CYCLING TO A RAILWAY STATION

EXPLORING THE INFLUENCE OF THE URBAN ENVIRONMENT ON TRAVEL RESISTANCE

MSc thesis Lizet Krabbenborg
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EXPLORING THE INFLUENCE OF THE URBAN ENVIRONMENT ON TRAVEL RESISTANCE

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By

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This document considers a research to cycling in access of railway stations. The interface between the urban environment and mobility had always been a fascination of mine, so I am glad that I could finish my studies with a topic from that field of research. With this thesis, I finish the master study Transport, Infrastructure and Logistics at the Delft University of Technology. The research was performed at the Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency). The Planbureau voor de Leefomgeving (PBL) is the national institute for strategic policy analysis in the fields of the environment, nature and spatial planning. This research was conducted at the department of Urbanisation and Transport.

This thesis would not have been established without the support and guidance of several people. First of all, I would like to thank my thesis committee. Many thanks go to Jan Anne Annema who was there from the start to help me formulate this topic I had in mind. He did not only gave me feedback and advice with his never ending enthusiasm, but he also gave me confidence in my abilities. I want to thank Goncalo Correia for his constructive criticism and valuable suggestions to further improve the thesis. I would also like to thank Bert van Wee for his impressive amount of knowledge and astute comments. His ability to always see the structure in a chaos, helped me to bring my thesis to the next level. And last, but not least, I want to thank Danielle Snellen. First of all for making me an intern at PBL, but mostly for her enthusiasm and dedication to the research. It was always a pleasure exchanging my thoughts and discussing my research with you all.

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Many authors have stressed the importance of good access and egress of railway stations in order to improve the total quality of a train journey. In the Netherlands, 50% of the access trips is made by bicycle and this share has potential to increase. The bicycle is a healthy, cheap, sustainable and in urban areas a relatively fast mode of transport. Thus, improvements of the bicycle access of railway stations would contribute to policy aims such as accessibility, liveability and social participation.

In order to improve the quality of bicycle access, the travel resistance (in terms of money, time and effort) of the bicycle trip has to be decreased. While many studies have been carried out on travel time and costs, studies on the effort factors, such as comfort and social safety, remain behind. Yet, not enough is known about the cyclists’ perception and experiences. Factors that influence cycling resistance relate to the natural environment, socio-demographics, psychological factors and the urban environment. The latter group of factors lies most within the power of decision-makers to change and improve bicycle access and is therefore the focus of this thesis.

The performed literature study found many instruments that try to assess the bicycle-friendliness of urban environments (‘bikeability’) with the underlying objective to compare areas and point out parts that are most in need for improvement. However, in most of these instruments, the consideration of the cyclist’s perception is lacking since the various instrument’s factors are not validated with the cyclist. That while giving values (weights) to the factors is important since they give insights in which factors matter (most) in the eyes of traveller so decision-makers can make efficient choices in the development of urban environment around stations.

Therefore, for this thesis the following main research question was formulated:

**Which urban environment factors (with focus on effort) determine the quality of railway stations access by bicycle and how do travellers rate these factors?**

In order to answer this question an experiment in the form of a survey was designed and conducted. The experiment consisted of a stated preference (SP) choice experiment with the aim to reveal the values respondents would give to several urban environment factors. Because of the visual character of these factors it was decided to use visual alternatives (pictures) in the choice experiment: an uncommon approach that also gives several uncertainties. Since the literature review indicated that factors related to time are probably much more important in travel resistance than factors related to effort or costs, it was decided to exclude travel time from the main choice experiment in order to avoid unbalanced alternatives and to devote a second part of the experiment to the relation of effort factors with travel time by an adaptive stated choice experiment. The third part of the experiment consisted of questions about personal characteristics with the aim to find out whether socio-demographics or cycle habits have influence on cycling resistance in access. The experiment ended with an optional part containing a rating test that was included with the aim to check the outcomes of the first part since the character of the choice experiment is rather explorative and contains several uncertainties.

The literature review collected many urban environment factors that might influence cycling resistance in access. Since literature on walking behaviour in relation to the urban environment is more extensive, also factors from walking studies were used. Due to time limitations of this thesis and the explorative character of the subject, only five of these factors could be included in the choice experiment. Since scientific literature on bicycle resistance factors in access is rather scarce and incomplete concerning effort aspects, it was decided not to select the five most commonly mentioned factors, but to make a selection according to the theory of ‘the five traveller’s needs’: the experience, comfort, ease, speed,
safety & reliability. With the use of interviews with experts from the field of mobility in combination with the theoretic categorization, the following factors were selected for the experiment: ‘vegetation’ (represents experience), ‘social safety’ (safety & reliability), ‘bicycle parking’ (comfort), ‘bicycle lane volume’ and ‘right of way’ (both for ease). As explained, the factor of speed was examined by adding adapting travel times in the second part of the experiment. In this part, respondents had to choose between a route with travel time of five minutes with the unattractive sides of the factors (no vegetation, no social safety, far bicycle parking, crowded bicycle lane, no right of way) and a route with varying higher travel times (up to 12 minutes) containing the opposite, attractive, sides of the factors.

The experiment was sent out in the form of an online survey and data from 162 respondents were collected. The data were analysed with a simple Multinomial Logit Model (MNL) in order to find the weights of the five selected factors. Also the influence of personal characteristics was examined by including interaction variables in the utility function of the MNL. In general, the outcomes confirmed the expectations in terms of sign and size of the values. Of the examined factors, ‘bicycle parking’ and ‘right of way’ were valued as most important. The factors ‘vegetation’ and ‘bicycle lane volume’ received lower weights. The factor ‘social safety’ was not found to be significant when the complete sample of respondents was used. The inclusion of personal characteristics revealed that among others female and young people (<15 years) do have a small (but statistically significant) preference for routes with ‘social safety’ (which was visualized by the amount of people walking on or watching the street). The analyses of the travel time showed that on average people are willing to cycle 8.5 minutes for an attractive environment compared to 5 minutes travel time through the unattractive environment. Thus, the five effort factors in the attractive alternative (trees, no traffic lights, 50 meters between parking and platform, many people watching or walking on the street and not a crowded bicycle path) are appreciated with on average 3.5 minutes additional travel time. These numbers imply that urban environment factors do influence route choice in access and thus the bicycle resistance.

The outcomes of this experiment on the relation of urban environment with cycling in access seem plausible. Here must be noted that the outcomes have to be treated carefully since this experiment was only a first exploring step in the research on this topic. The findings of this thesis indicate that decision-makers should take effort related aspects into account in (re)development of station areas and surrounding bicycle routes. Especially the factors with high values (‘bicycle parking’ and ‘right of way’) should be taken serious in case decision-makers want to improve bicycle access. The values can also be used by implementing them as weights in (existing) instruments that assess bikeability. That will improve the reliability of the instrument’s outcomes on which routes/areas are in most needs for improvement and thus decision-makers can make more efficient choices.

Besides these recommendations for practice, there are also several main recommendations for future scientific research. First, considering the outcomes, it is advised to zoom in on the factors that matter. For example, ‘bicycle parking’ is found to be important in travel resistance, but further research into this factor (not only looking at the distance to platform, but also type of parking, presence of security etc.) would give decision-makers more precise information on how to plan bicycle parking. Furthermore, it is also recommended to zoom out on the five factors used in this thesis. More research into which (effort) factors influence bikeability would give better and complete information on which factors to include in an experiment. Second, considering the applied methods, it is advised to enlarge the setup of future experiments (more respondents, representative sample and more advanced models) in order to get more reliable values. The SP analysis with adapting travel time might have given unreliable outcomes since people in real life situations perhaps choose the other (faster) option when they feel the stress of catching the train. It is therefore recommended to check the outcomes by using RP (revealed data). Furthermore, the use of visualisations is rather explorative and gave several uncertainties. Still, this visual method can be promising due to some advantages: respondents liked the survey and some effort-factors are very hard to express in words but can be expressed in visualisations. Hence, it is recommended to explore the possibilities of visualisations (fictive, but also non-fictive and moving images) in choice experiments and compare them with each other and standard (textual) experiments.
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1.1 BACKGROUND

The national government emphasizes the importance of public transport and its contributions to policy aims such as accessibility, liveability and social participation (Kim; CPB; 2009). Better public transport is desirable for both existing users as for potential users. Attracting potential users who would otherwise choose the car could even lead to a modal shift. Up to now, the network has been mainly upgraded in terms of efficiency and capacity. Also many of the large “key” stations in the Netherlands were rebuilt or renovated in order to meet the future demand and improve the transit to bus, tram, taxi, car, bicycle or metro (Rijksoverheid). While most plans are limited to the rail service and station itself, the accessibility of the rail network receives less attention (Brons, Givoni, & Rietveld, 2009). However, the train journey is almost always part of a ‘transport chain’: besides train, also an access and egress mode is used to get to and from the station. As figure 1 illustrates, access and egress have a large share in the total journey in terms of time. Many authors stress the importance of good access and egress of railway stations in order to improve the total quality of a train journey (CROW, 2009; Geurs & Klinkenberg, 2014; Givoni & Rietveld, 2007a; 2007b; Hale, 2011; Keijer & Rietveld, 2000; Klinkenberg & Bertolini, 2014; Krygsman, Dijst, & Arentze, 2004; Litman, 2015; Modder & van Uum, 2015; MuConsult BV, 2002; MuConsult BV, 2014; PBL, 2014b; Provincie Noord-Holland & Vereniging Deltametropool, 2013; Wardman & Tyler, 2000). Some studies have already proven that areas with better pedestrian facilities have higher transit rates (Parsons Brinckerhoff Quade and Douglas, Inc et al. as cited in Phillips & Guttenplan (2003)). Thus, the supposition is that in the urban environment of access and egress of railway stations opportunities lie ahead that can improve the quality of the total door-to-door train journey and in that way improve the total public transport network.

Figure 1: Access and egress of train trips expressed in distance and time. The ‘s’ stands for ‘station’. (source: PBL (2014a), edited by the author.)
Many ideas with the goal to improve access and egress of railway stations exist (see for examples Mu Consult BV, 2014) but the effect of such ideas on the quality of access and egress and eventually the total journey is unclear. The first step is to clearly understand what actually defines the quality of access and egress from the user’s point of view, in order to then determine how planning of access and egress should proceed. Most existing models and studies simplify rail access into ‘walk time’ and disregard other modes such as the bicycle (Wardman, 2004). The detail and complexity of access and egress get lost in the simplifications of travel time and, as a result, potential opportunities that might contribute to the quality of access and egress are missed (Hale, 2011). That is because quality of egress and access is not only defined by travel time, but also by the (traveller’s perception of) out-of-pocket costs and effort factors such as comfort and safety. To illustrate: a 10 minutes’ walk through a park can be perceived totally different than a 10 minutes’ walk through an industrial area. Despite evidence that physical activity is associated with environmental features, the relation between the urban environment and bicycling (the level of ‘bikeability’) for transportation has hardly been subject of research (Krenn, Oja, & Titze, 2014).

While international research on walking behaviour and its relation with effort factors and urban environment has increased, research on bicycle behaviour in relation to these ‘soft’ factors seem to stay behind. That while many experts see the bicycle as the ideal access and egress mode (Kager, 2015). In the Netherlands, the bicycle is especially popular in access trips with a share of almost 50% (see figure 2). Research indicated that even 60% of all people travelling to a railway station would prefer the bicycle as access mode (Tiemens, 2015). Thus, the bicycle share in access has potential to grow further. The problem is that it is unclear how policy-makers can efficiently improve the urban environment of the bicycle access since it is not clear what the traveller finds important.

As chapter 4 will conclude, most existing instruments that assess the bikeability of areas, base resistance factors for cycling on existing literature and do not give importance or weights to them. Yet, it is unclear how the factors relate to each other. In other words, it is unclear what the travellers finds important in the access journey. Increased insight in the relative importance of different factors can help decision-makers in making efficient choices regarding the urban environment.

This leads to the following problem statement:

*It is as yet unclear how the urban environment of access routes for bicycle to railway stations should be changed in order to improve the total trip quality since it is unclear how travellers weigh the cycling resistance factors for access.*
In the past, extensive research has been performed on travel costs and time as resistance factors, while the role of effort in quality of access and egress remains vague. Because of that, this thesis mainly focuses on the effort component regarding the urban environment.

1.2 RESEARCH OBJECTIVES & RESEARCH QUESTIONS

This thesis aims to bring about a more complete understanding of attitudes and behaviour regarding cycling in access trips and thereby inform the design and development of public policy measures related to the urban environment intended to improve and encourage train journeys. A literature research identifies factors that (might) influence the travel resistance of bicycling in access, interviews with experts in combination with a theoretic categorization pointed out the most relevant ones which were the variables (attributes) in a survey among (potential) train users. The aim of the survey is to find the importance, the weights, of the effort-related factors in relation to each other and to travel time. Also, the influence of personal characteristics (e.g. age, gender) on the weights are subject of investigation. Chapter 2 will describe these mentioned methods (literature, interviews, categorization and survey).

The focus is on how the urban environment influences the effort component since this is the most unexplored and therefore scientifically interesting component. The costs and time components are only described based on existing literature (paragraph 3.2 elaborates on this). This leads to the following main research question:

‘Which urban environment factors (with focus on effort) determine the quality of railway stations access and egress by bicycle and how do travellers rate these factors?’

In order to answer the main research question, the following sub-questions are formulated:

1. Which components and factors influence travel resistance of bicycling?
2. How do existing instruments assess bikeability and what can we learn from them?
3. How to design an experiment in order to find answers on:
   (a) What are the weights of the effort resistance factors?
   (b) Do different individual and social characteristics systematically relate to the value respondents attach to certain factors?
   (c) How does the value of the effort factors relate to travel time?

1.3 ADDED VALUE OF THE THESIS

1.3.1 ADDED SCIENTIFIC VALUE

The literature on quality of access or egress for transit is relatively scarce and focuses on work by only a few researchers (Phillips & Guttenplan, 2003). Research on costs and time as resistance components for travelling is very extensive, but the effort component stays underexposed. While especially walking behaviour and its relation with the urban environment is getting increasingly attention in literature, the research on bicycle seems to stay behind. Geurs (2015) remarked that the attention for the bicycle in Dutch research is much less than for example in the United States. Van der Bijl (2014) calls it the ‘paradox of the bike’: the bicycle in the Netherlands is so common that it is not recognized as subject for research. This study provides more insight into the urban characteristics that influence travel resistance of bicycling towards a station and how travellers weigh these factors in relation to each other. This thesis also gives more insight in how these effort factors relate to travel time. In other words, it is investigated how many minutes the respondents are willing to cycle extra for a pleasant cycle environment. Giving insight in the weights of the different factors and their relation to travel time in cycling in access is, as far the author knows, not been done before.
1.3.2 Added value to practice

Municipalities and urban designers, but also the public transport companies and of course (potential) travelers themselves would benefit from improved access for bicyclists. Getting insight in which urban characteristics influence quality of access and egress (and to what extent) can help decision-makers to proceed the planning of access and egress in the right way. Including weights in instruments that assess bikeability will lead to more reliable outcomes on which aspects of routes or areas are most in need for improvement. In this way, decision-makers can make more efficient choices in the (re)development of railway station areas.

Almost all municipalities and regions use strategic traffic models in order to determine their policy on mobility. Most of the current models do not incorporate slow modes (cycling and walking) in an adequate way, not even the multimodal ones (De Graaf, Hoogendoorn, & Barmentlo, 2015). In order to improve the route choice of these models, some kind of quality index has to be assigned to the links or zones in the model. This quality index should cover factors such as comfort. Past researches have shown that incorporating soft factors such as a ‘walkability indicator’ or pedestrian friendliness factor’ significantly improved the reliability of the models (see for examples (Cambridge Systematics, Bicycle Federation of America, & Michael Replogle, 1998; Evans, Perincherry, & Douglas, 1997; Park, Choi, & Seung Lee, 2015)). More insights in the relative importance of these quality factors could thus be useful for the improvement of traffic models and the policy decisions based on these models.

