastructure caused that bicycling as transportation mode started to decrease dramatically in these cities in the 1950's before the trend slightly began to reverse in the 1970s (figure 2.2). Owning a car was something combined with comfort, status and freedom, and better economy enabled more people to have higher standards. Bicycling as a practice disappeared until the 1970's when decision makers in Amsterdam began to plan road infrastructure on behalf of the existing urban city. The population started to resist the plans and forced the city council to have no other choice then change its decisions to balance between accessibility and livability (Bertolini 2011). As part of this change was the development of new bike routes, which then would provide the material that could be linked with the new mindsets of the citizens of Amsterdam.

Bicycling as a normal practice depends on how it is positioned within the interdependent network of social and material arrangements (Shove et al. 2012). Understanding practices within a society are important, but it requires continuous effort in fieldwork and analysis. Each individual has unique practices and how they are formed is dependent on several things. In terms of planning, it is helpful to understand how competence, meanings and material are transformed and generated. It could be helpful knowledge when making decisions about how the access to relevant elements should be distributed. Invention and disappearance of practices is a result of a transformation in the links between the elements. By understanding how links are made and broken, planners are to a greater extent able to influence people's practices.

Elements can change. If they do, does the practice evolve and become either almost the same, or it could transform into a 'better' or a 'worse' practice, depending on how drastic the attempt on influencing the elements are. The transition might include a re-arranging in daily life, and there is a challenge in deciding the moves towards achieving this. Shove says that this argues for cross-sectoral analyses of how policy making of all forms influences the texture and rhythm of daily life. Bicycling as a practice will evolve as material, meaning and competence change, and such changes are in part a consequence of the integrative work involved. A modification in the material, say the infrastructure, can require new competence. For example, new technology means technological skills, or new roads could mean new transportation patterns. It is therefore important to understand practices and the elements influence on each other, to understand the consequences of changing an element. As the development of practices is the source of changes in the social world, is studying them regarded as the key to locating the drivers of human action (Shove et al. 2012).

Shove, Pantzar and Watson's observations on previous elements involved in practices, propose that the three elements disappear in different ways, as previous competence often remain passive or inactive, material vanishes without particular notice, and meanings adds on to become part of other practices.

What do these observations mean for planners, policy makers and others seeking to promote more sustainable practices? This point could present important research but not within our abilities to investigate in this thesis. This question would rather be a step further in the investigation. Our task is to focus on what information is necessary for getting an understanding of cycling as a practice, which will create the basis for how to gain knowledge on how to facilitate the shift towards more sustainable practices. The theory of practice provides an understanding of what interventions could be built around. An understanding of practices will support defining problems, which is essential when aiming to achieve sustainable practices.

2.5 A Note on the Definition of Practices

In theories of practice are practices defining an activity that several people share and have in common. Practices define a group of people that act within a common category, but the individual could perform in different ways. Practices on the individual level are defined as practice as performance or *performed practice*, which would be the correct definition when referring to a specific person's action. In this thesis, we decided to simplify the reading experience and reduce wordiness by using the term *practice* instead of *performed practice* as a definition when referring to individual practices.

3.0 Methods

In this chapter, we will introduce the methods we have used to acquire the necessary information for conducting research. To be able to investigate big data for cyclists in collaboration with practice theory we have used different sampling methods, which helped us to gain knowledge for our research problem and question(s). We have participated in a workshop organised by the city of Copenhagen. We have used Oregon in the USA as a case study. We have collected data on voluntary cyclists in Copenhagen who participated in a mapping experiment, which we organised. The mapping experiment also included conducting in-depth interviews. The last method we have used for gaining knowledge on big data for cyclists is getting access to “Open street" cyclist data for Copenhagen in April 2017 collected by Strava Metro. The different research methods are presented in the paragraphs below, and we will describe how and when the different methods have been carried out through the master thesis period. This chapter will also describe the reliability and validity of the data and findings.

3.1 Qualitative and Quantitative Research Method

In this master thesis, we have chosen to use a qualitative and quantitative research method. As cyclist data is a relatively new research area in a world context (Romanillos et al. 2016), will different data sample methods enable us to find the advantages and shortcomings in the information that big cyclist data provide. The different methods complement each other, and regard to Creswell (2008) has it become more common to legally use quantitative and qualitative methods in the same research project. A few years ago, it was more normal to conduct research using either a quantitative or qualitative method (Creswell 2008). Hopefully, the use of both methods will help us to strengthen our conclusion. When data from both methodological approaches are used to analyse the same research question, the term “mixed methods design” is commonly used (Creswell 2008). The combination provides a complete analysis to answer a research question and following sub-questions (Creswell & Plano Clark, 2010).

The quantitative data have been based on information from the smartphone application Strava, where bicycle routes are tracked and visualised on a map, and numbers on distance, time and speed give information about the route. Strava Metro is associated with the company Strava which is a smartphone application that tracks cyclists routes. They are aggregating and anonymising the Strava Metro data to provide it to urban planners or transportation agencies which could use the data in a planning process (Strava 2017 a). The contact with Strava Metro enabled us to get access to cyclist data that represented the Strava activity in Copenhagen in April. This data is called “Open street data”. The case of Oregon in the USA enabled us insight into quantitative and qualitative data, where the Oregon Department of Transportation purchased data from Strava for information on the city’s cyclists. A meeting with Alexander Bettinardi and Susan Peithman in the Oregon Department of Transportation gave us insight into how they interpreted the data. We have collected qualitative data on cyclist practices in Copenhagen by conducting individual in-depth interviews with the participants in the Mapping Experiment. Ahead of the interviews did we systematise each participant's cyclist data from Strava. The data from the Strava application enabled assumptions of each cyclist’s practice before getting familiar with each participant. Using “mixed method design” enabled us to use qualitative data to elaborate and explain questions that the quantitative data provided. This approach is based on the fact that the quantitative data and its result will show a general overview of the research problem, while through qualitative data, it is necessary to elaborate or explain the large continuous image to enhance the validity in our master thesis (Creswell 2008). The flow in our research method is illustrated in Figure 3.1. The next paragraphs in this chapter will describe each method more accurately.

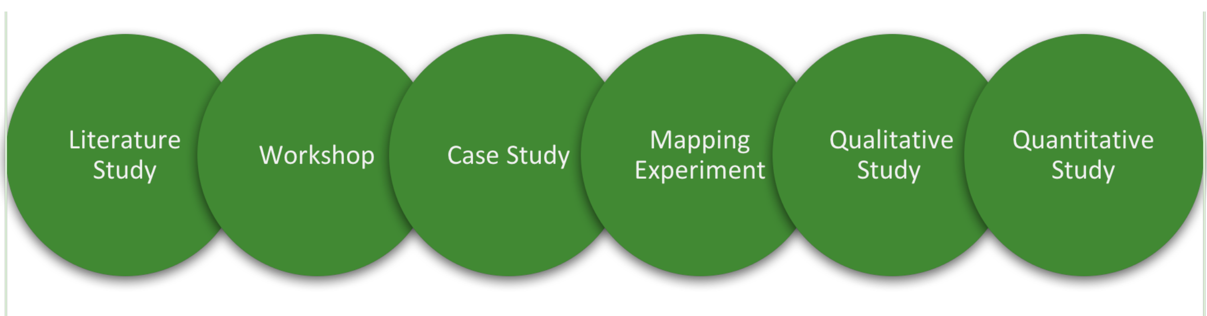


Figure 3.1 Research Method Flow through the Master Thesis.

3.2 Literature Study

Various types of literature have been used to gain knowledge of the research topic and field. Research articles and books have mainly been accessed through search engines such as the Aalborg University Library Service and Google Scholar. The following keywords were used when finding reviewed literature: Big cyclist data; GPS cyclist data; Cyclist data Copenhagen; Intelligent Transport Systems; GPS applications; Strava smartphone application; Cyclist Data Planning Tool; Cyclist Data in Oregon; Practice Theory and Mobility.

We approached our professional network such as university professors, transport agencies, and urban planners to receive relevant literature and in specific cases. These literatures were in form of research papers about cyclist behaviour, official documents from transport agencies on cyclist data, and statistics on counts of cyclists in Copenhagen. The literatures used are properly referred and cited in the master thesis and can be found in the reference list.

3.3 Workshop

The 20th of February 2017 we did participate in a workshop about *Big Cyclist Data needs and challenges in the City of Copenhagen* (City of Copenhagen 2017). The workshop was organised by the Traffic section in Copenhagen Municipality and funded by the organisation Climate KIC. The workshop consisted of presentations held by experts and the participants, and a case competition. Around 40 volunteers participated in the workshop, where the majority were urban planners or developers of intelligent transport systems. We used the workshop as an opportunity to get knowledge of the topic and discuss our ideas with experts in the field, which inspired the formulation of our research questions. The workshop presented challenges and inspired our interest in big cyclist data and intelligent transport systems. Bahar Namaki Araghi, ITS Project Manager, and Emil Tin, IT and Process Specialist in the City of Copenhagen, have been proffesionals we subsequently had contact with. During the early master thesis period, we had a meeting with Bahar Araghi about the research topic. At the end of the master thesis period, we had a meeting with Emil Tin where we presented our findings and discussed further research.

3.4 Case Study on Cyclist Data in the Oregon Department of Transportation

According to Yin (2009) a case study is an empirical study method that enables the researcher to look into a single phenomenon and the context. The purpose is to give a detailed insight into factors and variables in the research topic and how it is connected. At the beginning of the semester did we e-mail relevant persons connected to cyclist data. We wanted to use the Netherlands and the state Oregon in the USA as case studies as they have collected cyclist data for usage in an urban context. The response from the Netherlands was late, and the amount of information published online was limited. However, we decided to have Oregon in the USA as the only case study, and we managed to have regular contact. Oregon purchased data from Strava Metro as a source of information on the cyclists across the state. Our contact persons in the Oregon Department of Transportation (ODOT) were Alexander Bettinardi and Susan Peithman, where the conversations mainly were conducted through e-mail.

A case study's strength as a method is that it collects a diverse set of research techniques (Yin 2009). In the case of Oregon, the research techniques covered document analysis, literature study and interview. ODOT do not have public or official documents on their work conducted with the data from Strava. They requested a question set, which they could provide an official response to. After developing the question set and presenting it to them, we agreed on having a meeting through a virtual meeting portal that they invited us to, and the meeting allowed for clarifications and follow-up questions (Appendix 7). The meeting with Susan Peithman and Alexander Bettinardi took place Monday the 24th of April 2017 and lasted for one hour. We posed open questions in an attempt to enable ODOT to reflect upon their usage of the cyclist data and the level of relevance the data present in planning projects. By posing open questions did we not limit their answers, and we were able to receive information that we afterwards could reflect upon. The interview was recorded and transcribed directly after. We also created a structure for how this part of the analysis should be presented.

3.5 Strava Metro Data in Copenhagen

We approached Brian Riordan from Strava Metro to elaborate the possibility of accessing Strava Metro's cyclist data on Copenhagen. We agreed on one month Open Street Data in Copenhagen for April, without any cost. In cooperation with our supervisor Morten Elle, we signed a contract (Appendix 5) with Strava in April 2017. We presumed that it would give us insight into how big cyclist data can be interpreted and into what information cyclist data does provide.

A Web Visualisation tool and a Geographical Information System software enabled us to access the data from Strava Metro. In order to visualise the data in form of heat and density the web visualisation tool was provided. To access detailed information were QGIS utilised. The images used for visualising the data in the analysis of the Strava Metro is primarily from the Web Visualisation tool, as the tool has a good design for displaying the road infrastructure and the data.

3.6 The Mapping Experiment

The mapping experiment is our own data collection took place during a one-week period from Monday 27th of March to Sunday the 2nd of April 2017. The participants are cyclists in Copenhagen who voluntarily signed up for our research. We designed a flyer (Appendix 1) and shared the flyer with people outside a bicycle event in Copenhagen and on several Facebook groups, such as the group of the Danish Cyclist Federation. The result of our marketing was ten voluntary cyclists, who all did manage to participate in the whole week. We thought there might be a risk that only one type of cyclists, mainly training cyclists, could make up the sample of people since the experiment required the utilisation of a sports application (Strava). I turned out that a variety of cyclists wanted to participate in the experiment. All of the participants were cyclists that use the bicycle as the main transportation mode in their everyday life. A various sample of people was in compliance with what we desired. We ended up with three females and seven males, and the age range is from 23 years to 67 years. They are representing people who studies at university or works, are parents of young children and people who are retired. Ahead of the interviews we only knew their gender. It was not until the interviews were conducted that we got information about their age. This means that the assumptions of their bicycle practices did not rely on their age.

The ten participants in Copenhagen used the Strava application to track all their daily bike routes in one week from Monday to Sunday. They saved all their bicycle trips, and we got access to the data by following their Strava user profile. Each bicycle trip provided data about the route on a detailed digital map, and numbers on bicycling distance, time of the day, time of duration and average and maximum speed were available. During the week did we structure the information in excel templates which are attached as appendices. Regularly following their routes enabled us to interpret the data that created assumptions of their bicycling practice. When the mapping experiment came to an end we conducted in-depth interviews with each participant, to ask questions about their daily routes and route choices in Copenhagen.

The experiment was pilot-tested two weeks ahead the real experiment. One person was asked to track his bicycle routes with Strava in one week, to see if any problems occurred. The pilot test identified that it was challenging to remember to activate the application ahead of a trip, and therefore did we encourage the participants to put a visible sticker on their bike as a reminder for activating the Strava application. The pilot test also enabled us to understand what data Strava provides, and an attempt on interpreting the data enabled us to conduct a pilot test of the in-depth interview with the same person. The conducted pilot test created a starting point for introducing the experiment to the participators (Appendix 2) and the development of the interview guideline we wanted to use (Appendix 3).

3.7 In-depth Interview

Each of the ten in-depth interviews lasted for about one hour and has been conducted within a period of four days, from April the 3rd to April the 6th 2017 (Appendix 4). A structured interview guideline for all of the interviews (Appendix 3) was made by inspiration from Kvale and Brinkmann's principles of interviewing (2009). The general questions were structured and designed in a semi-structured manner, which means to enable the person being interviewed to talk openly around a question, and allows us as interviewers to ask follow-up questions (Kvale & Brinkmann 2009). The main part of the interview consisted of specific questions to each participant, and the questions were based on our assumptions from the observations from the Strava data. Practice theory's elements of practice were used to structure and inspire the questions we posed to each participant, in order to gain understanding of their practices. The interview was held in Danish/Norwegian instead of in English, to not limit their reflections upon questions in case if English language was a barrier. Only one interview was conducted in English because of the participant being international. During each interview did we use our computers to present the data in form of maps and numbers in excel sheets, which are attached for each participant in the Appendix. The maps showed their routes, and allowed us to discuss specific examples of their bicycle practices. The excel sheet and mapped routes were a useful method that supported the discussion and enabled the participant to remember their routes and their underlying choices. Regarding privacy rules did we ask each participant if there were any information we should keep confidential. The interviews were recorded if the participants accepted it, which they all did. Through the ten in-depth interviews did we as interviewers share the role as interviewer and transcriber.

3.8 Reliability and Validity of Results

The Strava application is favoured by athletes and limits the validity of the cyclist data we got from Strava Metro for April 2017. The representativeness that the cyclists represent could to a large extent rely on training cyclists. The small percentage that Strava cyclists represent of the total amount of cyclists does also limit the scope of the data. Despite the fact that the type of cyclist who represent the Strava data mainly represent training cyclists, the Open Street Data will be valid in terms of giving indications on the usage of Copenhagen's infrastructure. It also gives us an insight into how big cyclist data works in a planning context.

The number of 10 voluntary participants with a wide range of age, gender and occupation made it possible for us to distinguish between different types of life stages and practices. The variation the participants represent has benefited the research and the analysis. We posed open questions during the in-depth interviews to not affect their answers but rather allow for reflections. The interviews were recorded and transcribed, and the analyses of the mapping experiment present the answers that were given from each participant. The 15th of May did we provide each participant with the first draft of the analysis of their bicycle practice that enabled the participants to give us feedback on their respective parts and comment if the rendering was misleading or private.

The interview with ODOT is conducted with persons that have a central role in the purchase of the Strava data as both have been involved in the cyclist data project before it was purchased. They are still involved with the data today. Susan Peithman is a valid source of information in this case as she identified the need for cyclist data and proposed the purchase of Strava data. She is currently partly working on identifying research projects that relate to findings in the Strava data. Alexander Bettinardi advised the Strava purchase and was involved in designing the structure of the data. He is currently working with data analysis. We therefore qualify the response from Bettinardi and Peithman as valid answers that represent ODOT's usage of the data.

Chapter 03. Method has described the methods in our master thesis. The master thesis has an affordable quality as the choice of methods, appendices and references have been carefully reviewed which give the thesis a more verifiable standpoint, to enable the reader to understand how specific information is obtained in the thesis.

4.0 Analysis

The empirical data have been analysed to create the basis of our further discussion and reflection upon our sub-questions. The first part of the analysis presents the Oregon Department of Transportation and their utilisation of the cyclist data they purchased from Strava Metro. The second part presents the analysis on cyclist data in Copenhagen, which we received from Strava Metro. The third part presents an analysis of the Mapping Experiment, which includes analysis of the interpretation of the Strava data for each participant followed by an analysis of the respective in-depth interview. Each chapter presents the content of the different parts.

4.1 Part 1 - Big Cyclist Data in Oregon, USA

The first part of our analysis is about Oregon Department of Transportation in the USA and how they have used data from Strava Metro in their bicycling planning. We will introduce Oregon and look into the literature that provide knowledge about Oregon as a bicycle state, Strava Metro as a supplier of big cyclist data, and what research that has been conducted in Oregon in connection with cyclist data. Furthermore, we will continue with analysing the outcomes of the interview with Alexander Bettinardi and Susan Peithman, where the elements of practice theory are in focus.

4.1.1 Oregon Department of Transportation

Oregon is a state located on the West coast of the United States. The Oregon Department of Transportation (ODOT) was the first state transportation agency to purchase data from Strava Metro. As we mentioned in Chapter 1.Introduction, did the Strava Metro data have an economic cost of $20 000 USD, covering one and a half year of the Strava users bicycle rides in Oregon for each minute of 2013 and half of 2014 (ODOT 2016a).

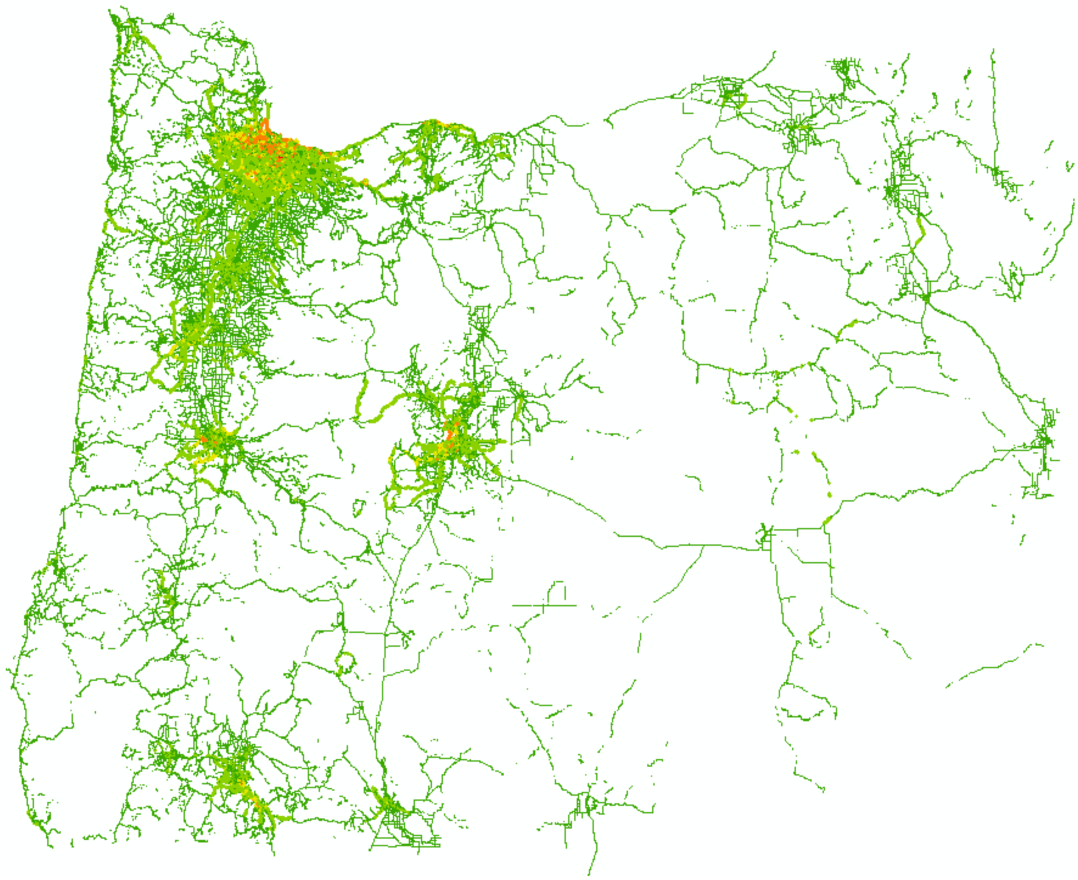


Figure 4.1.1 Heat map, Oregon. The colour (green - red) indicates the Strava activity across the state (ODOT 2016a).

The Open Street Map (OSM) that Strava Metro uses for visualising bicycle activity requires to be accessed in a Geographical Information System (GIS) software. The figure 4.1.1 shows a heat map of Oregon and indicates the level of cyclist activity. The lowest volume of bicycle activity are symbolised with green colour (11 - 100), orange signifies medium bicycle activity (101 - 500) and the highest volume of bicycle activity are symbolised with red colour (501 - 10 000). If the data is to be delivered as a product to customers such as transport agencies does Strava Metro process the data to deliver a product that does not compromise privacy. Strava Metro describe their service as: *"Strava Metro makes riding, running and walking in cities better. Millions of people upload their rides and runs to Strava every week via their smartphone or GPS device. Metro anonymizes and aggregates this data and then partners with departments of transportation and city planning groups to improve infrastructure for bicyclists and pedestrians" (Strava 2017).*

According to a document that describes the purpose and needs for the Strava bicycle data project (ODOT 2014) did ODOT want assistance from Strava Metro to understand how and where bicyclists are bicycling in Oregon, rather than how many. The document emphasises that strategies for volume data collection are still needed, as bicycle and pedestrian information is very limited in the State (ibid.). Also a part of the reason why they wanted cyclist data was because they desired to know where to put bike counters and how to adjust the location of existing bike counters to capture more bicycling behaviour (ODOT 2016a, Strava 2017b). According to Strava, has Portland in Oregon experienced an increase in the amount of bicyclists from 1.1 % in 1990 to 7.2 % in 2015, which is the highest rate in the United States (Strava 2017 b). As an example to illustrate the number of bicyclists in Portland has Copenhagen experienced that bike commuters have grown from 30 % in 1990 to 50 % today (Strava 2017b). In the US has the investment in motorise travel options like highways and transit facilities been a priority when building the infrastructure (Broach et al. 2012). In recent years have politicians began to gain knowledge of sustainable transport and the potential for better health and environment in planning, and there is nowadays a greater focus on pedestrian and bike planning in American cities (Broach et al. 2012). Jennifer Dill, a researcher at the State University of Portland, has conducted research on cyclist data in Portland in collaboration with other researchers. They developed a method for sampling bicyclist data, by using GPS units to observe the behaviour of 164 non-exercise cyclists in Portland. This resulted in a bicycle route choice model, and the findings included that cyclists in Portland are sensitive to route distance, traffic lights, and traffic volume, and less sensitive to other infrastructure characteristics such as off-street bike paths and bridge facilitations for commute trips (Broach et al. 2012). More recently did Broach and Dill conduct further research in Portland, which is titled Using Predicted Bicyclist and Pedestrian Route Choice to Enhance Mode (Broach and Dill 2016). The result is base on the previous research conducted in 2012, and now they discovered that the connection between route and mode choice was even clearer than previously (Broach and Dill 2016).

Apparently it is not only the state that tries to understand the usage of the bike infrastructure in Oregon with help from big cyclist data, as Jennifer Dill and others have shown interest in conducting research in this field. In May 2016 did Oregon adopt a Bicycle and Pedestrian Mode Plan that supports decision making for walking and bicycling investments, and includes strategies and programs. The cyclist data from Strava suppose to help filling in the gaps that are described in the plan (ODOT 2016b).

Susan Peithman, the active transportation policy lead at ODOT, explains that they did not have adequate bicycle count data across the state. Together with her colleague Margi Bradway (now at Portland Bureau of Transportation), they elaborated the idea about using Strava data in supporting bicycling planning. They both used Strava themselves for tracking their bicycle routes and thought that the application presented an opportunity for capturing cyclist data as many users voluntarily put their cyclist data forward to a certain extent. *"(...) there were no good data in general, so at least this was something, you know" (Appendix 7).* In 2013, they only had access to live point data in the form of countings from a few local permanent counters, and also from a couple of permanent counters on some of the larger off-street trails and designated recreational routes. As an agency did they not have a comprehensive count program at Oregon, and the cyclist data from Strava could facilitate the development of a program (Bettinardi and Peithman 2017).

After the contract between ODOT and Strava was negotiate did ODOT receive bicyclist data for the entire 2013 and six months in 2014, which included data on activity counts, time of day profiles, and counts of cyclist cross over a given link minute by minute. Margi Bradway worked with the analysis of the data together with Alexander Bettinardi, who advised the Strava purchase and became the data analysis resource (Bettinardi and Peithman 2017). Strava Metro was able to separate the bike trips into travels to work (commute) and other trips such as recreational travels. Strava did this based on details like the origin and destination of the bike trip, the time of day and the duration of the activity. Strava processed the data before delivering it to ODOT in order to protect the privacy of the users. ODOT only received segment level counts, which were not connected in order to form a full picture of how people are bicycling and why (Bettinardi and Peithman 2017).

ODOT's purchase of bicyclist data from Strava is innovative, as the knowledge of cyclist data in planning was and still is limited. The collection of cyclist data is to a less extent elaborated in literature or research papers as the field is beginning to develop. In order to gain knowledge on how the cyclist data has been used and discuss the purchase with ODOT did we succeed in conducting an interview with Susan Peithman and Alexander Bettinardi on Monday the 24th of April 2017. They both work in the Oregon Department Of Transportation. We connected through a virtual meeting as they are located in Oregon, and we are located in Copenhagen. During the interview did we ask them questions that allowed them to reflect upon what information the Strava data could give answers to in planning cases, and to what extent the information have informed the decision making in the planning of bicycle infrastructure. The interview gave us insight in how ODOT until now have interpreted the data in some project.

The information from the interview meeting will be presented according to the elements in practice theory, to get an understanding of what extent the Strava data gave ODOT insight to bicycle practices. It could be quite adjudicating to place information from the interview within only one of the elements as the elements affect each other, but we have chosen to structure the interview analysis in relation to where we believe the information has the most belonging.

4.1.2 Competence

This paragraph will elaborate to what extent ODOT got an understanding of cyclists' competences when analysing the Strava data.

Strava were able to identify rides for a commute. Other rides could be for example a recreational type of ride, but this type of travels was not categorised. Identifying trips for commute enabled ODOT to get an understanding of to what extent this type of travel existed at a certain road segment, without knowing specific users. The Strava data could enable to form certain characteristic features of this type of travel, for example where they tend to appear and when. Bettinardi explains that by looking at the Strava data could they analyse that commute trips are conducted in the morning and the afternoon.

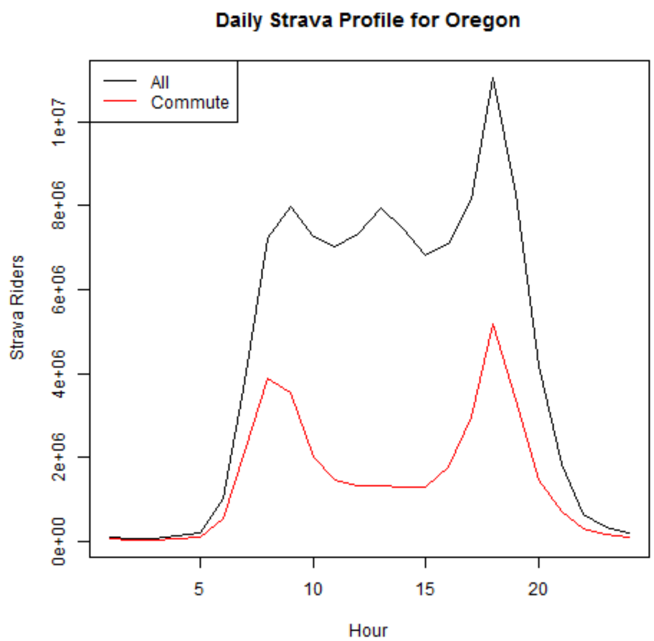


Figure 4.1.2 Time of the day profile of commute rides versus all rides (Bettinardi and Peithman 2017).

The figure shows the number of daily Strava rides in Oregon, distinguishing between rides for commute and the rides in total. The graph for all Strava rides shows that the amount increases at the beginning of the day and peaks between 15:00 and 20:00 before the graph point downwards, compared to the commute trips where the commuter trend have much more morning and afternoon peak characteristics (Bettinardi and Peithman 2017).

4.1.3 Material

This paragraph will elaborate to what extent ODOT got an understanding of cyclists' material when analysing the Strava data.

By looking at the maps provided from Strava (figure 4.1.3) and the numbers on how many cyclists there are in certain segments in Oregon, would it be possible to identify where people bike and where the most popular road segments are located. Further, this would provide some thoughts about which infrastructure that should be prioritised.

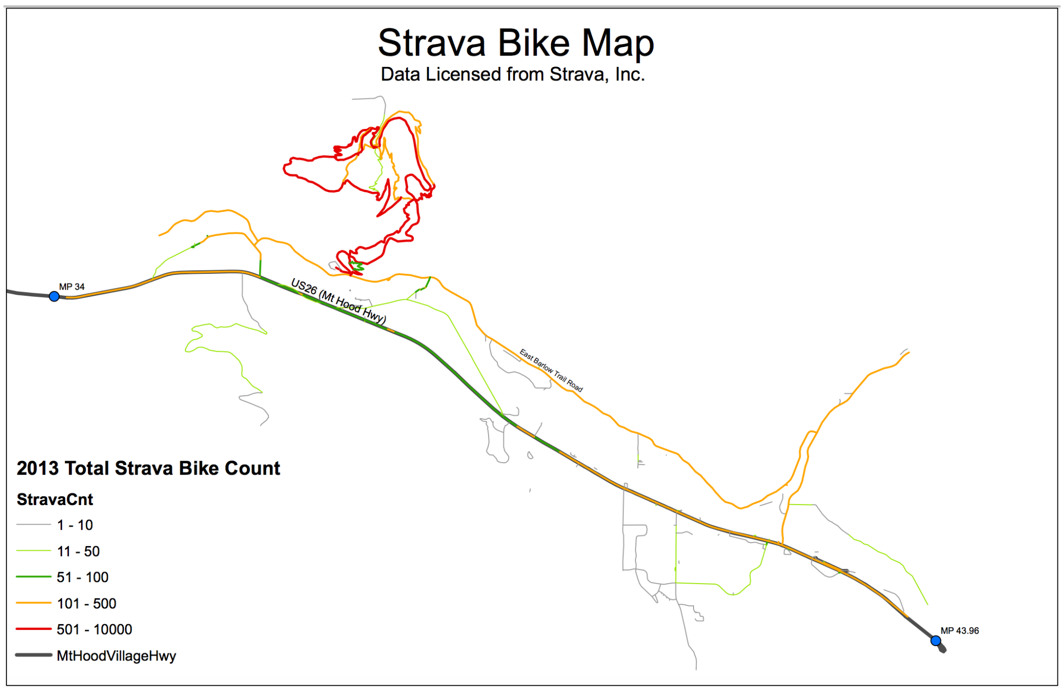


Figure 4.1.3. Total Strava Bike Count at Highway 26 and surrounding bike paths (Bettinardi and Peithman 2017).

