INFLUENCING ROUTE CHOICES OF CYCLISTS BY INFORMING

Civil Engineering Bachelor thesis

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SNUFFELFIETS

provincie :: Utrecht

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1 INTRODUCTION

Cycling is an important mode of transport in the province of Utrecht and in the Netherlands in general. In 2019 the province announced that she wants to be the bicycle region of Europe. To achieve this, improvements have to be made to the bicycle network. In 2019 the province started with a project called the Snuffelfiets (Sniffer Bike) which, amongst others, would help to increase their knowledge on cyclist behavior. This project consisted of 500 participant cyclists that cycled around with a box attached to their bike that measured their GPS location and the air quality on that location (ultrafine particles $PM_{2.5}$).

Most travel policies aim only for an increase in bicycle usage, but do not encourage cyclists to make better route choices. Encouraging travelers to make different route choices is a method that is already applied to car drivers, where drivers can change their travel route based on information their receive for example about traffic jams, which results in reduced amounts of congestion. Steering cyclists towards different routes will not reduce congestion but it may be beneficial to the traffic flow in densely populated cities, and it can increase traffic safety, which results in can increase in health benefits for cyclists.

In this research it is investigated what the opportunities are for the province when it comes to achieving their ambitious bicycle policy goals by influencing the route choices of cyclists. In this, the preference of the cyclists is put in the center. When influencing the behavior of a traveler, the willingness of the traveler is very important for the effectiveness of the method. Therefore, this research focusses on what the cyclists of the province want and matches this with the goals of the province.

2 RESEARCH CONTEXT

2.1 THE PROVINCE OF UTRECHT

In 2019 the Province of Utrecht released an implementation program for cycling in which it was stated that she wants to become the bicycle region of Europe by 2028 (Provincie Utrecht, 2019). Influencing the route choices of cyclists can be important in reaching these goals. The policy goals of the province are central in this research because the final recommendation is specifically designed for the province.

The province of Utrecht will become the bicycle region of Europe by ensuring that in 2028 important locations, such as schools and workspaces, are safely, comfortably and quickly accessible by bicycle (Provincie Utrecht, 2014). Another aim of the province is that in 2023 50% of the trips under 15 kilometers are made by bike. There are many advantages of traveling by bike for both the cyclists (e.g. health and flexibility) and the environment (e.g. emissions and space).

The main issue for the bicycle network in the province is the occurring shortage of capacity in all bicycle facilities (on the road and in storage facilities). In certain densely populated urban areas there is simply no more space of bicycles and cyclists. This is mainly caused by the growing amount of jobs and inhabitants of the province and the increasing popularity of the bicycle. And since the province aims to strongly increase the bicycle usage changes have to be made to the network to accommodate these travelers. Furthermore, the crowdedness on the road and the increasing differences in speed on designated bicycle lanes is creating more dangerous situations. Over the years, there has been an increase in both severe cyclist accidents and smaller accidents. Also, in locations where different types of transport modes meet more conflict situations occur, with negative effects on the traffic safety and traffic flow.

The issues with the capacity of bicycle facilities, the safety cyclists on the road and traffic flow within the network urge the province to create more space. The focus of the province is on creating a safe, comfortable and fast regional bicycle network, where safety is priority number one. In addition, the bicycle policy not only talks about accessibility but also stresses the importance of health, live ability and equality. The province aims to increase bicycle usage but also places a high importance on the quality of cycling through the network.

2.2 SNUFFELFIETS

In her policy the province describes she wants to increase the knowledge on cyclists behavior. Snuffelfiets is one of the province's projects that is part of mapping the use of bicycles throughout the region. Over a year 500 volunteer civilians gathered data about their bicycle movements (GPS) and the air quality ($PM_{2,5}$) on their travel routes (Althuis, et al., 2020). In an app the participants could see where they had cycled and what the air quality had been like on their route. Furthermore, the data on air quality was made publicly available on the project website (Snuffelfiets, 2020). Figure 1 is an example of what the measured air quality data for all cycled routes on one day looks like.

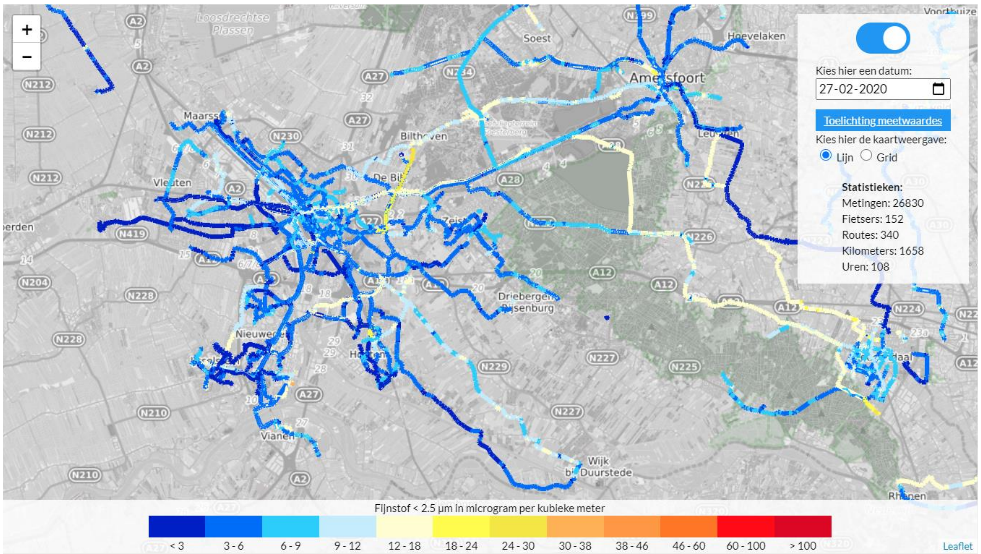

Figure 1 - Overview of measured air quality in the Snuffelfiets project on one day (Snuffelfiets, 2020)

Snuffelfiets is an example of a citizen sensing project. Such projects are charactered by their active involvement of citizens in the planning process of local and regional mobility, in the form of collecting and exchanging mobility related data. Benefits of these projects are that they can help to pinpoint local problems better, create more understanding of the current needs, and better predict future travel behavior (Booth & Richardson, 2001). Moreover, actively involving citizens results in raising awareness amongst citizens, it can initiate a dialogue on the subject, and increases the exchange of data (Kobernus, et al., 2015).

A citizen observatory is a two-directional platform for information exchange, where the goal of the project and the process is set up by experts and managers and the participants provide data for the organization. In the Snuffelfiets project the participants also received information about the air quality on their travelled routes. Giving feedback to participants has proven to be a good method to keep participants motivated and open up the dialogue (Keseru, Macharis, & Wuytens, 2018). In this case the feedback that participants received enabled them to choose cleaner travel routes.

It was never an aim of Snuffelfiets to influence the route choices of cyclists, but now that the project is coming to an end, it might have been a positive byproduct. There exist different methods of influencing cyclists route choice behavior, which are characterized by the target group, the type of informing used, and which route choice factors cyclists are informed about (chapter 3.2.). The target group of Snuffelfiets was a group of 500 citizens of the province. The participants of Snuffelfiets were stimulated to choose different routes via information about one particular route factor, namely air quality and they received this information via an app.

These 500 participants play an important role in this research, since their route choice behavior is looked at further. Informing about air quality is one way to influence route choice behavior and it is investigated how effective this has been within this group. Furthermore, by questioning this group of active cyclists in the province of Utrecht a picture is painted of what/if other ways of influencing route choice behavior may be effective.

2.3 INFLUENCING CYCLIST ROUTE CHOICE BEHAVIOR AND THE RELEVANCE OF THIS RESEARCH

Influencing travel behavior is about altering a travelers decision making by suggestions and reinforcement (Thaler & Sunstein, 2008). In transport, influencing traveler behavior has been a focus for many years already. People are starting to understand the importance of strategies that steer individuals into better decisions for themselves and society at large (Heiskanen, Brohmann, Fritsche, Schonherr, & Aalto, 2009). However, these strategies have not been implemented on large scale yet because of the lack of studies that show the usefulness of different methods for mobility.

When it comes to influencing cyclists to make better choices, many different techniques can be used. A technique can be to provide information to cyclists about certain topics that are important to them. Research shows that cyclists route choices are complicated but that they do not necessarily choose the shortest route. It was found that cycle trips are around 10% longer than the shortest possible path (Winters, Teschke, Grant, Setton, & Brauer, 2010). In a cyclists' decision making other factors are also considered important, such as number of heavy vehicles and traffic volume (de Vos, 2018) (Segidilha & Sanches, 2014). Furthermore, when choosing a travel route there is always a level of uncertainty in the route characteristics. A traveler can make more informed and confident decisions on their route when they are informed about the characteristics of the possible routes (Dill & Gliebe, 2008).