1.4 Thesis outline

The first chapter has explained the background and problem, the research questions and the added value of the thesis (chapter 1). The second chapter will describe the methods used in this thesis (chapter 2). Thereafter, the literature research of this thesis will follow with a theoretic background on resistance factors in bicycling complemented by the most relevant literature in walking (chapter 3). The output of that chapter is an overview of factors that is used as input for the experiment (the survey). The second half of the literature research is the description of existing instruments that attempt to assess the suitability of urban environment for cycling (‘bikeability’) in chapter 4.

The phase of the experiment starts with chapter 5 that will describe the design and construction of the experiment. This chapter will start with the selection of the attributes from the list of factors found in chapter 3. The statistics of the respondents and the execution and outcomes of the experiment will be described in chapter 6. This chapter will also concisely describe the statistical methods that are used to analyse the outcomes of the experiment. The thesis ends with the conclusions and recommendations for further research in chapter 7. The experiment (survey) is included as an appendix.
2.1 INTRODUCTION

The main aim of this thesis is to find the importance, ‘the weights’, of urban environment factors for bicyclists in access of railway stations in relation to each other and to travel time. In order to determine these weights, an experiment in the form of a survey among (potential) train users is conducted. Before the survey could be spread, several methodological steps had to be taken in order to design the experiment in a correct and efficient way.

This chapter will describe the methodology, or the research approach, of this thesis. Four methods form the basis of this research: literature research, interviews, categorization and surveying. In the next sections these methods will be described. This chapter only contains the methodological description of the methods, the actual conduction of the methods can be found in chapters 2 and 3 (literature research), section 5.2 (interviews, categorization) and the remain of chapter 5 (design of the survey).

2.2 USE OF LITERATURE

First of all, an extensive literature research was conducted with the aim to get insights in bicycling behaviour and what kind of factors are of influence. As stated, the focus is on factors related to the urban environment, but also other types of factors are incorporated in the literature review in order to get a complete picture of ‘bikeability’. The outcome of the literature review is a list with urban environment factors that (possibly) influence bicycling behaviour in access. It has to be emphasized that the factors might be of influence because the studies used in this part are not always specified on access of railway stations and moreover, also literature on walking behaviour is used. That is because pedestrian literature is more extensive and reveals more types of factors that influence walking behaviour. These theories are included since walking and bicycling show many similarities in the relation with the urban environment in contradiction to in-vehicle modes. Still, the differences between walking and cycling are also described and kept in mind (see section 3.3).

For the literature research to the factors and bicycle use (chapter 3), scientific literature was used which was found via Scopus or the library of the TU Delft and PBL. Both qualitative as quantitative studies were used in order to get a complete picture of bikeability in access. The literature consisted of documents as journal articles, dissertations and books. The literature with quantitative data mainly concern documents from the last 15 years, while important qualitative studies on cycling and walkability are up to 70 years old.
Literature research is also conducted for chapter 4: the chapter about instruments that assess bikeability. The research to the instruments considered scientific literature, but also looked at instruments from grey literature. That is because not all instruments have a scientific origin since some are developed with for example a commercial or practical goal in mind. In the problem description and the introducing sections of some chapters, also a few sources from recent articles from various news websites were used in order to illustrate the on-going discussion about bikeability outside the scientific world. Furthermore, several statements made by prominent researchers from the field of mobility (a.o. Karst Geurs) at recent conferences were used to emphasize the relevance of this thesis in today’s society.

2.3 Interviews and Categorization for Attributes Selection

Before the start of the experiment, a selection of factors was made. Testing all the factors (that were found with the literature research) in an experiment would give the most complete outcome of the experiment, but is not feasible in this time set for this thesis and the chosen explorative type of surveying (which will be described in section 2.4).

Thus, the list of factors had to be reduced to a few attributes (in choice experiments, factors are called ‘attributes’). This was done with the help of interviews and a theoretic categorization. Another method that could be used to point out a set of attributes is by enumerating the factors on base of their appearance in articles and scientific reports. A disadvantage of this method is that it heavily relies on existing literature. According to several prominent researchers (Karst Geurs [2015] and Kevin Krizek [De Bruijn, 2015]) bicycle behaviour is still a quite undiscovered field of research. Thus, depicting attributes solely on basis of the existing literature is with bikeability as subject not desirable since the literature is expected to be incomplete on effort-factors. Experts are expected to have a broader view, than a selection of scientific studies on bikeability, on which environmental features are important in the perception of cyclists.

The first three interviews were held face-to-face with researchers from the field of mobility (employees of PBL). Their names are Anco Hoen, Danielle Snellen and Hans Nijland. The aim of these interviews was twofold: to check the completeness of the factors list and to find out how the rest of the interviews should be conducted. First they were asked which factors they expected to be important in bicycle access to the station from the viewpoint of the traveller. This question was asked in order to check whether no important factors were missing in the list of factors. Thereafter, the interviewees were showed the factors in a random order and were asked to choose the five factors that would be most interesting to include in an explorative stated choice experiment about travel resistance of bikeability in access to railway stations. In the discussions that followed from this question emerged that it would be more interesting to include a variety of attributes in the experiment in order to cover different types of aspects of bikeability. Hence, the factors were ordered according to a categorization found in the literature review (the five traveller needs of Van Hagen [2011]). The last question the three interviewees was asked was choose the five most important factors that influence travel resistance on the bicycle in access to the railway station.

In order to have a more robust selection of the attributes, this last question was also presented to other employees of PBL. These people were not selected on their specific expertise, but were surveyed as regular Dutch citizens who are (potential) bicyclists in access. The factors were placed randomly on a card and presented to the employees. Their selection of attributes in conjunction with the categorization found in literature, led to the selection of five attributes. The conduction of the categorization and the interviews can be found in section 5.2.
2.4 Surveying

In order to find the relative importance of the selected attributes, a survey is conducted. As the literature review will reveal personal characteristics are expected to play an important role in travel resistance and therefore have to be incorporated in the survey. Furthermore, not only the effort-factors in relation to each other, but also in relation to travel time is investigated. Thus, the survey is designed in such a way that it provides data that can give answers to the following three questions:

(a) What are the weights of the attributes?
(b) Do different individual and social characteristics systematically relate to the value respondents attach to certain attributes?
(c) How does the value of the effort attributes relates to travel time?

The survey consists of a part with questions related to individual characteristics (the questionnaire) two parts with different types of choice experiments and one part a rating experiment. The methods will be explained in sequence to the three stated questions above.

2.4.1 Determining Weights of Attributes

Determining the weights of the attributes can be done with several types of methods in order to understand individual preferences: choice experiments, contingent rating, contingent ranking and paired comparisons. Asking travellers how they would rate or rank certain factors are the easiest methods, but not desirable since people are poor analysts of their own behaviour (Chorus, 2014). Nowadays, contingent rating and ranking tests are hardly used as main experiment in scientific studies in the field of transport.

In choice experiments, respondents are presented sets of alternative combinations of attributes (the ‘factors’) of a good (or route in this case) and are asked to choose their most preferred alternative. Choice modelling is based on the theory of Value which states that the utility derived from a good is the sum of the good’s attributes (Snowball, 2008). Observing the choices is a much more reliable unit of measurement than ranking of rating since trade-offs are latent (Snowball, 2008). Therefore, this thesis conducted a choice experiment among (potential) travellers in order to find out how they value certain attributes. Because the subject of this thesis is rather unexplored, which makes the choice experiment explorative, also a rating test was included in the survey with the objective to check the outcomes of the choice experiment.

Stated Preference data

In order to analyse choices, data is required. Two types of data collection paradigms can be distinguished: Revealed Preference (RP) and Stated Preference (SP). In a RP survey, respondents are asked what they actually did while in a SP survey they are asked what they would do in a certain situation. Each of these two types have their advantages and disadvantages. Collecting RP data requires a lot of time and money, the attributes contain measurement errors and the choice set is non-clear. Besides, the universal choice set (all routes to a railway station) is very large. Studies based on SP data have proven to be more efficient in obtaining significant effects regarding aspects that have high impact on people’s choices (Beelaerts van Blockland, 2008). Therefore, this study will conduct an SP choice experiment. However, the disadvantages of SP should be kept in mind. The most serious disadvantage is the reliability since respondents answer under the hypothetical situation and there is a chance that the answers do not correspond with actual behaviour (Sanko, 2001).

Efficient choice sets

The choice experiment has the form of a stated preference survey with an efficient design. An efficient design is a relative new type of a fractional factorial design. The idea of a fractional factorial design is that useless choice situations are deleted from the survey which makes the survey shorter and more efficient. Since the efficient design method can give more accurate outcomes and improves the reliability of the weights (Rose & Bliemer, 2007), this one is used in the survey. The aim of an efficient design is to balance
utilities of the options in each choice set (Molin, 2014). Hence, the method needs to estimate the utilities of the choice alternatives when constructing the experimental design. For this, priors are required: best guesses on parameter values. These priors had to be retrieved in a pilot survey since literature cannot provide priors of the attributes used in this research. The pilot survey had the classic type of fractional factorial design: an orthogonal design. Another function of the pilot survey is that the questionnaire could be tested and improved before sending out the final survey.

**Visual alternatives**

Most surveys present the alternatives with text, but due to the visual characteristic of this thesis’ subject, a visual approach was considered to be more suitable. Research on visual surveys compared to textual surveys is very scarce. It is yet unclear which type of survey leads to more reliable outcomes. Some argue that using images may clarify particular attributes (e.g. architectural style) and that they make choice task more realistic for the respondent (Jansen, Boumeester, Coolen, Goetgeluk, & Molin, 2009). The discussion on the (dis)advantages of visual surveys is still continuing among researchers in different fields of work. Despite these uncertainties about visualisation, this approach has been chosen since most of urban environment factors such as ‘trees’ or ‘crowdedness on bicycle path’ are hard to express in words but easier in pictures.

According to Grava (2003), there are three main methods to conduct a visual survey: 1) take the respondent to different sites 2) use images of sites or 3) use video projection of the various sites. This experiment has used the second option since taking respondents to sites is very time consuming what will results in low amount of respondents. A video projection allows a good perception of the interactions happening in a street, something a static picture is less able to do (see for example Perdomo et al. (2013)). However, using images is far cheaper and requires considerably less time than the other two methods. Section 5.3.1 explains how the design of the images in the experiment was established.

**Analysis of the data**

The outcomes of the choice experiment are analysed with a Multinomial Logit Model (MNL): a standard analysis in these kind of surveys. More advanced models that can be used to analyse choice experiments, such as Latent Class and Mixed Logit, could give more reliable outcomes but are not used in this thesis since these methods require more respondents. Moreover, the conducted experiment is rather explorative and therefore the focus is not so much on the analysis of the data, but on the design of the experiment.

### 2.4.2 The Personal Characteristics

In order to find whether personal characteristics such as gender systematically relate to the value respondents attach to certain attributes, these personal characteristics are incorporated as interaction variables in the MNL. The personal characteristics of the respondents are gathered with a questionnaire. Respondents were able to choose answer categories which are based on the categories of CBS (Statistics Netherlands).

### 2.4.3 Relation with Travel Time

This thesis also provides outcomes on the importance of the urban characteristics in relation to travel time since the literature study revealed that while it is expected that travel time is most important in travel resistance, this has hardly been substantiated. Due to the expectation that the travel resistance component of time is much more important and heavier than cost and effort, travel time is excluded from the main choice experiment in order to avoid unbalanced alternatives. Hence, an extra part in the survey was devoted to the relation of effort factors with travel time with the use of an adaptive stated choice experiment. In this part, the respondents are showed the most unattractive environment with low travel time and the most attractive environment with higher (varying) travel time. The outcomes of this part reveals how many minutes people are willing to cycle extra for the route with the attractive effort attributes.
2.5 Conclusion

In order to determine the weights, four types of methods (literature research, interviews, categorization and surveying) were used. The sequence and their influence on each other is illustrated in figure 3. This figure illustrates the main methods in relation to each other and the products.

The literature research provides a factors list that forms the input for the interviews. The aim of the interviews in combination with the categorization is to select a set of attributes. These attributes are the input for the choice models. The survey consists of two types of choice modelling (choice experiment, adapting choice experiment) a questionnaire and a rating test. Before constructing the final survey, a pilot survey was conducted. The aim of this pilot is twofold: to retrieve priors for the efficient design of the (final) survey and to check the questions of the survey on their clarity. The output of the survey provides answers on the questions:

(a) What are the weights of the attributes?
(b) Do different individual and social characteristics systematically relate to the value respondents attach to certain attributes?
(c) How does the value of the effort attributes relates to travel time?

The literature research concerning the factors list can be found in chapter 3, the research about instruments in chapter 4. The outcomes of the expert interviews and categorization in 5.2 and the design of the survey in the remaining of chapter 5. The answers are described in chapter 6.
3.1 INTRODUCTION
While motorized vehicles are extensively researched by traffic engineers and modellers and the pedestrian has often been subject of research in literature by urban designers (Van Veelen, 2015) the bicycle seems to get less attention. Even in the Netherlands, a typical ‘bike country’, the amount of scientific literature on this mode stays behind while the use of the bicycle is increasing. It is at least remarkable that the so-called new ‘bicycle professor’ of the Netherlands, Kevin Krizek, is an American (RU, 2015). Among others, Forsyth and Krizek (2011) emphasize the lack of knowledge about the cyclists’ perception and experiences.

This chapter describes the factors influencing bicycle behaviour according to scientific literature and defines what a successful urban environment for bicyclists actually is, in order to answer the sub question: “Which components and factors influence travel resistance of bicycling?”. These factors are summarized in a table at the end of this chapter what will be used as input for the experiment which is described in chapter 5. The first two sections, 3.2 and 3.3, provide a theoretic background on a journey and bicycling behaviour. Section 3.4 describes urban environment factors influencing bicycling and section 3.5 shortly describes other types of factors relevant to cycling. The chapter ends with a concise conclusion in section 3.6.

3.2 A JOURNEY
The journeys people make daily consist of many decisions. Five sequential choices can be distinguished: first the trip frequency choice, followed by a destination choice, mode choice, time choice and finally the route choice (Van Nes, 2013). The latter (route choice) is the focus of the experiment of this thesis. The overall choice whether or not to go to a certain destination depends on two aspects: the utility at the destination and the disutility (travel resistance) of the journey. If a person ranks the utility higher than the travel resistance, the person will go to the destination. The travel resistance can be divided in three components: money, time and effort (Van Wee & Annema, 2014a).

The cost component of door-to-door railway journeys concerns out-of-pocket costs such as fare and parking costs. The costs of such a journey is already low compared to a car journey. Travellers pay on
average twice as much for a kilometre travelled by car than for a kilometre by public transport \(^1\) (KiM; CPB, 2009). Concerning bicycle in access, journey costs are almost negligible. Bicyclists only have to pay if they want guarded parking or rent a bicycle. The purchase price of a bicycle varies between 50 and several hundreds of euros, what makes it an affordable transport mode also for the lower incomes. In the prosperous Netherlands, travel time is more important in mode choice than travel costs (Van den Heuvel, 1997). The time component of access is often expressed as total time taken in minutes. The travel time depends on the average speed and the covered distance. Recent research showed that bicyclist are prepared to cycle up to 3.6 kilometres to a railway station (La Paix Puello & Geurs, 2015). The table on the next page shows the subcomponents of travel time of different modes.

Table 1 Travel time – subcomponents travel time (Van Wee & Annema, 2014b)

<table>
<thead>
<tr>
<th>Car</th>
<th>Public Transport</th>
<th>Bicycle</th>
<th>Walking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking time to parking lot</td>
<td>Hidden wait time* Access time</td>
<td>Egress time</td>
<td>Walking – journey time</td>
</tr>
<tr>
<td>Car – ride time</td>
<td>PT – ride time</td>
<td>Bicycle – ride time</td>
<td>Walking – journey time</td>
</tr>
<tr>
<td>Parking search time</td>
<td>Walking time transfer</td>
<td>Parking time</td>
<td></td>
</tr>
<tr>
<td>Walking time to parking lot</td>
<td>Wait time transfer</td>
<td>Egress time</td>
<td></td>
</tr>
</tbody>
</table>

* PT-travellers are dependent on the departure time set by the carrier. Because of that, they sometimes have to wait at their origin before they can leave.