Figure 4.1.3 shows a specific example of what the Strava data helped ODOT to identify. ODOT were asked about what kind of use this mountain highway gets. The Strava data allowed ODOT to quickly pull up a map that shows the usage of the segment(s). The map shows some orange lines on the state highway, but on the parallel trail road is the orange colour more consistent. *"(...) like an example to me this might say that we did spend a lot of time and resources putting a bike lane on Highway 26, and we could try and make a much safer bike path up on the parallel facility (...)"*. The Strava data identified an alternative route that they were previously unaware of in this case.

Peithman explains that if they have identified a target area for improvements, could the Strava data help them on deciding where the best place is to put money. *"(...) Would it be on state roads or should we support improving the local roads with access to the state roads? (...) Because our long-term goal is to develop a full project list of places in the state that have gaps, and then if there is a gap in the state system we would use something like the Strava data to determine if it is more appropriate to fix the gap on the state roadway or to support an alternative local route"* (Appendix 7). She further explains that the Strava data is a nice compliment when making a case for case decisions in specific projects, and refers to the parallel route example that could help decide where the best place is to upgrade and facilitate. ODOT have found out that *"(...) routes that are more heavily used by Strava riders are also more heavily used by the general bicycling public. Therefore, if there are two parallel roads and one has more Strava users, one could reasonably say that the route with more Strava users is also more popular with the general public"* (Appendix 6). This statement can indicate that ODOT makes decisions based on the most popular used road.

Based on where cyclists' rides do the Strava data provide information on which areas that should be prioritised when improving infrastructure. The Strava data could also provide a deeper look into types of facilities that people prefer if there are any options within a certain target area (Bettinardi and Peithman 2017), as the parallel route example illustrates.

The time of the year profiles that the Strava data provide could be used in specific cases when looking at exactly when in a year people are outside using the infrastructure. ODOT used the Strava data in a specific situation where they were asked about when maintenance should go out to sweep the shoulder for bicyclists. The time of day profile on that certain area showed that more of the Strava riders are out in the summer, and not that much in the winter. The maintenance work was then advised to be done in the off-season which is the winter, and also probably before spring when the season starts.

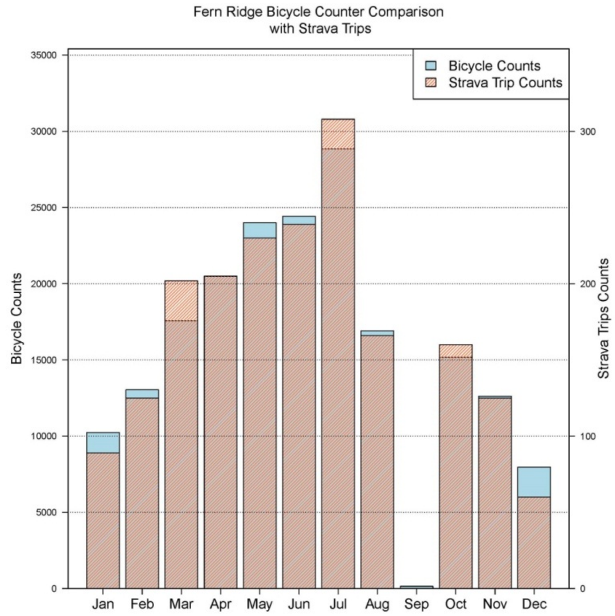


Figure 4.1.4. Diversity in counts of trips that Strava and the count station represent, Jan. – Dec. 2013 (ODOT 2016a).

ODOT would also use the data for making valid arguments about that infrastructure are being used, which is necessary in the context of the United States as bicycle issues need to be proved. *"The Strava data have been really good at showing that there are people riding places"* (Appendix 7). The largest volume of cyclist data comes from Portland, which makes sense, as Portland is the biggest city in the state.

What the Strava data also enabled to identify was the variety of routes people chose to bike at particular areas. In a specific case about bicycle traffic on a bridge above a highway did the Strava data identify that cyclists chose different roads to access the bridge. The bicycle counter located at the bridge did therefore not capture all the traffic, which became an issue. The Strava data enabled ODOT to find a new location for counters, which captured more of the bicycling activity (Maus 2014). This example does also relate to the competence of bicycle practices, as it identifies that cyclists choose different routes in this area.

4.1.4 Meaning

This paragraph will elaborate to what extent ODOT got an understanding of the meaning behind cyclists' choices when analysing the Strava data.

According to Bettinardi (2017) is the closest ODOT has got to understand why people are out bicycling and using the system is when looking at the seasonality and the time of the day. For example, could the Strava data on seasonality identify the amount of Strava cyclist in summer compared to the winter, and also show the number of Strava riders at different times of the day. This could enable assumptions on why people are not bicycling at particular parts of the day or year. The Figure 4.1.5 below shows the amount of cyclist at a recreational route in the desert on a day during the summer season.

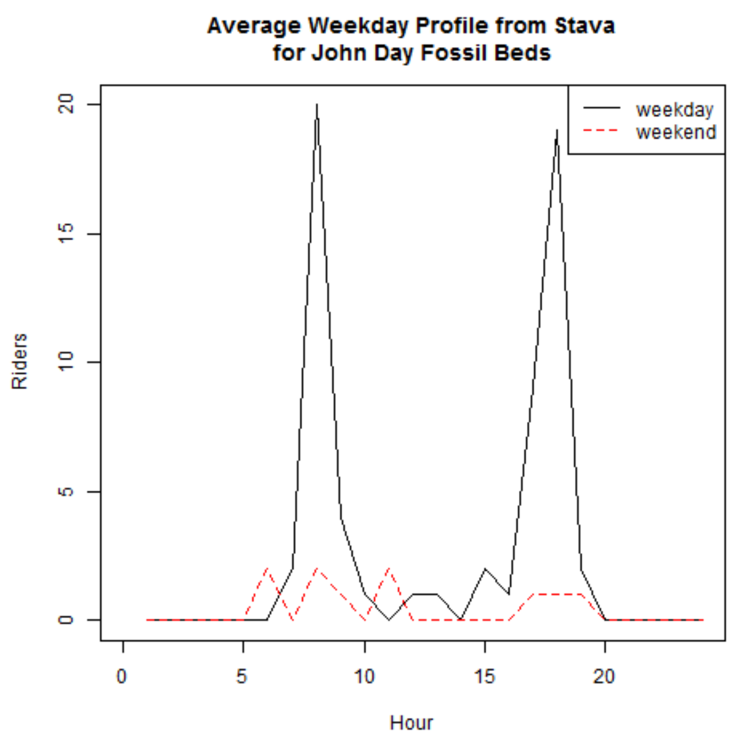
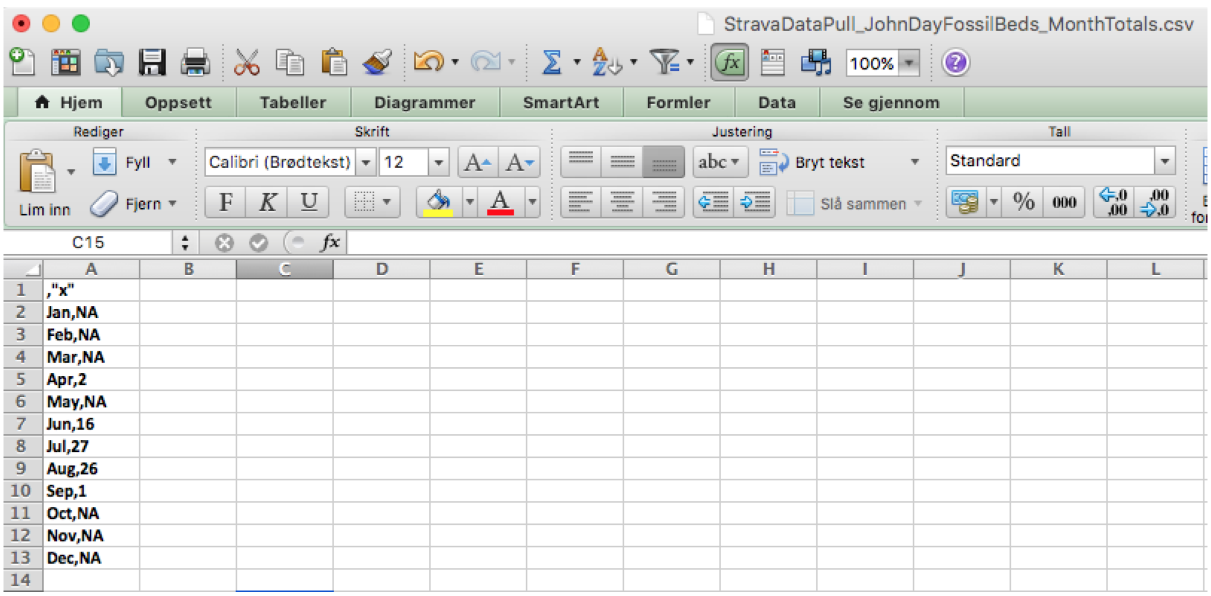


Figure 4.1.5. Cyclist counts on an average weekday during summer (Bettinardi and Peithman 2017).

The amount of Strava riders peaks at the morning and in the afternoon and is rather low in the middle of the day during a weekday, which shows that people avoid bicycling at this route at this time of the day. As the route are located in the desert are ODOT able to assume that people avoid this area at midday during summer because of the outside temperature is being too hot and therefore unsuitable for bicycling. As the graph peaks in the morning and in the afternoon shows that people rather bike at this part of the day when the sun often is less intense.

Looking at the data for the same route have identified that almost zero Strava riders are bicycling this route during winter. The figure 4.1.6 present data for which month the most cyclists are riding in.


StravaDataPull_JohnDayFossilBeds_MonthTotals.csv

	A
1	,"x"
2	Jan,NA
3	Feb,NA
4	Mar,NA
5	Apr,2
6	May,NA
7	Jun,16
8	Jul,27
9	Aug,26
10	Sep,1
11	Oct,NA
12	Nov,NA
13	Dec,NA
14	

Figure 4.1.6 Monthly counts of Strava cyclists at John Day Fossil Beds, Oregon (Bettinardi and Peithman 2017).

"(...)we can look at what month they are riding in, and again this is a desert, and I guess snow in the winter, and you can see no one is riding out in the winter months and the only riders are in the summer". Likelihood of snow during winter allows ODOT to assume that snow is the reason for why cyclists are not bicycling in the desert during winter.

The Strava data could be used for supporting certain "background" knowledge. For example, it is assumed that a low number of people are bicycling during the winter, and the Strava data provides numbers that prove this regarding its cyclists. The reasons behind why the number of bicyclists is low at certain times of the year or the day are not possible to identify by only looking at the Strava data.

4.1.5 Summary of ODOT's Utilisation of Big Cyclist Data

ODOT have used the Strava Metro data in specific projects that needed to understand bike travel where no other information was available (Appendix 6). In those cases of specific questions, Strava has provided very good information and helped the decision process (ibid.). Bettinardi further points out that the issue is that the data only gets accessed when there is a specific question of it, as opposed to systematically using it, which could mean building a program of bicycling improvements around what the data is telling them. The Strava data is used when it is necessary to prove with numbers or maps that people are using the infrastructure, in order to have evidence that supports arguments about the needs around upgrading and investment.

Instead of using the data for getting knowledge on why and how people bike do they to a large extent use the data for getting information on heavily used locations, the usage of certain infrastructure segments, or time of the day and time of the year counts at certain segments. This data could give an impression of why people are bicycling at a particular time of the day or year, or at certain segments. Bettinardi points out that this data is rather not used for the purpose of understanding why they are choosing to cycle, but more on looking at when they ride (Bettinardi and Peithman 2017). Further could this information to a large extent help the decision making on what routes that should be prioritised when upgrading.

"(...) it is hard to say that this Strava purchase is really tying into that (being part of an intelligent transport system), more of just trying to fill in the gap of the emptiness that exist around bicyclist and pedestrian data." - Alexander Bettinardi (Appendix 7)

Overall has the Strava Metro data enabled ODOT to understand and explain many questions regarding bike use of the system (Appendix 6). Unfortunately, do ODOT not have the appropriate resources to prioritise the analysis of the data or actively implement it in the planning of bike infrastructure (ibid.). Part of the reason could be that as a state agency do they not deal with bicycle and pedestrian movement to the same extent as cities do. They try to make it a priority and to make the best use of the purchased Strava data.

4.2 Part 2 - Strava Metro Cyclist Data for Greater Copenhagen

In Part 2 of our analysis, we intend to introduce how Strava Metro data is used as a planning visualisation tool in urban planning. Chapter 1 Introduction mentions that Strava is a company in the United States who collects cyclist data in vast amounts. Strava have developed a digital bike community where cyclists around the world track and log their rides in the Strava smartphone application. Strava Metro process this data to provide a product that can be used as a tool by such as urban planners and transport agencies. The State of Oregon was the first state in the US that purchased Strava Metro data. We as authors of this thesis managed to negotiate Strava Metro data for Copenhagen in the period of April 2017. Our contact person in Strava Metro was Brian Riordan, who has the role as the Customer Success Lead. We received the data from Riordan and his colleague Haynes Bunn, the Customer Success GIS Engineer. This data are of the same type of data that ODOT purchased from Strava in 2013-2014 but is in a newer version with more functions. We accessed the data through the geographic information system softwares QGIS, and through a web data visualisation tool. Most of the figures in part 2 are images from the web data visualisation tool. The information that the product of Strava Metro aims to provide is explained below in 4.2.1 and are followed by analysis and interpretations of Big Cyclist Data provided by 4.2.2 Strava Metro Data in Copenhagen.

4.2.1 Introduction of Strava Metro Data

Strava Metro is a product where cyclist data is visualised to enable analysis, and support infrastructure planning. The data is usually delivered over a two year period, where the data for the previous year creates a baseline for the monitoring of the next year of data. The data can distinguish between commute riders and athlete riders, and part of the day, weekend and weekday. The following paragraphs intend to explain what information the product of Strava Metro provides. The Strava Metro User Guide (2017) and Strava Data for Copenhagen are the primary sources of the information presented below.

4.2.1.1 The Default Data View

The Metro Data is visualised interactively and pictures the entire activity conducted on the infrastructure. It involves showing the number of cyclists aggregated to streets, intersections, origins and destinations. The GPS data also enable to visualise heat at street level and the crossing time at each intersection are represented. A blue to red colour scheme symbolise the streets, where the darkest blue signifies the lowest cyclist counts and the darkest red signify the highest counts of cyclist activity. The default data view present different points of view that can be switched on and off. These views represent six different options, which are explained below.

Rides

Counts of each bicycling activity that have been conducted on the road or path segment are shown in the Rides view.

Figure 4.2.1. Data View for Rides. Example on total Strava activity count in April 2017, Copenhagen (Strava Metro Web 2017).

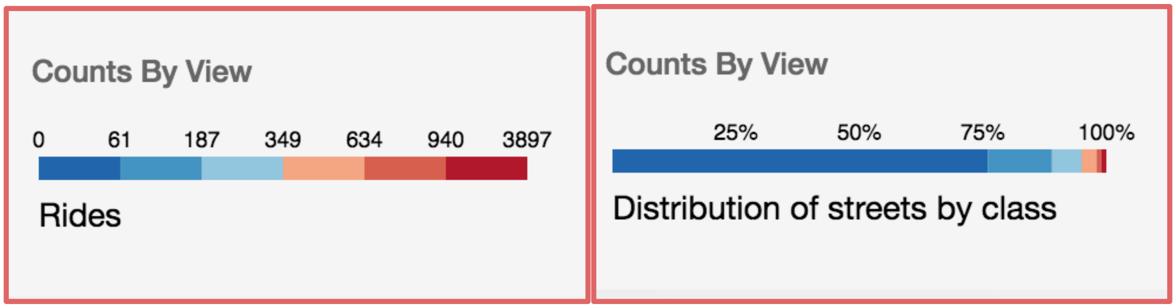


Figure 4.2.2. Total Strava activity counts in Copenhagen in April 2017. (Strava Metro Web 2017)

Commutes

The count of each bicycling activity that has been classified as a commute travel is represented at each road segment when activating the view on Commutes. The categorising of commute trips is done automatically by the Strava Metro software and is based on details as origin and destination of a bike trip, the time of the day and the duration of the activity.

Cyclists

The Data View on Cyclists represent the counts of cyclists that have biked on a given road segment. The same colour scheme (dark blue - dark red) is used to indicate the number of cyclists.

Intersections

The green "nodes" represent the activity volume in an intersection. Large nodes represent high activity. Bright nodes signify long crossing times. The crossing time presented below is based on the median value, which instead of only representing wait times also includes the crossing time to a large extent. This means that the value can at times be very low, and would not be representative in indicating the waiting time at intersections. Because of the numbers being based on the median value, there are no specific intersections that appear as especially bright in the web visualisation tool. The Strava data in GIS provides numbers on highest crossing times, which include the waiting time.

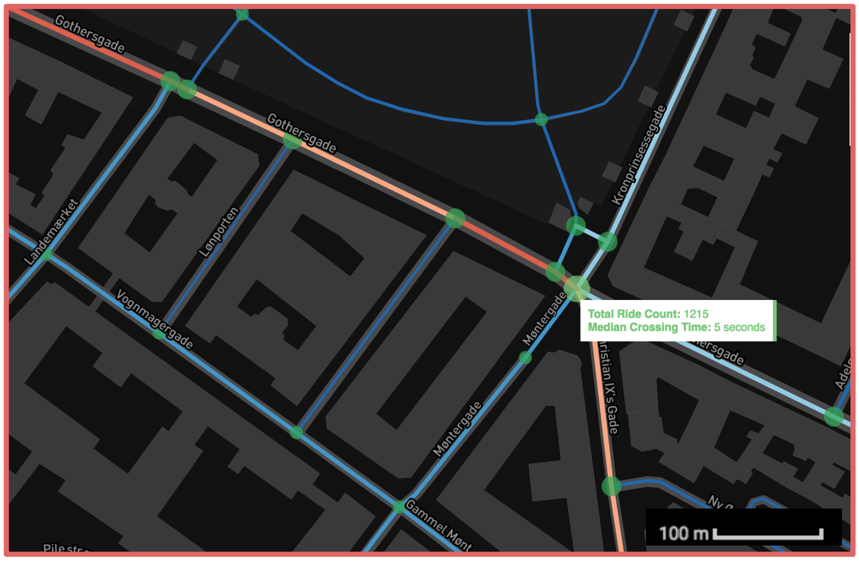


Figure 4.2.3. Intersection View. Traffic light intersection on Gothersgade. Median Crossing time 5 seconds (Strava Metro Web 2017).

Origin Destination

Polygons for Origins and Destinations are represented based on the number of rides, commutes or cyclists starting within each polygon. High counts symbolised with lighter polygons and lower counts symbolised with darker polygons. All destinations associated with a particular origin polygon could be indicated on the map. High destination counts are signified with dark pink polygons, and lower destination counts are signified with light pink polygons. This is exemplified in the figures below.

Figure 4.2.4. Indicates how many bicycling trips that have been started in which areas. Within one of the polygons; "57 Rides Started Here" (Strava Metro Web 2017).

Figure 4.2.5. Example on polygons that shows the locations of the destinations associated with a certain origin. How many trips that ended in the same polygon/area are also shown within the polygons (Strava Metro Web 2017).

The Heat Map View

Intense colour represents dense activity in the respective area.

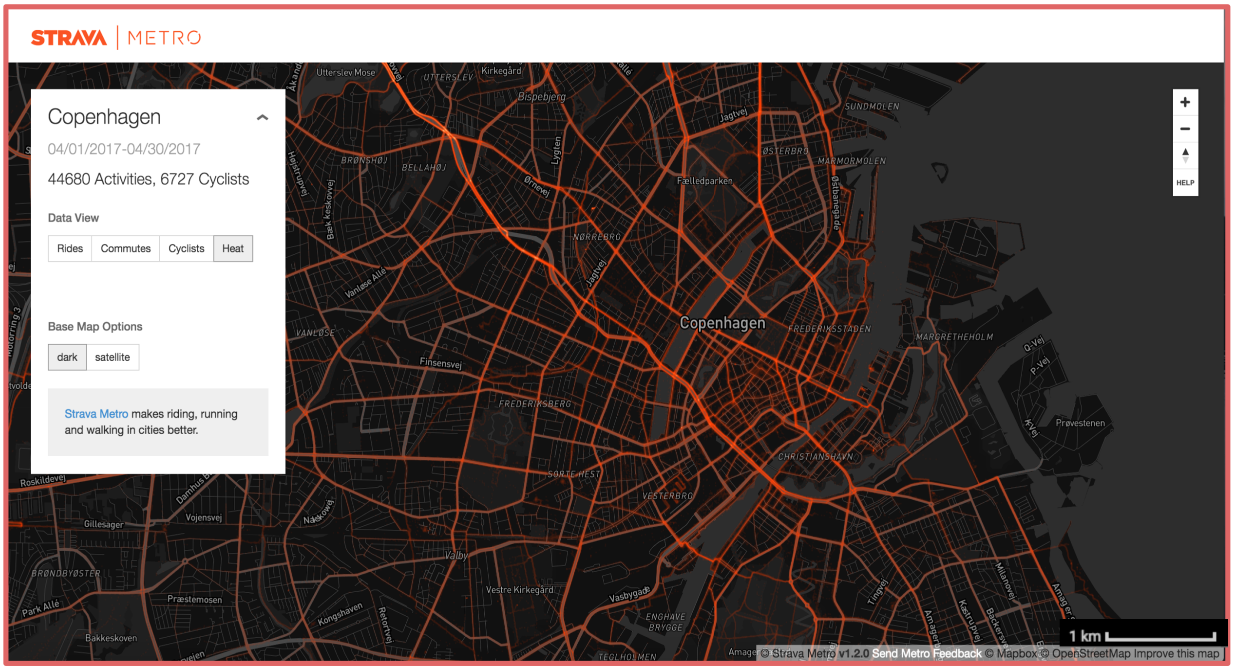


Figure 4.2.6. Heat Map Copenhagen City April 2017 (Strava Metro Web 2017).

4.2.1.2 Product Contents

Strava Metro's product consists of data files, which requires a Geographic Information System in order to be accessed. The information the data files provide are described below.

DATA	DESCRIPTION
Edges	Edges are shown as lines on the map that indicate the infrastructure network. The edges are able to show the distance of the edge/line in kilometres and metres, starting and ending points of the edge and street name.
Year, Season, and Month	Strava Metro are enable to separate trips into monthly counts. This enable to give an understanding of the peak-riding season.

Day, Hour, and Minute	This data shows counts of unique bike trips or cyclists on a road section for the day, hour and minute. The data does also give information on which direction the trips/cyclists are going on the street.
Origin Destination (Polygon) Data	The data shows polygons that represent the starting and ending polygon for all Strava bike trips. An array makes it possible to show the polygons that a trip touched during the activity. Polygons for origin and destination will protect the user's privacy as they do not show the exact start and end points. This data presents a different option when indicating recreation and commute trips.
Intersections (Nodes) Minute Data	Represent the count of cyclists or activities that have crossed an intersection for the day, hour and minute. The data are also able to provide information on intersection behaviour, which could be presented as the median, maximum, or minimum wait time at an intersection.
Demographic Files	Strava Metro provide the purchaser demographic data to support the understanding of the users that constitute the data. **Greater Copenhagen April 2017 Demographics:** **Athlete ID Count: 6727** **Activity Count: 44680** Average (Activity) Distance: 36951.854999104103 **(Meters)** Median (Activity) Distance: 27858 **(Meters)** Average (Activity) Time: 6171.1973350827979368 **(Seconds)** Median (Activity) Time: 4713 **(Seconds)**

	Male Count: 5610 Male Count Under 25: 316 Male Count 25 - 34: 878 **Male Count 35 - 44: 1326** Male Count 45 - 54: 1295 Male Count 55 - 64: 343 Male Count 65 - 74: 55 Male Count 75 - 84: 1 Male Count 85 - 94: 1 Male Count No Bday: 1393 **Female Count: 574** Female Count Under 25: 40 Female Count 25 - 34: 129 **Female Count 35 - 44: 144** Female Count 45 - 54: 89 Female Count 55 - 64: 19 Female Count 65 - 74: 3 Female Count 75 - 84: 0 Female Count 85 - 94: 0 Female Count No Bday: 150 Blank Gender Count: 0 Average Uploads: 311.2428 **Commute Counts: 22374** If we divide the activity count on the amount of athletes does the result show that each athlete in average has 6,6 activities during the month. Commute trips represent about 50% of the total activity counts.

4.2.2 Strava Metro Data in Copenhagen

During the time period of April 1, 2017 - April 30, 2017 did Strava collect cyclist data on 44 680 bike activities in total and 6727 unique cyclists in Copenhagen. The figure 4.2.7 below illustrate the area we received data from.

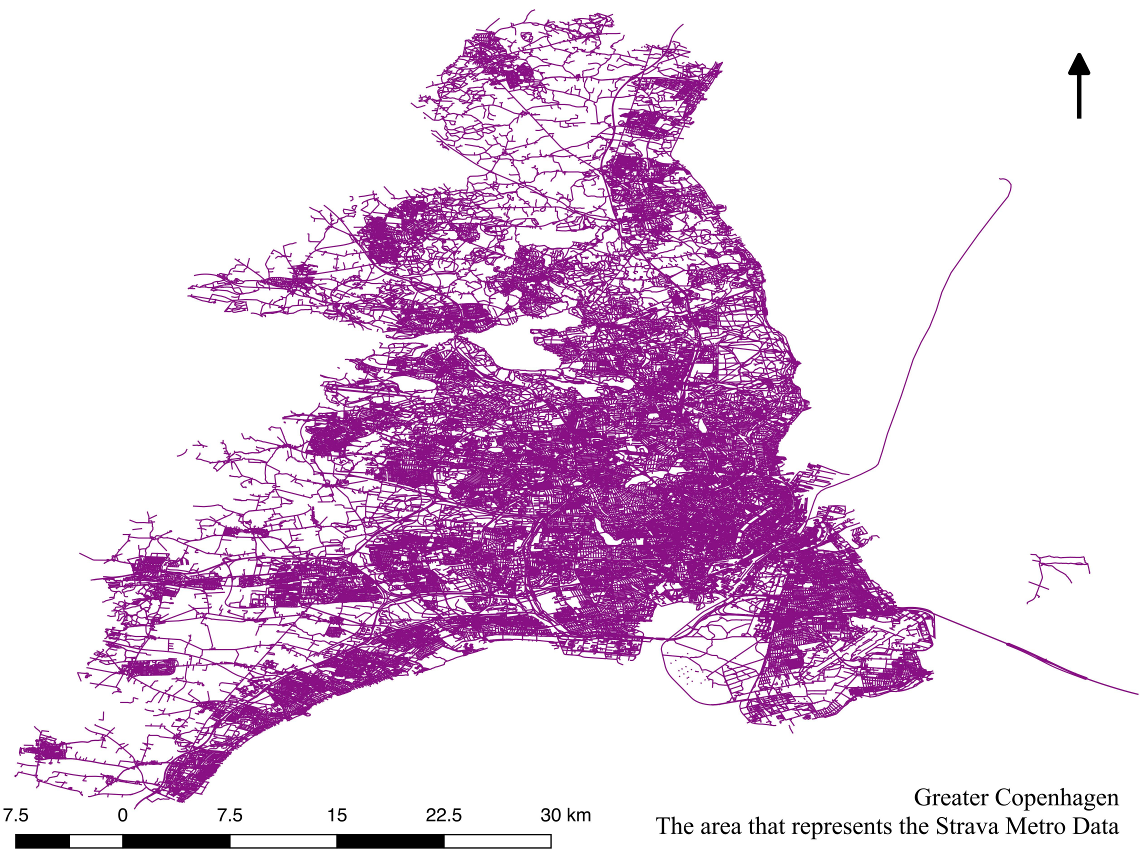


Figure 4.2.7. The area that represents the Strava Metro Data (Strava Metro Qgis 2017).

4.2.2.1 Bike Activity in Copenhagen

The Copenhagen Map below is accessed through The City of Copenhagen (Figure 4.2.8) and illustrates which roads in Copenhagen who have bike paths (lines coloured in pink, green, orange) and what bike paths that are planned to be built (dotted lines in pink, green and orange). The Copenhagen Map is used to understand the bike infrastructure in Copenhagen.

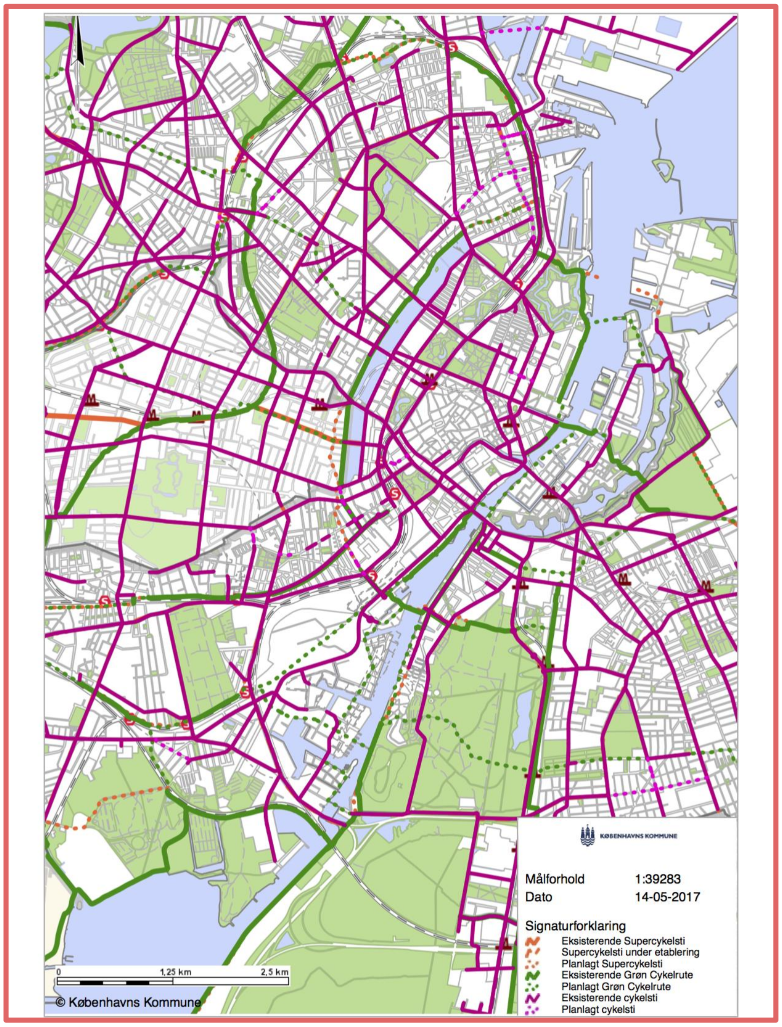


Figure 4.2.8. Copenhagen Bike Paths. Pink/Green/Orange: Existing bike path/green bike path/super bike path. Dotted lines: Planned bike paths (City of Copenhagen 2017b).