Currently in transport, most projects about travel behavior focus on the shift in transport modes to more sustainable modes and do not address influencing route choices of cyclists specific. However, the CROW bicycle council does acknowledge the importance of influencing the route choice behavior of cyclists. They have published a report that shows the issue of crowdedness of bicycle lanes, and that lists several measures policy makes can take to tackle this (de Lange, Talens, & Hulshof, 2017). They stress that environmental planning and road design are not the only tools to influence the decisions of travelers on transport modes and travel routes. It is advises that the authorities, such as the province of Utrecht, adopt a package that combines infrastructural measures, communication about alternative routes and behavioral changes of cyclists.

An example strategy from the CROW bicycle council is to integrate unknown and unfamiliar routes into the mental maps of cyclists, to reduce the traffic volume on other roads. This recommendation is an example of how influencing route choices of cyclists can be important to the province. The creation of several bicycle highways that will connect urban areas plays an important role in the bicycle implementation plan of the province. These new bicycle lanes provide a lot of opportunity to reduce the traffic intensities on alternative routes. To ensure optimal use of these new links, cyclists need to be made aware of these alternative routes and their advantages.

Next to this, influencing cyclist route choices can also benefit the health of bicycle users by increased safety and cleaner travel routes. Furthermore, different route choices may also result in an improved traffic flow in a way that traffic is better distributed in areas with limited space. Both the well-being/health of cyclists and the crowdedness due to the lack of space in urban areas is mentioned as major issues in the newest bicycle policy of the province. The safety of bicycle users is mostly jeopardized by other road users. The province states the issue relates to the large speed differences (due to the increase of e-bikes and pedelecs) and other types of vehicles on the road. Thus, the traffic safety of cyclists may be improved if they make more use of bicycle-only roads and avoid crowded areas.

Adopting a policy that includes methods of influencing route choices is not enough to reduce the issues the CROW bicycle council describes. The willingness of cyclists to change their travel behavior plays an important role in the effectiveness of these methods (Khattak, Koppelman, & Schoffer, 1993). People prefer to make decisions based on shortcuts and habits when possible, even when these habits they have fallen into are not the most rational or effective. (Lehner, Mont, & Heiskanen, 2015) (Mont & Power, 2013). Due to the complexity of human decision making and behavioral biases the literature is not in agreement on the effectiveness of influencing travel behavior, and thus route choices of cyclists (Hummel & Maedche, 2019) (Goodwin, et al., 2004) (Gutiérrez, Hurtubia, & de Dios Ortúzar, 2020).

More needs to be known on the subject of willingness to change cycle behavior to increase the effectiveness of the methods that aim to influence this behavior. This research helps to increase the understanding of the route choices that cyclists make and what according to them may be effective methods to influence route choice behavior.

2.4 Research aim

The aim of this research is to evaluate what methods of informing cyclists may be effective in influencing the route choice behavior of cyclists in the province. The expected effectiveness is based on the stated preference of the inhabitants themselves. This research concludes with a recommendation to the province on which methods of informing may benefit their policy goals.

2.5 Research questions

In this chapter one main research question and several sub research questions are defined. The main research question is as follows:

What methods of informing cyclists can be used by the province to influence cyclists into choosing routes that will benefit them and the province?

1. What methods of influencing cyclists have been used, or are in use to steer cyclists towards better travel routes? And how are these methods characterized?

2. What is important for cyclists in the province in their route choice decision making?

3.1 How important are different route choice factors in choosing a route for the inhabitants of the province?

3.2 What do the inhabitants prefer, when it comes to the different types of informing, and receiving information about the different route choice factors?

3. Was the method used in the Snuffelfiets project a good method to influence route choice behavior amongst the participants? Why or why not?

2.6 Reading guide and Methods

This report has already addressed the context of the research, in terms of the provinces' policy goals, the Snuffelfiets project and the relevance of influencing route choices of cyclists. The research questions defined above are the structure for the rest of the report. Chapter 3 will summarize several methods of influencing route choices that have been applied here in the Netherlands or in Denmark, where cycling is also a popular mode of transportation.

Next, research question 2 and 3 are addressed in chapter 4. Here, a survey is conducted amongst the participants of Snuffelfiets. The survey focusses on the route choice decision making of the participants of Snuffelfiets. The results of the survey show whether participants of Snuffelfiets changed their travel routes because of the information about air quality hey received. In addition, the participants are asked to grade the importance of different route choice factors and which the types of informing and information about which route choice factors may stimulate them to cycle alternative routes.

The results of the survey and the goals and issues stated by the province in *Uitvoeringsplan Fiets 2019-2023* are taken together and based on this a recommendation is made for which methods would be most effective for the province and what further research should be done. This can be found in chapter 5 and 6.

3 ANALYSIS OF METHODS THAT INFLUENCE ROUTE CHOICES OF CYCLISTS

3.1 EXISTING METHODS

Many countries throughout the world are known with cycling as a mode of transport. However, none of these countries have developed their cycling infrastructure in the way that the Dutch have done it. In the Netherlands, cycling is one of the main transport modes and has become part of the overall culture. However, other European countries such as Denmark, Sweden, Finland and Germany have also been successful in creating a safe and convenient bicycle infrastructure (Pucher & Buehler, Cycling for Everyone: Lessons from Europe, 2008). Countries with a less developed bicycle infrastructure mainly focus their campaigns on encouraging people to cycle, therefore these are not interesting for this research. Several Danish and Dutch campaigns that aim to influence cyclist's behavior are discussed below. Table 1 shows the existing methods of influencing route choices of cyclists and table 2 lists the methods with potential or interesting elements.

Two Dutch methods from the cities Groningen and Rotterdam have shown to be effective (Pers berichten Gemeente Rotterdam, 2018). The basis of these methods (*Smart Routes* and *Rit010*) was to inform cyclists about the advantages of taking the alternative route and they aimed to reduce the amount of traffic on a specific route. In Rotterdam there were often bicycle traffic jams on the North-/South bicycle route and an alternative route, through more green areas and with less traffic lights, was promoted (De Verkeersonderneming, sd). The promotion was done via flyers and road signs. In Groningen there was an issue with capacity on several road due to large amounts of students cycling from the city to the campus (and back). The campaign focused on first year students because they had not developed any habits yet and promoted a route that was faster, safer and more attractive (Slimme en Gezonde Stad, 2017). The evaluation of these two projects has shown that steering cyclists towards different routes can work.

This project in Groningen shows that people who have not yet fallen into certain travel habits can be influenced more easily. In Copenhagen there has been a campaign that focused specifically on new residents (*Newcomers, New cyclists*), with the reason that they have not yet fallen into strong habits, and can thus be easily influenced into making certain decisions (Cycling Embassy of Denmark, 2017). Unfortunately, the exact effects of this initiative have not been measured (yet) but one can imagine that steering new residents towards the bicycle and into certain habits can be beneficial to a city.

Another interesting Danish campaign is the *School route pamphlets* campaign, which aimed to inform parents of the safest route to school. The pamphlets opened a dialogue between schools and parents as to what is the safest way to bring children to school (Cycling Embassy of Denmark, 2017). The school pamphlet campaign is a very nice example of how informing people about different routes or travel modes and presenting them with the advantage of changing their behavior can help to improve, in this case, traffic safety. *Bike to Work* is a large campaign that encouraged people to cycle to work. Participants can join in a team and win a trip around the world (Cycling Embassy of Denmark, 2010). With 100.000 participants a year and the sense of community and participating together, the campaign has been very successful.

Of course, in the Netherlands many more campaigns and projects exist that aim to influence the behavior of cyclists. A small research project as a part of the *Snuffelfiets* project was conducted that aimed to investigate if air quality influences cyclists in their decision making. 15 participants were informed about the air quality on their routes and possible alternative routes through a workshop, but after the workshop it could be concluded that not one participant changed their route because of this information (Althuis, et al., 2020). This research already would suggest that information about air quality is not a reason for people to change their travel routes.

The Province of Utrecht currently uses the *Ik fiets* (I Bike) app where cyclists are rewarded with points for each kilometer they cycle (Ik Fiets, sd). The app rewards people with discounts and charity donations, but also gives the cyclist basic feedback on their travel. The aim of this app is to encourage bicycle use and to make it more fun and rewarding. The implementation program for cycling (2019-2023) of the province of Utrecht also describes how this app, in combination with Schwung-services, may be used to give cyclists earlier green at intersections. Such an innovative approach will result in more attention and usage for the app.