While time and money are quite easy to measure, the effort component is more complex. Research on that component is very scarce compared to the extensive literature about travel time and costs. The effort component includes aspects like uncertainty, (dis)comfort and perceived travel time. The figure below shows the time spent in access is valued much lower than the time in the train or at the origin and destination. Only the time during the transfer is valued even lower.

The hour Dutch people daily spend on travelling is valuable and the perceived comfort and convenience of the travel conditions have great direct and indirect impacts on the health, wealth and happiness of people. Long and unpleasant daily commutes can increase stress and reduce traveller satisfaction (Litman, 2015). Van Hagen (2013) described three strategies to improve the door-to-door journey: accelerate, enhance and condense (see the right image of figure 4). For bicycle in access this means shorter, faster and more pleasant routes between home and railway station. According to Van Hagen (2011), five travel needs can be distinguished: the experience, comfort, ease, speed and safety and reliability (see figure 5). These travel needs are placed hierarchically in a pyramid in analogy to the Maslow pyramid (Maslow, 1954). According to Van Hagen, safety and reliability are basic requirements: potential travellers will avoid areas they perceive as (socially) unsafe. ‘Speed’ is the main desire of a customer: most travellers would choose the option with the shortest travel time between origin and destination. The next desires are ‘ease’ (clear overview without much hassle) and ‘comfort’. The last desire is ‘experience’, this considers cleanliness, materials and other visual aspects.

\(^1\) The public transport user pays on average 9 cents per kilometre. The costs per person vary widely: students travel for free while for example a first class ticket in a train costs over 2 euros/kilometre. A kilometre by car costs on average 22 cents.
3.3 The Bicycle

The bicycle is a typical Dutch mode of transport: the Netherlands have the highest modal share in terms of trips in Europe as the figure below illustrates. The bicycle is a healthy and cheap mode of transport for the user. In urban areas, the bicycle is often even the faster option. The mode has also benefits for the society: it is sustainable (no emissions or noise) the required infrastructure is cheap and it improves public health (Olde Kater, 2007). The bicycle as mode also has some disadvantages: the difficulty of carrying loads, the risk on theft, it is strongly weather dependent, it has to be parked, and it is slower than motorized transport outside the urban areas. Heinen (2011) also appoints physical effort as a disadvantage. Especially when people have to wear a suit to work, the bicycle as transport mode can be uncomfortable. However, it also seems assumable that some people see the physical effort as an advantage and reason to choose for the bicycle. Furthermore, the distance a cyclist travels is limited due to factors such as speed and physical effort.

Figure 6 Cycling and walking share of daily trips in Europe, North America and Australia, 1999–2009 (Buehler & Pucher, 2012)
3.3.1 BICYCLING BEHAVIOUR

How a person ranks the utility of a destination and the disutility of a trip depends not only on the route characteristics. Bicycling behaviour depends besides the urban environment also on factors related to preferences and attitudes, experience with cycling, socio-demographic profile, lifestyle, weather influences and alternatives means of transport (Hunt & Abraham, 2007). Many authors did research into for example the influence of gender, age and travel purpose on the choice for cycling. Handy (2005) also appoints social norms to play an important role in choosing alternatives to the car. Figure 8 is based on her theories. Bicycling and walking show many similarities and therefore walking theories are often used in literature on bicycle. It is useful to use walking literature since that is much more plentiful than bicycle literature, however the differences between the two modes should be kept in mind. Niemeier and Rutherford (1994) state that bicyclists depend less on the built environment than pedestrians. Forsyth and Krizek (2011) state that the needs of cyclists substantially differ from pedestrians, transit users or motorists. A bicyclists is faster (18 km/hour) than a pedestrian (5 km/hour), uses a different section of the road, needs parking facilities and requires a vehicle. Pikora et al. (2003) found in their research to slow modes that while for walking the factors personal safety, aesthetics and proximity of destinations were considered most important, for bicycling the weights were highest for continuity of the route and traffic safety. These differences indicate that walkability and bikeability should be assessed with different instruments.

Rietveld and Daniel (2004) developed a theoretical framework for bicycle use (see figure 8). The framework includes both factors which can be influenced by policy and factors which can hardly be changed by policy. The left box shows factors which can hardly be changed by policy measures (individual features, socio-cultural factors and natural environment such as weather circumstances). Concerning the generalised costs of bicycling, Rietveld and Daniel (2004) mention the following aspects: Monetary costs (parking bicycles and maintenance costs), travel time (depends on waiting time at crossings, level of detour, adequacy of cycling infrastructure, the spatial structure), physical needs & comfort (depends on quality of infrastructure, pollution levels, flatness surface, weather circumstances), risk of injury, risk of theft and personal security (the ease of going out at any time of the day without being anxious).
Heinen (2011) divides the factors that determine the choice for bicycle in trips into five groups: the built environment, the natural environment, socio-economic variables, psychological factors and the fifth group includes further aspects related to cost, time, effort and safety. Factors such as rain (natural environment) are of high influence on the perceived cycling resistance, but these cannot be influenced or improved by policy-makers. Since this thesis is written from the viewpoint of decision-makers on how access can be improved in physical terms, the focus will be on the built environment factors. Since the term ‘built’ implies that only factors related to build constructions (buildings, roads etc.) count, but factors related to traffic (other road users) can also be influenced by policy-makers, this thesis will use the term ‘urban environment’. Thus, all environmental factors that might influence the trip resistance of a bicyclists and are within the power of a policy-maker to change are called ‘urban environment factors’. These factors will be described in section 3.4. The other factors influencing cycling behaviour will be described shortly in section 3.5. Before going into detail on the factors, the next section describes what a successful urban environment for the bicyclist actually is.
3.3.2 SUCCESSFUL URBAN ENVIRONMENT FOR THE BICYCLE

The first authors who researched the physical environment for slow modes were American. The origin of bicycle behaviour researches and theories can be found in the literature on walking behaviour. Gordon Cullen analysed in his book ‘The Concise Townscape’ (1961) pedestrian routes by sketches and pictures from the user’s point of view. He stresses that characteristics such as landmarks, ornamentation, design styles and the way buildings open out into spaces, contribute to the quality of public space. His work focuses on the physical built environment as condition for walkability. According to Jane Jacobs (1961), the key to successful pedestrian environment is activity on the streets. She stresses the importance of diversity in order to have lively and safe streets. According to her, an area should serve at least two functions, building blocks should be short and vary in age and condition and there should be a sufficiently dense concentration of people. Another theory on successful public space for pedestrians is from Kevin Lynch (1960). He emphasizes the need of people to recognise and pattern their surroundings. According to him, a good environment for pedestrians is easy legible and has a clear image.

Jan Gehl (2010) builds further upon these theories. He emphasizes that public space should always be approached from the human point of view, with attention to sense of place, scale and dimension. He appoints three key factors for good quality of public space: protection, comfort and delight. Table 2 shows how these factors are subdivided in 12 quality criteria.

Table 2 The 12 quality criteria for successful pedestrian landscape (Gehl, 2010, p. 239)

| 1. Protection            | Protection against traffic and accidents – feelings safe |
|                          | Protection against crime and violence – feeling secure |
|                          | Protection against unpleasant sensory experiences (rain, snow, pollution, noise, etc) |
| 2. Comfort               | Opportunities to walk (room for walking, good surfaces etc.) |
|                          | Opportunities to stand/stay |
|                          | Opportunities to sit |
|                          | Opportunities to see (reasonable viewing distances, interesting views, lightning when dark) |
|                          | Opportunities to talk and listen |
|                          | Opportunities for play and exercise |
| 3. Delight               | Scale (buildings and spaces designed to human scale) |
|                          | Opportunities to enjoy the positive aspects of climate |
|                          | Positive sensory experiences (good design, materials, trees, plants, water) |

Ewing and Handy (2009) note that features related to walkability vary from objective to more subjective (see figure 10). While factors such as the sidewalk width can be measured objectively, factors such as the sense of safety or comfort may provoke different reactions for individuals. Literature points out numerous factors which might effect a person’s perceived performance of the walkability of a street. With few exceptions, the impact of these factors have not been objectively measured but their importance has been simply asserted by the authors (Ewing & Handy, 2009). Common critique on the urban design researchers and their observations is that they give ‘just some suggestions’ and are considered less influential than the engineer’s road design manuals (Park, 2008). As chapter 4 will show, most instruments developed for measuring walkability or bikeability limit themselves to factors of physical features (the first block in the figure).
3.4 Urban Environment Factors Influencing Cycling Resistance

As stated before, travel time is an important component in cycling resistance. The shortest access time would be achieved with a straight route between home and station without any interruptions. In reality though access routes are shaped and influenced by the urban environment. Widely varying factors of the urban environment somehow influence cycle resistance in terms of time, costs or effort. This subchapter takes a look at which urban environment factors are mentioned in scientific literature on bicycle behaviour. An overview of the factors described below can be found in table 3.

The first factor described related to the built environment is the distance between the origin and destination. Increasing distance leads to increasing time and effort. Due to the physical effort required, that relation probably increases disproportionally (Van Wee, Rietveld, & Meurs, 2006). In terms of access of railway stations, research showed the bicycle to be used most often for distances between 0.5 and 3.5 kilometres (Keijer & Rietveld, 2000; Martens, 2004). It is yet unknown how cycling frequency is influenced by the increase of distance of access and egress. It is assumed it will decrease with increasing distance like in regular trips (Heinen, Van Wee, & Maat, 2010). Factors such as mixed land-use, higher density and denser road network can decrease distances between origin and destination. With Transit Oriented Development (TOD) density increases and distances decrease. It seems logical that increase of density decreases distances and thus bicycle use will increase. However, studies on bicycling and density show varying results. Most studies show a positive effect of density of bicycling rates. However, in terms of access trips to railway stations, density can also have a negative effect of cycle rates. La Paix and Geurs (2015) found lower cycle rates in high-density areas in their study to bicycle in access. They ascribe the negative effect of high-density to the type of stations (large stations in city centres) that are often located in highly dense areas with a high use of BTM. In other words, the bicycle in high-density areas has to compete with access modes as walking, bus, tram and metro. Probably the higher density does not increase the travel resistance of the bicycle in access, but decreases the travel resistance of walking/bus/tram/metro.

Another factor which affects the travel resistance is right of way. Required stops during a bicycle trip increase the travel time, and probably the perceived travel time (and thus effort) even more. It is not surprising bicyclists prefer continuous facilities (Joo, Oh, Jeong, & Lee, 2015; Stinson & Bhat, 2004; Stinson & Bath, 2005) and that areas with more traffic lights correspond with lower cycling levels (Rietveld & Daniel, 2004). Dozza and Werneke (2014) found that interruptions of the right of way decrease traffic safety: cycling in proximity to an intersection increases the risk on an critical event fourfold.

Other road users also influence the bikeability of a street. Bicyclists prefer low-traffic residential streets (Abraham, McMillan, Brownlee, & Hunt, 2002; Stinson & Bhat, 2004) and a high bike lane volume is negatively perceived (Mozer, 1998). Park (2015) showed that low intensity of motorized vehicles positively influences the walkability of a street. The influence of intensity of motorized vehicles on bikeablity is less clear. However, La Paix Puello and Geurs (2015) did find bicyclists are hardly influenced by traffic congestion. A high intensity of other road users might negatively affect bikeability, but at the same time completely desolated streets can feel (social) unsafe to bicyclists. One of the most important aspects of social safety in a street is the presence of other people: ‘the eyes on the street’ (Jacobs, 1961). Around railway stations, the feeling of social safety is relatively low (a survey of CBS showed that 24% of the respondents finds station areas unsafe, compared to 14% in shopping area and 16% in public transport (CBS, 2012)). Moreover, more cycling facilitates objective (traffic) safety in the end. Collisions rates decline with the increase of people walking or cycling. It is unlikely that pedestrians or bicyclists become more cautious if their numbers are larger, but it appears that drivers of motorized vehicles change their behaviour when many pedestrians or bicyclists are present (Jacobsen, 2003).
Literature on the impact of the aesthetic dimension of the urban environment on bicycle behaviour is very limited. Cycling-oriented environments have so far mainly been viewed in functional terms (Forsyth & Krizek, 2011). In the meantime, many studies on how pedestrians perceive the visual urban environment have been done. The dimensions of a street profile, ‘the human scale’, is seen as one of the main factors in walkability studies (a.o. Cullen (1961), Gehl (2010) and Park (2015)). It is likely that bicyclists perceive the aesthetics in a different way, however until now scientific evidence on the ‘bicycle-aesthetics-relation’ is missing. According to Stefansdottir (2014) aesthetic features may alter the character of cycling, but probably do not stimulate additional bicycling. Some studies have shown that bicyclists are influenced by aesthetics in judging the quality of the bicycle environment (Su, Winters, Nunes, & Brauer, 2010), but determining which aesthetic factors influence bikeability in what way is very difficult since aesthetic experiences are subjective and differ per individual. Earlier studies did find out that bicyclists prefer flat and green areas (also when this was not the shortest route) (Krenn, Oja, & Titze, 2014) and beautiful green safe environments in urban areas (Wahlgren, 2011). Here must be noted that an overload of vegetation can also decrease the perception of social safety. In Houten for example, the municipality removed some bushes along the bicycle lanes because these made bicyclists feel unsafe. Also related to social safety is the presence of street lightning. According to La Paix Puello and Geurs (2015) low quality of street lightning in the surrounding of railway stations has a negative influence on bicycle use in access.

Factors that influence the (perception of) traffic safety are adjacent car parking (Stinson & Bhat, 2004; Stinson & Bath, 2005), presence of obstacles (Garcia, Gomez, Llorca, & Angel-Domenech, 2015) and quality of pavement (Bovı & Bradley, 1985; La Paix Puello & Geurs, 2015). A study with eye tracking showed that the cyclists on low quality paths focus more on the path itself and less on surroundings compared to cyclists on high quality paths (Vansteenkiste, Cardon, Philippaerts, & Lenoir, 2012). Safety is a basic need for travellers as the pyramid of Van Hagen (figure 6) illustrates. Or in the words of Rietveld and Daniel (2004): lack of safety is a reason not to cycle. Hopkinson and Wardman (1996) even say that increasing safety is likely more important in encouraging cycling than reducing travel time. This statement is probably not applicable on the Dutch situation since the level of traffic safety for cyclists is already relatively high in this country as figure 11 illustrates.

Figure 11 Fatalities and injuries for bicycling and walking in the Netherlands, Denmark, Germany, United Kingdom and United States (Buehler & Pucher, 2012)
Studies on the influence of a **separated bicycle path** on bikeability have varying results. It is often assumed that separating bicyclists from fast traffic is safer and therefore preferable. Studies have shown that bicyclists prefer bicycle paths to curb lanes, bicycle lanes and roads without bicycle facilities (Hunt & Abraham, 2007; Stinson & Bath, 2005; Wardman, Hatfield, & Page, 1997). Areas with more cycling facilities have a higher modal share of bicycles and higher level of bicycle safety (Heinen, Bicycle Commuting, 2011). Foreign researchers (Krizek, Johnson, & Tilahun, 2004; Stinson & Bath, 2005) have shown that especially non-experienced cyclists, woman and younger children find bicycle facilities important (Heinen, 2011). On the other hand, experienced bicyclists do not value bicycle lanes more than wide curb lanes (Taylor & Mahmassani, 1996). The effect of bicycle infrastructure on the objective (traffic) safety is unclear (Hunt & Abraham, 2007; Klobucar & Fricker, 2007) but the level of perceived safety increases with dedicated bicycle lanes. While these researches showed a preference for off-street facilities, some other researches show bicyclists prefer in-traffic cycling facilities (see for example Shafizadeh & Niemeier (1997). This mixture of outcomes can probably be explained by the type of method applied since especially the researches who used revealed preference (RP), found a preference for in-traffic routes. It may be that the respondents in the RP studies are all experienced bicyclists, which is likely in a RP study, who value safety less compared to the regular bicyclist. Moreover, it may be that in-traffic routes in the study are better connected to origins and destinations than off-road routes and therefore were more likely to be chosen (Tilahun, Levinson, & Krizek, 2007). Thus, the actual preference of bicyclists is probably not the in-traffic type, but this may be the best alternative available. Here must be noted that all mentioned scientific researches regarding separated bicycle path (see the table) are foreign and their outcomes might not apply to the Netherlands. In most foreign countries a separated bicycle path is strongly related with (sense of) safety while in the Netherlands (where most people are experienced bicyclists) that relation is probably less strong.