By studying the “Cykelregnskabet” for 2014, we found that the average number of rides on a weekday on Nørrebrogade was 42 600 and on Knippelsbro 41 400 bicycle rides in average on a weekday (City of Copenhagen 2014). The roads where bicyclists constitute more than 50 % of the traffic are located at Dronning Louises Bridge (Queen Louises Bridge), Nørregade, Frederiksborggade, Bremerholm, Fælledvej and Nørrebrogade (ibid.). According to “Cykelregnskabet”, the average weekday bicycle traffic across the inner city in 2014 was calculated to 267 720 rides (City of Copenhagen 2014). According to the automatic bike counter at Dr. Louise's Bridge, it was **370 431 rides in total** in direction Nørrebrogade in April 2017 (Appendix 8). At the bike counter with the Town Hall, it was **190 727 bike rides in total** in April direction northwest (Appendix 8). The Strava Metro data show **340 Strava rides** in **total** in Aptil by the count station on Dr. Louise's bridge and **781 Strava rides in total** by the count station with the Town Hall. These counts differ enormously in the number of rides and indicate that the share of Strava cyclists does represent a very low percentage of the total amount of bicyclists in Copenhagen. The Easter holiday during April affects the counts to be relatively low compared to other months, which means we can assume that the numbers may be even higher.

The map below shows the Strava cyclist activity coloured in red (high activity) and blue (low activity). The majority of the roads on the map are indicated in blue. Red lines are mainly located at main roads and in Greater Copenhagen (Figure 4.2.9). These roads tend to point towards the city centre. Some of the road sections that present high activity are located in the southwest part of Amager by the water. These roads are pedestrian and bike paths and are favourable for runners and cyclist (City of Copenhagen 2017 b), which indicate that it is used by training cyclists since the road is outside of the city centre and without car traffic that enables higher speeds. The other lines that indicate high activity are roads located in the northeast of Copenhagen, more accurately on Borups Allè, Østerbrogade/Strandvej and Lyngbyvej, which represent major transport roads in the urban and core urban region (Danish Ministry of the Environment 2015).

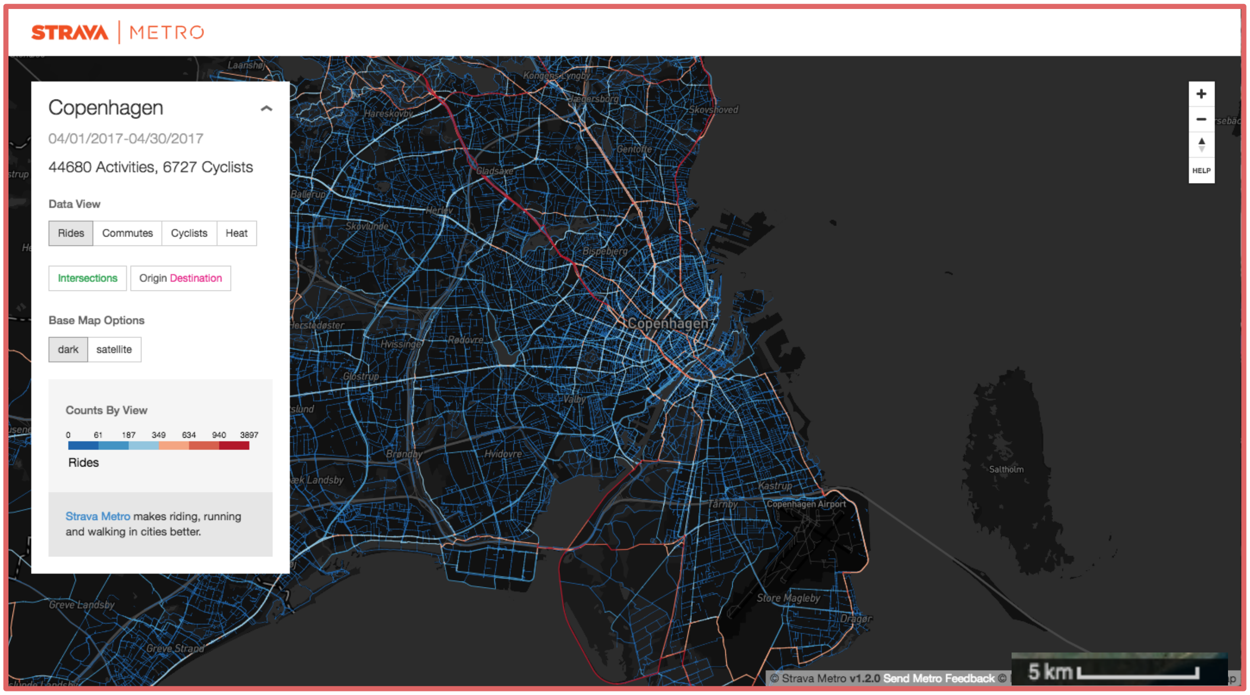


Figure 4.2.9 Data View for Rides in Copenhagen (Strava Metro Web 2017).

We found that a road section on Frederiksborgvej in Farum located outside the city of Copenhagen represent the highest Strava activity count in April, which was 3897 rides in total (figure 4.2.10). The activity count was highest between 15:00 and 19:59 during the day. Based on the total Strava activity count, the **average** amount of Strava rides **per day** is about **130 rides** on this section. The evaluation of the Farum route (Cowi 2014) present numbers on bicycle counts per day at Frederiksborgvej, where the counts have been collected by an automatic counter placed at Frederiksborgvej/Fiskebæksbroen, which is a location close to the road section representing the highest Strava activity count. The automatic counts were conducted during the third week of June in 2014. As the average amount of **Strava** rides per day is based on a number that includes counts for both weekends and weekdays, we aimed to calculate the average amount from the automatic counts with the same basis. Based on numbers from the automatic counts for both weekend and weekday, the number of bicycle trips on Frederiksborgvej represents **1555** rides **in average per day** in 2014. Comparing the Strava Metro data with the numbers from the automatic counts makes Strava represent about **8%** of the number of bicycle trips on Frederiksborgvej.

Figure 4.2.10. Highest Strava Activity Count in April 2017. Frederiksborgvej, Greater Copenhagen.

The map below (figure 4.2.11) illustrates two heavily used road segments that are indicated in orange and red (Åboulevard, Ågade, and Rantzausgade). North of the bridge does both Åboulevard and Rantzausgade appear as orange/red. The activity becomes denser where the roads are connected further north. The level of activity indicates that cyclists choose between two different roads in this area, which might be because of dense crowds on the bike paths in the area as Åboulevard is one of the main transport roads in Copenhagen. The map also signifies the Dr. Louise's Bridge with Nørrebrogade as a location with high cyclist activity. Further east does the light blue road on Fredens Bridge symbolise medium high cyclist activity. Another line/road we noticed was “Den grønne sti” or the green bike path that crosses Rantzausgade and Åboulevard and further goes direction Frederiksberg. The green bike path is separated from car traffic and involves a bike bridge that crosses Åboulevard. Medium activity on this road indicates that cyclists might choose this route instead of main roads.

Figure 4.2.11. Åboulevard, Rantzausgade, Nørrebrogade, Dr. Louises Bridge, and Fredens Bridge (light blue). The "green bike path" are symbolised as a light blue curve, which crosses Åboulevard by a bike bridge (Strava Metro 2017).

Toldbodgade (figure 4.2.13) is a street located in the urban core of Copenhagen in front of Amalienborg Slotsplads and between *Nyhavn* (south on the map) and *Kastellet* (north on the map), which are two common public places in Copenhagen. Toldbodgade is not classified as a bike path (Figure 4.2.8, City of Copenhagen 2017 b), but the Strava data indicate medium cyclist activity at this street.

Figure 4.2.12. Cars parked on Toldbodgade (Google Maps 2017).

The figure 4.2.12 above shows that there is no dedicated bike path at Toldbodgade and cars are parked on both sides of the street. The Strava data identify that the total count of Strava cyclists that are bicycling at Toldbodgade during April are 151 unique cyclists (figure 4.2.13). The bright blue colour indicates medium high cyclist activity. This data indicates that the street is used by cyclists although bicycling conditions are poor. In a planning perspective this could exemplify a situation where it is identified where cyclists desire to bike. This kind of analysis could contribute to the decision making on where new bike infrastructure should be implemented to facilitate bicycle conditions. Bike paths could replace car parking spots, contributing to a release of space and safer bicycling conditions.

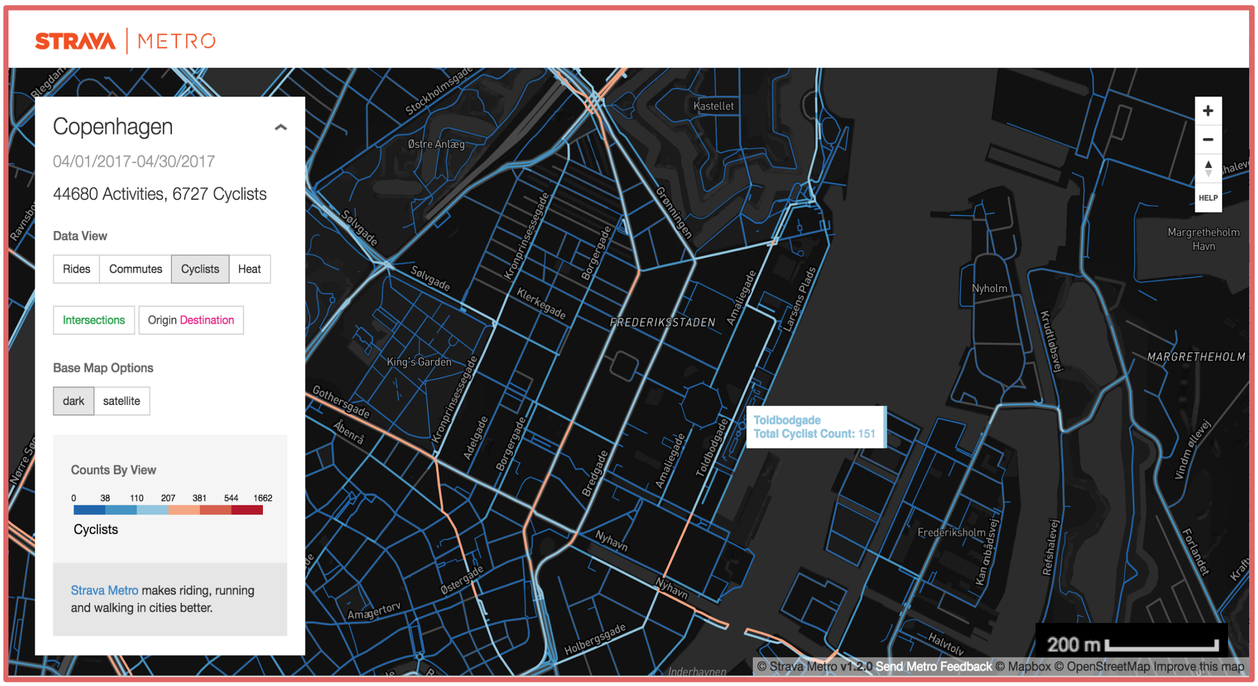


Figure 4.2.13. Data View for Cyclists on Toldbodgade (Strava Metro Web 2017).

Store Kongensgade and Bredgade are two parallel streets that are one-way direction roads, including bike and car roads. Figure 4.2.14 illustrates that Store Kongensgade (orange line) have 444 Strava rides in total and goes in direction Kongens Nytorv (towards the city centre) and Bredgade (light blue line) has 320 Strava rides in total and goes in the direction Østerbro (out of the city centre). As we have mentioned above is Toldbodgade (orange/light blue) a parallel road further east near the harbour and has traffic in both directions. The number of rides on the one-way roads to/from the city centre give us an assumption about that people chose one route when going to the city centre but another route when bicycling out of the city centre. Time of the day could maybe influence this, e.g. that people bike directly into the city centre to reach work/education, but after work/education may the person choose another route. The Strava data inform us that during morning hours does the road towards the city centre (Store Kongensgade) have 133 rides in total. The road with direction outward the city (Bredgade) has 94 rides in total during afternoon hours. This finding in Qgis can indicate that people choose direct and fast routes in the morning and chose alternative routes in the afternoon when people finish work/education.

Figure *4.2.14. Rides in Store Kongensgade (orange road) and Bredgade (light blue road) (Strava Metro Web 2017).*

4.2.2.2 Intersections

The map shows an intersection located on Åboulevard nearby the lakes at Nørrebro (Figure 4.2.15). Large nodes (green circle) indicate dense activity in the area. According to Strava data this is a busy traffic light intersection in Copenhagen, which also the orange/red colour on the road section indicates. At one of the intersections showed on the map does the count show a total of 1430 Strava rides during April. The median crossing time does only show 3 seconds, but this value is not representative for indicating waiting times. The Strava data in GIS shows numbers that represent the longest crossing time in this intersection at Åboulevard, which is a crossing time of 95 seconds during weekdays in the evening. This number is more representative in indicating the waiting time. In the morning hours, the longest crossing time at the intersection was 80 seconds on weekdays. The map shows that several roads and bike paths interact in this intersection, which might be the reason why the activity is dense and could cause long crossing times.

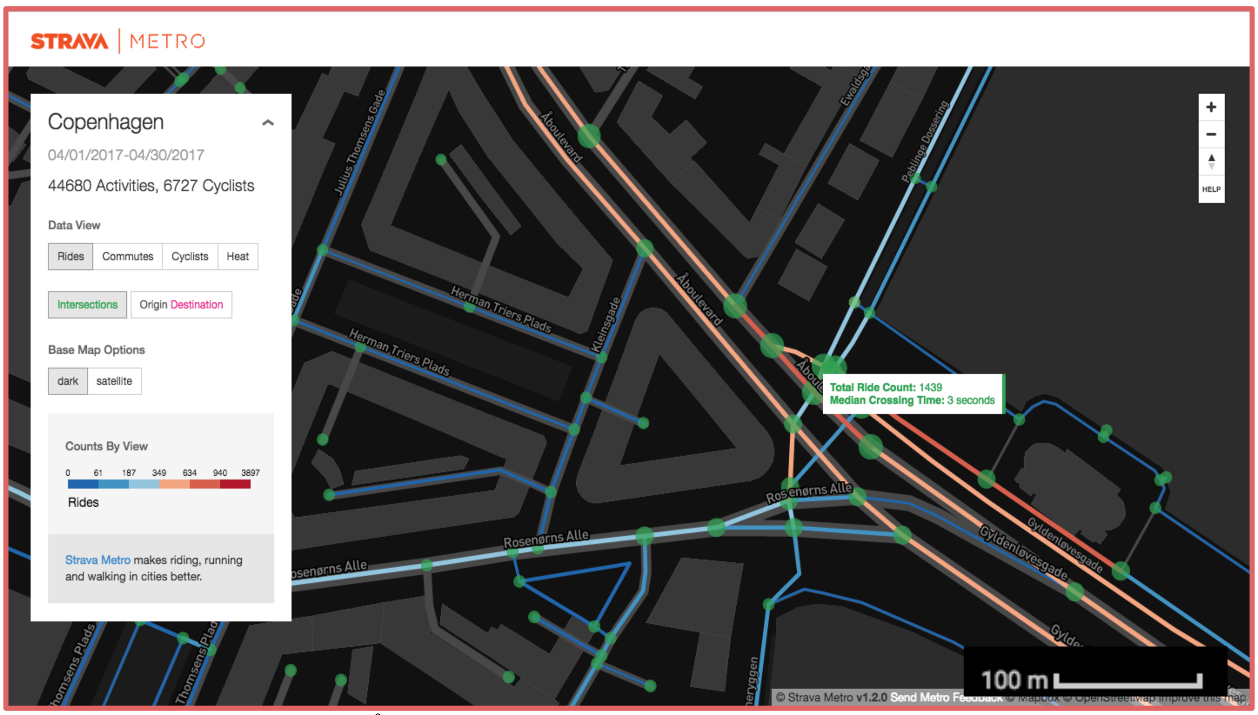


Figure 4.2.15. Intersection on Åboulevard. Total Ride Count: 1430. (Strava Metro Web 2017).

The median crossing time at a traffic light intersection on H.C. Andersen Boulevard heading towards the Town Hall does also show 3 seconds. The longest crossing time at this particular traffic light intersection shows 97 seconds on weekdays, which occurred during the evening.

The longest crossing time at this particular traffic light intersection during morning hours at weekdays were 65 seconds, and during the afternoon it was 77 seconds.

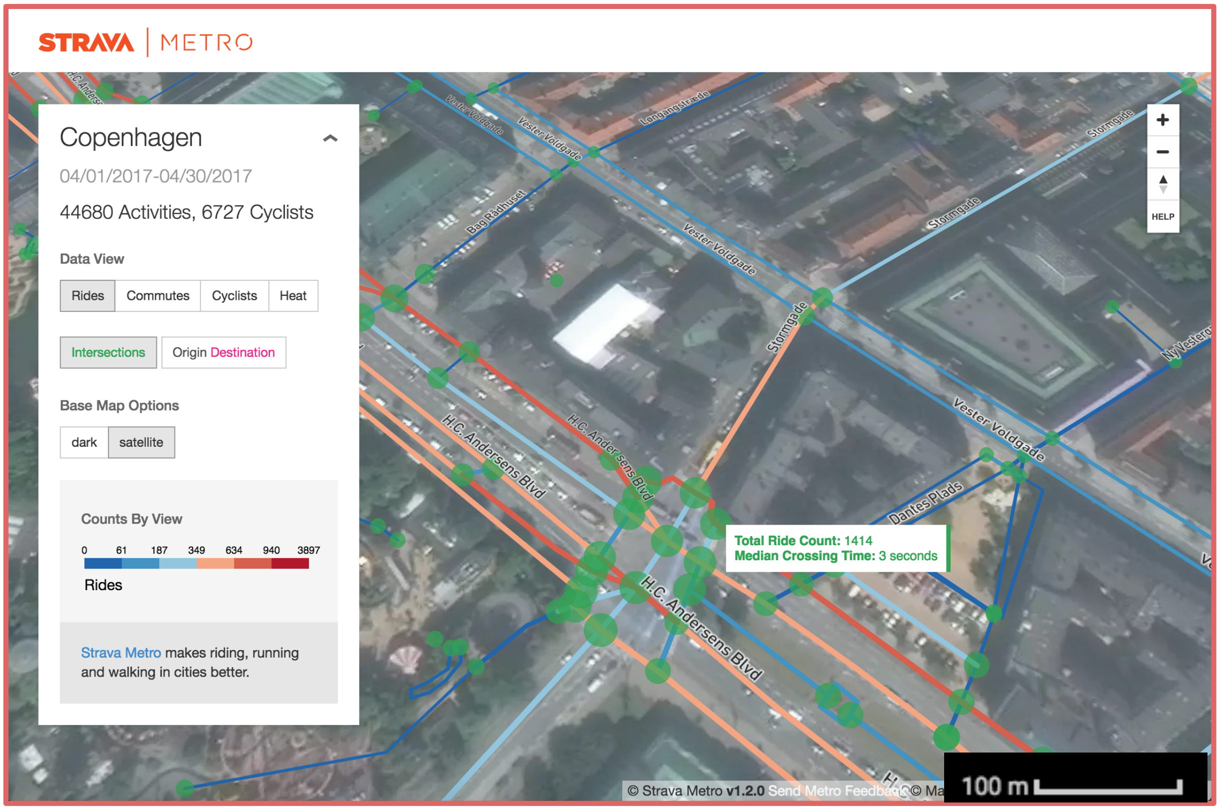


Figure 4..2.16. Traffic light intersection at H.C. Andersen Boulevard heading northeast. Total activity count: 1414 rides.

Despite that long crossing times occur does a large percentage of the Strava cyclists use this intersection. The data does not provide information about how often the long crossing times occur. The activity count and crossing times could indicate that this intersection represents an important part of the infrastructure, but that better cycling conditions in terms of shorter crossing times could be necessary to facilitate for cyclists.

4.2.2.3 Orgin Destination

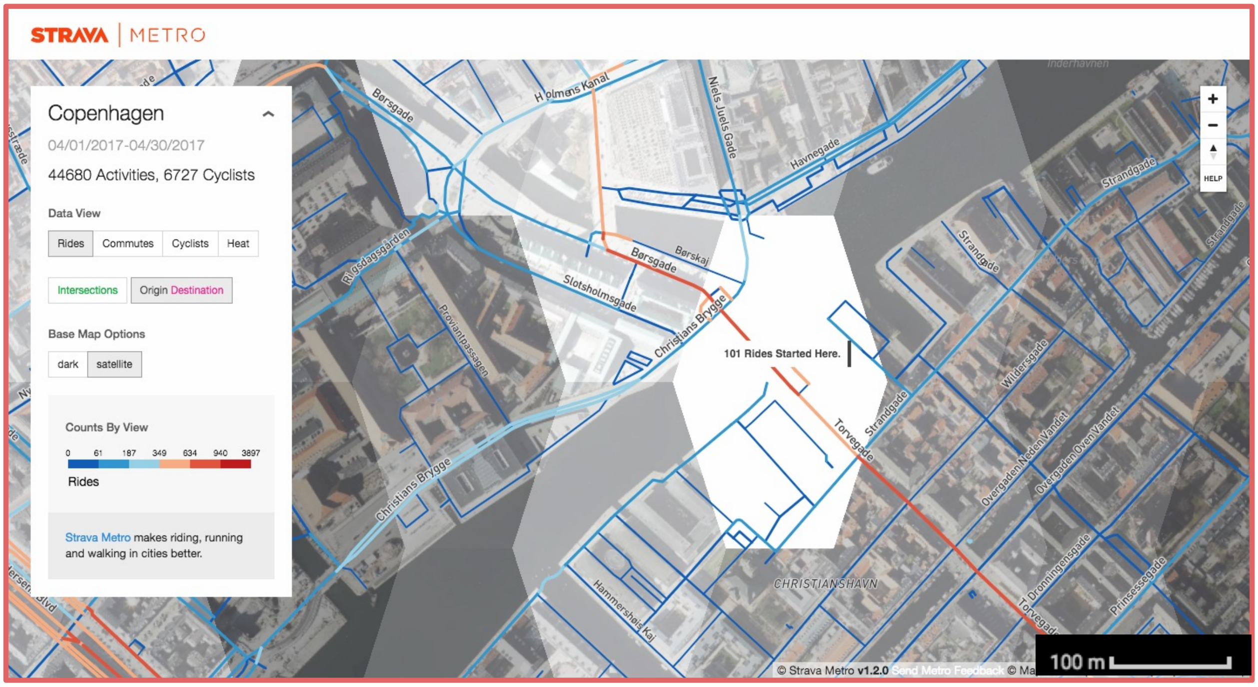


Figure 4.2.17. 101 rides started in this area of Christianshavn (Strava Metro Web).

The white polygon in Figure 4.2.17 shows the origin of 101 bicycling trips, which is in the Christianshavn area. The surrounding origins show between 20 and 50 rides. The highlighted area covers the Knippel Bridge who is one of the main thoroughfares from Christianshavn to the inner city, which could explain the difference of number on rides started in different origin areas. There are many workplaces in the harbour area, and the Metro station at Christianshavn is also located within the area of origin. The location of the metro station could influence the number of rides started in this area as it might indicate that people are taking the metro to and from work and cycle back home from the Metro station in the afternoon.

Figure 4.2.18 below illustrates in which polygons the destinations for the 101 rides from the area in Christianshavn are located. The dark pink polygon shows the destination of the majority of the rides starting by the Knippels Bridge, which are nine rides (Christianshavn to Hvidovre). The other polygons in light pink and white show the destinations where a lower number of rides ended.

Figure 4.2.18 Polygons that show the destination of the 101 activities started in Christianshavn (Strava Metro Web 2017).

The Strava data can identify what polygons/areas a trip interacted with during the ride. The polygon located at a part of Christianshavn shows information about the rides that have been started within that area. In total are there 101 unique rides. Figure 4.2.19 below presents a table of data that shows detailed information of specific trips. The exact route is not identified but the table informs about which polygons the trip intersected with during the ride. What day during the month the ride was conducted in and the time of the day is specified. The table does also identify if the trip was for commute, and what destination polygon the trip ended in.

copenhagen_edges_metro_od_data :: Features total: 42902, filtered: 42902, selected: 1

POLYGON_ID ▲	YEAR	DAY	HOUR	MINUTE	COMMUTE	DEST_POLYG	INTERSECTE
29775	2017	114	18	42	1	29441	{29441,29442,29604,29605,29606,29611,29768,2…
29775	2017	112	22	47	1	24386	{24386,24550,24551,24714,24878,25041,25204,2…
29775	2017	100	16	41	1	26981	{26981,27144,27307,27470,27633,27796,27797,2…
29775	2017	100	18	28	1	28776	{28451,28452,28613,28614,28615,28616,28617,2…
29775	2017	100	15	22	1	19334	{19334,19335,19497,19661,19823,19987,19988,1…
29775	2017	93	17	33	1	22568	{22568,22569,22570,22732,22896,23058,23222,2…
29775	2017	100	17	11	1	28472	{29775,29611,29448,29285,29122,29123,28959,2…
29775	2017	91	9	36	0	29288	{17014,17176,17177,17337,17338,17339,17341,1…
29775	2017	91	20	18	1	26840	{26840,27002,27003,27004,27005,27166,27168,2…
29775	2017	93	15	20	1	23915	{23915,24077,24241,24403,24566,24729,24892,2…
29775	2017	93	15	24	1	20490	{20490,20653,20815,20979,21141,21304,21467,2…
29775	2017	93	16	36	1	16365	{16365,16527,16691,16853,17017,17018,17180,1…
29775	2017	95	15	24	1	24044	{22584,22746,22747,22910,22911,23072,23074,2…
29775	2017	95	17	17	0	29774	{27984,27985,28147,28148,28149,28311,28312,2…
29775	2017	94	17	12	1	22235	{21748,21912,21913,22076,22077,22241,22242,2…
29775	2017	100	16	37	1	16365	{16365,16527,16691,16853,17017,17018,17180,1…
29775	2017	93	17	18	1	28855	{25460,25461,25462,25621,25622,25625,25783,2…
29775	2017	93	17	49	1	26814	{26814,26976,26977,27140,27303,27466,27629,2…

Figure 4.2.19 Detailed information on specific bicycle trips. Origin: Knippels Bridge, Christianshavn (Strava Metro QGIS).

4.2.2.4 Heat Map View

The heat map (figure 4.2.20) shows that the major roads into the city centre have the brightest colour, which means that the traffic roads and super-bike paths are the most used routes in Copenhagen by the cyclist. The well-known "Finger Plan" in Copenhagen have been used in urban planning since 1947 (Danish Ministry of the Environment 2015), which represent the main transportation corridors towards the City of Copenhagen and spreads out looking like fingers from the city centre and outwards Greater Copenhagen. The heat map illustrates that Strava riders use the road infrastructure in the city of Copenhagen to a large extent. The heat map can also indicate that many Strava cyclists are bicycling to and from the urban core of the city from the Greater Copenhagen in the north.

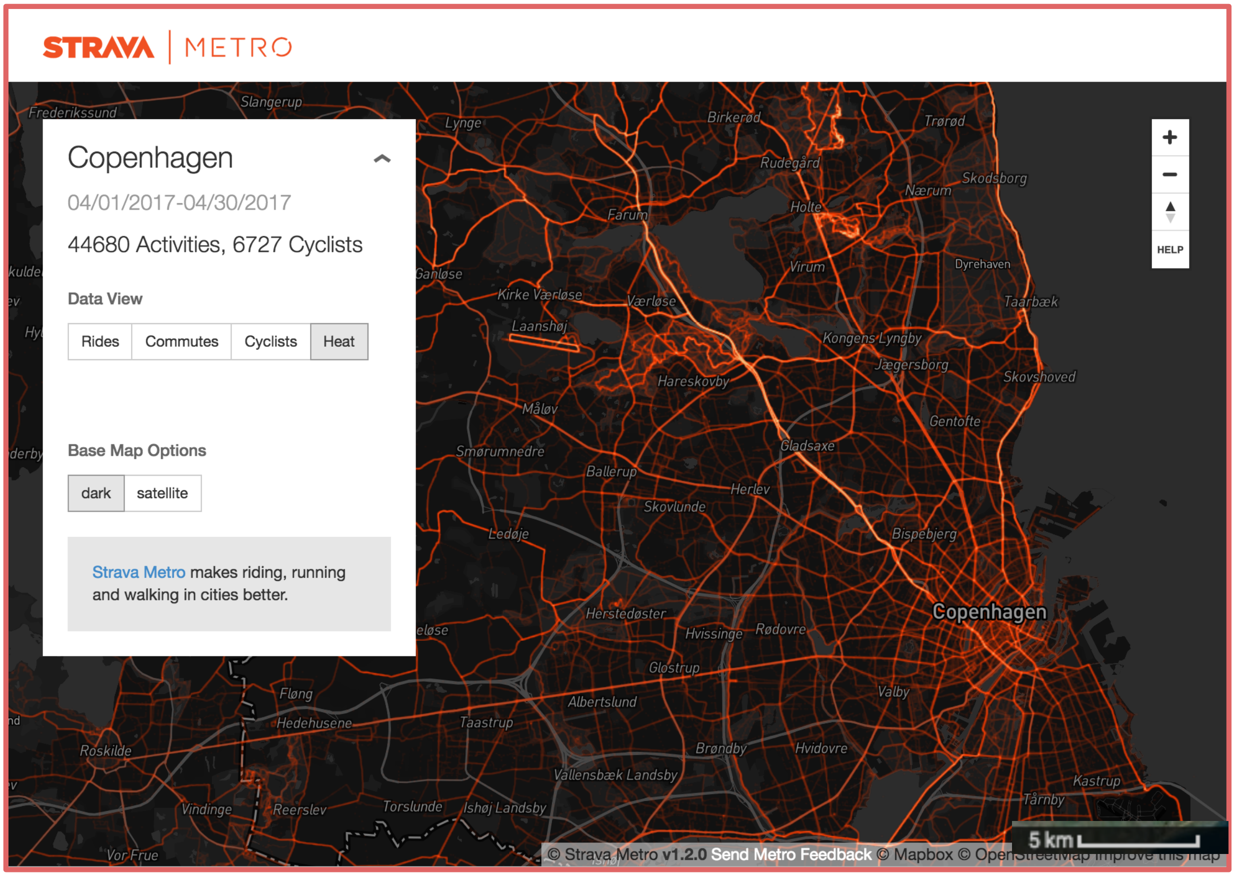


Figure 4.2.20 Heat Map of Greater Copenhagen April 2017.

4.2.3 Summary of Cyclist Data in Copenhagen

The Strava cyclist data provides an overview of the usage of the infrastructure. The Strava community represents a low share of the total amount of cyclists in Copenhagen, which limits the content of the data. However, it does indicate where cyclists intend to bike and especially highlights the most heavily used infrastructure, where one of the routes visibly is the "Farum" route that involves a super bike path and allows bicycling over longer distances. This finding supports the argument that Strava cyclists mainly represent the training cyclist.