The province also describes in this implementation plan that the app can also be used to inform about cycle highways. The awareness for cycling highways is something that returns in many policies. Two years ago, the municipality of Tilburg organized a *Seminar by Bike* to investigate what would be the best way to promote and increase the use of their new bicycle highway (Tilburg-Waalwijk). To find the best way of promoting this new highway different signs and road markings were judged by a group of inhabitants (Anguita, 2018). The aim is that the final design is used throughout the Netherlands to create a uniform way of marking bicycle highways (The Urban Future, 2020).

The municipality of Enschede also uses an app (*SMART*) to increase bicycle use. This app also has a Green function (*SMART Green app*) which triggers cyclists to travel more sustainable (Tubantia, 2018). When a cyclists has this app on their phone it can connect with traffic lights and tell them that a cyclists is coming, reducing the waiting time at intersections. There are also possibilities to give elderly or disabled people a longer green time. These apps can also be used to for example display how much emissions cyclists saved by taking the bike (Enschede Fietsstad, 2020). With apps like this it is difficult to say how much effect they really have on the use of bicycles, but they can be used as a platform to influence route choices of cyclists.

In Amersfoort and Leusden (province of Utrecht) a project called *033opdefiets* aims to map the experiences of cyclist and uses cameras to show possible cycle routes that are clean and comfortable. Together with the inhabitants they film travel routes from and to central points in the region that are smart and green (033opdefiets, 2020).

Nr.	Name method	Route changes	Target group	Factor	Stimulating/ informing
1	School route pamphlets	Specific: Use route X	Parents with children	Safety	Flyers
2	Snuffelfiets	Specific: Multiple alternative routes from A to B	Cyclists in the province	Air quality	Workshop
3	033opdefiets	General: more use of green routes	Cyclists in the region	Knowledge, surroundings	Videos, website
4	Rit010	Specific: One specific detour	Users of road X	Traffic volume, intersection design, surroundings	Flyers, signs
5	Smart Routes	Specific: More use of routes X and Y to/from point A	Cyclists to/from point A	Traffic volume, traffic safety, travel time	Rewards, flyers, info stand
6	Seminar by bike	Specific: More use of route X	Cyclists in region X	Bicycle lane, knowledge, comfort	Traffic and road signs

Table 1 - Existing methods of influencing cyclists

Nr.	Name method	Potential
1	Bike to work	Large community participation platform
2	Newcomers, New Cyclists	Target group that can easily be influenced
3	Ik Fiets	Existing platform/app for cyclists
4	SMART green app	Give green lights on certain routes, reducing travel time

Table 2 - Methods with potential or interesting elements

3.2 Elements within each method

Each of the methods from the previous chapter is built up out of three elements: the target group, the type of informing or rewarding, and the route choices factors that are used. A good method of influencing behavior addressed all three elements and makes sure they fit well together. Each of the elements is further addressed below and table 3, 4 and 6 show the alternatives for each element.

Target group

In the evaluation of *Smart Routes* the importance of a specific target group was highlighted. In this project, their target group were students. Some of these students were also new inhabitants of the city, which made it easier to influence them. The target group can range from very specific to general, based on the objectives of the project and the other elements.

Nr.	Target group	Nr.	Target group
1	Parent with a child age <18	4	Recently moved (last 6 months)
2	Student	5	Child age 18-
3	Elderly age 65+	6	E-bike or pedelec user

Table 3 - Target groups for methods of influencing route choices

Type of informing

Informing cyclists about their behavior (and possible alternative behaviors) can be done in a general way or more specific. Road signs and flyers are examples of general ways of informing. The information on a flyer or road sign is applicable to (almost) everyone that sees it. Specific information is information that fits the behavior of one cyclists and is based on his/her measured behavior or preferences. An app is the best tool for this. Some of the described methods also use rewarding systems to increase the effectiveness of the method but this is not included further in this research.

General		Fit to the person	
Nr.	Type of informing	Nr.	Type of informing
1	Flyers	6	App: Cycled routes only
2	Website	7	App: Alternative routes
3	Social media	8	Workshop
4	Road signs	9	Email
5	App		

Table 4 - Types of informing for methods of influencing route choices

Route choice factors

Lastly, the route choice factors play an important role in choosing a route and can therefore be used to have cyclists choose different routes. It should be noted that there is a difference in which factors are important in choosing a route, and which factors are effective to inform about. Much research has been done on the factors that influence why and where cyclists cycle. When choosing a route, cyclists have to make trade-offs between, for example the type of intersections, traffic volume, speed of other traffic, availability of bicycle lanes and distance (Menghini, Carrasco, Schüssler, & Axhausen, 2010). The existing knowledge on these trade-offs is mostly gathered using stated preference methods. Research shows that travel time and travel distance are the most important factors in cyclist route choices (Sener, Eluru, & Bhat, 2009) (Menghini, Carrasco, Schüssler, & Axhausen, 2010) (Yang & Dr Mesbah, 2013).

In table 5 several factors and their ranked importance in different researches can be found. Three of the researched papers state a clear order of importance (a ranking). *Menghini, Carrasco, Schüssler, & Axhausen, 2010* highlighted the importance of the existence, design and comfort of the bicycle lane. The research from *Sener, Eluru, & Bhat, 2009* showed that cyclists were mostly influenced in their decision making by the traffic volume, in particular heavy motorized traffic, and the existence of a continuous cycle lane. *Dill & Gliebe, 2008* pointed out that most travelers aim to minimize their travel time. Out of these three researches, only *Yang & Dr Mesbah, 2013* highlighted the importance of traffic safety. Based on these researches a list of all factors that play a role in route choice decision making is made (table 6). Participants are asked to state the importance of these factors in their route choice decision making. They are also asked about information about which route choice factor may influence their route choices. As said before, these factors play an important role in the design of a method.

Route choice factors	(Menghini, Carrasco, Schüssler, & Axhausen, 2010)	(Sener, Eluru, & Bhat, 2009)	(Yang & Dr Mesbah, 2013)	(Dill & Gliebe, 2008)
Travel time	1	1	1	1
Travel distance	2	2	2	1
Gradient or terrain	3	8	4	
Existence of cycle lane	4	5	6	3
Intersection design	5	7		4
Presence of parking	6	4	x	
Traffic volume	7	3	x	2
Speed limit (of other traffic)		6		
Design of bicycle lane	4	9		
Traffic safety			3	
Scenery			5	

Table 5 - Ranking of importance of route choice factors in different researches

Nr.	Route choice factors	Explanation
1	Travel time	The amount of minutes it takes to go from A to B.
2	Travel distance	The distance in kilometers between A and B.
3	Bicycle lane	Type of lane: cycle highway, separate from other traffic, bicycle street (NL fietsstraat), bike lane (on the road but cyclist only), shared road (all traffic mixed). Type of pavement: asphalt (quality), cobles, unpaved.
4	Intersection design	Type of intersection: Roundabout, basic priority, traffic lights.
5	Waiting time at intersections	
6	Parking facilities	Capacity and price. Type of parking: racks (basic, stacked), sheltered (half or in garage), guarded garage, bicycle locker.
7	Traffic volume (cyclists)	Amount of other cyclists. Relative to the available space.
8	Traffic volume (other)	Amount of other vehicles, such as cars and busses. Relative to the available space.
9	Speed difference	Speed of other road users: electric bikes, scooters, cars, heavy vehicles, busses.
10	Surroundings	Type of area: Green (forest or park), industry, city center, suburb. Nearby infrastructure: nothing else, car highway, rail track, local car roads, bus lane.
11	Traffic safety	Perceived safety of cyclist. This factors overlaps with: speed difference, traffic volume, intersection and road design, and weather conditions.
12	Weather	Types: Sun, snow/ice, rain, wind, hot vs cold.
13	Air quality	Can be measured or expected quality.
14	Elevation	Bridges, tunnels, and hills.
15	Knowledge	To what extend are the factors known. Uncertainty.

Table 6 – List of most important route choice factors

3.3 Summary of existing methods and the different elements

In this chapter, three elements of a method for influencing route choice behavior have been defined. These elements and the alternatives result from a literature analysis of existing methods to influence route choices of cyclists. The most important finding is that promoting one or two alternative routes to reduce traffic intensities and increase safety works. Furthermore, having a specific target group, that for example has not yet fallen into strong travel habits, can be beneficial for the effectiveness of the method. The defined target groups will be used in the survey to see if there are any differences in preference between the groups.

The aim of this research is to recommend one or more methods of influencing route choice behavior of cyclists in the province. Therefore, the participants will be asked their preference for the alternatives for type of informing and route choice factors that they are informed about. Based on the literature, nine types of informing were defined. These are the types of informing that the participants will be questioned about. This research will not further look into the types of rewarding that may influence behavior, since it is outside the scope of this research.

At last, a list of the most important route choice factors for cyclists was created. This list is used to evaluate the importance of each factor for the cyclists of the province and about which factors the cyclists would prefer to receive information.