Bicycle use in the Netherlands is increasing in the cities, especially in the city centres and surrounding neighbourhoods. This growth has increased most on routes to station areas which can be noticed by the large capacity problems of the bicycle parking (Klinkenberg & Bertolini, 2014). The importance of bicycle parking is often mentioned in scientific and grey literature. During discussions about how to improve the bicycle-train combination, parking places for bicycles are often seen as key to the solution. Van der Spek and Scheltema (2015) appoint bicycle parking as core factor of a good cycling network and therefore this needs proper management. Bicycle parking can be improved in terms of quantity (more parking places) and quality (surveillance, distance to platform, presence of real-time travel information etc.). Especially during rush hours, bicyclists face problems regarding parking facilities. Providing additional and automatic parking racks in rush hours would decrease cycle resistance to railway stations (La Paix Puello & Geurs, 2015). An evaluation study of Goudappel Coffeng (2002) even showed an increase of 20% in train use after the realization of new bicycle parking facilities on five stations.

Figure 12 Left picture: adjacent car parking can lead to dangerous situations (Dennis, 2009)
Figure 13 Middle picture: presence of obstacles on bicycle paths (Rietepietz, 2013)
Figure 14 Right picture: low quality of pavement (Kim, 2013a)
The most convenient location for bicycle parking is close to the platforms, to minimize the distance between parking and the train. The left image below shows bicycle parking located right under the platforms in station Houten. In recent years, several railway stations (a.o. Delft, Zutphen, Haarlem) followed the example of providing bicycle parking facilities right under or above the platforms. While these facilities are highly appreciated by the users, not every railway station can build these facilities due to lack of space or the high construction costs. Utrecht Central Station recently opened a 4-floor parking garage for bicyclists next to the station. A disadvantage of such a large garage is the rather large distance between parking place and platform.

The table on the next page summarizes the urban environment factors with their influence on bikeability. This table is based on the table found in Heinen (2011) and adapted to the subject of this thesis and completed with new studies. The next paragraph will shortly describe other types of factors which influence travel resistance of the bicycle.

Figure 15 Left picture: Parking garage for bicycles directly connected with platforms in Houten (Fietsersbond, 2014)  
Figure 16 Right image: Impression of the largest bicycle garage in the world. Located near Utrecht Central (Goed op Weg, 2014)
Table 3 Overview of urban environment factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Relation with bikeability</th>
<th>Articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Social) safety</td>
<td>Lack of safety is reason not to cycle</td>
<td>(Rietveld &amp; Daniel, 2004)</td>
</tr>
<tr>
<td></td>
<td>Eyes on the street improve feeling of social safety</td>
<td>(Jacobi, 1961)</td>
</tr>
<tr>
<td></td>
<td>Increasing safety is likely more important than reducing travel time to encourage biking</td>
<td>(Hopkinson &amp; Wardman, 1996)</td>
</tr>
<tr>
<td></td>
<td>Safety in numbers: more cycling facilitates safer cycling</td>
<td>(Jacobsen, 2003)</td>
</tr>
<tr>
<td>Adjacent car parking</td>
<td>Roads without car parking perceived safer</td>
<td>(Stinson &amp; Bhat, 2004; Stinson &amp; Bath, 2005)</td>
</tr>
<tr>
<td></td>
<td>Presence of on-street parking increased perceived comfort of cyclists</td>
<td>(Harkey, Reinfurt, Knuiman, Stewart, &amp; Sorton, 1998)</td>
</tr>
<tr>
<td>Street Lighting</td>
<td>Presence improves walkability</td>
<td>(Martinez &amp; Barros, 2013)</td>
</tr>
<tr>
<td></td>
<td>Low quality of lighting in station surroundings discourage cycling to station</td>
<td>(La Paix Puello &amp; Geurs, 2015)</td>
</tr>
<tr>
<td>Separate cycling path</td>
<td>Preference for separate facilities (off-street)</td>
<td>(Garrard, Rose, &amp; Lo, 2008; Hunt &amp; Abraham, 2007; Stinson &amp; Bath, 2005; Thomas &amp; De Robertis, 2013)</td>
</tr>
<tr>
<td></td>
<td>Experienced cyclists have no preferences for bicycle lanes versus wide curb lanes</td>
<td>(Shafizadeh &amp; Niemeier, 1997)</td>
</tr>
<tr>
<td></td>
<td>Bicyclist use in-traffic facilities much more often (also if comparable parallel off-road facilities exist)</td>
<td>(Shafizadeh &amp; Niemeier, 1997)</td>
</tr>
<tr>
<td></td>
<td>Bicyclists are 3 to 4 times at higher risk on segments without in-traffic bicycle lane</td>
<td>(Pulugurtha &amp; Thakur, 2015)</td>
</tr>
<tr>
<td>Presence of obstacles</td>
<td>Lateral obstacles lead to lower meeting clearances, lower speed and frequent reaction manoeuvres</td>
<td>(Garcia, Gomez, Llorca, &amp; Angel-Domenech, 2015)</td>
</tr>
<tr>
<td>Distance</td>
<td>Increasing distance &gt; much lower share in mode choice</td>
<td>(Parkin, Wardman, &amp; Page, 2008; Stinson &amp; Bhat, 2004)</td>
</tr>
<tr>
<td></td>
<td>Experienced cyclists prefer short travel time</td>
<td>(Hunt &amp; Abraham, 2007)</td>
</tr>
<tr>
<td>Density</td>
<td>Higher density (shorter distances) &gt; higher bike share</td>
<td>(Cervero &amp; Duncan, 2003; Litman, 2007; Parkin, Wardman, &amp; Page, 2008; Zahran, Brody, Maghelal, Prelog, &amp; Lacy, 2008);</td>
</tr>
<tr>
<td></td>
<td>Residential densities have no effect</td>
<td>(Rodriguez &amp; Joo, 2004)</td>
</tr>
<tr>
<td>Network layout</td>
<td>Fine-grained network &gt; higher share bike</td>
<td>(Southworth, 2005)</td>
</tr>
<tr>
<td></td>
<td>Fine-grained network &gt; No effect</td>
<td>(Moudon, et al., 2005; Zacharias, 2005)</td>
</tr>
<tr>
<td></td>
<td>More cycling infrastructure results in more cycling</td>
<td>(Barnes &amp; Thompson, 2006; Dill &amp; Carr, 2003; Nelson &amp; Allen, 1997; Pucher &amp; Buehler, 2006)</td>
</tr>
<tr>
<td></td>
<td>More cycling infrastructure &gt; No effect on frequency</td>
<td>(Moudon, et al., 2005)</td>
</tr>
<tr>
<td></td>
<td>Bicycle facilities prefer continuous origins and destinations</td>
<td>(Nelson &amp; Allen, 1997)</td>
</tr>
<tr>
<td>Right of way</td>
<td>More traffic lights correspond with lower cycling levels</td>
<td>(Rietveld &amp; Daniel, 2004)</td>
</tr>
<tr>
<td></td>
<td>Preference for continuous facilities</td>
<td>(Joo, Oh, Jeong, &amp; Lee, 2015; Stinson &amp; Bhat, 2004; Stinson &amp; Bath, 2005)</td>
</tr>
<tr>
<td></td>
<td>Cycling in proximity to an intersection increased risk on critical event fourfold</td>
<td>(Dozza &amp; Werneke, 2014)</td>
</tr>
<tr>
<td>Traffic intensity motorized vehicles</td>
<td>Low intensity positive influence on walkability</td>
<td>(Martinez &amp; Barros, 2013)</td>
</tr>
<tr>
<td></td>
<td>Traffic congestion hardly influences bikeability</td>
<td>(La Paix Puello &amp; Geurs, 2015)</td>
</tr>
<tr>
<td>Bicycle lane volume</td>
<td>Cyclists prefer low-traffic residential streets</td>
<td>(Abraham, McMillan, Brownlee, &amp; Hunt, 2002; Stinson &amp; Bhat, 2004)</td>
</tr>
<tr>
<td></td>
<td>High volume negatively influences bikeability</td>
<td>(Harkey, Reinfurt, Knuiman, Stewart, &amp; Sorton, 1998; Mozer, 1998)</td>
</tr>
<tr>
<td>Bicycle parking</td>
<td>Is important to bicyclists</td>
<td>(Abraham, McMillan, Brownlee, &amp; Hunt, 2002; La Paix Puello &amp; Geurs, 2015; Martens, 2007; Stinson &amp; Bath, 2004)</td>
</tr>
<tr>
<td></td>
<td>Preference for secure parking facilities</td>
<td>(Cleary &amp; McClintock, 2000)</td>
</tr>
<tr>
<td></td>
<td>Preference for (free) unguarded parking facilities</td>
<td>(La Paix Puello &amp; Geurs, 2015; Van Boggelen &amp; Thijssen, 2008)</td>
</tr>
<tr>
<td>Quality pavement</td>
<td>Influences level of bicycle access</td>
<td>(La Paix Puello &amp; Geurs, 2015)</td>
</tr>
<tr>
<td></td>
<td>Surface type is most important factor next to travel time in route choice</td>
<td>(Bovy &amp; Bradley, 1985)</td>
</tr>
<tr>
<td></td>
<td>Poor quality increases risk on accident tenfold</td>
<td>(Dozza &amp; Werneke, 2014)</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Bicyclists prefer green areas</td>
<td>(Krenn, Oja, &amp; Titze, 2014)</td>
</tr>
<tr>
<td>Building characteristics</td>
<td>Shops at street level improve walkability</td>
<td>(Evans G., 2009)</td>
</tr>
<tr>
<td></td>
<td>High number of street-facing entrances or upper-level windows improve walkability</td>
<td>(Park, Choi, &amp; Seung Lee, 2015)</td>
</tr>
<tr>
<td></td>
<td>Aesthetics are important for how bicyclists judge the route environment</td>
<td>(Su, Winters, Nunes, &amp; Brauer, 2010)</td>
</tr>
<tr>
<td>Human Scale</td>
<td>Streets with tall buildings or narrow streets negatively influences walkability</td>
<td>(Park, Choi, &amp; Seung Lee, 2015)</td>
</tr>
</tbody>
</table>
3.5 Other factors influencing cycling behaviour

In researching the relation between urban environment and bikeability it is important to be aware of other factors influencing cycling behaviour. Factors related to climate, topography and culture also influence cycling behaviour but are beyond the control of policy-makers. Since this thesis focuses on factors that can be influenced by policymakers, this paragraph will be concise and describes only the most important factors found in literature. The remaining factors that influence cycling behaviour will be described according to the categorization of Heinen (2011): *natural environment, socio-economic variables* and *psychological factors*. Especially theories on the influence of socio-demographic characteristics and habits on bicycle behaviour are interesting for this thesis since the choice experiment will provide data on what kind of people choose which routes. For example, it might be the case that women value different factors than men.

3.5.1 Socio-economic factors

According to some authors women cycle less than men (Krizek, Johnson, & Tilahun, 2004) while other claim the opposite (Witlox & Tindemans, 2004). According to Buehler and Pucher (2012) cycling is dominated by men in the United States, Canada and the UK. However, in the Netherlands cycling is gender-neutral. This difference might be due to the fact that traffic danger deters especially women (besides children and elderly) and that bicycling in the Netherlands is relatively safe (as figure 12 illustrated). While the average amount of trips by train is about equal for men and women in the Netherlands, men do cover longer distances by train (CBS, 2014a). No gender split in bicycle access to railway stations is found, but the influence of gender on bicycle use in access in the Netherlands is probably not of high impact. However, Krygsman (2004) did find that men accept a longer access, main and egress travel time than women do.

As said, elderly are a vulnerable group in traffic. However, the increase in bicycle use of 14% in the Netherlands between 2000 and 2011 is for a large part caused by elderly (50 years and older). Elderly bicycle more and further in the past years (KiM;, 2012). This increase in bicycling is probably related with the rise of the e-bike and the fact that the health of elderly has improved. Nevertheless, most researchers conclude that cycling levels decline with age (Heinen, 2011). Considering age in relation to train use, it can be noticed that especially people in the age between 15 and 25 years use the train. Only a small share of the elderly (about 4%) makes regularly use of public transport (CBS, 2014b). Again no exact numbers on this type of demographic characteristics in relation to bicycle use in access are found, but considering above mentioned numbers it seems reasonable to assume that cycling towards the railway station is dominated by young people.

Besides age and gender, income is also an important socio-economic factor. The relationship between cycling levels and income remains unclear: international researchers have varying outcomes on this relation. Though, data of CBS show that in the Netherlands the bicycle is used by people from all income classes for about the same amount of kilometres (CBS, 2014c). That while income is strongly related with car ownership and car ownership on its turn gives the individual another choice set (Rietveld & Daniel, 2004). Car ownership is also strong related with the degree of urbanization: people in rural areas have a higher chance on owning a car (Kampman, 2004). People without income make the most use of the train, while the people with low income (under 10.000 euros) use the train the least. Between the five higher income classes no big differences in train use can be detected (CBS, 2014c). Adults with a driver license make use of public transport for 9% of their travelled kilometres, for adults without a driver license this is 35% (KiM, 2013b).
3.5.2 Natural environment factors
A bicyclist is, in contradiction to a car driver, very prone to natural environment factors such as weather conditions, season and climate. In the USA, cycling is more common in summer than other seasons (Stinson & Bhat, 2004). The season is not only of impact due to weather circumstances, but also due to the hours of daylight. The (chance of) rain, low temperatures and darkness results in less cycling (Heinen, 2011). That decrease goes mainly for leisure trips, commuters are of less influence by these factors; if they are dependent on travelling by bicycle, they have to cycle anyway. Of all train trips has about 50% commuting and about 33% education/childcare as purpose (CBS, 2014c). Because of these facts, it seems reasonable to assume that a large share of the bicyclists in access are commuters.

Natural environment factors (e.g. rain) can make the traveller decide to take the car instead of the bicycle-train combination, but on the route choice level these factors have less influence. After all, if a certain route towards the station is cold and rainy, this will be the same for the other routes.

Hilliness is another factor found in literature that affects the travel resistance of cycling. Areas with hills show lower cycling levels (Hunt & Abraham, 2007; Parkin, Wardman, & Page, 2008; Rietveld & Daniel, 2004) and uphill grades (>5%) and steep downhill grades present safety concerns (Grava, 2003). Hilliness however is probably less relevant for the flat country of the Netherlands.

3.5.3 Psychological factors
Also habits and culture play a role in perceived bicycle resistance. Dill and Voros (2007) conclude that cyclists have a more positive attitude towards cycling and that having a positive attitude towards cycling increases the likelihood of actually using the bicycle. In some cultures, the status of the bicycle is low and the mode is seen as a ‘poor man’s vehicle’ (Verbeek, 2007). However that cannot be said about the native Dutch (the Dutch are even proud on their bicycle culture). Regression models do show that immigrants in the Netherlands have lower bicycle use (Verhoeven, 2009).

Other psychological factors that positively influence the likelihood to use the bicycle are: getting financial support by employer to cycle, living in urban environment, living near retail and services, being physically active, having deeply environmental beliefs (Heinen, 2011). A theory that has been widely discussed in the field of transportation and urbanism and relates to psychological factors, is called ‘self-selection’. That can be explained as “the tendency of people to make choices that are relevant for travel behaviour, based on their abilities, needs and preferences” (Van Wee, 2009, p. 280). For example; that people who like cycling self-select themselves to live in more cycle friendly areas. In other words, it is not the built environment that changes travel behaviour, but the attitudes of the people living there: ‘self-selection’ (Lamiquiz & Lopez-Dominguez, 2015). However, recent studies such as Aditjandra et al. (2012) show that the built environment does influence travel behaviour and mobility patterns.