Issues with specific type of infrastructure such as traffic light intersections could be identified. The Strava data provides a lot of detailed information and this data is especially useful in those cases of specific questions. Minute by minute counts enables analysis of daily activity in specific areas or at certain parts of the infrastructure and could support the identification of trends and characteristics. Compared to the Strava application is information on the cyclists themselves very limited in Strava Metro data, as personal information is processed to ensure privacy. We were not able to categorise any bicycle practices beyond the commute type of travels, as the data does not identify route choices or personal opinions. On the other hand, the Strava data could open up the discussion on the usage of the infrastructure and bicyclists' behaviours.

4.3 Part 3 - The Mapping Experiment

In Part 3 The mapping Experiment will we analyse the Strava data for each of the ten cyclists that participated during the week of the experiment. The cyclist data on each participant enabled us to create assumptions and develop questions about their bicycle practices, which we got answered during the interviews. To prevent the analysis in being excessively comprehensive because of large amounts of information, we have decided to simplify the analysis of half of the participants although the interviews and the data collection of each participant are similar in extent and scope. The aim is to uncomplicate the reading experience while still ensuring that necessary information is provided. We will first conduct a comprehensive analysis of five of the participants' bicycle practices, where the information are structured into 1) Strava Data, 2) Strava Map Analysis, 3) Interview Analysis, and 4) Bicycle practice according to Competence, Material and Meaning. The comprehensive analysis involves an extended explanation of our assumptions on the participant's bicycle practices and the actual reasons behind specific route choices. The Strava data includes an introduction to what extent the individual's bicycle practice can be understood by looking at numbers on distance, maximum speed, average speed, time of the day of the conducted trip, duration of the bicycle trip and the number of bicycle trips. The Strava Map Analysis contains a selection of the participant's mapped routes, where the aim is to give concrete examples of the assumptions we created about their bicycle practices. The maps give an overview of the specific route, and the time of the day the trip was conducted is showed below the maps in brackets. The Interview Analysis contains an analysis of the reasons behind their individual route choices, compared to what we assumed. The paragraphs about the participants' Bicycle practice according to Competence, Material and Meaning contain a summary of to what extent we understood the participant's bicycle practices by looking into the Strava data and conducting the interviews. Each extended analysis ends with a paragraph that compares the sources of information and the knowledge it provided.

The analysis of the five remaining participants will be presented in a shorter structure according to 1) Competence, 2) Material, and 3) Meaning. The paragraphs analyse to what extent each of the elements of practice are understood by looking at the participant's Strava data and the conducted interview.

We want to emphasise that the endeavour in collecting data and analysing the material is similar for all ten participants. Presenting the third part of the analysis in two different structures will hopefully prevent information to be repeated. Words that refer to the essence of the paragrapf are highlighted to improve the reading experience. The participants in the mapping experiment are listed below and are numbered in chapters from 4.3.1 - 4.3.10, where the extended analyses are highlighted with dark green colour and the compressed analyses are highlighted with light green colour.

4.3.1	**Female 58**	p.67
4.3.2	**Male 37**	p.75
4.3.3	**Male 25**	p.81
4.3.4	**Female 67**	p.88
4.3.5	**Male 48**	p.96
4.3.6	**Female 23**	p.101
4.3.7	**Male 61**	p.104
4.3.8	**Male 38**	p.108
4.3.9	**Male 21**	p.112
4.3.10	**Male 26**	p.115

Male Count: **7.**
Male Count Under 25: **1.**
Male Count 25 - 34: **2.**
Male Count 35 - 44: **2.**
Male Count 45 - 54: **1.**
Male Count 55 - 64: **1.**
Male Count 65 - 74: 0.
Female Count: **3.**
Female Count Under 25: **1.**
Female Count 25 - 34: 0.
Female Count 35 - 44: 0.
Female Count 45 - 54: 0.
Female Count - 55 - 64: **1.**
Female Count 65 - 74: **1.**

Figure 4.3.1 Overview of the Participants in the Mapping Experiment

4.3.1 Female 58

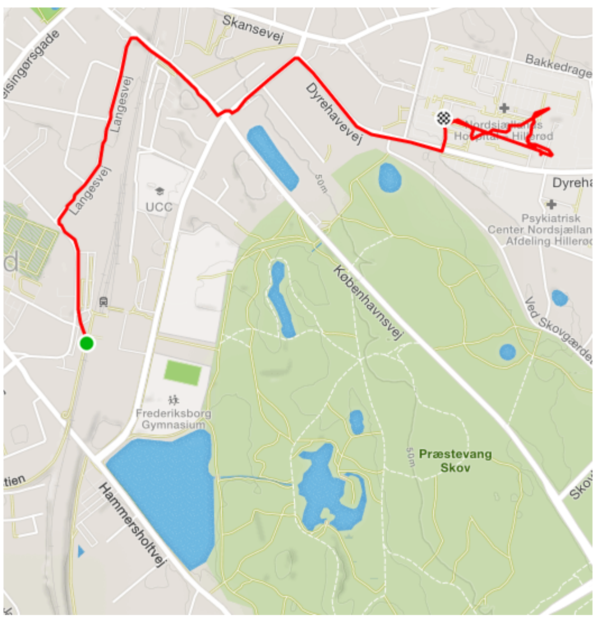
Female 58	Monday					
	Distance:	Moving Time:	Elapsed Time:	Average Speed:	Maximum Speed:	Origin - Destination
Route 1 Time 07:49	2,4 km	14:41 min	**1 h 10 min**	10 km/h	24,5 km/h	Hillerød train station - Hillerød Hospital
Route 2 Time 16:12	2 km	07:06 min	08:03 min	17,1 km/h	**73,1 km/h**	Hillerød Hospital - Hillerød train
Route 3 Time 17:04	1,9 km	09:24 min	10:47 min	12,7 km/h	28,8 km/h	Vesterbro (Ingerslevsgade) - Islands brygge
Route 4 Time 18:30	3,9 km	13:30 min	15:21 min	17,7 km/h	30,6 km/h	Islands brygge-Frederiksberg (forum)
Route 5 Time 19:55	3.9 km	14:54 min	15:35 min	16,1 km/h	34,6 km/h	Frederiksberg (forum)-island brygge

Figure 4.3.2. Strava data for Female 58 on Monday 27th of March. The complete week is available in Appendix 9a.

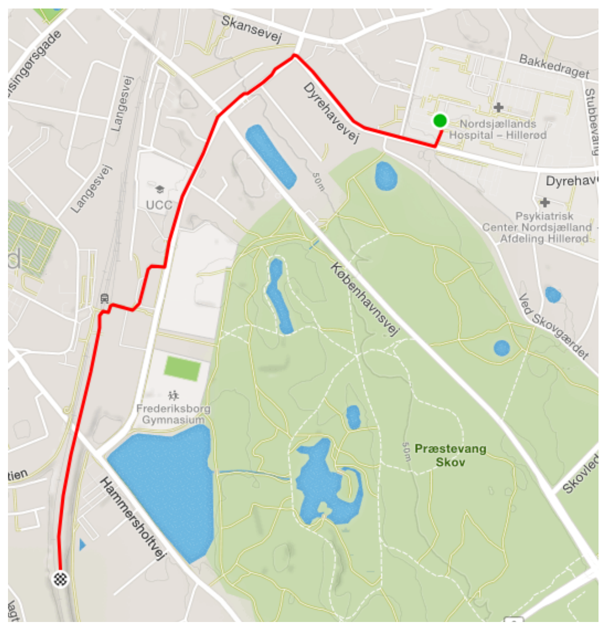
Female 58 seems like an active cyclist as she has **four to five daily routes** in average during the week. The Strava data can tell us that her routes are not long in the distance. Route 1 and 2 Monday (Figure 4.3.1), inform us about that she may do not remember to turn on and off the Strava Application since the elapsed time for Route 1 is 1 hour and 10 minutes. Maximum speed for Route 2 is 73 km/h, which could indicate that she is taking **public transport**, most likely the train and forgot to turn off the Strava tracking before entering the train. Female 58 has an **average speed around 16 km**/h throughout the week. She has many routes she chooses to bike, and the longest route in the distance is 10,5 kilometre, which is outside the city centre. In the city centre she bikes many short distances during a day.

4.3.1.1 Strava Map Analysis

Route 1 on Monday is mapped out below, and she starts the day bicycling from Hillerød train station to Hillerød Hospital. Route 1 seems **not to be the most direct or fastest route**. It could be that she did not know which way to bike to the hospital and that she is not familiar with the area. We assume that Female 58 forgot to turn off the Strava application when entering the destination as the red line indicates that she is not located on a bike path. On her way **back** to what we **assume** is the train station (Route 2) she chose a **more direct route**. We assume that she had to **rush** out from the Hospital to **reach** the train, which influenced her choice of route. The Strava data shows a maximum speed of 73 km/h and we assume the reason is that she did not have time to turn off the Strava application before she entered the train.



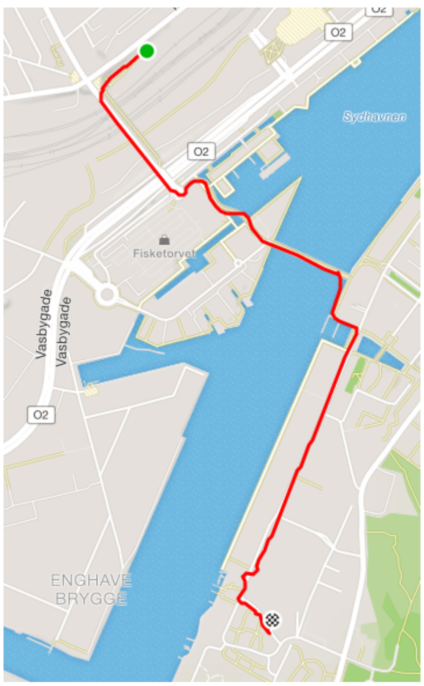
Route 1 Monday (07:49)



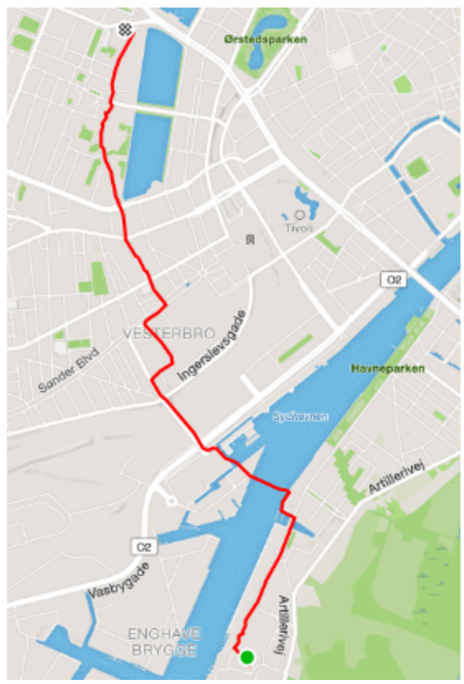
Route 2 Monday (16:12)

Route 3 Monday mapped below is from Dybbøls train station in Vesterbro to Islands Brygge. Female 58 rides on the **bicycle bridge** with Fisketorvet and it seems like the **most direct and fastest route** to choose. We assume that she forgot to track the first route in the morning since the Strava data does not show how she got to Dybbøls train station. We can assume that this is also the route she chooses when bicycling towards the train station in the morning.

Route 4 and 5 on Monday (Appendix 9a) was to Frederiksberg and back to Islands Brygge in the evening. She chose to take a **direct route**, and she chose the same route on Saturday (Route 1) that is showed on a map below. We assume she made a visit in the evening, and that she usually chooses this route as it is fast and direct.

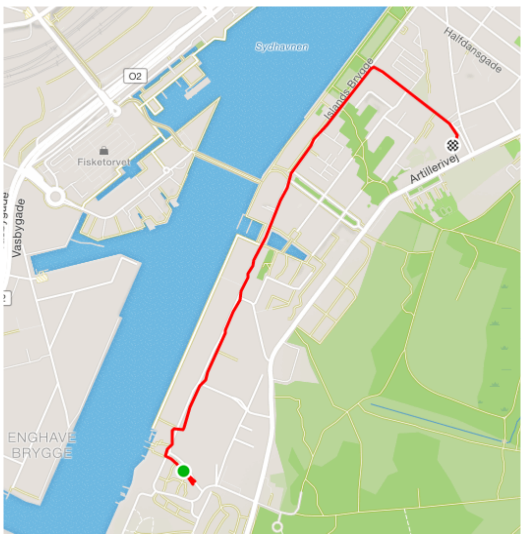


Route 3 Monday (17:04)

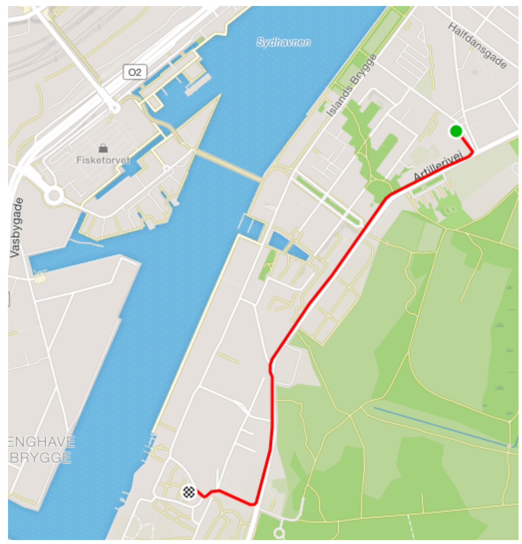


Route 1 Saturday (11:18)

The map below show Female 58's Route 1 on Tuesday, which is **located at Islands Brygge**. She has five routes located in this neighbourhood on both Tuesday and Friday. We assume she lives nearby and that the routes are to grocery shopping, the library and some other shops. Route 1 Tuesday is a route **by the water**, and we assume she enjoys to bicycle there since it is close to the waterfront. Route 3 Tuesday is in the same area, but here has Female 58 chose to ride on the **traffic road back home** and not by the water by Islands Brygge. It indicates that she is likely to choose different routes when she is at Islands Brygge, which is further investigated in the interview.

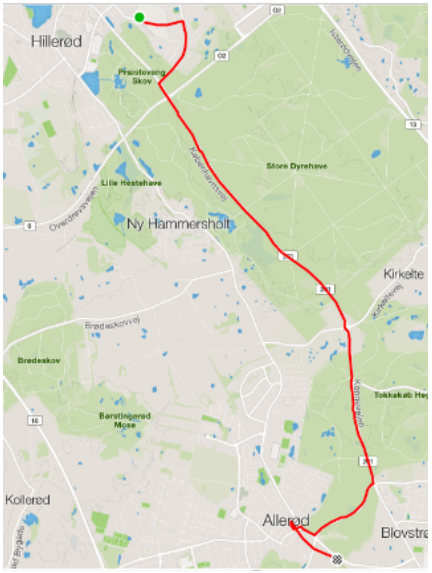


Route 1 Tuesday (08:03)

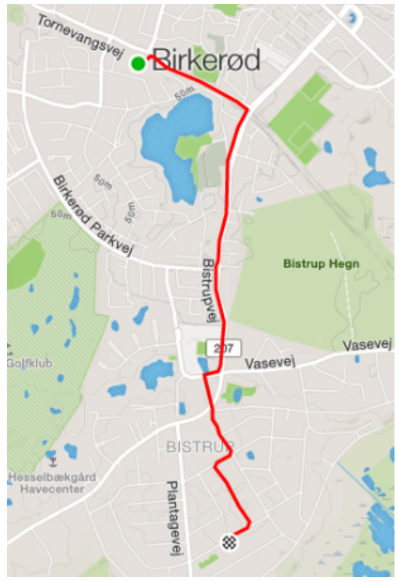


Route 3 Tuesday (17:39)

Female 58 has also been bicycling in **Greater Copenhagen**, more accurately in Hillerød and Birkerød (Route 3 and 4 Wednesday on the next page). On Route 3 Wednesday from Hillerød Hospital she has a route distance of **10,5 kilometre** before she **enters the train** from Allerød train station to Birkerød train station, where she started to bike again (Route 4 Wednesday). The distance could indicate that Female 58 has been **exercising when bicycling**. The **reason** behind the trip with the train in between the bicycle rides is **not possible** to get an **understanding** of by looking at the **maps**. It was a rainy day (Appendix 19), which can partly indicate the reason. We think the last route is missing and might been forgotten to be tracked as no bicycle activity shows how she entered the area on Islands Brygge where Route 1 on Thursday starts at 07:00 in the morning.



Route 3 Wednesday (15:55)



Route 4 Wednesday (16:31)

4.3.1.2 Interview Analysis

The interview with Female 58 informs us about that she lives at Islands Brygge and works at three different locations (Hillerød Hospital, Islands Brygge and Nørrebro), which matches her daily routes. Monday did Female 58 choose to make a **longer route in distance** from the train station in Hillerød towards the hospital. *"I have a longer fixed route to the Hospital to get **more kilometre in my feet**. I also have a fixed route back to the train station, then I choose the fastest way because I am tired and want to reach the train back home"* (Appendix 9b). Female 58 confirms that she forgot to turn on and off the Strava Application sometimes because she was in a hurry. Route 3 on Monday across the **bicycle bridge** to Islands Brygge is the route she **usually** chooses when going to and from Dybbøls train station because it is the **fastest** route.

Route 4 and 5 on Monday and Route 1 on Saturday was a route to a **fitness centre** and not to visit friends. *"A standard route to where I do fitness, I think this is the shortest and fastest route, but it does not mean that I do not take a detour sometimes. I am very light-headed when I bicycle, so there may be a few days I ride other roads in the Vesterbro area" (Appendix 9b).*

On Tuesday and Friday does Female 58 work at Islands Brygge, which makes sense to the routes around in the neighbourhood. She explains that she sometimes chooses to **not bike along the water** and instead **bikes on the car road** with Amager Fælled. *"When bicycling to work at Islands Brygge I tend to choose between two different routes. One of them is past Islands Brygge by the water, where there are no traffic lights I need to stop at. Another route is along Amager Fælled by the car road. There is a lot of morning traffic, and it is hard to get across the road to the right side of the bike path" (Appendix 9b)*. When we ask her about **what her choice is dependent on**, does she answer, *"The **weather**, if there is a lot of wind or side rain is it terrible to bicycle along the water, so then I usually choose the car road along the Amager Fælled" (Appendix 9b).* Female 58 **enjoy** cycling in pleasant and **beautiful surroundings** when the **weather is nice** and when she got **extra time**.

Every Wednesday she visits her **hometown Birkerød** after work at Hillerød Hospital. She either chooses to take the train or bicycle. On Wednesday did she choose to bicycle, but it **started raining during the ride**, so she decided to take the **train**. *"I would rather spend my time being with my husband instead of spending time bicycling in the rain the last part, so I went bicycling to the nearest train station"* (Appendix 9b). Female 58 continue with explaining that she does not enjoy to bicycle in the **winter months**. *"In the winter months it is difficult and time-consuming to cycle in the forest from Hillerød to Birkerød, it is also getting dark fast. I like to cycle in the forest in the summertime, but now it takes time because of snow and ice on the path*" (Appendix 9b). Female 58 was **driving back to Islands Brygge** with her husband, and the bike was back on the car. In this way she does **not need** to bike back home **late in the dark**.

4.3.1.3 Bicycle Practice According to Competence, Material and Meaning

Competence

Female 58 has been living and cycling in Copenhagen for **three years**. She knows her daily routes well, and she also thinks that she is **familiar with the bike infrastructure** in Copenhagen especially at Islands Brygge and Vesterbro. *"I do not use Google Maps, I know Copenhagen, also North Zealand. I have learned my routes by cycling around, as I enjoy to bike around in Copenhagen"* (Appendix 9b). She uses a map on the iPhone if she needs **help** with the **direction**, but she does **not** use Google Maps **to get a recommended** route. Female 58 has used the smartphone fitness application "Runkeeper" for six years, which gives her information about her cycling distances. This is the only information she is interested in knowing. She has never used Strava, and the biggest challenge was to **remember to turn it on and off**.

Material

Female 58 is in general **satisfied** with the bike infrastructure. She usually bicycles in the city, but also sometimes outside in Greater Copenhagen. Traffic lights do not bother her, as she is likely to turn right or left at a traffic light intersection if it is red, although it is not allowed. Sometimes does she bicycle a **longer and nicer route** if she got **extra time**.

Female 58 thinks **other cyclists** are the most dangerous regarding **unsafety**. *"I use my voice and the ring bell a lot when people not follow the rules.* ***Other cyclists often stop my flow*** *because they are texting on their phones or listening to music and therefore are less aware of others"* (Appendix 9b). Female 58 takes the bicycle with her on the **train regularly**. That is a practice she does every time she is at work in Hillerød. Routes with more **nature and less car traffic** are **not that important** to Female 58. Overall, does Female 58 enjoy the **infrastructure in general**, and usually she chooses the **fastest route rather than a green route**.

Meaning

Female 58 loves her bike. *"**It's my freedom**. I do not have to wait in long queues or look for an available parking spot"* (Appendix 9b). She also mentioned that bicycling enables her to drink alcohol in small amounts whenever she wants. She also uses the bike for grocery shopping and has bicycle bags to store the goods in. Female 58 does **not think** the bike **infrastructure** is a **problem** in Copenhagen. She means the **problem is the cyclists who use it**. *"The citizens of Copenhagen must take the mobile phone and headphones away when they are cycling and driving so they can be more present in the traffic. Eyes and ears must be present in the traffic and not on the mobile phone*" (Appendix 9b). She believes this will help to improve the traffic flow in Copenhagen. Female 58 has **always felt safe** in the **traffic**, but some **cyclists** can cause **dangerous situations**, which have contributed to that Female 58 has **difficulty on relying** on other cyclists. She also thinks that some bike paths are too narrow, but she does not believe it as a problem since it applies to everyone who is cycling in Copenhagen.

4.3.1.4 Understanding Female 58's Bicycle Practice

The Strava Data enabled us to understand that Female 58 is an **active everyday cyclist** who conducts several bicycle trips through a day. We could assume that she has the **competence** to take the **bicycle** with her on the **train** if she is going towards Hillerød. The **mapped routes** illustrate that she mostly chooses the **direct and fastest route** when bicycling in the city centre. When she is in **Greater Copenhagen**, the maps indicated that she is likely to **combine exercise** and **nature**. We could assume that the route from Islands Brygge and across the **bike bridge with Fisketorvet** towards the Vesterbro area is one of her **fixed routes**. The maps on each route enabled us to identify the share of direct routes and alternative routes. Female 58 conducted 27 rides in total during the experiment week, where 17 of the total number of bicycle routes were direct routes and 10 routes were alternative routes. The **in-depth interview** gave us an explanation about the **meaning** behind her different **route choices.** She enjoys bicycling by the **water and in green areas only** when it is **nice weather**. If the weather is rainy or windy she usually bikes **fast on the main road infrastructure.** The interview made an impression of that Female 58 is **engaged with the bike infrastructure,** as she **loves the freedom** the bicycling provides.

4.3.2 Male 37

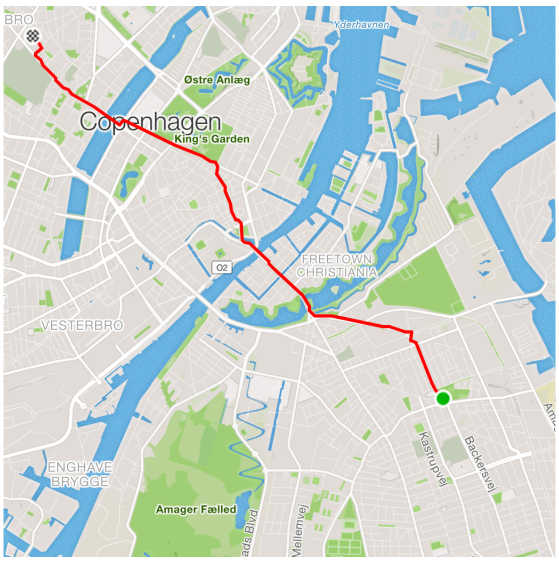
Male 37						
Tuesday	Distance:	Moving Time:	Elapsed Time:	Average Speed:	Maximum Speed:	Origin-Destination
Route 1 Time 07:16	6,3 km	20:42 min	22:39 min	18,3 km/h	28,8 km/h	Amager - Nørrebro
Route 2 Time 14:39	12,8 km	1h 11 min	1h 29 min	10,7 km/h	40 km/h	Nørrebro - Amager

Figure 4.3.3. Strava data for Male 37 Tuesday 28th of March. The complete week is available in Appendix 10a.

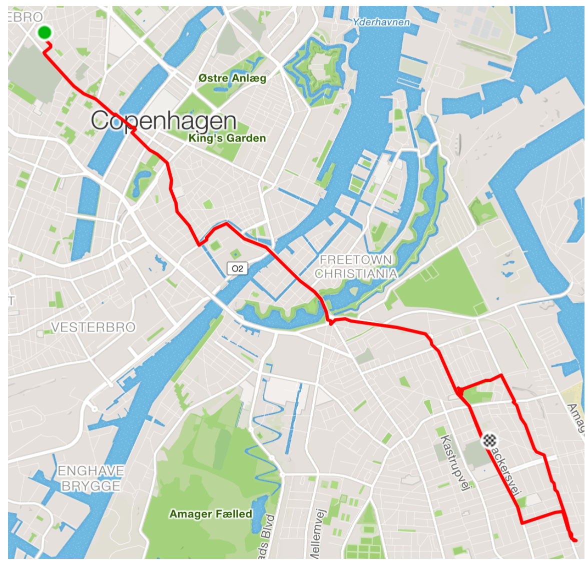
According to the Strava data on Male 37's rides in week 13 is he in average bicycling **two times a day**. The trips involve **the same origin and destinations** (Amager and Nørrebro), but the moving and elapsed times and distances on each trip **vary** (6 km - 12 km). The **variations** in **distance** and **duration** of the trips could **indicate** that his **choice of route differs** and that he might include errands or other stops along the way. Gaps between moving time and elapsed time on his route back "home" could also indicate that he makes stops along his way. His bicycling speed varies throughout the week, and sometimes does he have a **faster average speed** in his **morning** rides (18 km/h) compared to his **afternoon** rides (11 km/h). These numbers could indicate that he **wants** to ride **fast** in the morning, probably to an office or a university, but when **riding back home** could his bicycle practice be more **relaxed** and **spontaneous**. During the weekend were no bike activity tracked, which could indicate that it is certain occasions he does not use his bike on. The data does not tell us about what influences when he chooses to bike, and would be further investigated in the interview.

4.3.2.1 Strava Map Analysis

The Strava maps show that Male 37 uses **one specific route** when going from Amager to Nørrebro, which is the same route during the entire week (Route 1). On his **way back** from Nørrebro to Amager does he choose a **different route** (Route 2). Independent on which route he chooses does he always bike past Christianshavn, which is a quite busy area, and across the Dronning Louise's Bridge, which is also quite busy during the day.



Route 1 Tuesday (07:16)



Route 2 Tuesday (14:39)

On Route 1 Tuesday morning does he choose to bike up to Gothersgade, where he passes King's garden on his right hand side before he crosses the Dronning Louise's Bridge. When bicycling from Nørrebro towards Amager in the afternoon (route 2) he makes a different route as he turns to the right after the Dronning Louise's bridge, and passes Ørestedsparken instead of bicycling the same route past King's garden on Gothersgade. After crossing the channel are the routes similar again. This route from Nørrebro to Amager is similar throughout the week, which indicates that he has one specific route when bicycling towards Nørrebro and another specific route towards Amager. Neither of the routes seems to **involve** more **nature** than the other, but maybe he wants some variation in his daily routes, as he has no other bike rides beside these routes during the week.

As mentioned the route back to Amager from Nørrebro **tend to be longer in duration**. The maps on Strava show that he sometimes bikes around in his neighbourhood before entering the destination point that we assume is his home. The small detours showed on the maps indicate where he has stopped (Route 2 Tuesday). We **assume** that he **most likely** is he doing **errands** like grocery shopping or picking up children from a kindergarten or a school nearby.

4.3.2.2 Interview Analysis

Male 37 explains that it **feels a bit difficult** to bike **the same route back** to Amager **as** if he bikes straight ahead in the intersection after the Dronning Louises Bridge does he quickly end up in a pedestrian street. Therefore does he turn right when entering the intersection after the bridge instead of continuing straight ahead on his way back to Amager. This route did **Google Maps** recommend him. After becoming more aware of his bicycling practice during the mapping week has it come to his mind that he (too) easily stays with one fixed route. He confirms that the routes he chooses to and from Nørrebro is his **usual routes**, and he bikes here every day as he studies in the area. "*I believe the route is **shorter** when i'm driving out (to Nørrebro). I think it **feels** more **direct**. I have to **hold back** more at **intersections** on my way **back**, and I drive a bit outside somehow. If I don't drive this route on my way back am I guided down to Købmagergade, and that is a pedestrian street that I rather not drive through. That would be a bit dangerous to us all, I think"* (Appendix 10b). He further explains that the crossing after the Dronning Louise's Bridge is a bit difficult. Bicycling the **exact same route back** to Amager **as the route towards** Nørrebro means that he has to take to the left and therefore **stop several times** in the **intersection** before he gets to move down towards the inner city. He bikes at the right side of the road when entering the intersection, which makes it easier to keep right. In that way he **avoids crossing the street**. Looking at his daily routes made him think about that he should try to find some alternative routes on his way back towards Amager that could be a bit more direct.

He tends to do shopping on his way back from university. The **traffic lights** are some days **less satisfactory** than others, as on certain days does he feel that he needs to **stop quite a lot**. On his way back from university does he usually feel that he has less red lights because he takes a road **outside the busiest roads**. *"It may not be true, I haven't counted them, but it **feels** like that"* (Appendix 10b). He prefers **flow** in his routes and would be **likely** to choose a **longer route** if it had **more flow** than a route that was faster **but** included more stops in form of traffic lights and intersections. *"I think it is very nice when I feel there is a good flow in it (a route)"* (Appendix 10b). According to the Strava data are there no bike activities during the weekend. He explains that he was taking the bus because he visited family living **further away** and he did also have a glass of wine, which makes him prefer the bus.

4.3.2.3 Bicycle Practice According to Competence, Material and Meaning

Competence

Male 37 have been using the fixed routes to his university since summer 2017, which was the time he started studying. He has always been bicycling **short distances** when going to the gym or visiting friends. Previously did his profession demand to use a car while working as he had to carry heavy things, but after he began to study instead of going to work he did begin to use his bike as the main transport mode. Male 37 then **experienced** that **riding a bicycle** was **faster** than **driving** a car. The routes he knows well are his usual routes to university, grocery stores and to where his son is in school. He got to know his routes through **Google Maps** and chose the exact route that Google Maps recommended. *"I'm very **bad** at **finding** ways. (...) It is a bit new to me to ride as much **back and forth** as I am doing now, but I look at maps to consider if there are other ways I can bike"* (Appendix 10b). He **usually does not** try to bike **another route** than the route Google Maps recommend as he **worries about getting lost**.