4 THE SURVEY

4.1 THEORY

4.1.1 Basis for a transport research survey

The design of the survey is based on the steps provided by *Richardson, Ampt, & Meyburg, 1995*. The book focusses solely on survey methods for transport planning, which includes travel pattern surveys. Such a survey asks people how, where or why they travel. A survey can have several purposes, such as describing existing conditions, establishing explanations of conditions, and predicting or measuring the effects of system changes (Richardson, Ampt, & Meyburg, 1995).

This is the first step in the survey process is the preliminary planning and consists of defining the objective of the survey and a hypotheses. One or more objectives are defined to give the survey direction. The hypothesis describes what will be tested after the data has been collected. In addition, financial resources and manpower commitments are allocated. These resources define the quality and the quantity of the survey.

The choice of a survey method mostly depends on the objectives of the survey and what resources are available. The collection of data can be done using a cross-sectional survey, where you measure a large group at one point in time, or using a time-series survey, where a smaller group is measured at several points in time. The book defines eight different techniques to collect data, one of which is the self-completion survey. The advantage of self-completion surveys is that they are not very expensive and that the researcher saves time compared to a telephone or face-to-face survey. The main disadvantages are a low response rate, and limitation in the type of questions that can be asked.

After defining what information the survey should gather and how this is done, the survey is designed, tested and conducted. During the design, the consistency with the objectives should be constantly checked. At last, the data is gathered, analyzed and presented.

4.1.2 Stated preference

Transport surveys are useful to policy makes because they help to better understand and model travel behavior (Bonnel & Munizaga, 2018). Two main research methods can be distinguished: Stated preference (SP) and revealed preference (RP). Both these methods have been widely used to study travel behavior and are key in analyzing cyclists route choice behaviors (Hensher, Barnard, & Truong, 1988). However the stated preference survey is the most used method to gather data (Yang & Dr Mesbah, 2013).

The revealed preference method focusses on drawing conclusions from the data of peoples actual choices, their revealed behavior (Boyle, 2003). The fact that the data is collected for actual behavior is the main benefit of using RP. However, the method is limited in the way that data collection can be time consuming and that it cannot be used to test how travelers will react to future changes in the transport system (Yang & Dr Mesbah, 2013).

The stated preference method asks respondents about what choices they would make in different levels of an environment, their intended behavior (Boyle, 2003). For example, it can be used to collect route preference data (Tilahun & Levinson, 2010), such as what the important trade-offs in attributes are among cyclist route decision making (Sener, Eluru, & Bhat, 2009). In addition, SP can also be used to evaluate the traveler response to different intelligent transportation systems (Khattak, Koppelman, & Schoffer, 1993).

SP brings many advantages with it, of which the most important one is that this method allows researchers to test scenarios or options that in reality are difficult to obtain. Since this research aims to evaluate methods of influencing that are not in use in real life, the participants are asked to state their preference (SP). Another advantage of SP is that the data collection is easier and is more cost efficient than RP. The required resources for RP are higher than are available for this research. Furthermore, SP method allows for a larger sample size and there is more control over the variables of interest (Tilahun & Levinson, 2010) (Yang & Dr Mesbah, 2013).

The main disadvantage of SP is the validity of the responses. Because participants are asked to state their preference in a hypothetical situation, the responses may not be a true description of real life behavior (Bradley, 1988). This could be cause by that there are no consequences attached to the decisions or that the questions are too complicated and are misunderstood (Tilahun & Levinson, 2010).

4.1.3 Web based survey

Three main survey types can be distinguished: face-to-face surveys, telephone surveys, and self-administered surveys (van Evert, Brög, & Erl, 2006). The last includes internet and email surveys where the participants write down the answers to the questions themselves. Such a web based survey has the advantage that not much time has to be spend on conducting the questionnaire, documenting responses and processing the data. Furthermore, question branching can be used in web based surveys, since these are based on earlier responses of the individual (Sener, Eluru, & Bhat, 2009). Because of the limited resources, this survey is a web based survey.

4.1.4 Response rate

An expectation of the amount of responses is important to determine the balance between the quality and quantity of the questionnaire. *Deutskens, de Ruyter, Wetzels, & Oosterveld, 2004* and *Marcus, Bosnjak, Lindner, Pilischenko, & Schütz, 2007* both researched the relation between the length of the survey and the response rates. For a medium long survey (10-30 min) an average response rate of 25 percent was found. In addition, these authors found that the quality of the answers reduces significantly and the dropout rate increase if a questionnaire is longer than 30 minutes or is much longer than announced in the email (Deutskens, de Ruyter, Wetzels, & Oosterveld, 2004) (Marcus, Bosnjak, Lindner, Pilischenko, & Schütz, 2007). Because of this, the survey was designed with a maximum length of 20 minutes and as few open questions as possible.

Aside from the length of the questionnaire, there are also other methods that can be used to increase the response rate. Most importantly, the survey should be designed such that it is as easy for the respondent as possible (van Evert, Brög, & Erl, 2006). This includes for example a clear layout, limited long-answer questions and the usage of visual elements (De Bruijne & Wijnant, 2014) (Deutskens, de Ruyter, Wetzels, & Oosterveld, 2004).

4.2 Designing the survey

4.2.1 Survey objectives

The results of this survey will answer sub research questions 2, 2.1, 2.2, and 4. After completion of the survey, more will be known about the preference and receptivity of the inhabitants of the province towards different elements, and the effectiveness of the Snuffelfiets method. Their preference is tested for two method elements: the types of informing and route choice factors. Relations between the preference and different target groups and personal characteristics will be investigated.

Three objectives for this survey are formulated. Only for the second objective a hypothesis is given, because for the first and third it is difficult to do so. For objective one the null hypothesis is based on the results in table 5. Here it is clear that travel time and travel distance are the most important factors for cyclists when choosing a route and the others come after. To formulate a hypothesis for the second objective we look at a research described in Chapter 3.1, which aimed to investigate if air quality could change the route choices of cyclists. This research is quite similar to the second objective since the sample group were 15 Snuffelfiets participant. This research concluded that air quality had no effect on the route choices so the same is expected here. For the third objective no hypothesis is given since no comparable literature is found.

O1. The first objective of this survey is: To map which factors, and to what extent, influence the route choice decision making about the specific travel routes of the participants.

H1.0 The route choice factors travel time and travel distance have the most influence on the route choice decision making of cyclists in the province of Utrecht.

O2. The second objective of this survey is: To evaluate whether the participants of the Snuffelfiets project have changed their travel routes by bicycle based on the information they were presented with about the air quality on their travel routes.

H2.0 Informing cyclists about the air quality on their travel routes has no effect on their route choice decision making.

O3. The third objective is to get and insight in which alternatives of the two elements would be most effective on the cyclists (or specific target groups) in the province.

4.2.2 Survey method

The survey method and sample group mostly depend on the available resources for the survey. This survey will be designed and processed by one person, the project is limited in time and there are no additional financial resources. This survey will be a cross-sectional self-completion web survey. It is estimated that this approach is sufficient to address all objectives. A cross-sectional approach is used because a time-series based approach is not necessary to achieve the three objectives. The participants are questioned about their choices in the past and state their preference for possible future methods. Therefore, it is not required to question them on different time points. A self-completion survey has several positive and negative aspects. Most importantly, the possibilities of follow-up questions and to clarify unclear questions (or misunderstandings) are limited. However, since this survey is web based, conditional questions can be added, where an answer leads the participant into a different "path" of questions. Because of the limited resources, a self-completion survey is the best alternative.

Since the survey is a self-completion survey the expected response rate based on the literature is 20%. This response rate belong to a questionnaire of 10-30 minutes. The designed length of this questionnaire is around 15 minutes.

4.2.3 Sample group

All 500 participant of Snuffelfiets were asked to fill out the questionnaire but the final survey sample is 47. It is chosen to conduct this survey amongst the participants of Snuffelfiets because objective *O2* aims to evaluate whether the method of influencing behavior used in the Snuffelfiets project was effective. However, objective *O1* and *O3* can also be achieved by asking any other cyclists in the province. However, for this research it was chosen to only question participants because otherwise the sample would become too large and the results cannot be properly analyzed with the limited resources available. Furthermore, the results of this research show in which direction more time and effort should be invested, so it serves as a stepping stone for additional research.

This specific sample has some consequences on the quality and uncertainty of the results. The Snuffelfietsers do not represent the average cyclist in the province. They mostly are more active cyclists and have shown by participating in this project that they are willing to invest energy and time in their cycling behavior and community. If the results show that a type of influencing behavior does not work on these active and involved cyclists, than it is likely that it will definitely not work on the average cyclist of the province. To give more certainty on this, additional research is required with a sample more representative for the population.

Lastly, the total amount of responses of 47 is too little to ensure a high level of confidence in the results. The small sample limits the possibility of finding significant relations between groups and for example types of informing and route choice factors.