Also the trip purpose of a bicycle trip influences the travel resistance. To illustrate: Pikora et al. (2003) found in their study that in ‘cycling for transport’ permeability is more important than in ‘cycling for recreation’.
3.6 CONCLUSION

In short, cycling in the Netherlands is for all age groups, income classes, trip purposes and genders (Pucher & Buehler, 2007). Considering only access to railway stations, cycling is probably dominated by young people. However, exact numbers on the socio-demographics of cyclists in access are unknown. Cycling behaviour is being influenced by psychological factors, socio-demographics, natural environment and the urban environment. The first three types of factors can hardly or even impossibly be changed by policy measures. On the other hand, factors related to the urban environment are within the power of decision-makers to change.

The urban environment factors that somehow affect bikeability are widely varying and always related to one of the five travel needs: the experience, comfort, ease, speed and safety and reliability. Especially factors related to speed (e.g. distance, bicycle lane volume) have been subject of research. While walkability studies often incorporate factors related to experience (e.g. trees, building characteristics), these factors are less frequently seen in bikeability studies. Also studies on bicycle behaviour in access of railway station are quite scarce. That while the bicycle-train combination is seen as a promising combination that can increase in share in the future.

It is evident that many different factors are of influence on bikeability. However, it is yet unclear if and how these factors are applicable on bicycle in access to railway station. In most researches, the factor was researched in another country and not specified on access. It might be that travellers in access of railway station find other factors important than in the mentioned studies. Also, it is yet unclear how these factors can be made measurable. The next chapter will look at how the authors of some of the existing instruments did that.
4.1 INTRODUCTION

Bicycle, but mainly pedestrian, environment design issues have been subject of research since the 1970s. A decade later, researchers also started to assess the ‘suitability’ of the road network for the slow modes. To determine the suitability of a road network, measurement indicators and assessment instruments are needed (Emery, Crump, & Bors, 2003). These instruments may be helpful for policy-makers in making an efficient planning process towards a qualitative and integrated environment. Some assessment methods are specifically designed for modellers to incorporate in their regional travel model in order to improve the reliability of the outcomes. Another use of assessment methods is a commercial function. Several state-of-the-art methods are described in this subchapter and the varying functions will be explained.

This subchapter looks at existing instruments that try to assess bikeability in order to give an answer on the sub question: “How do existing instruments assess bikeability and what can we learn from them?”. Also some instruments related to walkability are described since the instruments on bicycle are often based on the walkability instruments and some instruments are even designed to apply for both modes. Moreover, the state-of-the-art on walkability instruments seems to be more developed than on cycling instruments. Section 4.2 will describe the types and categories of instruments that exist. Section 4.3 will give an overview of micro-level instruments and section 4.4 will describe the most important (state-of-the-art) instruments. The chapter ends with a concise conclusion in section 4.5.

4.2 LEVELS OF APPROACH

Brownson et al. (2009) made a categorization of the instruments that try to assess an area or route on suitability for bicycles (or pedestrians). They distinguished three types: the first group of measures is obtained by interview or surveys and examines the extent to which respondents perceive access to recreation, land use or transportation. The second group of measures use systematic observations, often called audits, with the aim to objectively quantify factors of the environment. The last group of measures uses existing data that are analysed with Geographic Information System (GIS).

The instruments can also be divided according to their level of approach: the scale. Two levels can be distinguished: the micro and meso-level. Most travel behaviour studies on slow modes test the meso-
level. With meso-level is meant the scale of the urban form with factors related to the 5D’s: density, diversity, design, destination and distance (Cervero & Kockelman, 1997; Cervero, Sarmiento, Jacoby, Gomez, & Meiman, 2009). Recent studies that research the relation of meso-factors with walkability are done by Cervero et al. (2009), Lamiquiz and Lopez-Dominguez (2015) and Lee et al. (2013). Two meso-level instruments that are widely used will be described below.

An often used (meso-level) instrument that incorporates all types of access (and egress) modes of a station is the **Node-Place model** developed by Vereniging Deltametropool (see figure 17) (Provincie Noord-Holland & Vereniging Deltametropool, 2013). In this instrument, a station gets points for six different factors: slow modes, public transport, car, proximity, intensity and mixture. The points for slow modes (walking and cycling) are based on the presence of OV-fiets\(^2\), presence of railway crossing, the amount of bicycle parking’s related to amount of travellers and the amount of access roads within a circle of 300 meters. Thus, a station can have the maximum rating for slow modes when these five criteria are met. Aspects such as safety, comfort and attractiveness are neglected with this meso-level approach. Groenendijk (2015) noticed that and extended the model with a third component: ‘the experience value’. However, this component is only applied on the station itself and not on the routes towards the station. Moreover, the Node-Place model assumes that the more fine-grained a network is, the more suitable it is for slow modes. This seems logical since the difference between the to be travelled distance and the distance as the crow flies decreases with a denser road structure. However, as explained in section 3.4, it remains unclear whether a dense road structure improves bikeability and walkability.

**Figure 17 Left image:** The Node-Place model of Vereniging Deltametropool (Provincie Noord-Holland & Vereniging Deltametropool, 2013)

**Figure 18 Right image:** Walkscore indicator of Portland (Walkscore, 2015)

Figure 18 shows a commercial application of walkability that developed for the real-estate industry. The **Walkscore** (Walk Score, 2015) is an indicator based on opportunity variables (e.g. access to basic services): a quite straightforward approach (Lamiquiz & Lopez-Dominguez, 2015). This web-based application rates the Walkscore of an area on a scale of 1-100. The measurement is based on an algorithm that incorporates the number, type and spatial distribution of amenities in the area. Amenities related to land use and activities are considered (shops, restaurant, parks etc.). The instrument uses data that is easily accessible and the method is very communicable. The score is often used in housing advertisements for example. However, in theoretical terms this walkscore says little about the walkability of an area. The score is not much more than a density measurement. Again, factors set by the authors of section 2.3 such as safety, comfort and attractiveness are completely ignored.

Thus, an instrument with solely a meso-level approach seems not suitable for assessing bikeability in terms of travel resistance. The micro-level approach on the other hand looks at what is directly perceived by the traveller (Park, Choi, & Seung Lee, 2015). Micro-scale factors are typically assessed with

\(^2\) OV-fiets is the bike rental of the Dutch National Railways
direct observations (Millstein, et al., 2013). The methods and instruments in the remain of this subchapter will therefore be of the micro-level type. Micro-scale factors have not been as extensively studied as meso-level factors. Meso-level instruments actually measure the urban form which is relative easy to measure with GIS programs (Park, Choi, & Seung Lee, 2015). That makes the meso-level instruments much cheaper than micro-level instruments since measuring micro-level often has to be done by foot and is time consuming. However, by solely focusing on meso-level instruments, opportunities will be missed since micro-factors may be more cost effectively and are relative easy to modify according to Rodriguez et al. (2008). For example, adjusting micro-level factors such as trees or pavement is much easier than changing meso-level elements such as density or land use.

4.3 Overview of Instruments on Micro-Level

As said, until the 1970’s, walking and cycling behaviour did not get much attention in the design and engineering of roads. One of the first behavioural concepts that was included in road design manuals dealt with walking speed, pedestrian volume and the supply of basic pedestrian infrastructure. An example of such a method can be found in the Highway Capacity Manual (HCM) (TRB, 1985; TRB, 2000). The HCM defined the performance measures for bicycle and pedestrian simply as ‘the degree of discomfort caused by overcrowding of the facilities’. At that time, pedestrians and bicyclists were treated as alien bodies in the mechanics of motorized traffic (Kroll, 2003). According to this model, the best possible street for slow modes is one without pedestrians or bicyclists present. This method contravenes in many ways with the theory of successful public space described earlier.

Instruments that followed increasingly included ‘effort factors’ related to the urban environment. Attributes such as sidewalk availability, ease of street crossings, type of terrain, building setbacks, maintenance, amount of conflicts, condition of infrastructure, visual interest and amenities were included in these instruments. Some measurements instruments assess an area from the viewpoint of a particular group of people such as elderly, other instruments stay generic. Instruments exist that focus on walkability or bikeability but also instruments exist that assess an area for slow modes in general. Not many instruments are found that are specified on bicycles accessing train stations, except the one of Scheltema (2011) which will be described in the next section.

Table 4 provides an overview of instruments and their attributes in order of appearance. The most recent instruments that are widely used will be described in more detail in the following subchapter. The analysis of existing methods has two functions. Firstly, an overview of which urban environment factors are considered in previous methods will give more insights in which factors are considered to be important. Secondly, this analysis will look at how the relative weights of the factors were validated. This will give insights in which methods exist that can find relative importance’s. The last column of the table indicates whether the instruments has assigned weights to the attributes. If so, then these weights are presented in the text of third column between the brackets. The weights should be interpreted in relation to each other: the exact value of a particular weight says little.

Instruments as PEF, BPEF and the Transit Friendliness Factor were implemented in regional travel models. The inclusion of the factors greatly improved the models abilities to predict car versus transit trip selection (Phillips & Guttenplan, 2003). This implies that the attributes used in these instruments do affect travel resistance. However, the relative importance of the attributes was not determined. Thus, it remains unclear whether for example street crossings weighs much heavier in travel resistance than sidewalk availability or the other way around. As the last column in table 4 reveals, not many of the instruments validated their factors in order to find weights.
# Table 4: Overview of instruments assessing walkability/bikeability on micro-scale

<table>
<thead>
<tr>
<th>Instruments*</th>
<th>Mode**</th>
<th>Attributes ***</th>
<th>Weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>TFI (Evans, Perincherry, &amp; Douglas, 1997)</td>
<td>P</td>
<td>Transit Friendliness Factor: Sidewalks + street crossings + transit amenities + proximity to destinations</td>
<td>no</td>
</tr>
<tr>
<td>BCI (FHWA; 1998)</td>
<td>B</td>
<td>Bikeability of segment: [0.966] presence of bicycle lane or paved shoulder - [0.410] bicycle lane or paved shoulder width – [0.498] curb lane width + [0.002] curb lane volume + [0.0004] other lane volume same direction + [0.022] 85th percentile speed of traffic + [0.506] presence of parking lane – [0.264] type of roadside development</td>
<td>yes</td>
</tr>
<tr>
<td>BLOS (Landis, 1998)</td>
<td>B</td>
<td>Bicycle level of service of segment: [0.507] traffic volume/lanes + [0.199] speed limit + percentage heavy vehicles + [7.066] 1/pavement surface condition + [-0.005] width outside through lane</td>
<td>yes</td>
</tr>
<tr>
<td>PEF (FHWA; 1999)</td>
<td>P</td>
<td>Pedestrian environment factor of area: sidewalk availability + ease of street crossings + terrain + connectivity of street and sidewalk system</td>
<td>no</td>
</tr>
<tr>
<td>BPEF (FHWA; 1999)</td>
<td>B</td>
<td>Bicycle environment factor of area: amount of sidewalks + land-use mix + building setbacks + transit-stop conditions + bicycle infrastructure</td>
<td>no</td>
</tr>
<tr>
<td>SPACES (Pikora, 2000)</td>
<td>P + B</td>
<td>Suitability of a neighbourhood for walking and cycling: 37 factors on: building types + path characteristics + street assessment</td>
<td>no</td>
</tr>
<tr>
<td>Bike ISI (FHWA, 2006)</td>
<td>B</td>
<td>Bicycle safety at intersections: [0.019] Main street traffic volume + [0.815] main street speed limit + [0.650] presence of turning-vehicle traffic across the path of through cyclists + [0.470] number of right-turn traffic lanes on main street approach * bike lane presence + [0.023] cross-street traffic volume * no bike lane present + [0.428] traffic signal at intersection * no bike lane present + [0.200] on-street parking on main approach</td>
<td>yes</td>
</tr>
<tr>
<td>PEDS (Clifton, 2007)</td>
<td>P &amp; B</td>
<td>Pedestrian Environment Data Scan: 31 items on: Environment + Pedestrian Facility + Road attributes + Walking/Cycling Environment.</td>
<td>no</td>
</tr>
<tr>
<td>Bicycle Balance explorer (Fietsbalans) (Fietsersbond, 2006)</td>
<td>B</td>
<td>Bikeability of a town/city: directness + comfort (hindrance) + comfort (pavement) + attractiveness + competitive position + bike use + traffic safety + urban density + bicyclists satisfaction + policy</td>
<td>no</td>
</tr>
<tr>
<td>BEQI (SFPHESES, 2009)</td>
<td>B</td>
<td>Bikeability of a segment: 22 indicators on: Intersection safety + Traffic + Street design + Land use + Safety &amp; other</td>
<td>yes</td>
</tr>
<tr>
<td>Fixing the link (Brouwer, 2010)</td>
<td>P</td>
<td>Walkability of area around station: 12 indicators on: Liveliness + Human scale + Legibility + Safety &amp; comfort</td>
<td>no</td>
</tr>
<tr>
<td>Recycle City (Scheltema, 2011)</td>
<td>B</td>
<td>Bikeability of routes towards station: 20 indicators on: Safety + Directness + Comfort + Attractiveness</td>
<td>no</td>
</tr>
<tr>
<td>MAPS (Cain, Millstein, &amp; Geremia, 2013)</td>
<td>P</td>
<td>9 indicators on: Building height and setbacks / road width / sidewalk / buffers / bicycle infrastructure / building aesthetics and design / trees / sidewalk steepness</td>
<td>no</td>
</tr>
<tr>
<td>Copenhagenize Index (Colville-Anderson, 2015)</td>
<td>B</td>
<td>Bikeability of a city: Advocacy + bicycle culture + bicycle facilities + bike share programme + gender split + modal share for bicycles + modal share increase since 2006 + perception of safety + politics + social acceptance + urban planning + traffic calming</td>
<td>no</td>
</tr>
<tr>
<td>Walkability measurement instrument (Park, Choi, &amp; Seung Lee, 2015)</td>
<td>P</td>
<td>Walkability to transit: [0.84] sidewalk amenities – [0.82] traffic impacts – [0.62] scale &amp; enclosure + [0.45] landscaping elements</td>
<td>yes</td>
</tr>
</tbody>
</table>

*Abbreviations: BCI: Bicycle Compatibility Index; BLOS: Bicycle Level of Service Model; PEF: Pedestrian Environment Factor; BPEF: Pedestrian and Bicycle Environment Factor; MAPS: Microscale audit for pedestrian streetscapes; ** B stand for bicycle; P stands for Pedestrian; *** Some of the formulas are simplified in order to keep it readable. The full formulas can be found in the original source.
4.4 Instruments: State of the Art
This subchapter will describe the last seven instruments of the above table. These instruments are not only selected on their year of appearance, but also because they are frequently used by decision makers.

4.4.1 General Instruments
The Bicycle Environmental Quality Index (BEQI) is developed by the San Francisco Department of Public Health for assessment of the bicycle environment on roadways and evaluation of streetscape conditions which promote bicycling in the city (SFPHES, 2009). The 22 indicators that form the index, are based on previous indices and studies. The weights of these indicators were determined with a survey (N=88). The respondents were asked to assign the indicators an importance on a 5-point scale. However the used method (rating) is not considered to be very valid and the response rate was quite low, this instrument at least gave a first indication of weights in contradiction to the following instruments.

The Microscale Audit of Pedestrian Streetscapes (MAPS) (Sallis) was developed to assess details of streetscapes considered relevant for physical activity of pedestrians. The conceptual framework of the instrument was developed using theory, expert consensus and policy relevance. The study focuses on checking the reliability of the factors by comparing the scores that were given by different people (Millstein, et al., 2013). In other words, the objectivity of the factors was tested. The relative importance of the factors was not part of the research. The instrument consists of 201 measures (attributes).