The reasons behind his **choice** of route when bicycling from Nørrebro down to Amager are explained during the **interview.** One of the reasons is that he quickly **ends up in a pedestrian street** if he chooses to bike straight ahead in the intersection after Dronning Louise's Bridge. In fact, **we** do know by being bicycling there ourselves that this is not the case as the design of the infrastructure makes it **possible** to **avoid** this area by turning left before entering the pedestrian street. The fact that Male 37 is **unaware** of this **solution** of bicycling towards Amager via the **same route** he usually bikes towards Nørrebro indicates that he **lacks knowledge** of the **bike infrastructure** in Copenhagen. It could also indicate that the **support** he gets from using **Google Maps** comes short in giving **information** on **routes**.

Material

He mentioned during the interview that he **prefer** wide bike paths as it provides a better **flow**, and also the "green bike path" at Nørrebro that **allows** him to bike without any **stops**. He thinks that he quite **often** has to **stop** in **traffic light** intersections, but it does **not** have too much **influence** on where he **chooses** to bike **during** a ride. Few traffic lights are preferable, but an alternative route should not differ too much in the **distance** from an original route to still be **effective**. He is rather **spontaneous** in considering alternative routes.

He says that he is likely to bike almost everywhere, but if he is supposed to **carry anything** special or if the distances are **above 20 kilometres** he would consider other transport modes.

Meaning

Male 37 thinks a route with **good flow** feels **nice** and **is more appreciated** than a route that is **direct but involves several** interruptions such as **road crossings and intersections**. However, his choice of route is not necessarily decided on behalf of good flow. As an example does he mention Christianshavn as a **chaotic** and busy **place** but **still** does he bike through this area **every day** as it **feels** as **the most direct** route when going from A to B.

He is **surprised** how much he **enjoys** to bike and also that the **distances are not that far** than he **previously believed** when **driving** a car. He explains that he thinks it is nice to see the city in a different way, compared to how you see the city when driving. *"I really think it is a nice feeling to get some exercise and relatively fresh air to the extent that exists in Copenhagen"* (Appendix 10b). When bicycling is he likely to do **errands on his way** as he thinks it is **easy** when **everything** is in **bicycling distance**.

4.3.2.4 Understanding Male 37's Bicycle Practice

The **Strava data** shows that Male 37's trips differs in **distance** and **duration**, which allow us to **assume** that Male 37 chooses **different routes** when bicycling. It illustrates that he might has the *competence* of bicycling for **different purposes**. The Strava data also made us **assume** that he bicycles for everyday purposes as he utilises the bike each weekday but not during the weekend, and at different times during the day. The **mapped routes confirm** that he has **one fixed** route towards Nørrebro and **one different** fixed route on his way back to Amager. The maps also show the **exact route** he chose to ride, and illustrate his usage of the bike infrastructure. His repetitive routes towards Nørrebro in the morning and back to Amager in the afternoon enabled us to assume that he bikes towards **work or studies** at Nørrebro and back **home** to Amager. We assume that the **short distances between these places** enable him to bicycle, and indicates the importance of the location of *material*. One of his mapped routes **indicated an answer** to **why** this route to a greater extent **differed** in duration and distance from the **other rides**, as the **map enabled us to identify** that he **made several stops** on Amager before entering what we assumed was his home. The **maps** on each route enabled us to identify the share of direct routes and alternative routes. Male 37 conducted 10 rides in total during the experiment week, where each route seems to be direct. The **interview** allowed Male 37 to explain that he easily sticks to specific routes, as he recently began to use his bike frequently for transportation. **Neither** the Strava data in form of numbers nor the maps indicates the **influence behind** his choice of routes, or what **affects when** he chooses to bike. However, did this information about **each** ride enable us to **question his different choices**. The **interview** gave us answers to **why** he **preferred** to choose **two different routes** when bicycling to university and when bicycling back home. The interview also gave answers to **why** he **chooses alternative routes** in **certain situations**, which mainly is embedded in his **desire** to **not need to make stops several times**. These routes could involve choosing roads **outside** the **busiest** areas.

4.3.3 Male 25

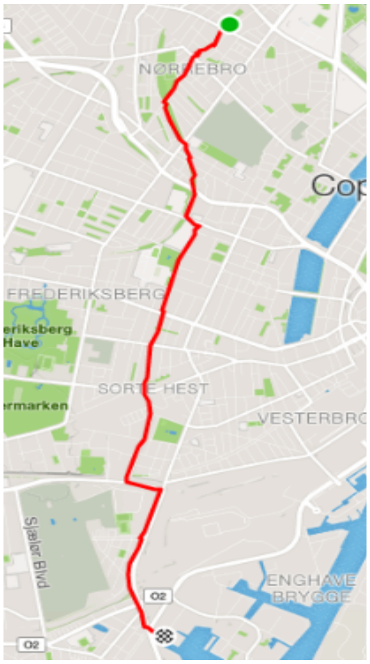
Male 25						
Wednesday	Distance:	Moving Time:	Elapsed Time:	Average Speed:	Maximum Speed:	Origin - Destination
Route 1 Time 08:02	6,4 km	20:33 min	25:34 min	18,7 km/h	38,5 km/h	Nørrebro-AAU
Route 2 Time 12:15	7 km	20:44 min	23:04 min	20,4 km/h	**43,6 km/h**	AAU-Nørrebro

Figure 4.3.4. Strava data for Male 25 Wednesday 29th of March. The complete week are available in Appendix 11a.

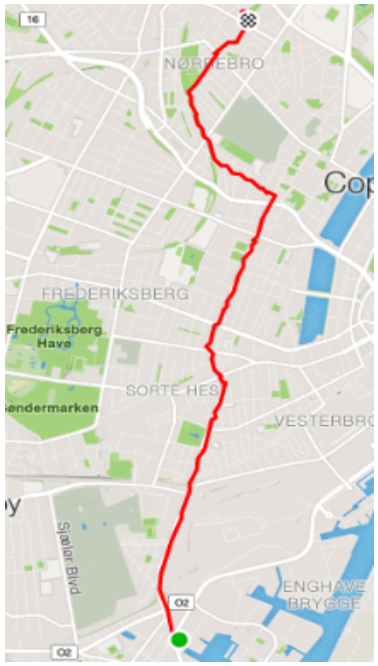
Male 25 is a cyclist who often bikes in a **high speed**, and his maximum speed was **43,6 km/h** on Route 2 on Wednesday. The average speed and maximum **speed** could **indicate** that he is **exercising** when he is out bicycling. The **distance** for each route through the week is **below 10 km**, which **indicate** that he might also be an **everyday cyclist** who uses his bike for transportation from **A to B** as well as for **exercise**. The **origin** and **destination** make us **assume** that he might live at Nørrebro and study in Sydhavnen at Aalborg University (AAU). Route 1 and 2 on Wednesday from Nørrebro to AAU and back again has a **gap of 0.6 kilometres** in distance (from 6,4 km to 7 km) which can either **indicate** that the Strava GPS is not accurate, or that the **routes are different from each other**. We will further look at the mapped routes and try to find out what might have caused the difference.

4.3.3.1 Strava Map Analysis

The mapped routes on the next page show Route 1 and 2 on Wednesday, which is the same day where the two routes differed in kilometres. Looking at the **mapped routes** enabled us **identify** that Male 25 has chosen two **different routes** when bicycling to AAU and Nørrebro. The answer to the question about what the gap on 0,6 kilometre causes, seems to be that he has used a **different route on the way back home**. We assume that he chose different routes because he might be **spontaneous** when bicycling and would like to bike different routes to and from the university as he has many trips out there.

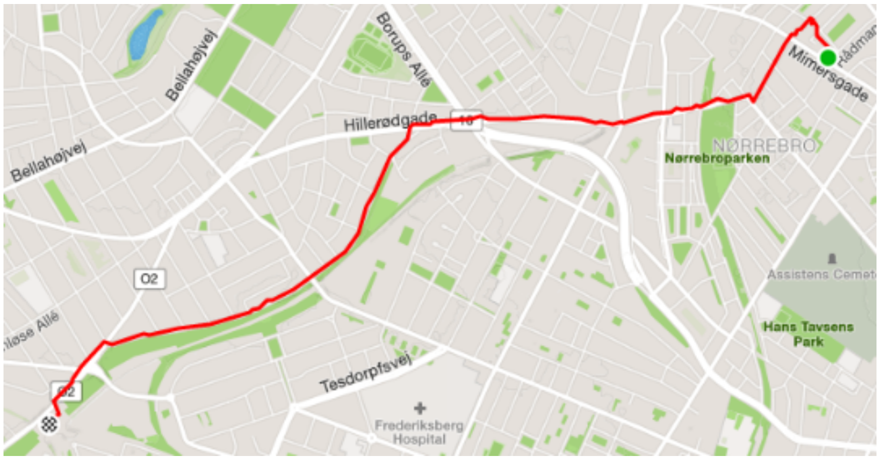


Route 1 Wednesday (08:02)



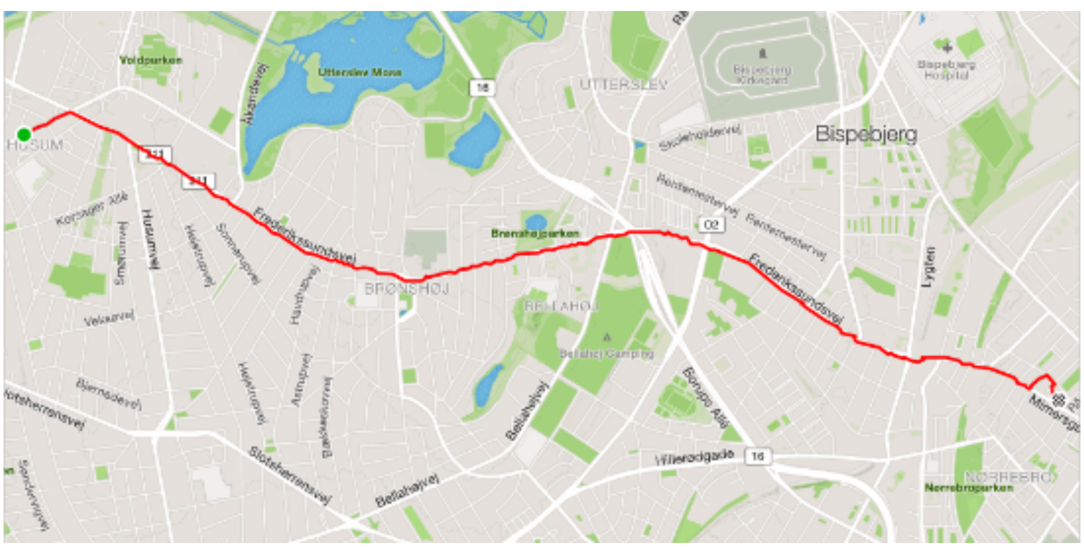
Route 2 Wednesday (12:15)

The mapped routes above show that Route 1 seems to **involve more nature** than Route 2. It also looks more **direct**, which the Strava data can confirm as Route 1 is 0,6 km shorter than Route 2. We want to **highlight Route 1 Friday** (08:36), which is from Nørrebro (home) to Flintholm train station in Vanløse, which a map on the next page shows. Male 25 has an average speed of 19,3 km/h, which for him seems to be quite normal. The interesting part is that he has crossed the main road with Hillerødgade and cycled in a **green bike lane** on his way to the train station. Previously we **assumed** that he was a **training cyclist** because of the speed, but on this route he has **not chosen** the **"fast" main road** but rather chose to turn left for a green route. It will be interesting to investigate the reason behind this choice when conducting the interview.



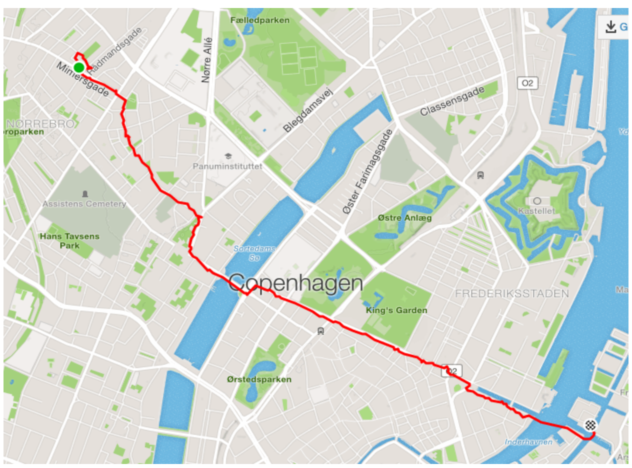
Route 1 Friday (08:36) Nørrebro to Flintholm train station.

Route 2 on Friday (15:07) starts from Husum train station and end in Nørrebro. We **assume** that he has taken the **train in the morning**, and came back with the train in the afternoon. Flintholm train station and Husum train station are located on the same train route and are stations right next to each other. We assume that he chose to stay at the train one extra station (Husum) or forgot to leave at Flintholm train station. This could also **indicate** that he wanted a **longer route** on his **way home**. However, Route 2 is longer in the distance (5,9 km) than Route 1 (4,3 km), but the average speed is the same on both routes. **It seems** that he chooses roads with less car traffic on Route 2, and we **assume** it is because he **enjoys** bicycling in **quiet surroundings**.

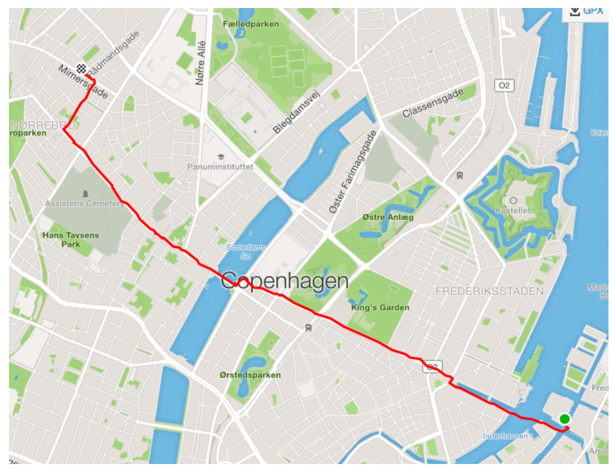


Route 2 Friday (15:07). Husum train station to Nørrebro.

Route 1 and 2 on Saturday/Sunday show a trip during the **weekend** from his home at Nørrebro to Christianshavn, close to the street food marked (Papirøen). Male 25 has chosen to bike in **Guldbergsgade**, a parallel street to Nørrebrogade. Guldbergsgade is in a **quiet neighbourhood**, and the car traffic is not as crowded as it is on Nørrebrogade. We **assume** that Male 25 prefer to bike this way because it has lower traffic volume. Route 2 shows his route back home **in the night** (00:34) the choice of route is different as Male 25 **chose to bike on Nørrebrogade** and not Guldbergsgade. Perhaps he decided to choose Nørrebrogade on his way back home since it was in the night and it is more street lightning at Nørrebrogade. We also noticed that the average speed on Route 2 is only 14,3 km/h, which is low in comparison to his other average speed.



Route 1 Saturday (17:35)



Route 2 Sunday (00:34)

4.3.3.2 Interview Analysis

From the interview with Male 25, it turned out that some assumptions were right and some were wrong. We asked why he chose to bike **different routes to the University in Sydhavnen** (AAU), and what the purpose of his choice of Route 1 and 2 on Wednesday was. Male 25 tell us that he likes to cycle Route 1 (Wednesday) because it is **greener** and there are not many traffic lights. *"It was a friend from the university that introduced the route for me about two years ago. Today this is my favourite route to and from AAU"* (Appendix 11b). When he **moved to Copenhagen** and started studying at the university five years ago did he use **Google Maps for support** to find a route to AAU. Route 2 (Wednesday) is the "old" route he used to bike, which goes through Frederiksberg and on Enghavevej on the main road. Sometimes does he cycle this "old" route, especially if he follows his study mates. It may give more sense to them to choose the main road instead of the parallel street, as this route might be more direct for them. If Male

25 bike alone he always takes the parallel street because *"**I like it more quiet**, and I also feel it is more direct since I live in direction Nørrebro "runddel"* (Appendix 11b). The Strava data can confirm that the Route 1 is 0.6 km shorter.

Friday, Male 25 was bicycling to Flintholm train station because he had a study excursion. Route 1 was a combination of the main road and a greener road. He is **familiar with the area**, and he did know which route to choose to the train station before he went cycling. *"I like to bike where it is green, **close to parks or on green infrastructure**. Less cars and cyclists are good! Road traffic, especially buses may seem unsafe"* (Appendix 11b). On the way back from study excursion (Route 2) Male 25 chose to go off at Husum train station, which is one stop further away from his home than Flintholm train station. The reason why Male 25 did this was because the **distance is almost the same** (1,6 km in distinction according Strava data), and it is **down hill** to Nørrebro. He knows the area well, and the **weather** was sunny and nice.

Male 25 explain that he was at the street food market "Papirøen" on Saturday. Route 1 to "Papirøen" went through **Guldbergsgade** instead of Nørrebrogade. Male 25 enjoys Guldbergsgade and explains that *"**I like this street**, there are **no traffic lights**, and it is nice and safe to ride there. I usually take this route when I'm going to the city centre"* (Appendix 11b). He also tells us that Guldbergsgade is **the easiest route** to choose from his home because he **avoids the main road** and **traffic lights**. Route 2 on his **way back home in the night**, he was bicycling **with a friend** and did not choose to bike on Guldbergsgade but at Nørrebrogade. The reason for his low average speed (14,3 km/h) was because he was cycling with a friend and had been drinking beer at "Papirøen".

4.3.3.3 Bicycle Practice According to Competence, Material and Meaning

Competence

Male 25 has been living in Copenhagen for five years and seemed to know the bike infrastructure in Copenhagen very well, especially around where he lives at Nørrebro. He used **Google Maps** when he moved to Copenhagen, but now he **only uses** it when going to **unknown addresses**. He uses Google Maps to look at **the recommended route** and if there are any buildings, locations or green areas he can **use as landmarks**, in order to know where to **navigate** when bicycling at unfamiliar routes. He used the Strava application for his first time during our Mapping Experiment, and he was impressed with how precise the GPS signal is. He also figured out that he could look into where **other friends are cycling** and compare different routes, which gave Male 25 **inspiration** and some ideas for **new routes**.

Material

Male 25 thinks that the bike infrastructure works well where he **usually** bike. The bicycling facilities have improved from Nørrebro to AAU, as the bike path at Frederiksberg did not exist a few years ago. **The upgraded infrastructure** makes Male 25 feel **safer** when cycling. Still, he does not enjoy the route that involves the bike paths in Frederiksberg, as they are **narrow** and there is a lot of **car traffic**. He feels **unsafe** as the **traffic are too close to the bike path**. *"I like the wide bike paths at Nørrebrogade, I have more of an overview there, but sometimes could it be challenging to know where to place myself on the path"* (Appendix 11b). The **traffic lights** seem to not fit with each other on the routes he usually chooses, as he feels that he has to **stop** several times during a ride. He explains that he feels that **car drivers are prioritised**, especially when cycling from Nørrebro to AAU in the **morning**. One **alternative route** he has chosen to AAU because of car traffic is a route where he can bicycle on car free and green infrastructure in a distance of 500m. He did not choose this route during the mapping week, but inform us about that there is less traffic volume, which Male 25 prefers.

Meaning

The bike is important in Male 25's everyday life. He usually bikes for **many reasons**, and if the bike gets broken such as a punctured tire does it feel difficult if he needs to use other modes of transportation. When going to work he chooses to take the bike with him on the train, as he believes it is **too far** to ride the **distance** of 25 kilometres. In the **summertime** is he likely to use the bike for **exercise**, and would sometimes choose to bike to work. Male 25 enjoys staying one extra train station further away from his home destination because it enables him to conduct a **longer cycle trip** home. He does it more often when it is **sunny**, and when he got **time to prior a longer route**. Male 25 often choose a green route and enjoys to bicycle for wellness and pleasure. He prefers car-free roads, as this type of infrastructure is quieter and gives a pleasant atmosphere in an otherwise hectic everyday life for Male 25.

4.3.3.4 Understanding Male 25's Bicycle Practice

The Strava Data gave assumptions on that Male 25 is familiar with the **bike infrastructure** on Nørrebro. His routes in this area and towards Aalborg University **vary** in **distance** and **choice of roads**. The duration of his trips and the speed indicates that Male 25 is a fast cyclist. The **maps** identified that he enjoys bicycling on **main roads** as well as on **green infrastructure**, which indicates that he is likely to vary his choice of routes. The mapped routes also **gave** the **impression** of that he **regularly** chooses bike paths with **less car traffic.** The **maps** on each route enabled us to identify the share of direct routes and alternative routes. Male 25 conducted 15 rides in total during the experiment week, where 8 of the routes were direct routes, and 7 routes were alternative routes (Appendix 11a). **The interview** revealed that Male 25 use **main roads** to **get fast from A to B**, but prefer to ride on **green bike paths** that have less car traffic, as it enables him to escape from hectic roads. In addition, the interview gave information about what kind of infrastructure that makes Male 25 feel unsafe, and that he is likely to combine bicycling with public transport.

4.3.4 Female 67

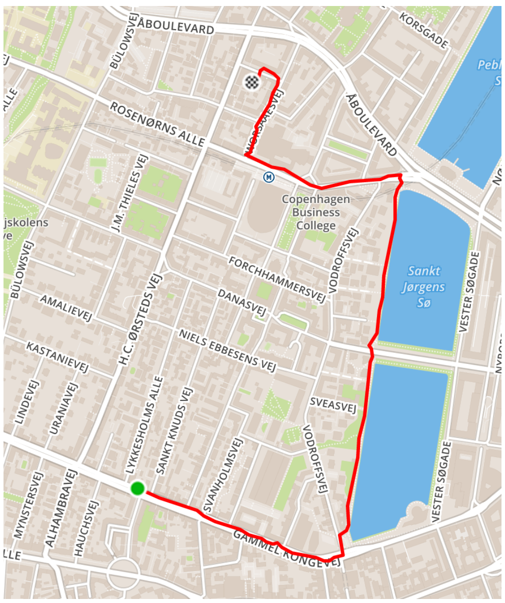
Female 67						
Monday	Distance:	Moving Time:	Elapsed Time:	Average Speed:	Maximum Speed:	Origin - Destination
Route 1 Time 07:17	6,7 km	31:56 min	34:04 min	12,7 km/h	21,2 km/h	Frederiksberg - Husum
Route 2 Time 12:09	2,9 km	14:02 min	27:06 min	12,7 km/h	21,6 km/h	Husum - Søborg
Route 3 Time 13:39	9,1 km	41:59 min	44:21 min	13,1 km/h	27,4 km/h	Søborg - Frederiksberg
Route 4 Time 15:40	1,9 km	09:30 min	11:13 min	12,6 km/h	27 km/h	Frederiksberg - Nørrebro
Route 5 Time 17:05	2,1 km	10:45 min	12:04 min	11,9 km/h	20,5 km/h	Nørrebro - Frederiksberg

Figure 4.3.5. Strava data for Female 67 Monday 27th of March. The complete week is available in Appendix 12a.

Based on the Strava data from week 13 does Female 67 bike **four routes** in average **per day**, which could indicate that bicycling is her main mode of transportation. Her route from Frederiksberg to Husum is **repeated** in some of the days through the week, which **indicates** that this is one of her **normal** routes. The distance of the trips that Female 67 conduct varies throughout the week. The number of kilometres she bikes in **total per day** span from 3,6 km to 36 km, and we assume that she usually bikes for **different purposes** and **occasions**. The time of the day when she chooses to bike varies in being in the morning, afternoon and evening. On some of her trips does the Strava data show a **gap** between **elapsed time** and **moving time**, which makes us assume that she has some **errands** along her trip. The gap could also **indicate** if she is **experiencing** a lot of **red lights** during her bicycle ride. Her maximum speeds vary to a greater extent than her average speeds (Maximum: 16 km/h - 38 km/h. Average: 8 km/h - 14 km/h). It might depend on **how much** in a **hurry** she is or **what bike infrastructure** she bikes on. Her average speed between 8 km/h and 14 km/h indicates a **comfortable** and safe **speed**.

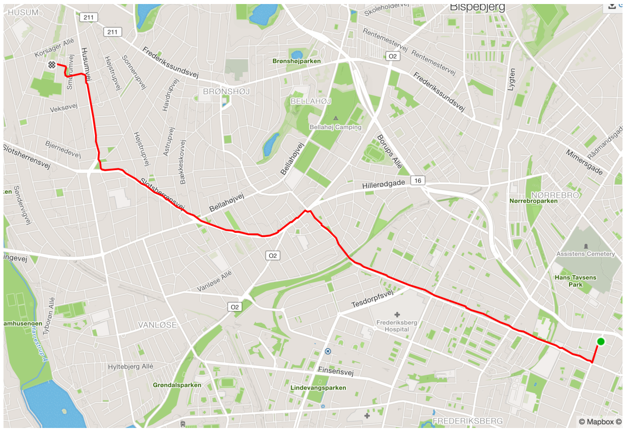
4.3.4.1 Strava Map Analysis

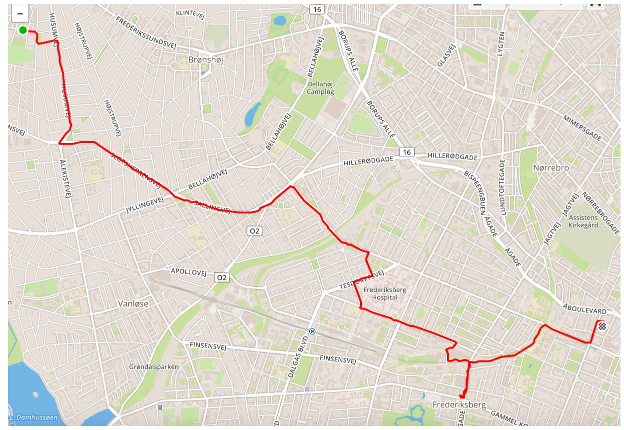
The map below shows Route 4 on Tuesday, where she is cycling in the Frederiksberg area. Female 67 has the **opportunity** to **choose a more direct** route **than** she did on Route 4. We are wondering if she wanted to bike nearby the lakes as a **nicer alternative** to the more direct route. The trip was conducted in the **evening**, which could indicate that she did not have **anything particular to reach** and therefore got **extra time** as most errands and plans are during the daytime.



Route 4 Tuesday (20:54)

On Wednesday morning (Route 1 on the next page) did Female 67 bike to Husum from Frederiksberg, which seems to be a route she conducts a number of times during a week. At her way back to Frederiksberg she chooses a route that is rather interesting. Instead of **keep bicycling** at Godthåbsvej she turns to the right, which **results** in a **less direct route**. We **assume** that she has a **stop** along the way at Frederiksberg, and that she is **uncertain** of the **direction** and **therefore** end up with a less direct route.

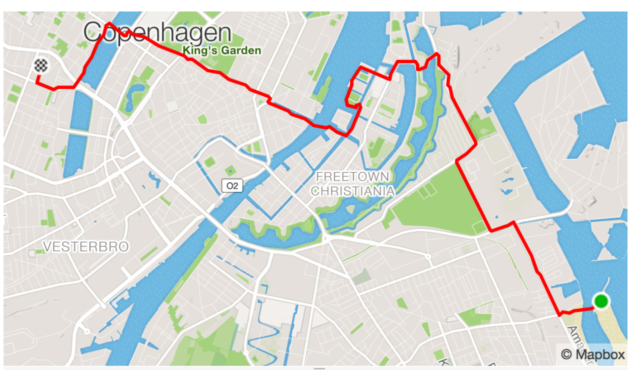


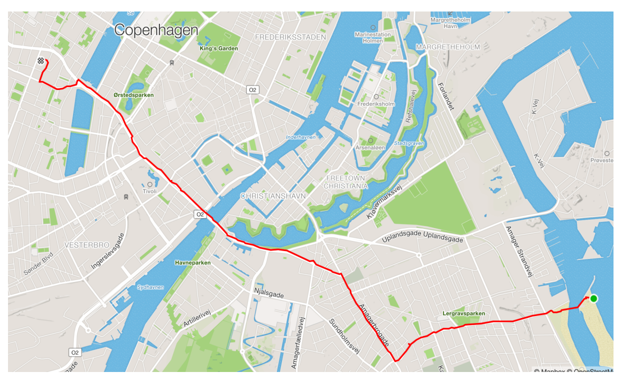


Route 1 Wednesday (07:22)

Route 2 Wednesday (14:07)

Female 67 has biked from Amager Beach to what we assume is her home at Frederiksberg (Route 5 Wednesday **evening** and Route 4 Saturday **evening**) on two of the days during the experiment week. We **identified** by looking at her **mapped** routes that she both times biked the **same route towards** the beach, but her choice of route on her way **back** home are **different as the maps below show**. On **Wednesday evening** she chooses a route that is 2,4 kilometres **longer** than the alternative. **It seems by looking at the map that this route involves nature to a greater extent** than Route 4 on Saturday, which could be the **reason** why she took the longer route. The reason why she did **not choose** the **same way** on Saturday **does not become clear** by looking at the **map**. The Strava data shows that she used 10 minutes **less** on this route on **Saturday evening**, which could indicate that she might wanted to choose the fastest route back home. We **assume** that **time constraints** could be the reason why.

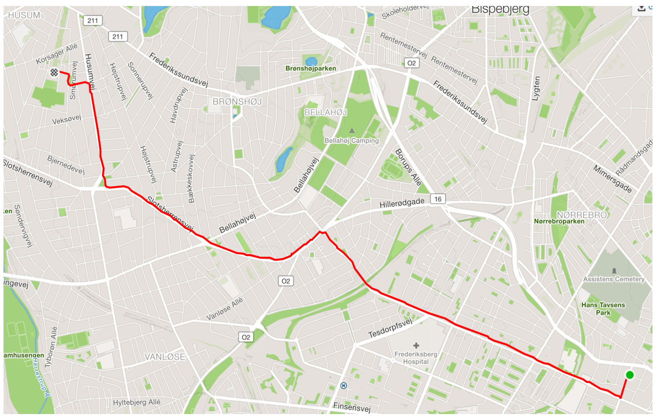




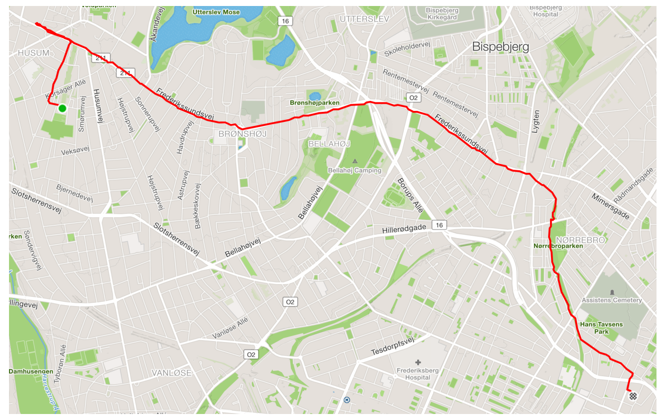
Route 5 Wednesday (18:46) 9,8 km

Route 4 Saturday (19:10) 7,4 km

On Route 1 and 2 **Thursday** did Female 67 again bike both ways towards Frederiksberg and Husum. Her route choice **towards** Husum is the **same as** on Wednesday Route 1, but the route **back** to Frederiksberg is **different**. The **detour** at the **beginning** of her trip back home (**Route 2**) indicates that she had a **stop along the way**, which might further have **influenced** her **choice** of route. The reason for why she chose exactly this way will be further investigated in the interview.