4.2.4 The questionnaire

The questionnaire is designed with three parts, where each objective is addressed separately. Depending on the answers the participants give, they will follow a certain path through the questionnaire. In between the questions, some explanation or theory is given to clarify the questions.

Part 1

Part 1 of the survey focusses on how the participants grade how much influence different route characteristics/factors have on their route choice decision making. The grading scale ranges from *no* influence to *a lot of* influence. This part is in line with objective *O1*. Table 6 lists the factors that the participants are asked to grade. The information on how much a factor influences the route choices of the inhabitants will be used, together with questions from part 3, to evaluate which route choice factors should be informed about.

Part 2

The second part of the questionnaire focusses on the follow-up of the Snuffelfiets project. The participants are asked to select one trip to answer the questions in part 2 and 3, since things would be too vague and brought if all trips are considered. The trip must meet three requirements: 1) the trip always has the same departure and arrival location, 2) the trips is (almost) always made by bike, and 3) the frequency of the trip is on average at least once in two weeks. Then, several characteristics of this trip, and of the most frequently taken route are asked. Next, all participants (that choose a trip) are asked about their usage of the Snuffelfiets dashboard, at which they could see the air quality on their route. Those who used the app frequently are asked about the effects this information had on their route choices (within the chosen trip). The results from all these questions are used evaluate whether this method of influencing is effective.

Part 3

The last part of this questionnaire focusses on the preference of inhabitants towards the alternatives for the two elements. The participants are asked in which target group they fit, so that later it can be analyzed for a specific target group which factors and types of informing they would prefer. Next, they are asked about which route characteristic they would prefer to receive information about and how they would prefer to receive this information. In the survey, a distinction is made between general and person specific types of informing. For each of these questions several alternatives are given for the participants to select, and they can select multiple answers. Table 7 shows all these possible answers. The results are used to evaluate what other methods may be useful for the province in helping to achieve their policy goals. Note that for the receptivity towards route choice factors the results from part 1 are also used.

Target group		Route choice factors		Types of informing	
1	Parent with child under 18	1	Travel time	1	Flyers
2	Student	2	Travel distance	2	Website
3	Age 65+	3	Availability and design bicycle lane	3	Social media
4	Recently moved (6 months)	4	Intersection design	4	Sign/road markings
5	Age 18-	5	Waiting time intersections	5	App (general)
6	E-bike or pedelec user	6	Bicycle parking facilities	6	App (personal, cycled route)
		7	Surroundings	7	App (personal, alternative routes)
		8	Safety of the route	8	Email (personal)
		9	Air quality	9	Workshop
		10	Traffic volume		
		11	Hight differences		

Table 7 – Alternatives for each element

4.3 STATISTICS THEORY

4.3.1 Standard deviation

The standard deviation is a statistics tool to tell how spread out the numbers in a data set are, and says something about the uncertainty of a sample (see Equation 1). The standard deviation is calculated for the importance of route choice factors for different target groups. Using the standard deviation of a sample, the confidence interval can be calculated. This interval indicated a range of plausible values for an unknown parameter, such as the average. The confidence interval is dependent of the chosen confidence level, where a 95% confidence level is common. This means that you can say with 95% certainty that the real value lies within the calculated confidence interval. In this research a confidence interval is calculated for the scoring of route choice factors in part 3 of the survey.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \mu)^2}{N}}$$ *Equation 1*

$$CI = x \pm z\frac{\sigma}{\sqrt{N}}$$ *Equation 2*

4.3.2 Chi square

In this research the chi square test is used to test whether two variables are related or independent of each other. The significance of relations between the importance of roue choice factors and target groups and personal characteristics is tested. The chi square χ^2 is calculated using the degrees of freedom (c), the expected value (E_i) and the observed value (O_i) (see Equation 3). A high chi square value results from expected values that are not equal to the observed values, which may indicate that the variables are related. The relation is significant if the calculated P-value is lower than the selected significance level. The used significance level is $\alpha = 0.05$. The significance level of $\alpha = 0.05$ indicates that the sample value must be in the top 5% of extreme values for the null hypothesis to be rejected, and thus to be able to conclude there is a significant relation between the two variables.

$$\chi_c^2 = \sum_{i=1}^{N} \frac{(O_i - E_i)^2}{E_i}$$ *Equation 3*

4.4 RESULTS OF THE SURVEY

In the following subchapters the results of the survey are elaborated and discussed, starting with some basic characteristics of the sample. Then, per chapter, each of the objectives from 4.2.1 is addressed. Lastly, the relation between the importance of route choice factors and the preference for information about a factor is looked at.

4.4.1 Characteristics of the sample

Some things have already been said about the representativity of the Snuffelfietsers in relation to the population of the province. The representativity of the sample when looking at age and gender is not very well balanced. 65% of the sample is male and the entire sample is 40 years or older (see figure 2 and 3). It is estimated that this is a good representation of the Snuffelfiets participants but definitely does not represent the population of the province of Utrecht. Consequently, this shortcoming in representativity has implications for the results and conclusions of this research. As mentioned before, further research is required on this topic with a better representative sample. The results of this research serve as a guide in the direction this follow-up research should go.

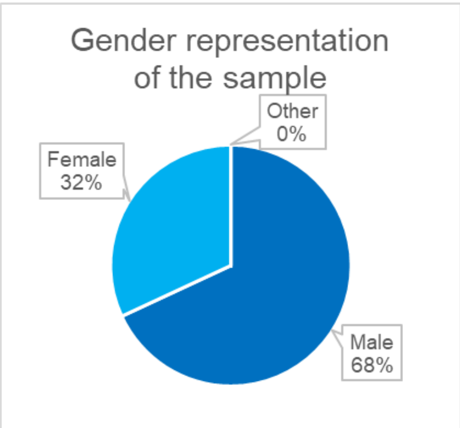

Figure 2 - Gender of the sample

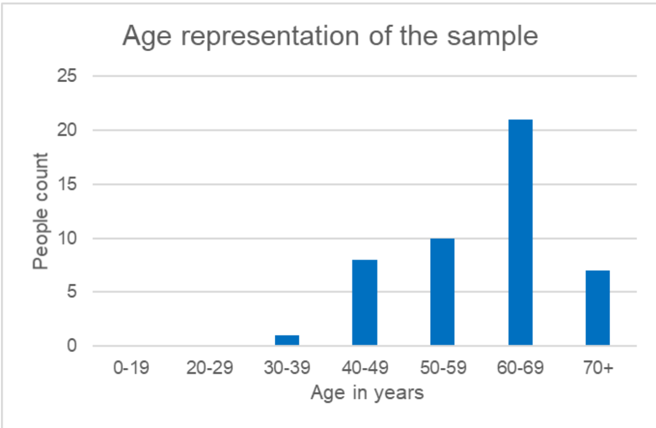

Figure 3 - Age of the sample

4.4.2 The importance of route choice factors

The first objective *O1* of the survey was to get an insight in which route choice factors are important for the cyclists in the province. In the survey all participants were asked to grade the importance (from very low to very high) of each route choice factor. Using a simple scoring system the factors all received a score (Appendix A). Figure 4 shows the results of this, including the standard deviation. The standard deviations for each score are calculated using Equation 1 and are displayed using error bars.

Chapter 3 highlighted the difference choosing a target group can make in the effectiveness of a method. Therefore, the results from three target groups that were represented in the survey are added to this figure. In total, six target groups were included in the questionnaire but the groups student, child -18 and recently moved were not represented in this group and could therefore not be included in this figure. Using the chi square test, it was investigated whether there are significant relations between route choice factors and the groups. Furthermore, it was tested whether there are any relations between the importance of these route choice factors and age, gender, trip types, trip location, trip frequency and trip length (time). As for the last four, the participants were asked to select their most frequent trip during the duration of Snuffelfiets. So the route choice factors are compared to the characteristics of this trip. To increase the quality of the test, some answers are taken together (Appendix C). For example, for the trip length two categories, instead of five, were created (less and more than 25 minutes).

This chapter further dives into these significant relations and what they mean. Furthermore, several non-significant but interesting results are discussed. But first the average scores of the entire group are discussed.