The Fietsersbond developed the ‘Bicycle balance explorer’ (in Dutch: Fietsbalansverkenner) (Fietsersbond, 2006). This is an instrument that quantifies the quality of bicycle facilities in a city (see figure 19). Their instrument is widely used in the Netherlands which gives a good overview and comparison of the municipalities. A survey about the satisfaction among bicycles users is included in the method. Besides a standard norm, also benchmarks per type of city are given. In this way, it is easy to compare a particular city with similar cities. The instrument uses the following 10 main measurements: directness (detour factor, delay, average speed), comfort (hindrance) (stop frequency, slow walking and biking, traffic nuisance, infra nuisance, lack of priority for bicycles, turns) comfort (pavement) (vibration nuisance) attractiveness (traffic noise) competitive position (ratio travel time bike/car, ratio movements bike faster, car costs per trip) bike use (modal split of bikes of trips under 7.5 kilometres) traffic safety (amount of heavily cyclists casualties) urban density (average number of addresses per square kilometer) bicyclists satisfaction (based on survey) policy (in how far the local policy incorporated bike policy in their plans). No weights are assigned to the different measurements, but the layout of this instrument enables the user to easily compare different cities on certain measurements with each other. Due to the lack of weights, the instrument is less suitable to compare the overall bikeability of cities with each other.

Example of Almere:

Figure 19 The Fietsbalansverkenner applied on the municipality of Almere (Fietsersbond, 2006)
Quiet similar to the Bicycle Balance Explorer is The ‘Copenhagenize Index’ (Colville-Anderson, 2015). This instrument is developed with the aim to create a comprehensive inventory and ranking of bicycle-friendly cities. Every year, the designers of the index rank metropolitan cities all over the world with their instrument. In the index of 2015, Copenhagen overtook Amsterdam for the first place. The instrument takes into account factors related to meso-level, micro-level, socio-demographics and bicycle culture. The 13 categories are: advocacy, bicycle culture, bicycle facilities, bike share programme, gender split, modal share for bicycles, modal share increase since 2006, perception of safety, politics, social acceptance, urban planning, traffic calming. Thus the instrument does not solely look at the suitability of a city for bicycles, but also takes into account the current use. For example, cities with a 50-50 gender split among cyclists receive extra points. The instrument gives insights in the overall bikeability of large cities, but does not say much about the micro-level bikeability. A point of critic is that the instrument includes factors such as ‘cycling culture’ that are hard to be judged in an objective way. Moreover, the instrument does not underpin the relative importance of the 13 categories. Cities can score high on politics if the aldermen have nice future policy for bicyclists and rank higher than cities without these future plans, but that does not say anything about the current bicycle situation.

4.4.2 INSTRUMENTS SPECIFIED ON STATIONS

A lot of the existing methods are developed by people with the aim to make areas safer for bicyclists and pedestrians. Also a lot of instruments are developed in the field of health sciences since an increase of physical activity can improve people’s health. Only three instruments in literature were found that are specified on railway stations. Two of them are designed by and in use by the NS (the Dutch Railways). The ‘Fixing the Link’ instrument (Brouwer, 2010) for pedestrian environment and ‘Recycle City’ instrument (Scheltema, 2011) for the bicycling environment. Both instruments are quite extensive with respectively 12 and 20 indicators. The most recent study is the one by Park et al. (2015) who researched the relation between micro-level walkability and station areas.

Brouwer (2010) looked in her thesis ‘Fixing the Link’ at the link between stations and city centres (see figure 20). She appointed 4 principles that define the quality of the link from the viewpoint of a tourist: liveliness, human scale, legibility and safety & comfort. The principles are mainly based on literature from the field of urban design and sociology (a.o. Kevin Lynch (1960) Jane Jacobs (1961) and Gordon Cullen (1961)) These principles were translated into 12 quantifiable factors in order to objectively validate the quality of 16 comparable links between stations and city centre. The instrument concentrates on the effort aspects of a journey, no factors that are direct related to time are included. Brouwer herself already appoints this as a weak point. The instrument could give a station which is located several kilometres from the city centre still a high score. Due to the focus on 1 type of station (‘large station in the centre of a middle sized city’), the validation instrument as proposed by Brouwer is not yet suitable for other types of stations. Another disadvantage is that the method requires intensive field research in order to measure all factors. Furthermore, the factors seem rather subjective: the four factors are assumed to be equally important without any underpinnings given.

Scheltema (2011) developed the instrument called ‘Recycle City’, that can assess the quality of the cycle routes accessing a station (see pyramid of figure 21). She used the customer needs pyramid of Van Hagen and co-authors (2000) as a basis for the instrument and applied it on cycle routes. This instrument uses 4 principles (safety, directness, comfort and attractiveness) that are translated into 20 quantifiable factors. A difference with Brouwer’s instrument is the use of hierarchy: attractiveness and comfort are seen as satisfiers than can only be met if the level of the dissatisfiers (safety and directness) is sufficient. One of the factors is ‘human scale’. Based on the theory of Jan Gehl (2010), Scheltema says that the built environment surrounding bicycle routes must have a human scale. Thus areas with high buildings score low points in this factor. This conflicts with the theory that high density has a positive influence on people’s need for travelling (Provincie Noord-Holland & Vereniging Deltametropool, 2013). Gehl also appoints that areas with tall buildings have more wind, what is undesired for pedestrian and cyclists.
**Measurements:**

1. Liveliness
   a. Mixed use;
   b. Use along the day
   c. Creating an atmosphere of Watching and Being Watched

2. Human scale
   a. Permeability
   b. Fine Grained Building Blocks
   c. Walkability

3. Legibility
   a. Orientation
   b. Linearity of Path
   c. Clarity of the Maps and Signage

4. Safety and comfort
   a. Pedestrian priority
   b. Eyes on the street
   c. Maintenance

**Example:**

Figure 20 An example of Brouwer’s method ‘Fixing the Link’ (2010): assessing the quality of pedestrian routes between station and city center

**Measurements:**

1. Safety
   a. Road division
   b. Visibility & lighting
   c. Pavement

2. Directness
   a. Linearity
   b. Continuity
   c. Right of way to bicyclists
   d. Orientation
   e. Fluency
   f. Flatness
   g. Legibility
   h. Transfer distance
   i. Bicycle parking capacity

3. Comfort
   a. Human scale
   b. Special bicycle amenities
   c. Bicycle parking types
   d. Bicycle racks
   e. Bicycle parking levels

4. Attractiveness
   a. Maintenance
   b. Liveliness
   c. Experience

**Example:**

Figure 21 An example of Scheltema’s instruments ‘Recycle City’ (2011): assessing quality of bicycle routes to a railway station
Park and co-authors (2015) used a different methodology in their study to micro-level walkability around railway stations. While Brouwer and Scheltema solely focused on previous literature in order to find urban environment factors, Park et al. asked travellers themselves. An (RP) survey among transit users (N=249) was administered in order to find walkability indicators. The survey provided data on socioeconomic status, trip origins, access mode choice and the walking routes. They extracted 38 walkability indicators that are grouped by factor analysis in ‘sidewalk amenities’, ‘traffic impacts’, ‘street scale and enclosure’ and ‘landscaping elements’. Their study gives an overview of the indicators that influence walkability together with their relative importance (weights). As shown in table 4, the first two mentioned groups of factors weigh much heavier (respectively 0.84 and 0.82) than street scale & enclosure (0.62) and landscaping elements (0.45). All indicators with a positive sign, positively influence walkability and are captured in the picture below on the left.

Figure 22 A street with the indicators that positively influence walkability on the right, and a street with the indicators that positively influence driving to a station on the left (Park, Choi, & Seung Lee, 2015).

### 4.5 CONCLUSION

This chapter allowed to identify that there is a gap in literature on using weights in instruments that assess bikeability. So far, the studies have mainly focused on which factor influence walkability/bikeability and how these factors can be designed into reliable measurements. The relative importance’s, the weights, have received little attention. It can be said that the consideration of the cyclist’s perspective is lacking since the various parameters are not validated with the cyclist (Noel, 2003). That while the weights are important since they give insight in which attributes matter in the eyes of travellers so decision makers can make efficient choices. The few instruments that did determine the weights (BCI, BLOS & Bike ISI for bikeability and Park’s instrument for walkability) found major differences in importance between the attributes. An instrument such as ‘Recycle City’ can give completely other outcomes if weights are attached to the attributes. The next chapter will look at how these weights can be determined.
**5.1 Introduction**

Many factors that influence bikeability and several instruments that assess bikeability were described in the previous two chapters. The question remains what the relative importance of these factors is. The literature review already pointed out the importance of time in travel resistance. The importance of the effort factors in relation to travel time is therefore an important focus point of the experiment. Also, as chapter 3 concluded, personal characteristics such as age and gender might influence one’s perception of travel resistance and are therefore an essential part of experiment. This chapter will provide an answer to the following questions:

How to design an experiment in order to find answers on:
(a) What are the weights of the effort resistance factors?
(b) Do different individual and social characteristics systematically relate to the value respondents attach to certain factors?
(c) How does the value of the effort factors relate to travel time?

During the development of the experiment, a pilot survey was used to get priors and to get insight in how to design the experiment. The design outcomes of the pilot are described in different sections of this chapter. The chapter will start with the selection of the five attributes out of the list of factors (table 3) section 5.2. The five attributes will form the input of the survey as the figure below illustrates. Sections 5.3, 5.4 and 5.5 sequentially describe the design to answer the questions a,b and c. The outcomes and estimations of the experiment will be presented in chapter 6.
5.2 SELECTION OF ATTRIBUTES

Identifying the number of attributes along with their number of levels is a first step in designing a survey. It is a popular belief in scientific literature that respondents can handle up to 7 attributes. More would confuse the respondents. However, some researchers believe that complexity (high number of attributes) is not an issue, as long as choice situations reflect real world situations (Molin, 2014). Regardless of which of these beliefs is true, a high number of attributes leads to a more complex research and requires more choice sets.

The number of scenarios presented in the experiment depends on the amount of alternatives and their levels. Each attribute can have 2 or more levels. For example, a survey with 4 levels and 8 attributes, gives $4^8 = 65536$ different alternatives. For the sake of simplicity, the amount of attributes and levels should not be too many since it would lead to increased number of different choice situations. An increase in attribute levels has proven to increase the error variance (Caussade, de Dios Ortazar, Rizzi, & Hensher, 2005). Furthermore, applying the same amount of levels on all attributes could lead to the desirable number of choice situations (Beelaerts van Blockland, 2008). Taking these findings into account together with some opinions of experts in stated choice (Eric Molin, Anco Hoen) it was decided to use 5 attributes with each 2 levels for the experiment.

As explained in section 2.3, the selection of the attributes is done with interviews in combination with a categorization based on the ‘five traveller needs’. The conduction of these methods is described below.

5.2.1 THE CATEGORIZATION

The literature review resulted in a list (table 3) of many different factors that somehow (might) influence bicycling behaviour in access to the railway station. Many factors show overlap and or correlations. In order to structure the factors, categories are made. As already explained in the literature review, five categories are distinguished by Van Hagen (2011): safety, speed, ease, comfort and experience. His categories are used to structure the factors.

As stated in chapter 2, this categorization is made because scientific literature on bicycle resistance factors in access is rather scarce and incomplete concerning effort aspects and therefore simply selecting the five most commonly mentioned factors would probably not be sufficient to cover the range of bikeability factors. The categorization makes it possible to make a selection of attributes that represent all categories. It prevents the possibility that for example only ease and comfort will be represented in the survey. Figure 24 present the categorization of the factors.

Figure 24 The factors from table 3 are structured according to the five categories of Van Hagen.
5.2.2 INTERVIEWS
Since the factors related to ‘speed’ are expected to give unbalanced alternatives, these are excluded in the choice experiment and thus attribute selection procedure (section 5.5 describes the part of the experiment that does incorporate ‘speed’). The other factors were randomly placed on a card as the figure below illustrates. A small of these cards were spread among employees of PBL. The accompanied question here was ‘Imagine you are cycling towards the train station to take the train. Which factors, besides travel time, would influence your travel resistance most?’. Three experts and ten employees filled in the paper by encircling five factors. The factors and their ratings can be found in table 5.

Figure 25 The attributes randomly placed on a card

The outcomes of the first question are shown in the table below. Two of the factors have not received points at all: adjacent car parking and human scale.

Table 5 The factors and their ratings

<table>
<thead>
<tr>
<th>Factor</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bicycle parking</td>
<td>13</td>
</tr>
<tr>
<td>Right of way</td>
<td>10</td>
</tr>
<tr>
<td>Bicycle volume</td>
<td>8</td>
</tr>
<tr>
<td>Social safety</td>
<td>8</td>
</tr>
<tr>
<td>Street lighting</td>
<td>6</td>
</tr>
<tr>
<td>Vegetation</td>
<td>4</td>
</tr>
<tr>
<td>Separate bike path</td>
<td>4</td>
</tr>
<tr>
<td>Quality pavement</td>
<td>3</td>
</tr>
<tr>
<td>Traffic intensity motorized vehicles</td>
<td>3</td>
</tr>
<tr>
<td>Presence obstacles</td>
<td>3</td>
</tr>
<tr>
<td>Building characteristics</td>
<td>2</td>
</tr>
<tr>
<td>Network layout</td>
<td>1</td>
</tr>
<tr>
<td>Adjacent car parking</td>
<td>0</td>
</tr>
<tr>
<td>Human scale</td>
<td>0</td>
</tr>
</tbody>
</table>

5.2.3 FINAL ATTRIBUTES & THEIR LEVELS
Taking into account the outcomes of the interviews together with the categorization of figure 24, the following five attributes have been selected: bicycle parking, social safety, bicycle lane volume, right of way and vegetation. However vegetation was not in the top five of the panel, this attribute is chosen in order to represent the category of ‘experience’. The five chosen attributes represent now the four categories of safety, ease, comfort and experience. The category of speed will not be represented by an attribute but by the second part of the survey. Including speed (as travel time) in the choice sets might lead to unbalanced alternatives, since it is expected that respondents will choose for the alternative with the shortest travel time and the relative importance between the urban characteristics becomes less clear. Moreover, by including travel time in the choice sets as an attribute, the author is limited to 2 or 3
levels, while an adaptive survey approach gives more accurate information on the switching point. The analysis on travel time will be further explained in section 5.4.

### Table 6 Final Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social safety</td>
<td>Many people watching or walking on the street (1) or few (0)</td>
</tr>
<tr>
<td>Bicycle parking</td>
<td>Close (50 meters) to the platform (1) or far (200m) (0)</td>
</tr>
<tr>
<td>Right of way</td>
<td>Many traffic lights on red (1) or no traffic lights (0)</td>
</tr>
<tr>
<td>Vegetation</td>
<td>Trees (1) or No Trees (0)</td>
</tr>
<tr>
<td>Bicycle lane volume</td>
<td>Crowded with other bicyclists (1) or empty cycle path (0)</td>
</tr>
</tbody>
</table>

### 5.3 Determination of the Weights

Now the five attributes are identified, this section will describe how their relative importance are examined. As explained in section 2.4, the weights will be determined with the use of a stated choice experiment. Also, in order to check the outcomes of the choice experiment, a rating test is included in the experiment. First, the design of the choice experiment will be explained. The design of the rating test can be found in section 5.3.2.

#### 5.3.1 The Choice Experiment

In choice experiments, respondents are asked to choose between 2 or more alternatives with attributes varying in their levels. The choice experiment in this thesis contains choice sets with 2 (unlabelled) alternatives. No base alternative is included because the author is not interested in how the respondents appreciate the bicycle compared to other modes. The respondents had to choose between the two alternatives during 12 choice sets. In the Pilot survey 16 choice sets were handled, but the respondents perceived that as too long and therefore the number of choice sets was reduced to 12. Below, the design of the visual alternatives is described followed by an explanation of the choice set design.