Route 1 Thursday (07:29)



Route 2 Thursday (12:29)

4.3.4.2 Interview Analysis

On Route 4 Tuesday she chose to ride along the lakes instead of taking the most direct route because she got **the time** to **choose** a **nicer alternative route**. This is in line with what we **assumed**. She further mentioned that she **tries** to bike **greener routes** as **often as possible** if she got the chance, but **usually** does she choose the **most direct and fastest route** when going **towards** a place. On Route 2 Wednesday back home to Frederiksberg did we **assume** that she had a **stop along the way** as she chose to ride a **detour**. This was **not** the case. She got **extra time** and wanted to **explore** something new such as **new roads** and other green places that **might** exist. *"I just went bicycling and didn't do anything special. I wanted to ride on those fun roads"* (Appendix 12b).

Wednesday evening did she bike out to Amager Beach, and on her way back in the evening (Route 5 Wednesday) did she choose a very **different** route. It was **longer** in **distance** but involved **more nature** than Route 4 on Saturday evening. The reason **why** she chose to bike a less direct route home that Wednesday was *"after having a bath do you feel well. I had time, and I was only going home to eat dinner"* (Appendix 12b). She wanted to bike in pretty and **nice environments** and having **no time constraints** allowed her to do so (Route 5 Wednesday). She further explains that it is **important for her** to **use** those bike paths that are nice and **facilitated especially for cyclists**. She prioritises the nice and green routes and the bridges over the channel whenever she got time. *"Alternative routes are important to use in order to get new impulses. It is good for the health and the brain, especially when you get older"* (Appendix 12b). Female 67 did also bike from Amager Beach on Saturday during the week. She **did not choose** to bike the nice route as she did on Wednesday (route 5). She explains the **reason** was the **weather**, and she wanted to take the **fastest way home** as it was **raining**. It makes sense, as that route (Route 4 Saturday) is **shorter** both in **distance** and **time** according to her **Strava data**.

Route 1 Thursday morning is her normal route towards Husum from Frederiksberg. Route 2 on her way back did she choose a route that was 2 km longer, and the Strava data on "moving time" shows that she used almost 15 minutes more compared to the more direct route. She confirms that the stop at the beginning of Route 2 influence where she biked after and her way back home became different. However is she familiar with this route as she used to live here as a child, *"it is my memory lane, it is nice"* (Appendix 12b). She explains that she chooses different roads in this area. Her choices depend on what she feels like doing or if it is something special she wants to investigate. Godthåbsvej and Rosenørns Alle are two favourite roads as they are calm and nice shops are located here. She thinks it is nice and fun to pay attention to where she earlier lived, as the area changes over time.

4.3.4.3 Bicycle Practice According to Competence, Material and Meaning

Competence

Female 67 have **always** used her bicycle for **transport**. When her children were young did she more often drive a car, but as they grew up has she begun to bike more as she got **more time** to **enjoy bicycling** at 'green' infrastructure. Her ***ability*** to use the bike for recreational purposes as much as for transportation enables her to bike for different ***purposes*** and on different types of ***infrastructure***. Her **competence** in varying her bicycle practices exemplifies how a competence **relates** to both **meaning** and **material**. If she is going to **unfamiliar** places is she likely to look at a **map** at home and **write down the directions** on a piece of paper that she carries with her during the ride. She does not use her smartphone for checking directions. If she has **extra time** will she **not check the directions at all** but try to **find** a route while bicycling. *"I **usually know** the direction"* (Appendix 12b). She thinks that she is **familiar** with **most places** in Copenhagen and knows where to navigate when bicycling around, as she has been living in Copenhagen since she was a child.

Material

She usually takes the most **direct** and **fast** route when going towards a place, **even if it involves chaotic** and **confusing intersections**. She describes the intersection at Åboulevard by the lakes as chaotic, as the markings on the pavement are confusing and cyclists head into the cross from several different directions. The intersection lacks a system for how people leave and enter it. Even though she finds this place confusing she does not consider taking other routes, as the intersection is involved in the most direct route towards where she lives. *"I think the intersection is fascinating, but it would not bother me if it became better"* (Appendix 12b). **Traffic lights** do **not influence** her routes as she usually practices an exercise for her back **while waiting** at red light, which also relates to a *competence* of involving other practices while being out bicycling. Going **home** from a place she usually chooses routes with **beautiful nature**, good **bike facilities** or **unfamiliar** roads.

Meaning

Female 67 use her bike for almost **every occasion**, as it is her favourite transportation mode. She **chooses** routes **dependently** on **how much time she has**. She bikes the fastest and most direct route when going to a place such as **work** because she is then trying to **reach something** and the time she has got is **limited**. *"When I bike towards a place do I want to be there as fast as possible. In these cases do I not bother to choose green bike paths, but I love doing it when I have extra time"* (Appendix 12b). She is likely to bike longer distances and detours if a route involves nature and new experiences, and would like to do this as often as possible as it is **important** to her. **It makes her feel well and healthy**, and longer distances allow her to **exercise**. She is normally not constrained by time when bicycling home from places and is then likely to choose alternative routes.

She often chooses to bike as she **feels it is safer than walking**. The bike provides her to get away fast if she finds herself in a situation she wants to avoid. This could include places where pushers are located in the evening.

Female 67 believes that crowded bike paths are extremely annoying, especially when crossing traffic light intersections, as **other cyclists** are bad at **using signs**. Because of **high traffic volume** and many cyclists at *Nørrebrogade* is she **likely to choose** to ride through *Assistens Kirkegård,* which is a **calm place** that allows her to **stress down before** bicycling on more chaotic and **busy roads** such as Jagtvej.

4.3.4.5 Understanding Female 67's Bicycle Practice

The Strava data enable us to create **assumptions** of her bicycle practices and competences, such as that she utilises the bicycle as **main mode** of **transportation**. **Varying distances** of her **trips** and **variation** in **the time of the day** she conducts her trips enable us to **assume** that she has the *competence* to bike for **different purposes**. The variations in distance also indicate that she *knows* **different parts** of Copenhagen. The maps **show** those routes that **tend to be repeated**, which allow us to assume her **normal** routes. **Combining** the **maps** with the **information** from the **Strava data** enable to a certain extent to **gain understanding** of for which **purpose** the routes are conducted. As an example does the routes Female 67 conduct during evening hours seem to involve **nature**, and **infrastructure** and **places** that are outside busy areas, which could indicate that these trips are for recreational purposes. We assumed that **detours** indicated that Female 67 made errands along the way, but the **interview revealed** that some of the detours were due to **other reasons**. The **maps** on each route enabled us to identify the share of direct routes and alternative routes. Female 67 conducted 27 rides in total during the experiment week, where 11 of the routes were direct routes, and 16 routes were alternative routes (Appendix 12a). The reasons for why her choice of route varies were investigated and answered during the **interview**. Her **engagement** in **exploring** new places and **varying** her routes were one of the key findings during the interview.

4.3.5 Male 48

Male 48						
Thursday	Distance:	Moving Time:	Elapsed Time:	Average Speed:	Maximum Speed:	Origin-Destination
Route 1 Time 07.40	3,2 km	11:03 min	11:50min	17,4 km/h	37,1 km/h	Sortedams sø-Frederiksberg
Route 2 Time 15.18	3,2 km	9:45 min	9:53 min	20,2 km/h	40,3 km/h	Frederiksberg-Sortedams sø

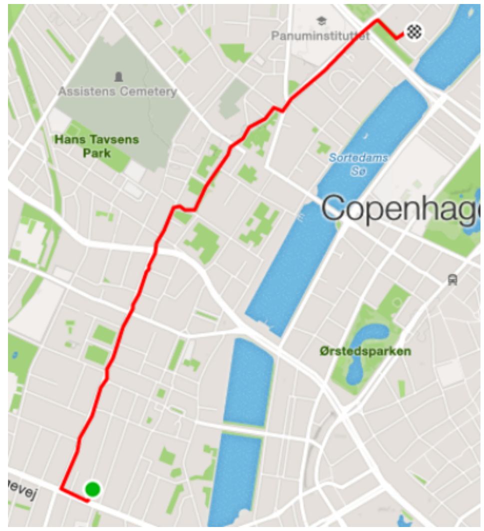
Figure 4.3.6. Strava data for Male 48 Thursday 30th of March. The complete week is available in appendix 13a.

Male 48 has used his bike on the **weekdays** but not during the weekend. In the weekdays does his trips vary between **2-5 routes** and the distance on his routes **does not exceed 3,4 km**. The **short distances** on his routes indicate that he **live** and **work** in the **same area**. Based on the information from Strava, the data gave us an impression of Male 48 being an **everyday cyclist** who has **short routes** around in the Nørrebro and Frederiksberg area with a fast average speed around 18 km/h.

4.3.5.1 Strava Map Analysis

Route 1 on Wednesday shows Male 48's most used route during the week. It starts from **Sortedams Sø**, where we think he might live, and goes along the lakes to **Frederiksberg** where we think he might work because he leaves in the **morning** (07:40) and is staying there until the afternoon (15:18). Route 1 is a **green route** that involves nature along the lakes, and he is cycling on a car-free road more than the half of the way to Frederiksberg. This can indicate that Male 25 like to ride on **car-free** routes to **avoid noise, busy roads and traffic lights**. By looking at the map, does it seem like Route 1 Wednesday is the fastest (9 min) route to cycle since it goes along the lakes where there are no car traffic and traffic light. Route 2 Wednesday (15:18) on his way home did Male 48 choose a **different** route, which seems to be **more direct**, but not so fast because the car road takes four minutes longer to bike compared to the route with the lakes. The average speed for Route 1 was 19,9 km/h, and for Route 2 it was 15,8 km/h, which also can indicate that it might be **slower to bike on the road** since **congestions** and waiting time are more likely to occur at traffic lights and roads compared to the bike paths **along the lakes**.

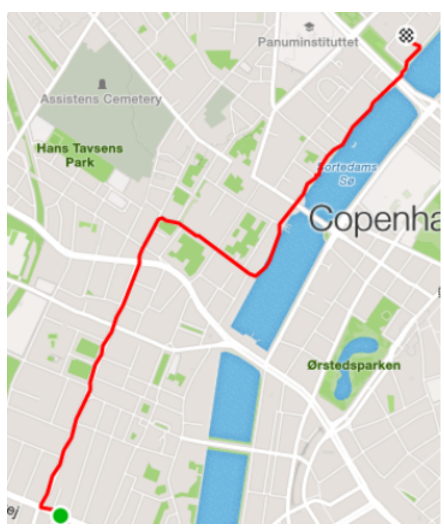
Route 1 Wednesday (07:40)



Route 2 Wednesday (15:18)

Furthermore, we found Route 1 on Thursday interesting. At the end of Sortedams Sø, Male 48 did a **stop in 20 seconds**. He chose to take a completely **different** route after been waiting for 20 seconds. Route 1 Thursday looks **less direct** and longer in duration than Route 1 Wednesday, which we assume is his usual route. Route 2 Thursday (15:18) he chooses another route, which the map shows below. There he cycles at the traffic road past Åboulevard and then down to the lakes. After looking at Male 48's routes does it seems that he has **one fixed route** to Frederiksberg (Route 1 Wednesday), but he also seems to be **spontaneous** in his choices of routes.

Route 1 Thursday (07:40)



Route 2 Thursday (15:18)

4.3.5.2 Interview Analysis

Location of home and work was correct, and Route 1 Wednesday by **the lakes** is the route he **prefers** when bicycling to **work**. *"It was my girlfriend who introduced the route to me for about five years ago. On that time did I not have a smartphone or Google Maps to help me, so in the very beginning did I only use to bike on the road and not by the lakes"* (Appendix 13b). Male 48 has tried **different routes** over time and got familiar with the area by cycling there over a longer period. On Route 2 Wednesday he chose to bike through **Elmegade** at Sankt Hans Torv. *"This is a road I enjoy to bike on, it's not very fast due to traffic lights, but it does not bother me. It's nice in Elmegade, and I like to ride here when I'm not busy. I don't think it's crowded on this route"* (Appendix 13b). The four extra minutes on this route compared with the route along the lakes does not matter to him since he likes the nice **atmosphere** on the route when the weather is nice.

We had to ask Male 48 about the **stop in 20 seconds** at the end of Sortedams sø on his way to work on Thursday. *"It was a weird route, and the stop was because the bike path was blocked because of roadwork. **I ended up with bicycling on some streets I'm not familiar with**, so it was a really weird route. **I had to stop many times**. I did not feel it was direct, and by Forum Metro station it was chaos"* (Appendix 13b). On his way back home the roadwork was completed, which enabled Male 48 to cycle under the bike tunnel at Dr. Louise's bridge. He cycled Korsvei straight down to the lakes. *"I **often** bike this way home. It's **fast**, and I get straight down to the lakes, I mostly take this route (Route 2 Thursday) back home"* (Appendix 13b). Male 48 learned this Route 2 by himself, as he escapes from the large, and to a certain extent dangerous, traffic light intersection in Åboulevard. During the interview did he mention that he **enjoys to bicycle in areas that involve nature or water** such as by the lakes, and also specific roads such as Elmegade when it is **nice weather**.

4.3.5.3 Bicycle Practice According to Competence, Material and Meaning

Competence

Male 48 has been living in Copenhagen for **22 years** and has used the **bike as main transportation** ever since. He owns a car, but he prefers to use his bike in the city because he has **experienced** that it is **faster to bike compared to driving** a car. *"I would never drive my car to work as bicycling is much faster"* (Appendix 13b). Male 48 uses GPS tracker when he is exercising. He uses Garmin Connect to see average speed, distance and heart rate. He has **never GPS tracked** his daily bike routes, but he enjoyed to see how far he cycled in a day and during a week. He uses **Google Maps to plan new routes** or when visiting friends, but sometimes does he have to use his **own knowledge** for finding even smarter routes.

Material

Male 48 is **satisfied** with his daily route past the lakes. He thinks it is safe, compared to some years ago when the road was shared with cars and pedestrians. Today he thinks it is like a highway for bicyclists, especially in the **morning** when the bike path is heavily used by everyday cyclists, training cyclists and children. The crowd does not bother him. He also enjoys the route by the lakes as he **only needs to bike past two traffic lights** on his way to work. Male 48 finds it less satisfying to bike through the intersection at the Åboulevard, as he thinks it is a **dangerous** place because of the **confusing structure**. In general is Male 48 familiar with the bike infrastructure in Copenhagen, which enables him to know how to avoid certain places he rather not bike at, such as the Ålboulevard and the narrow bike paths at Vesterbro.

Meaning

Bicycling means a lot to Male 48, as he dislikes taking public transport. *"There are so many people I think! I like fresh air. I can take a train or a bus, but not inside the city"* (Appendix 13b). He enjoys cycling around and appreciates the **freedom** it gives. He owns a bike for **everyday usage** such as **transportation in the city**, and a **racer bike** he uses for **exercise**. Sometimes he drives his car when he visits friends that live outside Copenhagen because of the distance. He usually prefers to walk when grocery shopping, but sometimes does he do the shopping on his ride back home, as it is convenient. Male 48 enjoys cycling places that makes him feel well, such as on Elmegade because of the nice atmosphere, by the lakes because of nature and it is fast, and on the cycle bridge by Fisketorvet because it is new and fancy. He **appreciates** these routes, but if he does **not have time** does he choose one of the **main roads** that he **knows is fast**. For **exercising** does he prefer to use the **superbike paths** around in Greater Copenhagen.

4.3.5.4 Understanding Male 48's Bicycle Practice

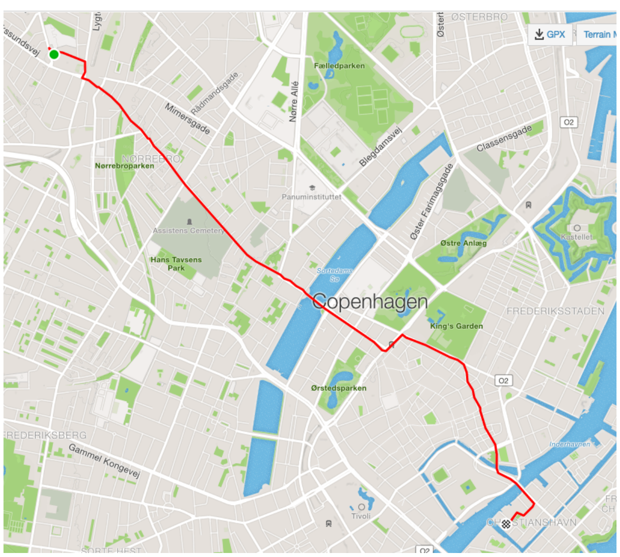
The Strava data made us **assume** that Male 48 is an **everyday cyclist,** as the data shows that his routes tend to be short and that bicycle activity only is conducted during the **weekdays**. The data also enabled us to assume that his workplace and home were located in the **same area**. The Strava data in collaboration with the **mapped routes** informed us about that his choice of route varies, especially towards work. The **maps** on each route enabled us to identify the share of direct routes and alternative routes. Male 48 conducted 14 rides in total during the experiment week, where 7 of the routes were direct routes, and 7 routes were alternative routes (Appendix 13a). The **interview** revealed **when** he is likely to choose an **alternative route** and the reason **why**. Less car traffic and places with atmosphere influence his desire to make alternatives. The stop of 20 seconds during one of his rides was **identified** through the **Strava data**. The reason **why** this stop occurred were answered during the **interview.** The interview also identified that Male 48 uses a racer bike when exercising and then often chooses to bicycle at the superbike paths As he did not conduct this practice during the experiment week did we not get information about his exercising practice through the Strava data.

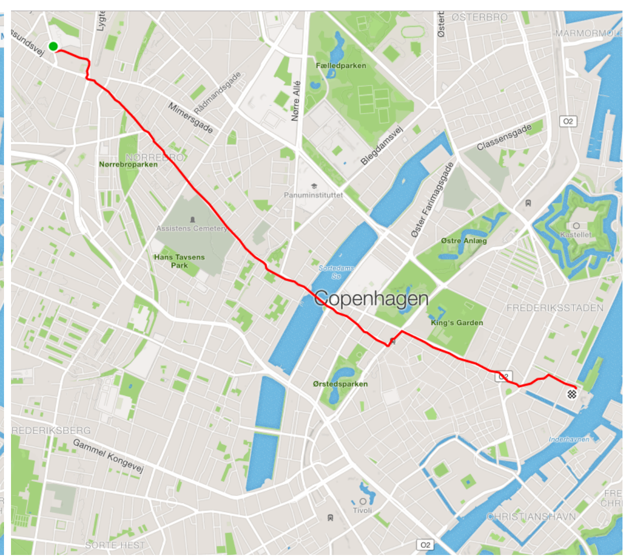
4.3.6 Female 23

Based on Strava Data presented in the Mapping Experiment, have Female 23 cycle **two routes daily** in average. She is one of the participants with the lowest number of routes throughout the week, with **10 routes in total.** Out of the total number of routes were 7 routes direct, and 3 routes were alternative routes (Appendix 14a). We assume that she is an **everyday cyclist** and not a training cyclist in relation to the information the data for destination, time and speed gives.

4.3.6.1 Bicycle Practice According to Competence

As a cyclist in Copenhagen can Female 23 be classified as a relatively **inexperienced cyclist**, since she only has lived here for one and a half year. When she moved to Copenhagen, she got help from friends and Google Maps when she cycled to an unknown address. The two daily routes she uses is routes she learned with help from her boyfriend and Google Maps. ***"It is these routes I know! My boyfriend has taught me routes and traffic rules. So my daily routes are learned 50% through friends and 50% through Google Maps"*** (Appendix 14b). Her daily routes are mapped out below.



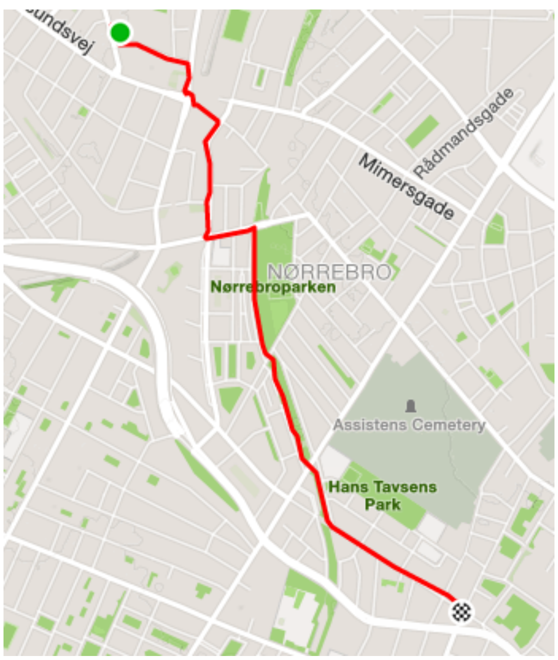


Route 1 Monday (08:55) Nørrebro-Christianshavn Route 1 Tuesday (08:19) Nørrebro-Nyhavn

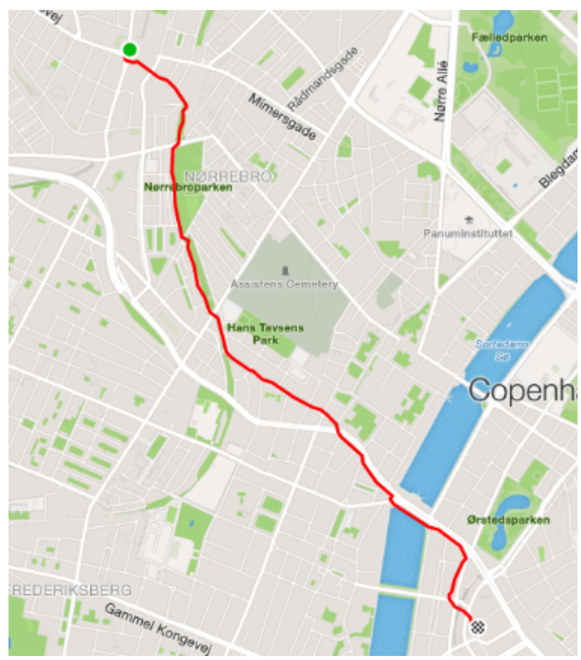
Female 23 knows here daily routes to work and study well, but beyond these routes, is the interest of exploring other possible routes limited, because she is satisfied with the route Google Map recommended her. ***"I use the route from Google Maps in 80% of the cases, because I think it is the fastest. I choose a different route if Google Maps are suggesting a road where I know there are a lot of people or traffic, e.g. Strøget"*** (Appendix 14b). Furthermore, when she moved to Copenhagen she **often took the bus**, but over time she gained knowledge of the transport possibilities in the city and **chose to bike instead**. It was because she figured out that the distance was not so far away as she thought it was, and the monthly card for **public transport was expensive.**

4.3.6.2 Bicycle Practice According to Material

The *material* has influenced her cycle practices though the short time she has lived in Copenhagen, such as the bike infrastructure and bike facilities. She likes to bike on **green bike lanes** when she is going in a direction where she knows there is a green bike route. She mentioned the green bike routes through Nørrebroparken or to Frederiksberg Center. Female 23 chose the green route with **Nørrebroparken** every time she is going in the direction to/from Vesterbro and the city centre, as she did on Friday and Saturday mapped out below.



Route 2 Friday (17:26)



Route 1 Saturday (21:00)

Female 23 also prefer **wide bike paths** because then she feels it is easier to have an overview. She thinks it is stressful and dangerous when vehicles are parking in parts of the cycle line when delivering goods in Nørrebrogade, which have wide bicycling paths in order to improve the accessibility to the bicyclist. Material such as traffic lights does not influence her choice of route because her opinions are that **traffic light is necessary** and have to be implemented in a city.

4.3.6.3 Bicycle Practice According to Meaning

Female 23 use the bike for getting her daily exercise and for transportation from A to B. ***"It's the only exercise I got"*** (Appendix 14b). On a rainy day, she could take public transportation, as she did on Wednesday. She usually used to take public transportation when moving to Copenhagen, but she **changed practice** after she figured out that the distances to her daily locations were not that far away. Since she already had a bike, she started to bike because she wanted to **save money and get exercise**. She prefers to bike out to the Technical University of Denmark (DTU) in Kongens Lyngby (20 km) when it is nice weather. When it is raining she prefer to take public transportation ***"I would not ride to DTU if there is rain, I do not spend time showering after a bike ride, then I have to plan the day more and go early and bring clothes. But short routes in the rain are OK, then it's okay to wear a rain jacket"*** (Appendix 14b).

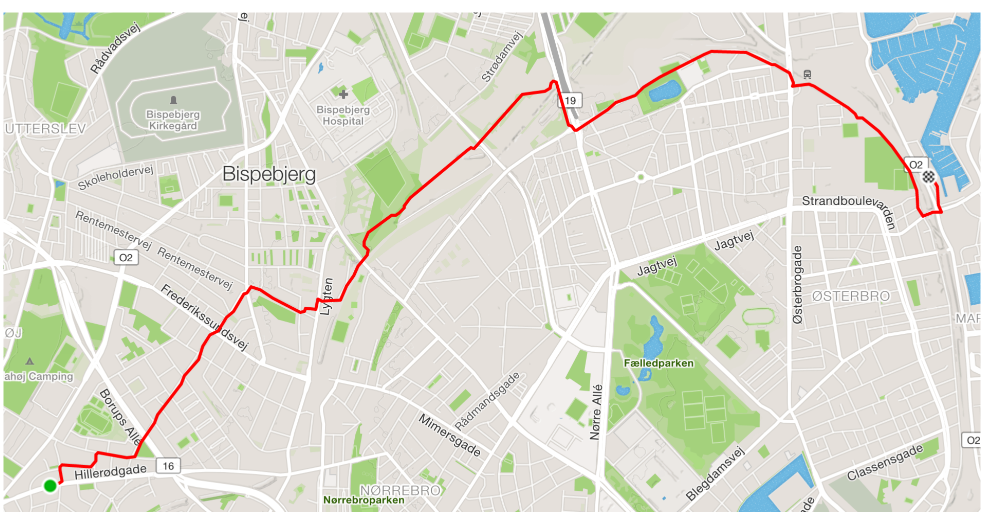
She thinks the bike path at **Nørrebrogade** is really annoying and dangerous when vehicles are parking in parts of the bike paths when delivering goods. She means the bike paths have a wide bike path for a reason, and since it is a lot of cyclist on the path she feels this really **stressful** when cycling there sometimes. Overall, Female 23 prefers to choose the most **direct way** from A to B and combine this with her **daily exercise**.

4.3.7 Male 61

During the mapping week did the **Strava data** show that Male 61 had between two or three bicycle rides each day (Appendix 15a). His average speed is quite fast throughout the week, varying between 14 km/h and 19 km/h. The fast speeds can **indicate** that he rides on roads that have **low traffic volume** that allows him to ride **fast**. The **distances** of his routes throughout the week **vary** between short trips below 2 km and longer trips of 12 km, but in average were the majority of his rides above 5 km. This information could **indicate** that Male 61 bikes for **different purposes**, as could be either for exercising or the fastest route as possible towards a certain place. The total number of Male 61's rides during the week is 10 routes, where 3 routes are direct, and 7 routes are alternative routes (Appendix 15a). He bikes **early** in the morning as well as **late** in the evening, which can support our **assumption** of that he uses his bike as the **main mode** of transportation and for **different occasions**.

4.3.7.1 Bicycle Practice According to Competence

Route 1 on Sunday the 2nd of April did Male 61 bike to Østerbro, which is the first ride in this week to this location. His average speed (20 km/h) and maximum speed (35 km/h) surprised us in being the fastest and second fastest speeds of all his trips during week 13. Based on his high speeds we assume that he is familiar with this route. As it looks like he is **avoiding main roads** and that he bikes **through green areas** indicate that this route is **well planned** and that he does not try to choose the most direct option.



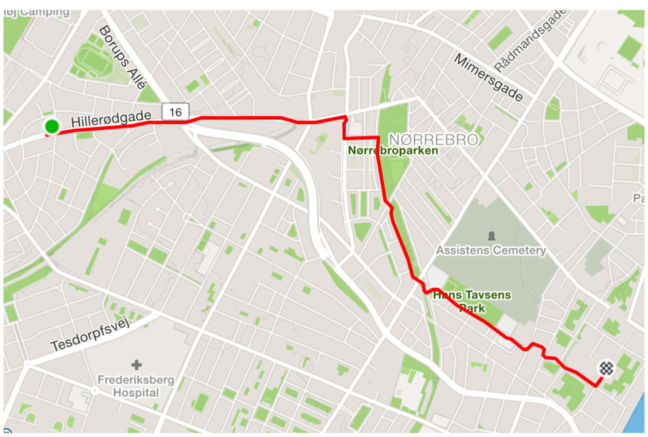
Route 1 Sunday (13:35)

During the interview do we point out that the data on this route shows an average speed of 20 km/h. He directly responds with *"Yes, I had a meeting I had to reach"* (Appendix 15b). He then confirms that the route is familiar.*"This is actually a route I have found that is bit special, where you actually drive without cars"*. He points on a **map** where it is possible to drive with **no other cars**, "*It is actually a bit secret. Not many know about this one"*. Male 61's engagement in **wanting** to find routes with **less or any traffic** made him **experiment** with new roads to find alternative routes. The experimenting has influenced his knowledge on bike infrastructure in Copenhagen and enables him to use a wide spectre of it. "*You could actually bike outside Copenhagen on cycle paths the whole way, without meeting any cars"* (Appendix 15b). Asking about how he find these alternative routes does he answer: ***"By looking around or by looking at a map at home enable you to find routes without cars"*** (Appendix 15b**)**. He seldom uses IT tools for finding routes, but he uses manual maps such as the municipality's bicycle map for orientation and when planning new routes. Some routes such as the superbike paths did he become aware of through **suggestions** from the Danish Cyclists' Federation (DCF) where he is a member. Mostly does he find alternative routes **by himself**, as he has the competence and the willingness to learn how he can use the bike infrastructure in a way that for him are preferable. ***"There is some sport in it*** *(experimenting to find new routes)"* (Appendix 15b). He has about two or three routes that he chooses between when bicycling to his office, and he does also choose between different routes when bicycling home from the city.

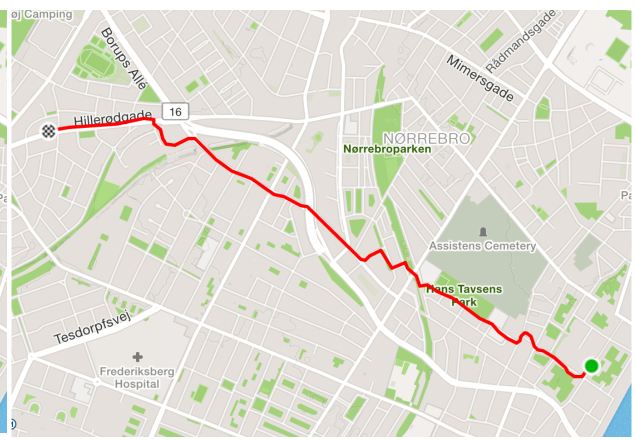
Bicycling several times on the same routes enable him to be familiar with the traffic lights, where he **adjusts his speed** when getting closer as he in that way could avoid to stop. Because of this does he say that he seldom experience red light at traffic lights.