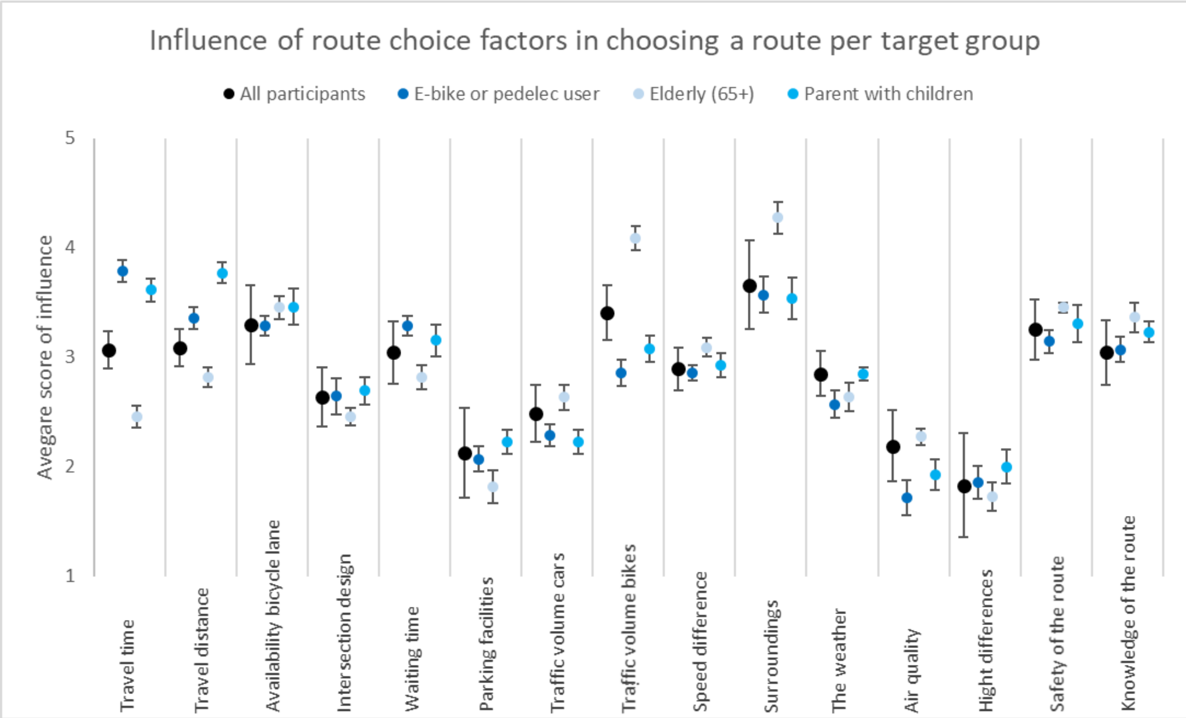

Figure 4 - The importance of route choice factors, for several target groups

4.4.2.1 The average score of importance for all participants

When looking at figure 4 and comparing this to the literature (table 5), one thing immediately stands out when looking at the average score of all participants. This is that travel time and travel distance did not receive the highest scores of importance. Chapter 3.2 summarized several researches that aimed to define which route choice factors are most important for cyclists, and they all concluded that travel time and travel distance always have the upper hand in choosing a route. Therefore, this is quite a surprising result.

Four route choice factors scored higher than travel time and travel distance, which are the surroundings, traffic volume (bikes), availability and design of the bicycle lane and safety of the route, in that order. The fact that the factors surroundings was graded the highest importance is surprising since this factor is not even always included in the literature researches and if included does not score high. For the other three factors however, a similar importance can be found in the literature.

An explanation for the low scores for travel time and travel distance and the high score for surroundings could be the purpose of the trips the questioned cyclists make. To explain. chapter 4.4.1 described that the sample group is not representative for the average population of Utrecht when looking at age, and older people relatively make more recreational trips than younger people. This can simply be explained by the fact that they do not have to travel to work every day and have more free time on their hands. It makes sense that for recreational trips travel time and travel distance are less important and the surroundings are more important than for a commuting trip. Thus, the age of the sample group could be an explanation for the surprising scores.

Air quality is ranked in the bottom three factors. On the one hand this is interesting since this group volunteered for a project that specifically focused on air quality, and therefore it would have made sense if the importance of air quality had been scored higher. However, the research within Snuffelfiets described in chapter 3.1 concluded that air quality is not an important factor in choosing travel routes. All in all, if air quality is not an important factor in choosing routes for this particular group, with a higher interest in the subject, than for the entire population the importance will likely lie even lower.

Lastly, it can be seen in figure 4 that the height difference on a route is least important to these cyclists. The literature differs on how important this factor is to cyclists. But this likely depends on which cyclists you ask. In the province of Utrecht the only height difference you encounter by bike are bridges and tunnels but in other regions or countries the gradient of the road might increase more and thus make this factor more important. In short, it is not surprising that this factor is the least important factor in choosing a route.

4.4.2.2 Significant relations

All calculated P-values can be found in Appendix B, where the values under alpha $\alpha = 0.05$ indicate a significant relation and are marked green. A P-value of 0.0325 for the relation between the importance of travel time and the age of the cyclist is found. Therefore, there is a significant relation between the importance of travel time in choosing a route and the age of the cyclist. Furthermore, in the figure above it can be seen that elderly grade travel time and travel distance as less important than the average of the group. To conclude, the factor travel time becomes less important in choosing routes when a cyclist become older.

Furthermore, a P-value of 0.0322 is found for the relation between age and air quality, where air quality becomes more important with the years. A slightly higher importance can also be seen in figure 4 when we look at the group Elderly 65+, but this does not seem like a large difference.

4.4.2.3 Non-significant but interesting relations

Next to the significant relations that are found, figure 4 also shows some interesting relations that are not significant. For example, it stands out that elderly score the factors surroundings and traffic volume (bikes) much higher than the rest of the group. The groups are very divided over the importance of these factors and the importance of travel time and travel distance. Surprisingly, this spread in scoring is not found in the standard deviation error bars.

In addition, it can be seen that e-bike and pedelec users score travel time as much more important than the average. Their average score is almost a whole point higher than the average. Furthermore, they scored this factor as most important when choosing a route. Obviously, e-bike and pedelec users travel much faster than the average cyclists. Therefore, it makes sense that there is a relation between them and the importance of travel time.

4.4.3 Alternative routes because of information about air quality

The second part of the survey aimed to evaluate whether the Snuffelfiets method of influencing cyclists to choose cleaner routes was effective. Table 8 shows that the majority of the participants frequently used the dashboard and that 12% of the total changed made changes to their routes. To be absolute, five people out of the total 41 who answered this question, either tried out alternative routes or frequently took a cleaner route. It should also be mentioned that 26% of the dashboard users became more satisfied with the current route as a result from the information. Due to the small sample it was not possible to investigate if there are any relations between the changes in routes and for example, gender, age, trip location, and the different target groups (chapter 4.5)

Changes in route choices	Frequent use of the dashboard		Standard deviation
	Yes	No	
Yes	12%	x	5.8%
No	54%	34%	

Table 8 - Changes in route choices due to the information on the dashboard

This change in route choices of 12% is much higher than the expected 0%. This hypothesis was based on a similar research within the Snuffelfiets project and it is therefore surprising that it results from this survey that people did change their route choices based on the information about air quality.

Thus, it can be concluded that informing these cyclists about the air quality on their routes via an app did affect their route choices. However, it should be noted that this group volunteered for Snuffelfiets and thus is more interested and influenced by the information about air quality. In the following chapter, several other possible methods that may be effective in influencing route choice behavior are investigated.

4.4.4 The preference for route choice factors and types of informing

To investigate which methods of informing the participants think might work, they were asked to state whether or not information about a certain route choice factor would stimulate them to consider alternative routes. Figure 5 clearly shows there are four factors that would have no such effect and six factors that might have. It should be noted that for this question the participants could only select yes or no, and thus there was not a more detailed grading system, like in chapter 4.4.1. Because of this type of questioning, unfortunately, the standard deviation and thus the uncertainty has become quite large.

When again looking at the specific target groups in this sample, no significant differences can be found, except a stronger preference of elderly to receive information about air quality (Appendix D). This relation is in line with the higher grading of importance of air quality from elderly.

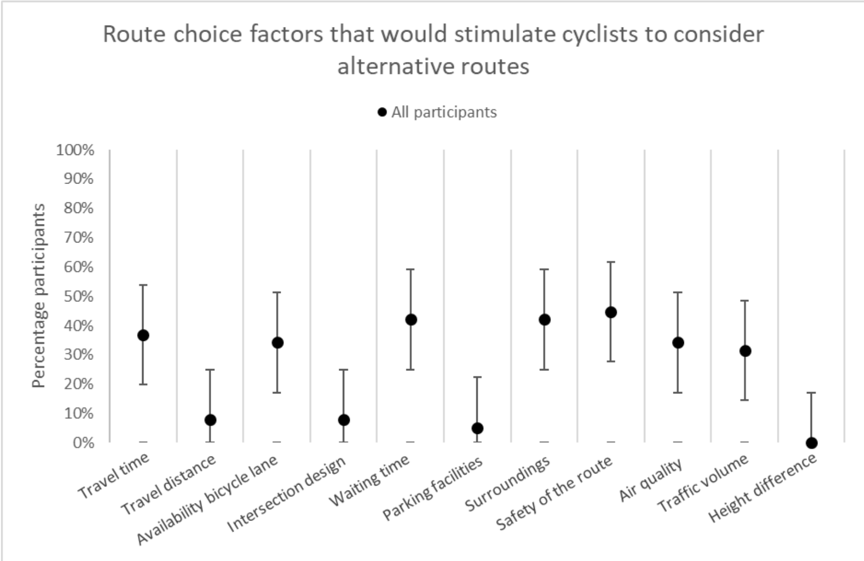

Figure 5 - Route choice factors that would stimulate cyclists to consider alternative routes

4.4.5 Relation importance of factors and preference for receiving information

In part 1 of the survey the participants were asked to grade the importance of each factor, and in the last part they were asked information about which factors would influence their route choice behavior. In figure 6 the results of these questions are put next to each other. It should be noted that in this figure the importance grading of traffic volume is the average score of traffic volume (bikes) and traffic volume (cars).