**Design of the visual alternatives**

Images can be presented in various ways. In previous studies one can find surveys using photos of sites or images of (3-D) simulated sites. Photos obviously can represent sites in a realistic way, while 3D images will feel fictitious for the respondent. However, it is very hard to find suitable sites for taking the photographs since the different sites have to be equal in everything except for the chosen attributes. Since this is very hard and time consuming to find, another option is to manipulate photos with Photoshop in order to be able to vary in the attributes as the second example in figure 26 did. Still the two sites in this example vary in way more factors, than just the five attributes tested (vegetation, crowdedness, land use, interaction with motorized traffic, and build type). Therefore is chosen to use images of fictive sites of the experiment in this thesis.

The street in the images of this thesis survey was designed according to the dimensions of the ‘residential street’ in the book ‘Straten maken’(in English: ‘making streets’) (Veenenbos & Bosch, 2011). With the use of the software of Sketchup, two 3D models were designed: one with and one without ‘social safety’. The people and trees were added to the images with the use of Photoshop. The street profile is 15 meters, the road is 5 meters wide, the buildings are 7.8 meters high and the trees are 8 meters high. The purpose was to represent a standard Dutch street. In the variant with social safety, ordinary Dutch row houses are used. For the ‘non safe’ variant, buildings with only few doors and windows were used. These buildings are based on the backsides of buildings, like in the bottom right picture of figure 26. Details of the buildings are left out in order to avoid that respondents would focus on one particular part of the image. In figure 27, the design of the images is shown.
‘Right of way’ is translated into amount of stops for traffic lights and barriers in order to keep it operable in the visual survey. Vegetation is visualized by the presence of trees. Social safety is visualized according to Jacobs (1961) four principles of a safe street: mix of primary functions, small building blocks, mixture of old and new buildings and concentration of people on the street. In the remaining of this thesis ‘social safety’ is described as ‘many/few people watching or walking on the street’ in order to keep it simple and understandable for the respondents. The attribute of bicycle parking is not visualized, but added to the pictures in text: ‘bicycle parking 200 meters from platform’ or ‘bicycle parking 50 meters from platform’. Bicycle lane volume is expressed in ‘many other bicyclists’ or ‘no other bicyclists’.

The two examples of figure 26 have used different viewpoints. The angle used in the survey of Martinez and Barros (2013) looks like a bird’s-eye view. However, a person’s eye level view seems more realistic and thus appropriate in choice experiments. The instrument BCI (FHWA, 1998) examined cyclists perceptions in choice experiments with short video’s. Criticism on this method is that the films were made with a camera that was placed along the roads and not on the position of the bicycle. The same criticism counts for the viewpoint taken by Batafakis (2014), since he took pictures from the middle of the road instead of from the sidewalks where the pedestrians actually walk. The alternatives in this thesis are therefore made from the viewpoint of a bicyclists who is cycling on the bicycle path.
The design of the choice sets
As explained in section 2.4, the choice experiment has an efficient design. In order to retrieve the priors that are needed for an efficient design, a pilot experiment was executed. Another aim of the pilot was to check the quality of the survey by asking feedback on the respondents of the pilot survey. Some defects could be solved and ambiguities could be cleared.

The choice sets were designed with the use of the software program Ngene. This program is developed for stated choice experiments and is able to specify designs with any number of choice situations, alternatives, attributes and attribute levels. The syntaxes used for the orthogonal design of the pilot and the efficient design of the final survey can be found in appendix [A1] and [B1].

The Pilot choice experiment (orthogonal design)
The pilot survey was filled in by 16 respondents. The statistics of the respondents can be found in table 7. The respondents in the Pilot were asked to underpin their choices in Part I with some keywords. The aim of this question was to check whether the attributes were visualized in a clear way. Especially the attribute ‘social safety’ is rather subjective and therefore difficult to visualize. It seems that the images used in this survey visualized social safety clear enough since respondents gave positive comments on the pictures with social safety at level 1: ‘feels safer with people’, ‘more fun’ and ‘cozy’. They also gave some negative comments if social safety was at level 0: “looks terrible”, ‘I don’t feel safe without people’. The other four attributes were also regularly mentioned in the comments. Keywords related to Distance to the platform and right of way were the most frequent ones as the table shows. Also keywords related to Cozy and Trees/Green were given quite often. The overview of the comments can be found in appendix [A3].

<table>
<thead>
<tr>
<th>Table 7 PILOT STUDY - Statistics respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td>Income</td>
</tr>
<tr>
<td>Occupation</td>
</tr>
<tr>
<td>Train use</td>
</tr>
<tr>
<td>Purpose train trips</td>
</tr>
<tr>
<td>Use bicycle in access</td>
</tr>
</tbody>
</table>

* Low: basisschool, VMBO, MAVO / middle: HAVO, VWO, MBO / high: hbo, university
** in thousands of euros per year (gross)
*** sometimes: 1-4 times a month / regularly: 1-3 times a week / often: more than 3 times a week

The answers of the respondents to part I of the pilot were analysed using a simple MNL model. The model specification file of de MNL model can be found in the appendix B3. Table 8 present the outcomes.

The column ‘value’ presents the weights of the attributes. These numbers should be interpreted in relation to each other, the exact value of the numbers does not give much information. The signs of the values confirm the expectation that the presence of traffic lights and the presence of other bicyclists on the bicycle lane have a negative influence on the choice for a route. Bicycle parking and social safety have both the highest positive impact. An example of how these values can be interpreted can be found in equation 5-1 and table 9. In that example, the probability a person will take route A is 88,9%, leaving a chance of 11.1% that the person will take route B.
The values retrieved from the pilot were used as priors for the efficient design of the final choice experiment. The best design Ngene gave in 500 iterations can be seen in appendix B2. The D-error is 0.63. This design does not contain a foldover-design as the pilot did. Taking the main disadvantage and advantage of a foldover into account (twice the amount of choice sets, but accurate in interaction effects) compared to the advantages of an efficient design (more accurate parameters on main effects, minimal amount of choice sets) was decided to use an efficient design for the final survey since the main critique on the pilot’s choice experiment was that it was too long.
5.3.2 The Rating Test
The above described choice experiment has some components (the visualizations or the ‘soft’ factors such as social safety) that might contain more uncertainties than simple regular choice experiments without these components. In order to check the reliability of the outcomes of the choice experiment, an extra rating experiment was added to the experiment.

This rating test was optional for the respondents and put at the end of the survey. First, the respondents were showed visualizations (see example in figure 28) of the five attributes and their levels. Thereafter, the respondents were asked to rate the 5 attributes on a 5-point Likert scale (with 1: unimportant and 5: important).

5.4 Measuring the Influence of Personal Characteristics
The literature review already showed that socio-demographic characteristics such as gender can influence bicycle behaviour. The 7 socio-demographic questions in the survey consider age, gender, current occupation, income, household, level of education and area of living. The area of living is included because the author expected to get response of people from varying living areas in the Netherlands (from rural to high urban areas) and type of living area might be of influence on how people rate the different attributes. A more extensive research into the personal characteristics is not desired since it will lengthen the questionnaire. Besides the questions about the socio-demographic characteristics, also a few (1-5) questions about bicycle use were asked. How often people cycle to the station, with what travel purpose, the time of the day (peak or off-peak) and how often they alternate their cycle route.

The aim of the inclusion of the personal characteristics is twofold. Firstly, socio-demographics have to be known in order to check how representative the sample of respondents is compared to the total population. Secondly, the inclusion of this part makes it possible to research whether the value respondents attach to certain factors is systematically related to different individual and social characteristics. Thus, the questions in this last part consider both standard survey questions (e.g. age, gender) as questions related to individual characteristics that might influence bicycling resistance.

The survey ends with these questions about socio-demographic characteristics and the respondent’s cycling behaviour. It is more common in surveys to start with these type of questions, but a disadvantage of that order is that respondents might quit with the survey due to the personal character of the questions. It is expected that by putting the personal questions at the end of the survey, respondents have lesser resistance to fill in these answers since they have already completed the major part of the questionnaire. Most of the questions about the socio-demographics provided the respondents categories to choose from. It is assumed that respondents experience less resistance to choose the category of for example their age instead of giving their exact age in numbers. The categories used in this part are based on the
categories used by the CBS (Statistics Netherlands). This standardization of categories makes it possible to easily compare the outcomes of this survey with (Dutch) averages.

The pilot study was used to check whether the questions were clear for the respondents. Only a few small changes in the wording of the questions were made for the final questionnaire.

5.5 Effort factors measured in relation to travel time

While the two parts described in the previous two sections provide outcomes on the weights of the 5 attributes, a third part of the experiment investigates the relation with travel time. This part is included because the literature review and expert interviews emphasized the importance of travel time in travel resistance. Thus, the aim of this part was to retrieve data that can be used to analyse the relation between travel time and the 5 effort related attributes.

The design of this part of the experiment is based on an experiment conducted by Tilahun, Levinson and Krizek (2007). They investigated the importance’s of different environmental attributes with the use of an adaptive stated preference survey. In each choice set, the respondents were presented two options: an attractive environment with a certain travel time and a less attractive environment with lower travel time. The environments tested in the survey were off-road facilities, in-traffic facilities with bike-lane and no side street parking, in-traffic facilities with a bike-lane and side street parking, in-traffic facilities with no bike-lane and no side street parking and in-traffic facilities with no bike-lane but with parking on the side. The researchers found out that the respondents were willing to travel up to 20 minutes more for the most attractive environment (off-road bicycle trail) in comparison to the least attractive environment (unmarked on-road facility with side parking). These extra minutes can be seen as the price respondents are willing to pay for the extra comfort provided by the attributes.

Similar to the experiment of Tilahun et al., respondents in the experiment of this thesis had to choose between the most attractive with higher travel time and the least attractive environment with lower travel time. The signs of values found in the pilot survey indicated which attributes are considered positive and which negative. The ‘attractive environment’ consists of the attributes: vegetation (level: trees present), bicycle lane volume (level: quiet), right of way (level: no traffic lights), bicycle parking (level: short walking distance) and social safety (level: many people walking watching on the street). The ‘least attractive environment’ includes the opposites of these levels. Figure 29 presents how these two environments were presented in the (final) survey.

![Route A](image1.png)  ![Route B](image2.png)

**Figure 29** Example of a choice set in part II. The computer survey showed the images in a larger size.

The pair of images was given to the respondent for 3 iterations. The first question is the one above, with travel times of 5 and 9 minutes. The travel times in the second and third question depend on the previous answer given by the respondent. Figure 30 clarifies this adapting approach. Thus, if the respondents answered 1=b, then the second question contained travel times of 5 and 11 minutes. The aim of this
The travel times used in the iterations are based on the finding that access distances greater than 3.6 kilometres are a deterrent for accessing the railway station by bicycle (La Paix Puello & Geurs, 2015). Also Keijer and Rietveld (2000) found that the bicycle is most attractive access mode for distances between 1.5 and 3.5 kilometres. With an average bicycle speed of 18 kilometers/hour, 3.6 kilometres takes 12 minutes and 1.5 kilometres takes 5 minutes. The average distance between home and railway station for cyclists is 2.5 kilometres (about 8 minutes). Based on these numbers, the travel times used in the iterations vary between 5 and 12 minutes. Figure 30 presents the iterations.

Initially, it was expected that a large part of the respondents would be willing to cycle only a few minutes extra for the pleasant environment. However, the outcomes of the pilot showed different results (see table 10). 4 of the 16 respondents even choose the 12 minutes alternative over the 5 minutes alternative. That means that they are willing to cycle 7 minutes extra for the pleasant environment. Some of the underpinnings respondents gave for their choice for choice B (the pleasant environment with longer travel time) are: ‘The travel time of this route is more reliable because there are no obstacles like traffic lights or other bicyclists’, ‘The platform is closer, than I take the two minutes extra travel time for granted’ ‘This route is calm, pleasant, safe and the platform is close by’.

Due to the wide spread of switching points found in the pilot and the convincing underpinnings respondents gave, it was assumed the design of this part in the pilot was sufficient and no changes for the design of the final survey were made.

Table 10 PILOT – the answers on Part II of the questionnaire (Travel Time)

<table>
<thead>
<tr>
<th>Switching point</th>
<th>-</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td># respondents</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>
5.6 Conclusion

The aim of this chapter was to design an experiment that can give answers on the following three questions: (1) What are the weights of the attributes? (2) Do different individual and social characteristics systematically relate to the value respondents attach to certain attributes? (3) How do these attributes relate to travel time?

The first step in designing an experiment is to select the attributes and their levels. The outcomes of the interviews in combination with the categorization based on the traveller’s needs led to the following five attributes: Right of way, bicycle parking, social safety, vegetation, bicycle lane volume.

In Table 11 the structure of the survey is presented. The first part of the survey consists of a choice experiment with 12 questions in order to find the relative weights of the five urban environmental attributes. The pilot study has shown that 16 choice sets would be too long. The pilot also provided priors that were used to make the choice sets in part I according to an efficient design. After part I, three questions regarding travel time are included with an adaptive choice experiment in order to find the switching point between the most attractive and most unattractive environment. The third part of the questionnaire contains personal questions regarding socio-demographics and bicycle habits. The experiment ends with an optional part containing a rating experiment. This part is included as an extra check on the outcomes of part I. The complete survey can be found in appendix [D]. The next chapter presents the results of the survey.

Table 11 The structure of the experiment (survey)

<table>
<thead>
<tr>
<th>Part</th>
<th>#Questions</th>
<th>Aim</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>I: Choice sets</td>
<td>12</td>
<td>Find the relative weights (question 1)</td>
<td>Choice experiment</td>
</tr>
<tr>
<td>II: Travel Time</td>
<td>3</td>
<td>Find importance effort factors in relation to time (question 2)</td>
<td>Choice experiment with adapting travel times</td>
</tr>
<tr>
<td>III: Personal</td>
<td>8-12</td>
<td>Influence personal characteristics on weights (question 3) and check whether sample is representative</td>
<td>Questionnaire (with categories)</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV: Extra</td>
<td>5</td>
<td>Check part I</td>
<td>Rating experiment on Likert scale</td>
</tr>
</tbody>
</table>
6.1 Introduction

This chapter describes the outcomes and analysis of the data retrieved with the survey. The aim of this chapter is to answer three questions: (1) What are the weights of the attributes? (2) Do different individual and social characteristics systematically relate to the value respondents attach to certain attributes? (3) How do these attributes relate to travel time?

The chapter is divided in three sections (6.2, 6.3 and 6.4) that will sequentially answer these three questions. But first, the statistics of the respondents will be described in section 6.1. The chapter ends with a concise summary of the findings (section 6.5).

6.2 Statistics of the Respondents

The final survey was designed in Google Form and distributed via email to the employees of PBL and family and friends of the author. The survey was also spread via social media networks such as LinkedIn and Facebook. In addition, the Dutch Cyclists’ Union (in Dutch: Fietsersbond) helped with spreading the survey by sending the survey to their members. In total 173 responses were gathered. Questionnaires that were uncompleted or showed a pattern of random answers were filtered out which lead to 162 usable responses. The figures on the following two pages show the personal characteristics (socio-demographics and habits) of the respondents which was retrieved from the third part of the survey.

6.2.1 Socio-Demographics

Figure 32 illustrates the socio-demographics of the respondents in the orange bars while the dotted grey bars illustrate the Dutch average. Especially the education of the respondents deviates from the average Dutch: a clear bias towards highly educated people. This can be explained by the fact that a large share of the respondents is employed at PBL, a research institute with mainly highly educated employees. This is probably also the reason for the lack of older (65+) people and young (<15 years) people. Besides, older people are less active on social media and often not that familiar with the computer, thus an execution of a survey via the internet is not very suitable to reach all age groups.
6.2.2 HABITS

The habits of the respondents are illustrated in figure 31. 8 respondents (5%) stated they never use the train. About two-third of the respondents stated they use the train once a week or more. Of the respondents who at least make use of the train rarely (N=154), 65% mainly use the train for work/school, 22% uses it mostly for recreation. 58% of these train users, uses the bicycle (almost) always as access mode. This number is rather high considering that the report of KiM 2014 showed that about 50% of all train trips has bicycle as access mode (see figure 2).

Of the 108 respondents who use the bicycle in access at least most of the time, 61% travels mostly in the peak and 20% off-peak. Of these respondents, only 2% varies its bicycle route towards the station often. Most of the respondents never (39%) of rarely (58%) varies its route.