4.3.7.2 Bicycle Practice According to Material

Male 61 has a **variation** in where he bikes from day to day. His choice of route back and forth from origin to destination are likely to vary in what extent it involves green or blue structures, and how direct it is. Wednesday evening did he bike to Nørrebro from Bellahøj (Route 1) and back again (Route 2). The maps show that Route 1 is less direct but involve nature as he bikes through Nørrebroparken. Route 2 seems like a more direct route even though that the Strava data shows that the elapsed time on both routes is the same. He chose different ways in each direction as it was getting **darker on his way back home**. He biked through **Nørrebroparken** when there still was **daylight**. After doing some thinking does he also say *"I'm bicycling on the Nørrebro route, the green route. (...) I think I just took 'the nice route' this way and when I went home I've just driven as quickly as possible"* (Appendix 15b). Daylight has an impact on his choice of route as it influences what he prefers. He says that he is likely to choose other routes when bicycling home if there are not enough daylight to ride in parks. *"There is no light in parks. That could have an impact"* (Appendix 15b).



Route 1 Wednesday at (20:09)

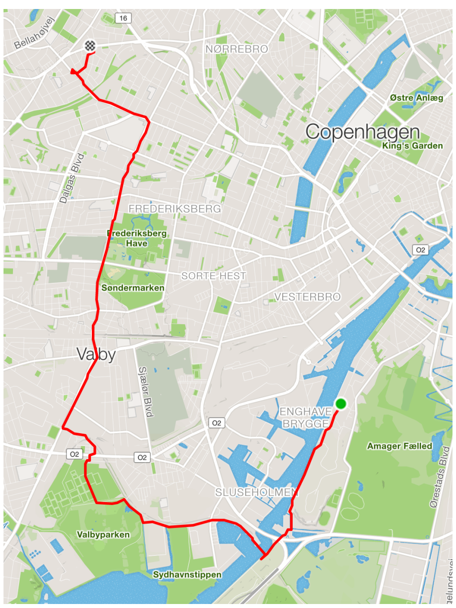


Route 2 Wednesday at (22:15)

Male 61 choose **superbike paths** when he gets the opportunity, not necessarily because he saves time but because it provides good bicycling **facilities** and **low traffic volume**. ***"I use the bike in different ways. I use it for pleasure, and from A to B"*** (Appendix 15b). He usually bikes in the outside of Copenhagen because of the location of his work office, but his profession would require to sometimes work at different locations, which would allow him to bike at various places during a week. This supports our assumption from looking at the maps that he bikes on many different parts of the infrastructure. **Daylight and darkness** have an impact on where he chooses to bike, which could often be the reason why he wants to bike in nice and natural environments during daylight, and tend to choose a more direct and fast route when it is dark.

4.3.7.3 Bicycle Practice According to Meaning

His choice of route depends on factors as **time constraints, time of the day, and the weather**. Male 61 has used the bike for transportation for his entire life, which have made bicycling a part of his life. ***"It is a pleasure. It is ideology. It is personal exercise.*** *I would like to be in good shape and save money"* (Appendix 15b). He wants to **involve nature and less traffic** in his cycling routes as much as possible if he got extra time, which the maps also indicate. *"I choose nice routes when I'm not in a hurry"* (Appendix 15b). He is likely to choose detours to have a nicer and greener route on his way back home from the city. Explaining one of his longer routes (Sunday Route 3) during the mapping week reveal that *"It was nice weather and I wanted to bike another way back home. It was a pleasure. From A to B the first part (referring to the meeting he had to reach), and then pleasure"* (Appendix 15b). He will be likely to choose **the fastest and most direct route** when he needs to reach something, even if it involve places with a lot of traffic. He mentions that the Town Hall Square (Rådhuspladsen) is a less good place for cyclists, but sometimes is this the fastest way to go through when going certain places.



Route 3 Sunday (17:30)

4.3.8 Male 38

Male 38 has in average two rides per day, which usually involves the **same origin and destination**, which is Amager and Gentofte (Appendix 16a). He does also include some short trips during the week and does bike during the weekend. His choice of route from Amager to Gentofte and back again throughout the week are often **different** from each other. The routes are quite long in distance, usually about 15 km. The total number of Male 38's rides during the week is 11 routes, where 6 routes are direct, and 5 routes are alternative routes (Appendix 16a). His speed on these rides is in average about 20 km/h, and his maximum speed varies between 34 km/h and 44 km/h. **The Strava data** on **speed** and **distance indicates** that he is a **dedicated cyclist**, and we **assume** that he might as well **exercise** while bicycling.

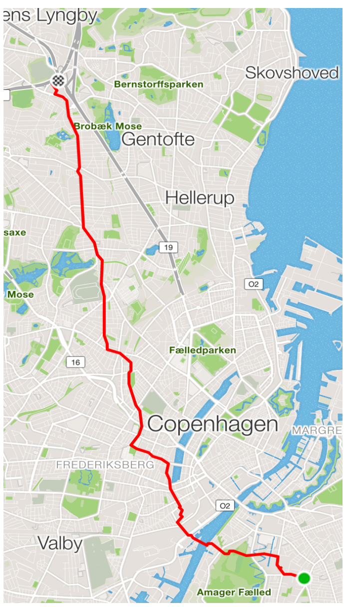
4.3.8.1 Bicycle Practice According to Competence

Male 38 began to bike in Copenhagen the day he moved into the city, which was 12 years ago. He is familiar with the cycling culture, but it took him a while to **get used to more cyclists**. He mostly bikes to his work, but he would bike in the city whenever it is necessary. He knows his cycle routes very well, and he used the **Municipality's bike maps** when getting to know his routes. He further explains that he likes to stay oriented, and he emphasises that **several opportunities exist**. *"I have invested a lot of time in finding fast routes"* (Appendix 16b). He does also **look** at his tracked routes on the Strava application to **find alternatives** to his bike routes. His desire to want to **avoid traffic** influences his ability to use the bike instead of a car for almost every occasion and purpose.

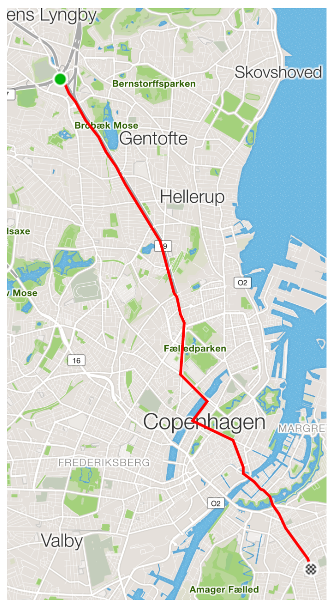
4.3.8.2 Bicycle Practice According to Material

It is approximately 15 kilometres to his work located in Gentofte. He got several bikes, but he mostly uses two of his "Bullitt's", where one of them is electric. A Bullitt is a combination between a sports bike and a Cargobike, and Male 38 uses the bike to **carry a lot of things** and for bicycling **fast at longer distances**. The bike enables Male 38 to bike often in his **everyday life** and for different **purposes**. Even though the bike is his main mode of transportation, he sometimes chooses to drive if he is going to an event after work. This is due to that he rather not park his Bullitt in the city for a longer period as expensive bikes are likely to get stolen. This statement could indicate that safe parking stations for bikes in the city are missing.

He got **three alternative routes** that he knows are **fast** when bicycling to work in Gentofte. One of them are very fast but also **less inspiring** as the bike path follows the highway. He is likely to choose a route that involves more **nature** when he got **extra time** and pampers himself with riding through parks as he did on Route 1 Thursday. The map shows that he bikes through Amager Fælled on his way to Gentofte, which is a less direct route than the alternative(s). Bicycling back towards Amager in the afternoon on Thursday (Route 2) he chose to bike the direct route nearby the highway instead of bicycling through the park. He explains it was relative **dark** after sunset and therefore did he not want to bike through Amager Fælled. He further explains that he in general always chooses the **fastest** route when bicycling home in the dark. When it is **light** outside during summer is he more likely to bike in areas with **nature**.



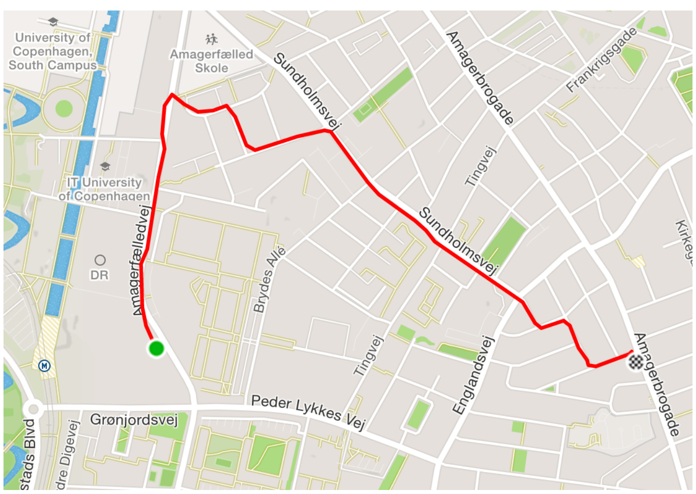
Route 1 Thursday (07:39)



Route 2 Thursday (17:18)

He explains that some of the traffic lights are difficult to be familiar with because some of them do not seem to have fixed intervals in when they change. He often experiences that he has to **stop** at a red light when entering a traffic light intersection while bicycling. He would then be likely to make an **alternative route**. Male 38 want to **avoid narrow bike paths** and those parts of the city that has this type of infrastructure. He often **bikes faster than the regular bicyclist** and often tends to overtake the road. He believes that a lot of traffic combined with narrow bike paths could present **dangerous situations**.

On Wednesday afternoon did Male 38 ride a short trip in his neighbourhood (Route 3 Wednesday). We are wondering why Male 38 chose to bike further on Amagerfælledvej instead of Peder Lykkes Vej. We assumed it had something to do with the infrastructure or that he desired a longer ride back home. During the interview did we find out that the Strava data is inaccurate because it shows that he was standing on the left side of the road when he, in reality, was standing on the right side. It makes sense that it is more **convenient to keep to the right.** He explains that he would rather take a **detour** as he thinks it is **difficult to cross** the road in this area.



Route 3 Wednesday (16:38)

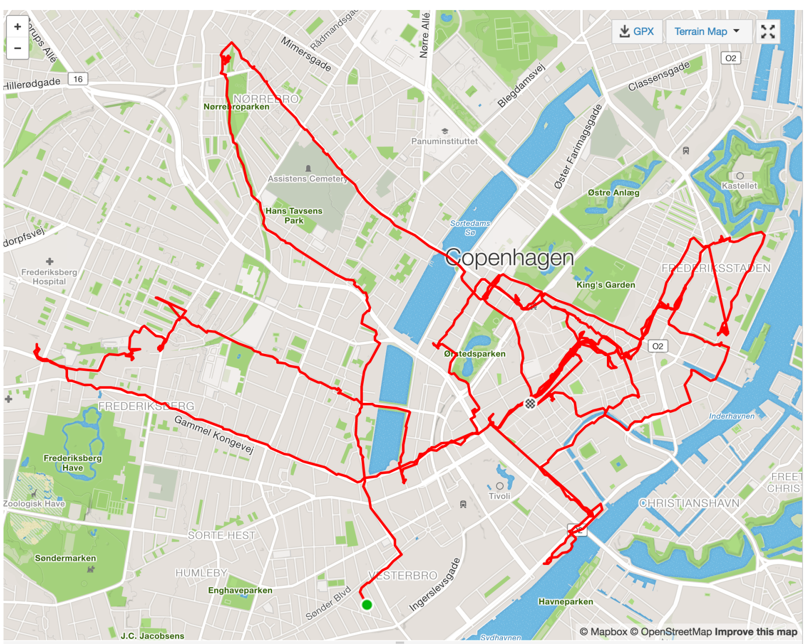
4.3.8.3 Bicycle Practice According to Meaning

The bike is his main mode of transport, which enables him to be **independent** on **traffic**. His choice of route is influenced by time constraints, time of day, the infrastructure itself and if he has errands. He is likely to choose the **most direct route**, but he wants to **try out several** routes to find the best route in terms of **distance** and how **fast** it is. *"I used a lot of time on planning my routes at some point, in order to find out how much extra time it would take if I was to take a detour. (...) It does make a difference. (...) I am most likely to choose the shortest route, but it could also mean a lot if there are many traffic lights and so on. (...) I bike many different routes because I really like to vary"* (Appendix 16b). Male 38 considers to bike routes that involve nature only if it does not differ too much in time compared to a fast route.

4.3.9 Male 21

Male 21 has been working as a **bicycle mail bid** in one and a half year, and the routes he bikes as a mail bid are the routes that are tracked during the mapping experiment (Appendix 17a). Male 21 does not bike any similar routes during week 13 because of his **work**. He gets to know the destinations of delivery, but he decides the routes. Since the destinations are not part of his personal daily life is it not possible to analyse the data as his individual bicycle practice. The mapped routes could still say something about his choice of route. It could seem like he is trying to bike as **direct** as possible. His maximum **speed** indicates that he is an **experienced** bicyclist as the speed is likely to range from 50 km/h to 65 km/h.

The bikes in every part of the city, and some of his routes as a bicycle mail bid also include bicycling to Lyngby, Hellerup and Tårnby. Looking at the maps during the week indicate that he is **familiar** with the **bicycle infrastructure** in Copenhagen.



Tuesday 28th of March (08:49). Example of one of his routes as a bicycle mail bid in Copenhagen.

4.3.9.3 Bicycle Practice According to Competence

He believes he is familiar with 99% of the bicycle routes he chooses to use. He explains that before he started working as a mail bid did he not know Copenhagen that well. As soon as he began to bike eight hours a day did the city appear different to him. To not become **tired of bicycling** the entire day when working did he start to **use roads that he had not used before.** More roads became familiar, which also is a continuous process. He also sometimes takes a break to just bike to **places he has never been before**. *"This is at least how I learn something new"* (Appendix 17b). He uses a bicycle **map** for navigating around in the city as the map on the smartphone is too small. A large map makes it easier when cycling long distances. *"It was very difficult in the beginning, but you get used to it, and you bike around with it in your hand, and finally it just becomes a part of it"* (Appendix 17b). In his everyday life would he never care to take public transport. If he was supposed to go 60 kilometres out of the city would he still choose to bike as he cycles **fast**.

Regarding traffic lights did he **learn** to catch the green lights by cycling the same road **several times**. *"I drive at Nørrebrogade five times a day, so you constantly get to learn how the traffic lights react if you bike fast, or a bit slower"* (Appendix 17b). Even though he hits red light sometimes does he not always stop and wait, as if he has something he needs to reach.

4.3.9.3 Bicycle Practice According to Material

Male 21 believes that the bike infrastructure in Copenhagen works well for the **general everyday bicyclist**, but as soon as you are getting **professional** and are bicycling **twice as fast at other bicyclists** are the bike paths **too narrow** to drive past others. He further mentions that cobblestones are annoying when driving with thin bicycle wheels. This **less satisfactory infrastructure** could influence where he **chooses** to bike.

The traffic lights do in most cases not influence where he chooses to bike. He could be likely to **choose other directions** if bicycling straight ahead on red light not is possible. He does not feel that he has a choice to make an alternative route at certain traffic lights, such as the intersection at H.C. Andersen Boulevard where he feels that there is **no alternative route to choose between** when going that **direction**. He is therefore sometimes **forced** to wait for about **two minutes** in this intersection. *"There is no other options. It is the only way through"* (Appendix 17b). He often experiences being close to getting hit by cars at traffic light intersections, as many car drivers tend to drive when the light is close to red. However, it does not influence his choice of route. He thinks that it should be **prioritised** to make the **bike infrastructure safer for bicyclists**. When talking about the bike infrastructure Male 21 points out that the bicycling bridges are very smart and desire this type of facility in the inner city. *"For example, a tiny bridge across one of the roads would be fantastic. You could manage to get out of traffic, and it would loosen up the congestion at the large roads"* (Appendix 17b).

4.3.9.3 Bicycle Practice According to Meaning

When bicycling, Male 21 is not dependent on other traffic, which enables him to have more **freedom** when transporting around. The routes he **chooses** to bike often **depend** on his **mood**. He would like to bike away from traffic when feeling **tired** to **avoid chaotic places** and not need to *think*. If he is in a **good mood** is he likely to ride in the **inner city** to be a **part of the traffic** and navigate around **fast**.

Male 21 feels it is important to be able to **bike past other bicyclists** as he bikes in a **high speed**. **Wide bike paths** are therefore preferable, as he does **not need** to **overtake on the car roads**. *"I feel safe when I bike at wide bike paths. People are so bad at bicycling, they overtake without responsibility, and they drive next to each other even though they know that they are not supposed to. (...) As soon as a bike path is narrow, which is where they are, do I not bother to wait for people so I bike out on the road"* (Appendix 17b).

4.3.10 Male 26

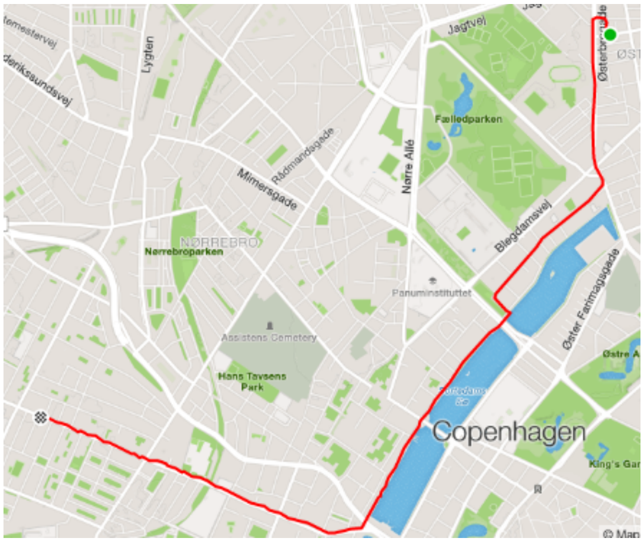
Male 26 has **three routes** in average per day and 19 routes in total during the experiment week (Appendix 18a). Out of the total amount of Male 26's routes are 16 routes direct, and 3 routes are alternative routes. His routes vary in distance, from 0,6 to 5,6 kilometres. We assume he is an **everyday cyclist** because the distances of his routes are quite short. The **Strava data indicate** that Male 26 prefer to **bike fast** as a cyclist, as his maximum speed sometimes is above 40 km/h. His average speed is around 18 km/h on each bike trip, which can indicate that he **combines exercising** when cycling.

4.3.10.1 Bicycle Practice According to Competence

Male 26 has been living in Copenhagen since August 2015. In the beginning, he cycled from August to October 2015 and then started using public transport in the winter period. During spring he began to bike again. He has not such good competence in the bike infrastructure since he has only lived in Copenhagen for less than two years. Male 26 know his route very well in the Frederiksberg area to work and to Aalborg University (AAU) in Sydhavnen where he is studying. ***"I find out the route myself, and I have never ask for help. It is with own learnings when I have been living in Copenhagen and Google Maps"*** (Appendix 18b). He knows common places like Nørreport station and Central station, but he uses Google Maps often to find unknown addresses in the city.

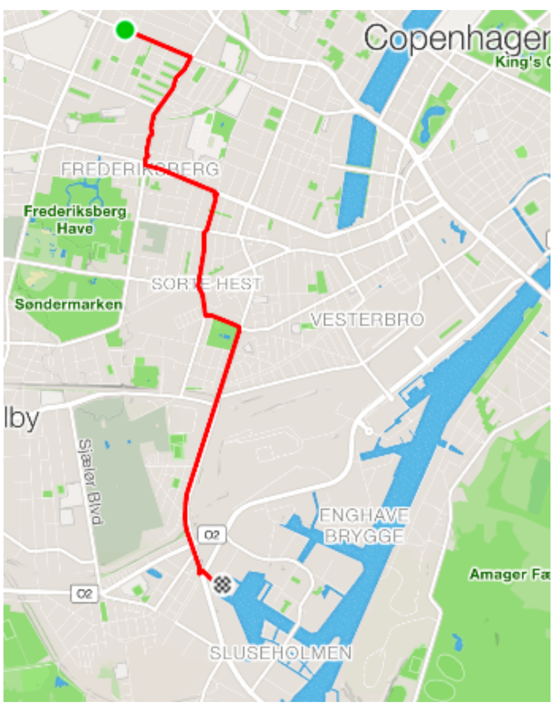
4.3.10.2 Bicycle Practice According to Material

Male 26 like routes that are **fast and direct**. Green and car-free routes are less important to him. He enjoys the bike paths along the lakes, which he also uses as a geographical direction tool. ***"I'm not very efficient to find my way in Østerbro, so the lakes is a good geographical spot to find my direction"*** (Appendix 18b). Route 2 on the next page shows the route where he uses the lakes as navigation.



Route 2 Saturday (12:58)

Male 26's daily route to AAU is mapped out below. ***"It is the fastest and shortest, I know it is. I have tried out other routes"*** (Appendix 18b). Male 26 have used this route for two months and have tried out some different routes with **help from Google Maps and by self-exploring**. He figured out this is the fastest and shortest route.



Route 1 Monday (14:09)

According to the infrastructure, does Male 26 feel that the route to AAU is missing bike paths at some parts, which he feel is dangerous because the space on the road is a limit. He takes the route regardless because the **time is the most important for him**. Male 26 can be standing and wait for 1.30-2 minutes for green lights at some traffic lights in Sydhavnen. He mentions that he are **too lazy to find other routes** and that he will wait for red lights instead of taking an alternative route. He thinks that route he takes is the fastest to ride anyway. In the nighttime, he experiments more green lights. ***"I can feel it goes faster, it is 3-4 minutes faster than daytime because it's no traffic and the lights are green more often"*** (Appendix 18b). He rides on red lights during night hours if there is no traffic.

4.3.10.3 Bicycle Practice According to Meaning

The first year, Male 26 did use public transport in wintertime because it was more comfortable since he meant it was cold to bike during winter. In January 2017 he started to cycle instead of taking the public transportation because he figured out it was expensive to pay for public transport. ***"I got provided with a bike from my landlord, so then I started bicycling already in January"*** (Appendix 18b). He is now used to bike in the cold now, and the main reason is to save money and get daily exercise. Male 26 prefers to bike on Falkoner Allè because he can **bike fast**. He dislikes to cycle on the **Åbouldevardvej, which is crowded** because of several cyclists in each direction. ***"Gammel Kongevej is also bad, it's a lot of traffic. I want to escape from this road as soon as I can because it's too big and crowded and has many traffic lights"*** (Appendix 18b). Male 26 think that the bike is the most efficient transport mode in Copenhagen, which also is **good exercise and it is cheap.** Today he uses the bike for all daily trips to work and university. Bicycling makes him feel that he has **more energy** at the end of the day.

4.3.11 Summary of the Analysis of The Mapping Experiment

The Mapping Experiment analysis gave a comprehensive understanding of the participant's bicycle practices. The quantitative Strava data supported the development of questions about bicycling practices and the usage of the infrastructure, which enabled us to identify 'abnormal' behaviour. The mapped routes and the information about each route formed the basis for our qualitative interview method. The qualitative interviews support the understanding of each unique bike route and address the cyclist behaviour. This enabled us to understand the broad range of bicycle practices, which we did not manage to figure out of when only looking at Strava Data. The participants reveal that their fixed routes are most likely the direct and fastest in time. Sometimes the participants choose different routes from and towards the same origins and destinations, which created a route that differs from their fixed route and leads to an alternative route.

Some common features are involved in when and why the participants choose alternative routes, as the participants often described their choice of a green route with wellness. The appearance of choosing green routes are likely to occur on days with nice weather, as many of the participants explained that the weather conditions were part of the reason why they wanted to choose a green route. The alternative routes also appear when the cyclist has extra time and when they are not constrained by something they need to reach. This type of routes seems to have the purpose of exploring new routes and areas, or involve places that the cyclist has relations to. How attached a bicyclist is to find and use alternative routes differs between the individuals. Some of the participants expressed more than others their need for alternative routes and showed a greater ability to vary their selection. The cyclist itself creates the meaning related to bicycle practice, and the meaning connected to the cyclist is dependent on each situation. The analysis of the participants revealed that there are differences in how fast cyclists tend to bike. Higher speeds (male 21, male 25, male 38, male 48, male 61, female 58) indicate that the cyclist is choosing bike infrastructure that allows fast bicycling, and that they are dedicated bicyclists that are familiar with the bike infrastructure. These bicyclists are also often those that are likely to explore and find new routes. Those bicyclists with less experience (Female 25, Male 26, Male 37) tend to rely on fixed routes and their routes vary to a less extent. After been analysing the last part in our analysis, we will in Chapter 05.Discussion answer the Sub-Questions based on the three parts of the analysis.

5.0 Discussion

In the discussion we will answer and reflect upon the Sub-Questions. The reflections are based on the findings in the analysis. The discussion presents three parts, where the first part goes into an reflection of ODOT's use of the Strava Metro data. The second part discuss the usage of Strava Metro data in the context of Copenhagen, and the third part presents reflections on the findings from the Mapping Experiment which combined Strava data and qualitative interviews.

5. 1 Oregon Department Of Transportation

The discussion on ODOT aims to answer and reflect upon the first sub-question, which is as follows: *What information did the Big Cyclist Data from Strava Metro give the planners in Oregon (USA), and to what extent does it provide an understanding of cyclists' practices?*

ODOT (2014) describe their need for cyclist data as something they desire because they are lacking information on how bicyclists are riding in Oregon. Cyclist data across the state was very limited and almost absent until they in 2013 purchased the data from Strava. In comparison with Copenhagen where policies and bike facilities systematically have been implemented in order to encourage people to bike is ODOT far behind in implementing the bike as a part of the planning processes. The different level of general knowledge on their cyclists presents two different starting points for Oregon and Copenhagen when it comes to the utilisation of cyclist data. Until now have ODOT used the data primarily for understanding when and where bicyclists are riding. In an article about ODOT's purchase of Strava data (Maus 2014) does Margi Bradway, formerly at ODOT, emphasise that the Strava data would give an understanding of why people bike, and that she is hoping that one of the key points would be that Strava data is not only quantitative data. She explains that the Strava data aims to give an understanding of cycling behaviours and provide answers to questions about why cyclists make the decisions they do (ibid.), and will not replace the countings they conduct. These arguments on explaining the purpose of purchasing Strava data in 2014 is not in compliance with how ODOT is currently using the data, where they now emphasise that the Strava data is used for understanding the usage of the infrastructure and not cyclist behaviour. ODOT explain that they still desire to know where people are travelling from and to get a deeper understanding of where people bike. The Strava data only gives information on origin and destination indirectly with heavily used locations, and it does not provide the full trip record of starting and ending points.

Bettinardi elaborate that if ODOT receive origin and destination information, would they might not have resources to do anything with it or not even have a need for this information. *"Maybe we really do not want or need to know that "half" of those miles travelled were just for fun, a loop, not going anywhere. (...) If we want to spend the time and money to really understand why people are using the system, will we want to plan for all of it, or are there just certain trips that we want to accommodate?"* (Appendix 6). The Strava data supports ODOT when projects need accurate information on e.g. usage of particular road segments. The Open Street Maps illustrate where bicyclists are located and provide numbers of riders at different sections, which could support the decision making on whether a local road or a state road should be prioritised when investing money in upgrading the infrastructure (Bettinardi and Peithman 2017). The priority of a route is based on the number of rides, which could give an accurate understanding of where bicyclists tend to ride as heavily used road sections by Strava riders would indicate that the roads are prevalent in the general public (ibid.). The reason why a particular road is involved in a cyclist's choice of a route does not become clear by looking at the Strava data because individual route choices are a matter of diverse opinions. Sometimes are certain road sections heavily used because it is the most direct route option and not necessarily roads people enjoy bicycling on. ODOT uses heat maps and numbers on bicyclists to indicate which roads that should be prioritised (Bettinardi and Peithman 2017), but the Strava data would not give answers to what an upgrading of the road should entail. By only looking at Strava data it might involve a pitfall when planning an upgrade the infrastructure, as possible measures would be based on assumptions and therefore involve uncertainty in its efficiency.

The Strava data currently provides ODOT with information about the travelled routes (in 2013/2014), which could also in some cases create a basis for finding research projects about cyclists practices. At the beginning of the Strava purchase did ODOT create a Strava Workgroup that aimed to explore pilot projects where the Strava data could inform policy and project decisions (Maus 2014). One of their findings when analysing the Strava data was an intersection where the bicyclists' behaviour was suspicious. Identification of infrastructure where the bicyclists' practices tended to differ from each other resulted in a desire to find answers to why bicyclists behaved abnormally in that intersection. This situation exemplifies that the Strava data could help identify less satisfying infrastructure which further creates a need for deeper understanding of certain behaviours. Parts of this workgroup left ODOT shortly after they acquired the Strava data, which could partly explain the reason why the utilisation of the data has varied in recent years. ODOT do not have a lot of resources towards bicyclists data and analysis. During the interview did ODOT give an impression of that the use of the data is limited to specific projects because they do not have resources that primarily is attached with analysing the data. Because of this, it is difficult to create reasons to investigate the data or consider its uses (Bettinardi and Peithman 2017). They have not continued purchasing Strava data which could to some extent mean that the data from 2014 are less representative regarding representing the currently usage of the infrastructure. However, ODOT did not mention that the use of the data is limited regarding that the purchase is not continued. On the other hand, are they currently working on creating a comprehensive count program where data sources such as Strava would be needed to collect *user based* count information (Bettinardi and Peithman 2017).

5.1.1 The Material Context's Influence on Route Choices

What kind of bike infrastructure that bicyclists prefer could to some extent be indicated by using Strava Metro. Peithman explains that this could be indicated on a map if it shows that bicyclists have chosen one type of infrastructure rather than another in the same area. ODOT did experience this when identifying that the off-street road parallel to the highway was more used as a bike path than the bike path by the highway was. The Strava data opens up for creating assumptions on what the reason might be but does not illustrate the diversity in the reasons why bicyclists are likely to choose exactly that type of infrastructure. Preferences are rather differing between each bicyclist, and GPS data would fail to illustrate a bicyclist's experience during cycling. Jennifer Dill who conducted research on bicycle behaviour found that bicyclists' choice of infrastructure differ partly depending on what type of bicyclist they are (Broach et al. 2012; Broach and Dill 2016). Within a city context could choice of infrastructure differ depending on gender and how frequently a cyclist is cycling. In order to find out what influences cyclists' choice of the route did Dill use GPS tracking that recorded the purpose of the trips and combined it with qualitative data in the form of answers to questions posed in a survey (ibid.). By doing this, did Dill succeed in gaining an understanding of what might influence bicyclists choice. Regarding what information the Strava data provides could it to a certain extent signify that cyclists choose different bike infrastructure, but sometimes the data comes to short in explaining why the choice have been made.

Strava Metro provided ODOT with data about which travels that are commute travels. This identification does to some extent provide information on what kind of trips are conducted in some parts of Oregon, which we before hand did not assume that the data would provide. This information enables an understanding for what purposes the Strava users bikes. A typical commute travel would be expected to focus on getting from A to B and therefore tending to choose the most direct route, but according to Dill's research (2012) and the results from the conducted experiment does it not seem that commuting cyclists choose fixed routes. ODOT could not look at the choice of routes as Strava Metro did not provide them with origin/destination information. This missing information limits their ability to identify to what extent cyclists choose direct routes or alternative routes. Regarding the mapping experiment, we were able to determine routes that differed from each other but included similar origin and destination, which created questions on what influences the cyclists' choices. The Strava data could, however, identify the usage of a selection of infrastructure at a particular area, and could in that way create questions on why cyclists choose differently in certain areas.