It can be seen that the three factors that received the highest grading of importance are also factors that the cyclists would want to receive information about. However, something interesting happens when we look at the factor air quality. This factor was graded as one of the least important factors in the decision making process but the participants do indicate that information on this subject would influence their route choices. This could be explained by the fact that they already have experience with receiving information about air quality and that they were quite satisfied with it.

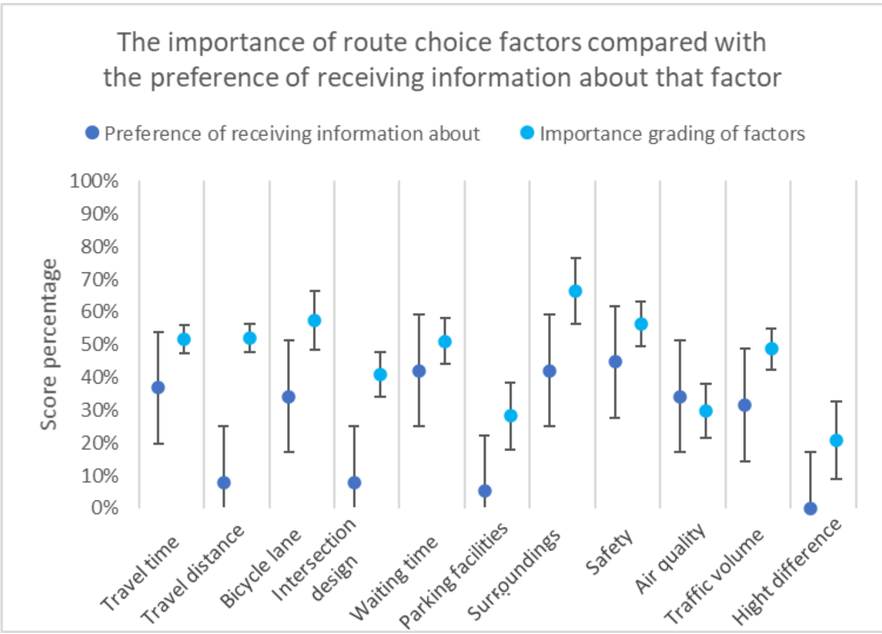

Figure 6 - Route choice factors; the importance compared to preference of receiving information

4.4.6 Types of informing

The preference of the participants for the types of informing was also tested, as can be seen in table 9. The percentage is the ratio of people that a particular form of informing would stimulate them to consider alternative routes. Despite the high uncertainty range, due to the limited sample size, there are still three types of informing that stand out. There is a strong preference for receiving information via an app on the mobile phone which proposes alternative routes. Two other forms of informing that score well are an app that only informs about the cycled routes and information via signs on the road. It should be noted that the apps provide personal information and the signs information that is applicable to all cyclists.

Type of informing	*Percentage "Yes*	*Confidence interval (95%)*
Information on social media	19.4%	4.8% - 34.1%
Information on the website of the province	20.0%	5.4% - 34.6%
Information via an app on mobile phone (general)	20.0%	5.4% - 34.6%
Information on the road (e.g. signs)	38.2%	31.6% - 44.9%
Flyers that are spread on the route	6.1%	0.0% - 27.3%
Information via email	19.4%	3.4% - 35.3%
Information via an app on mobile phone, with advices for alternative routes (personal)	57.1%	54.5% - 59.8%
Information via an app on mobile phone, only information about cycled route (general)	34.5%	23.8% - 45.1%
Information from a workshop	7.1%	0.0% - 28.4%

Table 9 - Preference for types of informing

5 CONCLUSION AND DISCUSSION

A survey was conducted to investigate what is important for cyclists in the province of Utrecht when choosing a route, and how this knowledge can used to influence these route choices best. Several aims were defined to answer sub research questions 2 and 3.

Four route choice factors (1. Surroundings, 2. Traffic volume bikes, 3. Availability (and design) of bicycle lane, and 4. Safety of the route) were scored with an above average importance. Thus, these four factors are most important for the Snuffelfiets participants in choosing a route. These results are contradicting the literature, where travel time and travel distance are mostly scored most important (chapter 4.2). This difference with the literature has likely to do with the older (in age) sample that likely make more recreation trips than the average population. Since this is just an estimation, additional research is also required to make a better distinction between commuting trips and recreative trips. It is reasonable that there is a difference in how cyclists are best influenced between these trip types.

In general not many significant relations are found between the target groups and the importance of route choice factors and their preferences. However, the most interesting (non-significant) relation that is found is that travel time is more important for e-bike or pedelec users than the average of the group. The literature suggests that it is good to focus on a specific target group. So, more attention should be given to the three target groups that could not be analyzed, since the best target groups for influencing behavior are those who have not yet fallen into any habits.

As for the second survey objective, it can be concluded that the Snuffelfietsers were influenced more about the information about air quality than was expected. However, due to the particular sample it is not certain what the effects would be on a more average cyclists group.

The last part of the survey shows that there are six route choice factors that may be effective in influencing the behavior of cyclists in the province. These are travel time, availability (and design) of bicycle lane, waiting time, surroundings, safety of the route, air quality and traffic volume. No interesting significant relations were found between the factors and other cyclist characteristics, except a relation between age and the preference for information about air quality.

When comparing the importance grading of route choice factors with the preference of receiving information about these same route choice factors, some things are noticed. Firstly, three route choice factors scored high for both questions, which are surroundings, availability and design of bicycle lane and safety of the route. Furthermore, air quality received a low importance score but the participants did indicate that information about this may affect their route choices. This could have to do with the fact they have already experienced receiving information about this factor.

Lastly, it is concluded that there are three types of informing that may be effective on cyclists of the province. These are informing via an app (either about cycled routes or about alternative route) and by placing signs aside the road.

6 RECOMMENDATION

This research aimed to evaluate what methods of influencing the route choice behavior by informing would be effective on the cyclist of the province. The preference and predictions of the inhabitants were addressed in the survey, but for the recommended methods to also match with the policy of the province, three main policy goals are defined: 1) Improve the (bicycle) network traffic flow (in relation with the shortage of capacity), 2) make cycling safer, cleaner and thus more healthy, and 3) make cycling more comfortable and faster.

The results of the two methods in Groningen and Rotterdam (*Smart Routes* and *Rit010*) suggest that it is possible to relieve specific intersections or roads where capacity issues, caused by cyclists, occur, by informing them about alternative routes. The Snuffelfiets participants have stated a preference for being informed via road signs, which is a good method of informing when dealing with specific locations in the network. The information on these signs could address advantages of the alternative route for the cyclists in the form of traffic safety, bicycle lane design and of course traffic volume.

Influencing route choice behavior will not be the solution in making cycling safer, cleaner and healthier. However, the survey shows that cyclists do value in what types of areas they cycle. Displaying safe, clean and healthy cycling areas, in for example an app, enables cyclists to make these better route choices. Both from the literature and this research results that safety is something that cyclists value highly when choosing a route.

Lastly, cycling in the province needs to become faster and more comfortable. An example of how this is already being applied are the bicycle highways or fast cycling lanes. These roads are designed specifically for fast and comfortable transport by bike. However, these roads and their benefits are often unknown to cyclists. Especially e-bike and pedelec users should be made aware of these routes due to the higher travel distance and the significant relation between this group and the importance of travel time.

Thus, the survey results show that there are opportunities to influence the route choices of cyclists in the province. For each policy goal a method can be designed to help achieve these goals, however more research is required on for example the influence of different trip types on the route choices of cyclists. Feedback from the participants showed that the difference of influencing route choices for commuting and recreational trips was underrepresented in this research.