Explaining potential societal benefits of the purchase of Strava data does Bettinardi (2017) emphasise that the usage of the Strava application or similar applications could influence bicyclists' utilisation of a bike. Sharing information via smartphone applications could benefit the person itself and also contribute to the count of the usage of the infrastructure (ibid.). When local bicyclists are getting involved from a bicyclist perspective could they start to demand that the information is being used in the planning process, and insist that the data should be used as additional information in new projects. *"They have the ability to be more plugged into the conversation and contribute directly to the counting information we get, by either participating when bicycling or through Strava (...)"* (Appendix 7). The involvement of cyclists could influence the meaning of why they should use applications for sharing their bicycle route information, and also have an effect on the reason why cycling is important as the information contributes to the decision making. These types of route tracking applications could provide the bicyclists with a voice that enables them to participate and be counted more than they have been in the past.

5.1.2 Summary of Discussion on ODOT

ODOT use the Strava data efficiently in individual cases and projects, where information about seasonal ability or usage of specific infrastructure are desired. The Strava data provides evidence on that infrastructure is being used, which could be further used as an argument in the upgrading of bike infrastructure. ODOT does not use the Strava data to gain knowledge about cyclist behaviour or understanding bicycle practices, but rather for understanding where and when bicyclists are out using the bike infrastructure. The limited utilisation of the data is primarily due to the lack of resources within the state agency to deal with the analysis of the data. The small amount of knowledge they had on their cyclists before the purchase of the data could have an influence on the degree of the implementation and usage of the data. Currently are the cyclist data across Oregon based on the data from Strava and a few automatic counters, which does not enable them to get representative numbers of cyclists that use the system.

5.2 Strava Metro Data in Copenhagen

The discussion on Strava Metro Data in Copenhagen aims to answer and reflect upon the second sub-question, which is as follows: *To what extent are the data provided by Strava Metro in compliance with the information collected by the in-depth interviews conducted during the Mapping Experiment in Copenhagen?*

5.2.1 Highlighting Areas that are used Beyond the Designed System

Big cyclist data could be used on identifying certain areas where the bicycling public show their desire to leave the designed system. Agencies might be able to help improve connections, by formalising the bike paths people desire to take. We highlighted Toldbodgade as an example. The in-depth interviews indicated that choosing different roads and routes than the main roads are important to them. Big cyclist data could enable to identify where cyclists choose differently than what is given that they should. It could be argued that in order to be able to identify these areas. When looking at big data, it would be beneficial to know on beforehand which area to prioritise. This was the case when we found out of the problem in Toldbodgade, as we are familiar there and have experienced the area as a problem area.

5.2.2 Strava Metro Shows the Density and Activity at Traffic Intersections

The Strava data indicates high density and activity at some of the traffic intersections, such as Åboulevard and H. C. Andersen Boulevard. Further does the data show that the crossing times at these intersections potentially can be very long. The interviews during the experiment week gave us the impression of that some of the cyclist does not care about red lights because they understand it is necessary, and others prefer to avoid many traffic lights but sometimes does the infrastructure make it difficult. Traffic light intersections at main roads would be challenging to avoid as it would be involved in a direct route and alternative roads are to a less extent present. The Strava data indicates that even if a traffic intersection has crossing times above one minute are the volume of cyclists high. On the other hand do we not know how often crossing times above one minute occur at a certain intersection. Also, the data is not able to explain why a high amount of cyclists still cross intersections despite long crossing times.

At one of the traffic light intersections on Åboulevard did the Strava data indicate dense activity. The Strava data shows that many bike paths and car roads are interacting in this cross, which would from this point of view make up the reason why the activity in this intersection is dense. Some of the participants involved in the mapping experiment explained that the confusing markings of the bike path and the lack of a traffic light that controlled the cyclists heading from a different direction when entering the intersection was the main reason for traffic chaos. The different type of information sources exemplifies the gap that could arise between assumptions and the actual reasons. Additionally is this an example on that even though the data shows high activity density at this intersection and could qualify as a favourable intersection, does it not necessarily mean that the intersection is well functioning.

5.2.3 The Number of Cyclists on One Way Direction Roads

Strava Metro gave us an overview of each path and road that has been used by Strava cyclists in April 2017. By comparing numbers on rides on two parallel one-way streets, where Bredgade leads out of the city and Store Kongensgade leads towards the city, the data indicated that more people tend to choose one way towards the city in the morning, and a different way back in the afternoon. The tendency of choosing different routes in the morning compared to the afternoon was confirmed in the interviews with the participants, which revealed that cyclists with more knowledge about the infrastructure in Copenhagen did more often take another route home from a place, such as work or university. The interviews gave impression of that the participants tended to choose other routes on their way back from a place, as they then often was not constrained by time.

5.2.4 The Representativeness of a Sport Application in Urban Planning

The Strava cyclists in Copenhagen make up a tiny percentage of the total amount of bicyclists in the city. Comparing the counts from the automatic bike counter on Dr. Louises Bridge with the number of Strava rides at the same place makes Strava represent 0,1% of the total amount of bicycle rides on this section in April. Comparing the Strava rides with the counts from the counter by the Town Hall makes Strava represent 0,4%. The percentages confirm that most of Copenhagen's bicyclists are not represented in the data. In Oregon the Strava data represents about 1% of the total amount of bicyclists in urban areas across the state (ODOT 2016a). ODOT find this number representative enough to be able to use the heat to validate thoughts around planning issues, but they explain that they would not use the numbers as accurate counts (Bettinardi and Peithman 2017). In the recreational areas that mostly are used by experienced and dedicated bicyclists, Strava represents about 5-10% when comparing the numbers with the bicycle counters (ibid.). We compared numbers on rides received from automatic counters at Frederiksborgvej with the data from Strava Metro and found that Strava represented about 8% of the rides conducted on this road section located at the Farum route outside Copenhagen. These percentages indicate that Strava represent a larger percentage in areas where the general public does not ride. The Strava data could therefore only be used as indicative information, as the counts do not comply with reality.

The Strava application is an application that to a certain extent is being used for exercising and sport. The heat map could indicate that Strava cyclists live or work in either the city of Copenhagen or in the north of Greater Copenhagen, and that they might use their bike for transportation as well as for exercising as the distance they ride is long, especially towards Farum. It could be argued that a large percentage of the contributors to the Strava data sample are those that use the application as training cyclists. Training cyclists would typically have training equipment that supports bicycling as a sport and also have interest in wellbeing and health. Education and health relate to each other as it is proved that those with high education have more knowledge about health and are therefore more concerned about their personal health than those with lower education (Smith 2014). This could suggest that the Strava cyclists represent a community of educated individuals with a good economy that can afford bike equipment that enables exercising. The Strava application data is underlying the Strava Metro data, which could create a risk of that there is a high proportion of training cyclists that make up the data sample. In order to increase the representativeness of the Strava cyclist community should the application invite the everyday cyclists to utilise the application by modifying the feedback the application provides. If the feedback features relate to everyday cycling in addition to training it could attract a wider spectre of cyclists. Location of delays, CO2 reduction, and health output are examples on possible features.

5.2.5 The Representativeness of the Most Heavily Used Roads

The Strava Metro data highlights the roads that appear as most heavily used, and when looking at the Strava Metro data for Copenhagen does heavily used roads appear to be main roads. This further indicates a bicycle practice of getting fast from A to B. According to the "Cykelregnskabet" is the main reason for that the Citizens in Copenhagen choose to bike because it is the fastest (50 %) and easiest (49 %) transport mode to use in Copenhagen (City of Copenhagen 2015), which could support the finding in the Strava Metro data of that main roads often are involved in direct routes. It could be argued to what extent heavily used routes are the most important routes. If only prioritising roads that appear as the most heavily used would only certain bicycle practices be facilitated which in this case would be the fast and direct cycling from A to B. Alternative route choices could vary to a large extent and the roads included in these routes could appear as less used compared to main roads. This presents a risk of that alternative bicycle practices can be overlooked.

5.2.6 Summary of Discussion on Strava Metro Data in Copenhagen

The Strava Metro data open up the discussion on where new bike paths should be implemented, but it can provide a risk on where to prioritise bike infrastructure if only relying on the highest amount of rides. It is important to emphasise that a high volume of cyclists does not necessarily indicate that favoured places or infrastructure. The interviews from the mapping experiment inform that people tend to choose roads with high traffic volume such as main roads when desiring the most direct and fast route, but are likely to choose alternative routes when they have extra time. This support that it is necessary to have a varied selection of infrastructure in an urban context. A decision made exclusively on big cycle data could contribute to that certain bicycle practices become overlooked as it to a large extent informed about where the majority of cyclists ride. The results from the interviews implied that cyclists often tend to differ between the choice of routes when going places depending on factors as time constraints, time of the day and state of mind. This type of information that applies to the cyclist's route choices is limited in big (quantitative) cyclist data as personal opinions and choices are absent.

5. 3 The Mapping Experiment

The discussion on The Mapping Experiment aims to answer and reflect upon the third sub-question, which is as follows: *To what extent does in-depth interviews of cyclists in Copenhagen supplement big cyclist data in terms of the elements of competence, material and meaning?*

After been doing an analysis of the Strava Data from the application and the in-depth interviews of 10 cyclists in Copenhagen, we will further discuss the main findings of The Mapping Experiment. Because of that the Strava application mostly attract and invite training cyclists to use the application could have created a bias in our research and of the representativeness of the 10 participants, if the participants only represented one type of cyclist such as the training cyclist. The actual sample represents a variation in types of cyclists, which further is reflected in the empirical data collection. The qualitative interviews represent information that we were not able to collect from neither the Strava Metro data nor the Strava smartphone application. However, the Strava application enabled development of assumptions and questions that we posed to each during the interview. Our assumptions about their route choices did sometimes match the explanations that the cyclist presented during the interview, but the explanation could also be surprising. For example, we assumed that Female 58 most likely chooses to bike at routes that are direct and therefore fast, which matches her explanation during the interview where she emphasised that her route choices to a less extent involve nature as it is more important to her to reach her destination. A less direct route that Female 67 conducted made us assume that she was aiming to do an errand and was uncertain of the direction. During the interview, she explained that she did not aim to do anything special, and the reason why the route became less direct was that she desired to explore an unfamiliar area. Our assumption that she was uncertain of the direction was partly correct, but this was not the reason why she chose the route.

The quantitative Strava Data gave us an indication of what type of cyclist the participant represent. Data such as numbers on distance, duration of the activity, average speed and maximum speed enabled us to assume whether a ride was conducted for training or everyday purposes. Supplementing mapped routes to the facts enabled a better understanding of the routes. This mapped route data shows origin and destination of the routes which enabled assumptions on which area each cyclist work and live, as we could identify repetitive routes throughout the week and look at the time of the day when the route was conducted. The qualitative data from the in-depth interview supported the understanding of what the reason behind the choice of route. We did manage to understand how competence, material and meaning affect each other, which we found different from person to person. We will exemplify this with examples from the analysis and discussion of main findings.

The participant's amount of daily routes varies between two and five routes in average. When approaching the participants, it often occured that those with few daily routes lacks knowledge on the infrastructure in Copenhagen compared to those with several daily routes. The Strava Data and the mapped routes helped us to assume the level of experience of each participant, which enabled us to look at common features of particular bicycle practices by investigating the time of the day when cyclists tend to choose alternative routes and what infrastructure they use.

The smartphone provides digital map tools such as the application Google Maps, which is a tool that in recent years has been introduced to the society. It seems to be a tool that mostly inexperienced bicyclists use, but also by experienced bicyclists when going directions they are not familiar with. We found that some of the participants were likely to use Google Maps when planning routes, either to unknown locations or to find alternative routes to where they tend to bike often. New technology and well-developed infrastructure could enable the cyclist to explore new routes, such as finding the fastest route, or finding preferable bike conditions. Some of the cyclists do also use geographical knowledge as a tool for navigation to find the right direction, such as main roads, the harbour, the lakes at Østerbro-Nørrebro-Frederiksberg and parks. We found that those cyclists that have bicycled in Copenhagen before the technological development tend to have a more varied range of routes than those cyclists that tend to rely on technology. When we compare the mapped route on Strava for those we assumed was less experienced cyclists with the Google Maps route suggestions, did we identify that these routes match each other, which further supported our assumption on the level of (in)experience for the cyclist who has not lived and cycled for an extended period in Copenhagen. Exploring new areas and expand alternative route choices seems limited for someone and completely normal for others. Participants who indicate a tendency to choose differently when going from and towards similar locations may appear to be experienced with the bike infrastructure. Even though that technology revolutionises how people navigate today, are handheld maps, friends or personal curiosity still a part of how the infrastructure is explored.

It appears that the participants enjoy cycling on green bike paths and areas where there are less traffic volume and noise because it creates wellness, but even that they prefer to bike in green and nice surroundings does it not necessarily mean that they always choose a green bike route. Bicycle practices differ between individuals and the individual him/herself, and bicycle practices depend on a variety of factors that influence to what extent an alternative or a green route are chosen. Sometimes are cycling on roads with high traffic volume the most direct and fastest route when going from A to B. What a person prefers varies with the situation they are in, as in certain situations could fast routes be favoured and in other situations could green routes be favoured. When looking at the participants' mapped routes, we found that out of 143 routes in total, 84 routes were direct routes, and 59 routes were alternative routes. These numbers illustrate that the participants to a large extent also chooses alternative routes, as alternative routes represent 41% and direct routes represent 59% of the total amount of routes conducted during the experiment week. The situation that influences the choices of bicycle practices are individually and difficult to indicate by only analysing the Strava data.

When only looking at the Strava data and the mapped routes for the participant's routes during evening hours when it is dark outside, we managed to indicate that they chose direct and faster route compared to what they did during daylight. The qualitative data identified that the participants preferred to bike direct routes after dark, partly because of the lack of light on low-traffic roads and in parks. This exemplifies how the situation influences people's preferences. During daylight were the participants more likely to bike through green areas. This finding could say something about why the season and the weather influence the use of the infrastructure. This would support that cyclists are more likely to choose alternative routes during summertime when daylight is longer compared to wintertime when it is dark and people would be likely to choose more direct routes.

The mapped routes in conjunction with the in-depth interview present evidence about the diversity of how and why cyclists are using the infrastructure. Either to chose the quickest route, or to try a new alternative route for exploring new places which the participants mean creates new experiences. Female 67 describe an alternative route as, *"I just went bicycling, and didn't do anything special. I wanted to ride on those fun roads"*. These types of routes are difficult to get an understanding of by only reading the Strava Data and mapped routes. Male 48 who enjoys to cycle in Elmegade because of the nice atmosphere indicates that some also enjoy cycling in specific surroundings and environments. It seems that choosing alternative routes are satisfying in the sense of creating a feeling of wellness and exploring new places.

There were mixed opinions about traffic lights among the participants. We got the impression that the cyclist who has used the same route for a long time have learned to adapt their practice in order to reach the green traffic lights. The interviews revealed that the ability to achieve a flow when bicycling has to be obtained by cycling at similar places in an extended period of time. In this case is it clear how the three elements affect each other and influences bicycle practices. The cyclist has desired the *competence* to adapt to traffic lights because achieving a flow during a bicycle ride is important. The traffic lights are to some extent annoying if the red lights create stops several times during a route. The *material* can influences the *competence* to be acquired, as comfortable cycling is a *meaning* of good drift (for someone). Cyclists that often experience red traffic light can experience less flow on their routes, which also can influence to make spontaneous decisions that create alternative routes. The elements of *meaning* and *material* in traffic lights can create different outcomes, either adapting to the traffic light intervals or making spontaneously alternative routes.

The Strava Data provides real-time information on the participant's routes, which made it possible to identify exactly where on the road segment a cyclists stop and the duration of the stop. At one of Male 48's normal routes he did a stop for 20 seconds in one of the intersections he normally does not stop at. The reason why Male 48 had this stop along the route at his ride was not possible to identify when only looking at the mapped route. During the interview it turned out that the stop was due to construction work. This exemplifies that the Strava data gave information about a disturbing event during his ride, but did not give answers to the reason behind.

5.3.1 Summary of Discussion on The Mapping Experiment

The Strava Application data and the mapped routes give a partial image of each participant's bicycle practices. The supplement from the in-depth interviews helped us see differences in what qualitative and quantitative data give answers on. The combination seems to be important when doing research on people's bicycle practices in an infrastructure context. We manage to identify that there are four types of bicycle practices among our participants: 1) cycling the most direct way from A to B, 2) cycling for wellness, 3) cycling for creating experiences and 4) Cycling for exercising. Summarising the information from the interviews identified these practices. There is different bicycle practices linked to different infrastructure, and a cyclist can also vary between different bicycle practices and have more than one. The bicycle practices can also be combined, as for example could cycling from A to B be combined with exercise, or bicycling for exercise could be combined with creating experiences. Alternative bicycle practices are as well as important as the bicycle practice that big cyclist data tend to highlight, namely cycling that focuses on getting from A to B.

Further, in the conclusion we will describe our major findings from the analysis and the discussion and answer our research question.

6.0 Conclusion

The conclusion is based on the findings in our empirical research, which is presented in the analysis and discussion. Finding answers to our sub-questions enabled us to conclude an answer to our problem formulation, which is as follows:
"To what extent can Big Cyclist Data give an understanding of bicycle practices in an urban planning context?"

As we got a varied selection of participants in the mapping experiment, from students to elderly, and from experienced to inexperienced cyclists, did the interviews identify a significant diversity in the reasons behind how, when and why cyclists choose to ride. Although were we able to distinguish between certain bicycle practices and place those we found most common in four main categories, which are 1) Cycling from A to B the fastest and most direct way, 2) Cycling for wellness, 3) Cycling for creating experiences, and 4) Cycling for exercising. The understanding of the different bicycle practices is explained in the four following paragraphs:

We identified that one common bicycle practice was 1) the practice of getting from A to B in the most direct way. The *material* such as the infrastructure and the surroundings did not influence this practice, as the most direct way was seen as the fastest option anyway. Also the number of traffic lights or traffic volume, the bike facilities or the surroundings was indifferent regarding directness. Direct routes were often identified as the cyclists' normal practice as these routes often were repeated, and often represented the route the participant chose to bike towards work or education or when being constrained by time. IT tools such as Google Maps could have an influence on the occurrence of this practice as these tools suggest the fastest route from A to B, rather than suggesting routes that show where experiences are created. The interviews with the participants revealed that IT tools were likely to be used when going unfamiliar places or when being new to the city.

A bicycle practice that seems as well as important as the choice of direct routes is 2) cycling for wellness. This practice would *mean* cycling in places with a pleasant atmosphere or surrounded by nature and fresh air. Most of the participants explained that this created a *feeling* of pleasure. The practice is usually conducted when having extra time when bicycling. The feeling of wellness and satisfaction depend to a large extent on the *material* such as the surroundings and also to a certain degree the infrastructure. Bike facilities could influence the level of wellness and pleasure such as wide bike paths, which could mean lower interaction with other road users. The location of the bike bridges that crosses the channel provides pleasant surroundings and separates cyclists from road traffic, which is preferable for most cyclists in particular situations. Bicycling in streets with a pleasant or vibrant atmosphere would not necessarily provide bike facilities such as dedicated bike lanes or infrastructure that facilitate low interaction with other road users. It would still promote wellness and pleasure as a *meaning* to the practice as the atmosphere and the surroundings influence the experience. Bike routes that involve nature create wellness and pleasure as it both provides beautiful and quiet surroundings and infrastructure without car traffic. These types of routes are often seen as less direct and can limit the level of usage of this kind of areas in everyday cycling.

Further, we identified that the participant's 3) cycle for creating experiences. This is a practice that the participants conduct when desiring to explore new places or choose to bike a route in unfamiliar areas in order to create new impulses and stimulate their senses. This is a rather spontaneous practice that is likely to appear when a cyclist is not constrained by time or by someone. The *meaning* is not necessary to bike in specific surroundings such as nature or at certain infrastructure, but just bicycling without any specific reason.

The last bicycle practice that we were able to categorise were 4) cycling for exercise. Some of the participants had the ability to combine cycling with training. This practice was embedded in the concern about personal health. Bike conditions that enable fast bicycling such as bike lanes that are separated from road traffic and wide bike paths, and also longer destinations characterise the practice for exercising.

Big cyclist data are not able to distinguish between all kinds of bicycle practices. It could give assumptions about the reason why particular infrastructure are used, but opinions about why a variety of practices are conducted are only possible to identify by observations from qualitative data such as interviews. The conducted interviews during the mapping experiment revealed that the cyclists tend to choose alternative routes when they do not have any time constraints. These alternative routes were likely to be less direct routes. Each cyclist tended to conduct different bicycle practices during a day, where the choice is likely to depend on the situation, such as the weather, responsibilities such as errands and appointments, and personal mindset.

Different types of infrastructure need to be implemented if the various bicycle practices should be maintained. It could be argued that different type of infrastructure creates different kinds of bicycle practices, but the same bicycle practice could also be conducted on different types of infrastructure. As an example, the usage of the bike infrastructure in Copenhagen shows that a recreational type of infrastructure could both be used by cyclists that want to get from A to B, or for exercising, or for pleasure. This was a finding that was identified when looking into both big cyclist data and qualitative cyclist data. The cyclist data in GIS showed that a broad spectre of the bike infrastructure in Copenhagen is used, and the qualitative interviews identified for which purposes the infrastructure are being used. Combining both sources of information has provided an understanding of the usage of the infrastructure and what influences bicycle practices. This knowledge can support the facilitation of better bike conditions and invite more people to use the bike infrastructure.

Qualitative interviews do not represent the overall population to the same extent as big cyclist data does. It rather represents the diversity in the choices of the cyclists, as choices differ between individuals but also the individual itself conduct various choices. As the interviews represent variation in opinions and actions, it will mean that a certain number of interviews need to be conducted before it is possible to create and understand a pattern among the bicycle practices that exist. How many interviews that should be carried out before a holistic understanding of cycling practices could be created is not easy to indicate, but a representative selection has to be assured. When collecting qualitative data and conducting interviews, is cyclist data in form of maps, numbers on counts, and time of the day profiles useful in developing questions about practices and behaviours.

In our mapping experiment we used the Strava application, which enabled us to look at individual route choices. This created the basis of information that we used when developing questions of each unique cyclists. In big cyclist data as we have identified through Strava Metro was it not possible to look at the individual choice of roads during a certain trip because of privacy issues, which limits the information on the cyclists' choice of bicycle practices. On the other hand, big cyclist data opens up the discussion and provides information that could contribute to the development of questions about cyclist practices at certain locations, and support the identification of further research projects that aim to elaborate on the findings.

Without conducting interviews, the understanding of cyclist practices would to a large extent be based on the general public and those practices that seem to be most common. In many situations would this be the choice of a direct route when bicycling from A to B. Big cyclist data highlights the most heavily used road segments which often could seem like the most popular areas, and therefore would the data primarily focus on where most cyclists tend to bike. This could risk that the understanding of cycling practices are generalised, and the diversity that the actual public represent are overlooked. This would further mean that alternative bicycle practices become less prioritised as different bicycle practices are not easily identified on a map. Further, there would be a risk that decisions would be based on assumptions as big cyclist data mainly provide quantitative information to specific questions rather than giving answers to qualitative questions. In decision making could it represent a challenge when knowledge lacks on the overall usage of the bike infrastructure, as it contributes to uncertainty on the efficiency of new implementations and measures. Interviews about opinions and experiences could be a way of reducing the risk of implementing inefficient measures, as the decision making would to a less extent be based on assumptions.

Regarding big cyclist data could the decision making be influenced by how the data is interpreted. In the interpretation of the data would it be needed to be aware of that certain areas and type of infrastructure that big cyclist data shows as most used does not necessarily represent well-functioning infrastructure or the most necessary infrastructure, although this infrastructure also is important. From the interviews did we identify that various types of infrastructure are important, which would to a less extent become visible on a map. The Strava data indicate that main roads are the most heavily used roads, and the interviews revealed that cyclists choose main roads because these roads are often direct and therefore also fast. This shows that this type of infrastructure is necessary when the focus is to get from A to B. The type of direct infrastructure is to a certain extent limited in the overall bike infrastructure network compared to the different options that alternative routes represent. An alternative route could include several parts of the bike infrastructure and therefore are choices more widespread than the choices that represent direct infrastructure. This could be one of the reasons why of main roads often are highlighted as most heavily used. Planners should be aware of the reason why certain infrastructure is highlighted when interpreting the cyclist data, otherwise it could present a pitfall in the planning process.

The Strava data that represented the bicycle activity in Copenhagen illustrated high bicycle activity on the “Farum” route, which is a route that tends to be used by active cyclists, as it is located outside the urban city of Copenhagen. Calculations show that Strava represents 8% of the total number of bicyclists at one of the sections on this route. Compared with an urban context does Strava represent 0,1% and 0,4% of the total amount of bicyclists at Dr. Louises Bro and by the Town Hall. These numbers indicate that the Strava data is illustrative in highlighting that a larger amount of bicyclists are represented on routes used for active bicycling.

It seems that the most reliable method of gaining an understanding of the diverse opinions among bicycle practices are by collecting qualitative data, as each cyclist represent various route choices. Qualitative interviews highlight the diversity that exists amongst cyclists and gives answers to questions about behaviour. The conducted interviews showed that a low percentage of the total amount of cyclists provides valuable information, but in order to develop reliable knowledge on bicyclist behaviour and different practices must a certain percentage of the total amount of bicyclists be represented. Regarding creating a platform of reliable big cyclist data in forms of visualisations and quantity, a certain percentage of the total amount of cyclists must be represented, but just as important as the quantity would be to ensure the representativeness of the different types of cyclists. If both quantitative and qualitative data are used as information sources, it will provide a vast amount of information. The challenge is again to ensure the representativeness of those involved in the data sample. Developing a data collection method that covers information from both quantitative and qualitative sources would enable that other bicycle practices could be identified beyond those we categorised, which were bicycling with a focus on 1) direct and fast routes, 2) cycling for wellness, 3) cycling for experiences, and 4) cycling for exercise. Even that the sample only consisted of ten participants did the varied selection of cyclists enable us to categorise practices, which could indicate that a larger sample could identify an even greater variety of bicycle practices.

The next chapter will present the perspectives on our research, and will include highlighting ideas that should be of interest in further research. In Chapter 7.Perspective we will first address the factors that limited the research scope in the master thesis and then present potential future research projects within the field.

07. Perspective

We have now presented our conclusion for our research on Cyclist Data and practices in an urban context. In Chapter 1.Introduction did we mention that earlier research about Big Cyclist Data goes back approximately ten years and has been absent in the implementation of transportation development in cities (Romanillos et al. 2016). It has been a challenge to find valid sources of research within Big Cyclist Data. The workshop arranged by the City of Copenhagen gave us an insight in that technology and methods for cyclist data collection will be a major topic in the future. Big cyclist data caught our interest and as we began to research did some factors limit the scope of the research. The limitations of our research are further explained in the following paragraphs.

The spring semester 2017 have a timeframe from February to June. We developed a project plan in the beginning of the semester and we have followed it throughout the entire master thesis period. The time constraints have limited the number of participants in our mapping experiment and the subsequent in-depth interviews. We are not in the position of collecting a large amount of data in a time period of five months, but we have collected a relatively appropriate amount of data for our purpose to find answers to our problem formulation. Regarding the mapping experiment, we found that the number of ten participants would represent an amount of data we could manage to process and analyse within the time frame of the thesis. Finding ten voluntary cyclists to participate in the mapping experiment were not as challenging as we concerned, and enabled us to conduct the mapping experiment. Utilising a smartphone application to collect cyclist data enabled us to question specific practices, and the number of participants enabled us to investigate our assumptions further. This research gave us concrete examples to refer to, which we believe provides a substance in our research. We experienced that cyclists were likely to participate in our experiment, which we think indicate that citizens are open to being involved in projects that concern their everyday life.

The collection of and access to big cyclist data are in general limited and are usually owned by private companies that do a business out of distributing the data to e.g. cities and transport agencies. Access to digital GPS tools that provide big cyclist data is also limited. As authors of the master thesis, we discussed and agreed early in the master thesis period that we would use cyclist data from Strava to get an insight into big cyclist data in Copenhagen, as the company has a history of delivering data to transport agencies to facilitate planning processes. After receiving the cyclist data from Strava Metro, we understood that it could not be classified as big data. Strava is a smartphone application for persons that exercise, which limits the data's scope of various types of cyclists and the level of activity. However, the Strava data provided an insight in how cyclist data potentially can contribute in planning, and supported our knowledge on to what extent this data enabled an understanding of bicycle practices.

The cyclist data we received from Strava Metro can either be accessed in a Web Visualisation program or in Geographic Information System softwares. As we do not have access to GIS software in our study program is our competence in how GIS is utilised limited. Our competence in using GIS developed during the master thesis period and we managed to use it in specific cases where we needed information that was not accessible through the web visualisation tool.

We want to emphasise that our aim was to investigate to what extent big cyclist data gives information on bicycle practices, rather than finding a method on how cyclist data could be collected or give suggestions on how planners should implement the data in urban planning. This research would require more time, and increased technological knowledge, and also cooperations with technological developers, planners and the municipality.

Further development with this master thesis would require extensive and comprehensive research in order to elaborate on the possibilities and limitations in the field of big cyclist data, as the field of research is limited today. In context of Copenhagen the bicycle practices of its citizens should be further investigated since there is a significant amount of cyclists in the city, which would most likely increase in the future. The data sample that Strava Metro provides does not cover a wide selection of cyclists, neither a large percentage of the bicyclists in total, and does therefore not represent the ideal cyclist data sample for usage in urban planning.

To ensure an effective implementation of big cyclist data in the planning process and prevent the pitfalls that reduce its reliability we have collected some points within the field that needs to be investigated. Further research should include:

- Investigating the possibility to develop a method that covers information from both quantitative and qualitative data sources, where the method ensures that qualitative (cyclist) data supports and supplement quantitative (cyclist) data. We will propose to experiment with a smartphone application that automatically monitors bicyclists' routes with GPS by recognising when a bicycle trip starts. Additionally, the application should collect qualitative data by enabling the cyclist to give feedback. The developer of the application should also have the opportunity to questionnaire its users. The majority of the participants in the mapping experiment expressed that they will be more likely to use a smartphone application frequently if they know that the information exclusively is used in the planning of better bicycling conditions. Guaranteeing that the information will be used in urban planning can serve as an incentive to attract cyclists to use the application.
- To develop a "cyclist data" strategy for decision makers and planners to ensure the implementation and utilisation of the cyclist data in decision-making processes. The strategy should suggest how the cyclist data should be utilised by actors on the local level.
- Investigate how (big) cyclist data could be involved in cross-sectoral planning, in order to create a holistic planning approach. Cross-sectoral planning on bicyclists can provide better collaboration between the actors, which creates a platform of information and data transfer.
- Investigating how large amount of data is necessary in order to create big cyclist data, and who and how many should be involved in order to ensure representativeness. When are cyclist data "big", and representative for use in urban planning?
- Protect the privacy of the people that shares their personal cyclist data to developers such as IT companies or actors such as municipalities.

These pinpoints represent examples of where in the field of cyclist data there should be conducting research. The elements in practice theory were relevant in relation to understanding to what extent the interviews and the Strava data gave insight to bicycle practices and opened up for discussing the importance of competence, material and meaning in a bicycle practice context.

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09. Appendices