Furthermore, due to the small sample group and the particular characteristics of the group there lie some uncertainties in how representative these results are for the entire cycling population of the province. It is recommended to carry out a similar research amongst a larger and more representative group. This research should focus on the route choice factors and types of informing that were shown to be most important or promising. In addition, the three target groups that could not be addressed in this research should be included.

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APPENDIX A

Factor = …	Points	Count	Score
No influence	1	From survey	Points * Count
Little influence	2		
Average influence	3		
High influence	4		
Very high influence	5		
		=Total count	=Total score
Final score:	=Total score/Total count		

Table 10 - Scoring system route choice factors

		Average score of importance
1	Surroundings	3.66
2	Traffic volume bikes	3.40
3	Availability bicycle lane	3.30
4	Safety of the route	3.26
5	Travel distance	3.09
6	Travel time	3.06
7	Waiting time	3.04
8	Knowledge of the route	3.04
9	Speed difference	2.89
10	The weather	2.85
11	Intersection design	2.64
12	Traffic volume cars	2.49
13	Air quality	2.19
14	Parking facilities	2.13
15	Hight differences	1.83

Table 11 - Ranking of route choice factors, based on importance

APPENDIX B

	Parent of children under 18	Elderly (65+)	E-bike or pedelec user	Trip types	Trip location	Trip frequency	Trip length (time)	Gender	Age
Travel time	0.0890	0.2283	0.0988	0.7664	0.7947	0.6058	0.2746	0.4665	0.0325
Travel distance	0.0565	0.5192	0.4597	0.8580	0.5345	0.6032	0.2397	0.5503	0.1729
Availability of bicycle lane	0.6143	0.7061	0.3427	0.5051	0.8754	0.9174	0.2027	0.8662	0.6408
Intersection design	0.5302	0.9013	0.1608	0.1323	0.9387	0.7861	0.1664	0.7292	0.6430
Waiting time	0.1052	0.4190	0.4540	0.7073	0.7676	0.2302	0.3420	0.9630	0.9332
Parking facilities	0.3734	0.6003	0.9501	0.8846	0.6521	0.9439	0.6753	0.3134	0.5827
Traffic volume (other cyclists)	0.3269	0.1145	0.4520	0.3140	0.8257	0.4431	0.3735	0.3445	0.4651
Traffic volume (cars)	0.1836	0.1940	0.1788	0.8256	0.3306	0.0897	0.4577	0.0585	0.4913
Difference in speed	0.3445	0.6518	0.8685	0.6705	0.3273	0.6266	0.2151	0.3341	0.4058
Surroundings	0.1789	0.3283	0.3604	0.2257	0.1215	0.2590	0.4511	0.2483	0.3025
The weather	0.9982	0.1602	0.2343	0.6765	0.8742	0.0833	0.7432	0.4797	0.5022
Air quality	0.3291	0.8124	0.2623	0.3954	0.4169	0.6578	0.8463	0.0228	0.0322
Height differences	0.3658	0.7132	0.8188	0.7712	0.3230	0.4912	0.0923	0.1038	0.1795
Safety of the route	0.2582	0.5693	0.9189	0.4473	0.7994	0.5584	0.5417	0.9350	0.3393
Knowledge of the route	0.9656	0.3027	0.6293	0.8323	0.6059	0.8513	0.0408	0.3014	0.8326

Table 12 - Results Chi Square tests first part survey

APPENDIX C

Trip type		Trip location			Trip frequency	
In survey	In χ2 test	In survey	In χ2 test		In survey	In χ2 test
All combinations	Home-Work	1 tm 10	Rural	1-3	1 to 3 times a month	< 3 times a week
Work	Home-Other	1 = Rural	Average	4-6	1 to 2 times a week	≥ 3 times a week
Home	Work-Other	10 = Urban	Urban	7-10	3 to 4 times a week	
Store					≥ 5 times a week	
Family/friends						
City/town center						
Supermarket						
Sport facility						
Trip length (time)		Gender			Age	
In survey	In χ2 test	In survey	In χ2 test		In survey	In χ2 test
0 - 5 min	< 25 min	Men	Men		0-19	40-49
5 - 10 min	≥ 25 min	Women	Women		20-29	50-59
10 - 15 min		Other			30-39	60-69
15 - 20 min					40-49	70+
20 - 25 min					50-59	
≥ 25 min					60-69	
					70+	

Table 13 - Grouping answers for chi square test

APPENDIX D

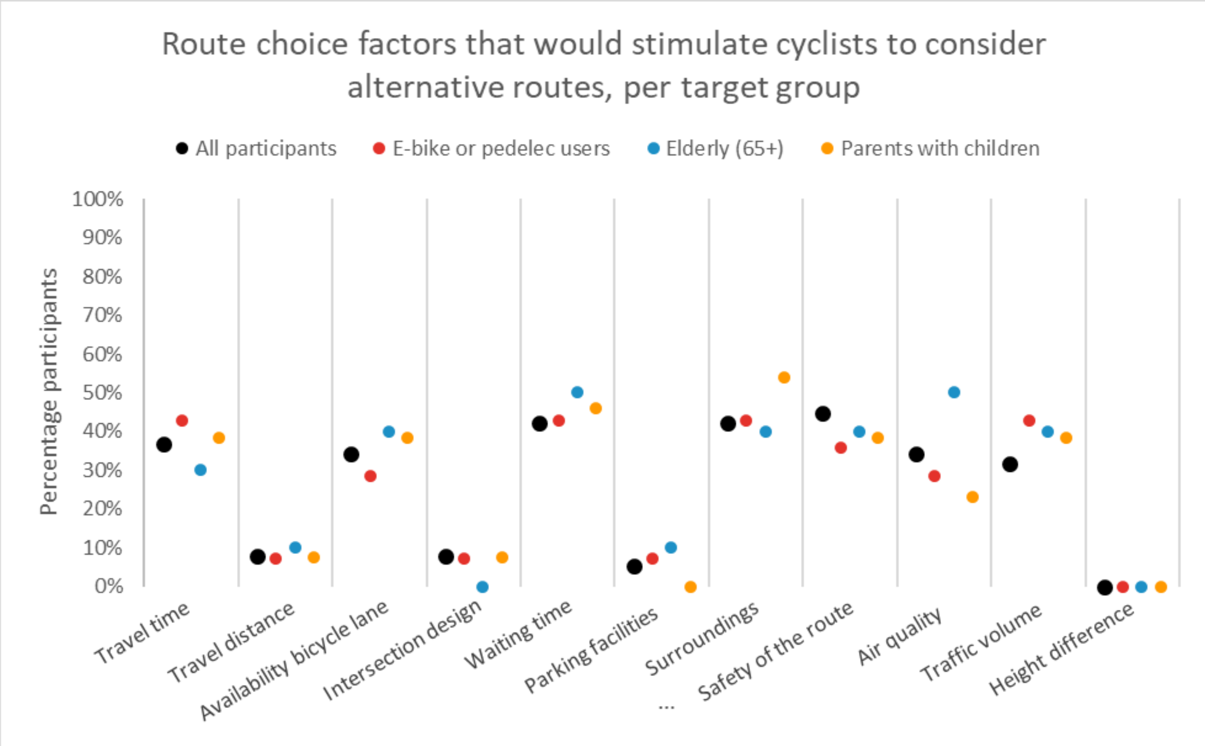

Figure 7 - Route choice factors that would stimulate different target groups to consider alternative routes

	Parent of children under 18	Elderly (65+)	E-bike or pedelec user	Trip types	Trip location	Trip frequency	Trip length (time)	Gender	Age
Travel time	0.8814	0.8027	0.3908	0.6706	0.9920	0.5102	0.3010	0.7173	0.7367
Travel distance	0.2631	0.3855	0.6904	0.4278	0.3664	0.9767	0.2526	0.5435	0.4744
Availability bicycle lane	0.5366	0.4024	0.5366	0.5292	0.2235	0.4274	0.2119	0.4930	0.0762
Intersection design	0.8814	0.8027	0.5757	0.3567	0.0566	0.1025	0.9468	0.3106	0.3276
Waiting time at intersections	0.7155	0.3495	0.7155	0.3497	0.6239	0.9188	0.9090	0.8319	0.7294
Parking facilities	0.2948	0.3685	0.6287	0.9390	0.8163	0.0758	0.8919	0.7544	0.4608
Traffic volume (all)	0.2631	0.4588	0.2631	0.9139	0.7429	0.4934	0.4088	0.9267	0.7791
Surroundings	0.9139	0.5734	0.4278	0.7320	0.9169	0.6715	0.6602	0.9442	0.8014
Air quality	0.2046	0.0337	0.5757	0.6706	0.2905	0.2300	0.9468	0.3106	0.2076
Safety of the route	0.7324	0.7028	0.7324	1.0000	0.7032	0.1746	0.4204	0.7400	0.4886

Table 14 - Results Chi Square tests for third part survey