Figure 31 The figures of the respondent’s habits
Figure 32 The respondents’ socio-demographic characteristics. The dotted lines indicate the Dutch average based on CBS.
In order to investigate the relationship between the different personal characteristics, a Pearson correlation matrix was calculated with the use of SPSS statistics 22 software. As shown in the outcomes in the matrix below, no unexpected significant correlations are found. The variables ‘age and occupation’ (0.674), ‘age and income’ (0.706), ‘occupation and income’ (0.603) show most correlation and are indicated with the purple colour. Also ‘train and purpose’ (0.508) shows a relative high correlation. Because of these correlations, ‘occupation’ and ‘income’ will not be incorporated in the analysis of the personal characteristics in section 6.4.

### Table 12: The Pearson correlation matrix of the personal characteristics

<table>
<thead>
<tr>
<th>gender</th>
<th>age</th>
<th>education</th>
<th>area of living</th>
<th>income</th>
<th>household</th>
<th>occupation</th>
<th>train</th>
<th>purpose</th>
<th>bicycle</th>
<th>peak</th>
<th>variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>1</td>
<td>-1.98**</td>
<td>-0.82</td>
<td>-0.32</td>
<td>-0.41</td>
<td>-0.82**</td>
<td>-0.82</td>
<td>-0.82</td>
<td>-0.82</td>
<td>-0.82</td>
<td>1.51</td>
</tr>
<tr>
<td>b</td>
<td></td>
<td>0.12</td>
<td>0.89</td>
<td>0.04</td>
<td>0.74</td>
<td>0.83</td>
<td>0.46</td>
<td>0.27</td>
<td>0.48</td>
<td>0.70</td>
<td>0.03</td>
</tr>
<tr>
<td>c</td>
<td></td>
<td>0.82</td>
<td>0.81</td>
<td>0.12</td>
<td>0.97</td>
<td>0.57</td>
<td>0.68</td>
<td>0.29</td>
<td>0.78</td>
<td>0.70</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>age</th>
<th>education</th>
<th>area of living</th>
<th>income</th>
<th>household</th>
<th>occupation</th>
<th>train</th>
<th>purpose</th>
<th>bicycle</th>
<th>peak</th>
<th>variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>-1.98**</td>
<td>-0.82</td>
<td>-0.32</td>
<td>-0.41</td>
<td>-0.82**</td>
<td>-0.82</td>
<td>-0.82</td>
<td>-0.82</td>
<td>-0.82</td>
<td>1.51</td>
</tr>
<tr>
<td>b</td>
<td>0.12</td>
<td>0.89</td>
<td>0.04</td>
<td>0.74</td>
<td>0.83</td>
<td>0.46</td>
<td>0.27</td>
<td>0.48</td>
<td>0.70</td>
<td>0.03</td>
</tr>
<tr>
<td>c</td>
<td>0.82</td>
<td>0.81</td>
<td>0.12</td>
<td>0.97</td>
<td>0.57</td>
<td>0.68</td>
<td>0.29</td>
<td>0.78</td>
<td>0.70</td>
<td>0.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>education</th>
<th>area of living</th>
<th>income</th>
<th>household</th>
<th>occupation</th>
<th>train</th>
<th>purpose</th>
<th>bicycle</th>
<th>peak</th>
<th>variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>-0.62</td>
<td>0.13**</td>
<td>0.41**</td>
<td>-0.33**</td>
<td>-0.41</td>
<td>-0.41</td>
<td>-0.41</td>
<td>-0.41</td>
<td>0.03</td>
</tr>
<tr>
<td>b</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>c</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>occupation</th>
<th>train</th>
<th>purpose</th>
<th>bicycle</th>
<th>peak</th>
<th>variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>b</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>c</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21**</td>
<td>0.21</td>
<td>0.21</td>
</tr>
</tbody>
</table>

### 6.3 Estimations of the Weights

The weights were estimated using the data retrieved in Part I of the questionnaire (the choice sets). The values were estimated with a Multinomial Logit Model (MNL), which is a standard method in finding Beta’s (weights). For these model estimations, the software of BIOGEME was used. As explained in section 5.3.2, also a rating test was included in the questionnaire in order to check the outcomes of Part I. Section 6.3.2 will describe the outcomes of the rating test. First, the analyses of Part I will be described below.

#### 6.3.1 Multinomial Logit Model

The model specification files can be found in appendix B1. Below, the basic utility function is given. The alternatives are unlabelled and consist of generic parameters. This Utility function forms the basis of the specification files used for the calculations in BIOGEME. The standard specification file can be found in the appendix B3.
$U_i = \beta_1 \times Trees + \beta_2 \times Volume + \beta_3 \times Light + \beta_4 \times Park + \beta_5 \times Safe + \epsilon_i$  \hfill (6-1)

Where:

- $\beta_i$: The Beta’s of the Attributes
- $Trees$: Dummy Variable for existence of vegetation (1) or no vegetation (0)
- $Volume$: Dummy Variable for bicycle volume, heavy (1) or quiet (0)
- $Light$: Dummy Variable for presence of traffic lights (1) or absence (0)
- $Park$: Dummy Variable for bicycle parking close to platform (50m) (1) or far (200m) (0)
- $Safe$: Dummy Variable for amount of people walking and watching on the street: many (1) or few (0)
- $\epsilon$: Random Error Component

The data retrieved in Part I of the questionnaire (the choice sets) were used in order to estimate the Beta’s (weights) of the utility function. The table below presents the results of the MNL model. The estimates in the table (under ‘value’) illustrate the preferences of the respondents for the 5 attributes. A higher value indicates a higher preference compared to a lower one (as equation 5-1 illustrated in the previous chapter).

Table 13 MNL results (final survey)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Name</th>
<th>Value</th>
<th>Std err</th>
<th>t-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right of way</td>
<td>B_LIGHT</td>
<td>-0.968</td>
<td>0.122</td>
<td>-7.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Bicycle parking</td>
<td>B_PARK</td>
<td>0.974</td>
<td>0.0798</td>
<td>12.21</td>
<td>0.00</td>
</tr>
<tr>
<td>Social safety</td>
<td>B_SAFE</td>
<td>0.0435</td>
<td>0.0773</td>
<td>0.56</td>
<td>0.57</td>
</tr>
<tr>
<td>Vegetation</td>
<td>B_TREES</td>
<td>0.465</td>
<td>0.0593</td>
<td>7.84</td>
<td>0.00</td>
</tr>
<tr>
<td>Bicycle lane volume</td>
<td>B_VOLUME</td>
<td>-0.328</td>
<td>0.0593</td>
<td>-5.54</td>
<td>0.00</td>
</tr>
</tbody>
</table>

In contradiction to the pilot survey, not all five attributes were found to be significant. The attribute ‘social safety’ is found to be insignificant. However, the analyses of the next section (incorporation of personal characteristics) will show that for some groups of people (female for example) this attribute does significantly affect route choice.

The most important attribute positively influencing route choice is, as expected, bicycle parking (level: 50 meters to platform). This attribute is calculated with a relative high t-test, which means that the Beta is calculated with high accuracy. Also the presence of vegetation positively influences the choice for a certain route, but in a much lesser degree. The presence of traffic lights of the attribute Right of way influences the route choice the most negative, followed by many bicyclists on the bicycle path of the attribute bicycle lane volume.
6.3.2 RATING TEST

The fourth part of the questionnaire, which was optional, contained 5 rating questions. These questions were added as a check for the outcomes of the choice experiment. Of the 162 respondents, 113 also finished this extra part of the questionnaire. First, visualizations of the five attributes were showed. Thereafter, the respondents were asked to rate the importance of the five factors on a scale 1 (not important at all) to 5 (very important). The survey can be found in the appendix. The tables below show the answers of the 113 respondents.

Table 14 Respondents answers on the five ratings questions

<table>
<thead>
<tr>
<th>Attribute</th>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation</td>
<td>113</td>
<td>18%</td>
<td>21%</td>
<td>21%</td>
<td>25%</td>
<td>15%</td>
<td>100%</td>
</tr>
<tr>
<td>Right of way</td>
<td>113</td>
<td>1%</td>
<td>4%</td>
<td>23%</td>
<td>29%</td>
<td>43%</td>
<td>100%</td>
</tr>
<tr>
<td>Bicycle lane volume</td>
<td>113</td>
<td>7%</td>
<td>24%</td>
<td>35%</td>
<td>23%</td>
<td>12%</td>
<td>100%</td>
</tr>
<tr>
<td>Social Safety</td>
<td>113</td>
<td>42%</td>
<td>31%</td>
<td>11%</td>
<td>14%</td>
<td>2%</td>
<td>100%</td>
</tr>
<tr>
<td>Bicycle Parking</td>
<td>113</td>
<td>4%</td>
<td>7%</td>
<td>16%</td>
<td>32%</td>
<td>41%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 15 The means and standard deviations of the ratings

<table>
<thead>
<tr>
<th>Mean</th>
<th>Vegetation</th>
<th>Right of way</th>
<th>Bicycle lane volume</th>
<th>Social safety</th>
<th>Bicycle Parking</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.98</td>
<td>4.11</td>
<td>3.08</td>
<td>2.02</td>
<td>3.97</td>
<td></td>
</tr>
<tr>
<td>1.34</td>
<td>0.94</td>
<td>1.10</td>
<td>1.13</td>
<td>1.12</td>
<td></td>
</tr>
</tbody>
</table>

The rating test does not show unexpected outcomes. Similar to the MNL model, bicycle parking (3.97) and right of way (4.11) are seen as the attributes with the highest values. The third most important attribute is bicycle lane volume (3.08), followed by vegetation (2.98). Social safety is indicated as relatively unimportant with a mean of 2.02. The fact that the outcomes of the rating test correspond with the outcomes of the choice experiment, strengthens the credibility of the found values.

6.4 INFLUENCE OF PERSONAL CHARACTERISTICS

As explained earlier, personal characteristics such as gender might play a role in travel resistance and route choice. In this section is aimed to reveal the underlying sources of heterogeneity in the route preferences. Both the demographic characteristics and the habits of the respondents were included in the MNL as interactions variables. An example of the Utility Function with incorporation of a personal characteristic (gender) is presented below.

\[ U_i = \beta_{volume} \times Volume + \beta_{light} \times Light + \beta_{park} \times Park + \beta_{safe} \times Safe + \beta_{trees\_male} \times Trees \times Male + \beta_{trees\_female} \times Trees \times Female + \epsilon_i \]  \hspace{1cm} (6-2)

Where:
- \( \beta \): The Parameters (Beta’s) of the Attributes
- Trees: Dummy Variable for existence of vegetation (1) or no vegetation (0)
- Volume: Dummy Variable for bicycle volume, heavy (1) or quiet (0)
- Light: Dummy Variable for presence of traffic lights (1) or absence (0)
- Park: Dummy Variable for bicycle parking close to platform (50m) (1) or far (200m) (0)
- Safe: Dummy Variable for amount of people walking and watching on the street: many (1) or few (0)
- Female: Dummy Variable for female (1) or no female (0)
- Male: Dummy Variable for male (0) or no male (0)
- \( \epsilon \): Random Error Component
The categories used in demographic characteristics are based on categories CBS uses. However, since the sample of this thesis is limited in its size, some categories had to be combined. For example in the age category, the sample of people ‘older than 65 year’ was so small that is was combined with the ‘44-64 year’ group.

An overview of the results is presented in table 16. The results without an a or b were found to be significant. The complete list including the standard error term, t-test and p-value of the interactions can be found in appendix [C].

One can see that the respondents from rural areas (defined as less than 1500 addresses per km2) have a higher preference for routes with the presence of trees than people from urban areas (0.694 versus 0.351). Also, they have a larger dislike for streets with crowded bicycle paths but tend to give less value to the distance between platform and parking place. The highly-educated people choose less often for streets with traffic lights but are less influenced by a crowded bicycle path than lower educated people.

Looking at the different age categories, it can be noticed that the dislike for the presence of traffic lights increases with the age. On the other hand, the preference for a small distance between parking place and platform is decreasing with increase of age. Gender also plays a role in route choice. Male respondents on average attach more value to the absence of traffic lights but care less about the other four attributes. Female respondents slightly prefer the streets with many people watching or walking on the street (attribute ‘safe’). However for male respondents, no significant value was found considering the attribute ‘safe’.

Habits also seem to play a role in route choice. More frequent users of the train (1 or more times a week) have lower weights for the presence of trees. People who mostly use the train for recreation, attach more value to the presence of trees, choose less often for streets with crowded bicycle paths and attach less value to a small distance between parking and platform.

The respondents in the questionnaire were asked to imagine to be cycling towards the railway station in order to catch the train to school or work. Still, people who usually have recreation as travel purpose, attach more value to attractiveness factors like ‘trees’ compared to typical commuters. The differences between the purposes ‘recreation’ and ‘work/school’ emphasize the idea that commuters attach more value to fast and fluent trips compared to people with a recreational purpose.

Comparison of the respondents who never/not often use the bicycle in their access trips to respondents who do this always/often show little variations in the weights. The latter group care slightly more about the presence of trees and the absence of traffic lights and are less bothered by a crowded bicycle path.

The last habit researched in relation to route choice is the time of the day the respondents usually cycle to the station. The respondents that cycle mainly on peak, care more about a nearby parking spot, attach less value to trees and are more bothered by traffic lights.

While the main effect of ‘social safety’ was found to be insignificant, some of the interaction variables turned out to be significant. Most of them (low level of education, young age, train use never/rarely) show positive numbers of social safety. Thus, ‘many people walking or watching on the street’ is valued positive by these groups. Striking is that two other variables (bicycle in access often/always, time of day on peak) show negative signs. Perhaps these kind of people are so focused on cycling to the station fast and fluently that they consider people on the street as obstacles or some other kind of travel resistance.
Table 16 Beta's of the interaction variables

<table>
<thead>
<tr>
<th>Attribute: Main effect</th>
<th>LIGHT</th>
<th>PARK</th>
<th>TREES</th>
<th>VOLUME</th>
<th>SAFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of living ‘urban’ (&gt;1500 addresses/km²)</td>
<td>-0.981&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.351&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.223&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0306&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Area of living ‘rural’ (&lt;1500 addresses/km²)</td>
<td>-0.942&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.775&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.694&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.538&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0688&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>High level of education (hbo/wo)</td>
<td>-1.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.977&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.392&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.230&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0583&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Medium level of education (havo/vwo/mbo)</td>
<td>-0.893&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.698&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.760&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.139&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Low level of education*(basischool/vmbo/mavo)</td>
<td>-0.201&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.882&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.669&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.432&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.19&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age young (&lt;24 year)</td>
<td>-0.682&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.449&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.365&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.334&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age middle (25-44 year)</td>
<td>-0.987&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.465&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.356&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0726&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Age older (&gt;44 year)</td>
<td>-1.14&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.772&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.474&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.273&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00614&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Female</td>
<td>-0.805&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.507&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.333&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.246&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Male</td>
<td>-1.12&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.902&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.428&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.324&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.135&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Train use never/rarely</td>
<td>-0.971&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.684&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.542&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.476&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.264&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Train use 1-4 times a month</td>
<td>-0.757&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.665&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.617&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.133&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Train use 1-3 times a week</td>
<td>-1.21&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.823&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.399&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.140&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0360&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Train use &gt;3 times a week</td>
<td>-0.892&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.22&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.390&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.271&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0450&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Travel purpose both* (equally recreation/work)</td>
<td>-0.598&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.702&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.283&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.194&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Travel purpose recreation</td>
<td>-1.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.624&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.625&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.581&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0799&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Travel purpose work/school</td>
<td>-1.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.967&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.332&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.177&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.143&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bicycle in access never/not often</td>
<td>-0.840&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.940&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.384&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.389&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.139&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Bicycle in access often/always</td>
<td>-1.10&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.912&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.463&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.230&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.184&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time of day both (equally off and on peak)</td>
<td>-0.438&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.488&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.864&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.411&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0707&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time of day off peak*</td>
<td>-0.542&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.560&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.693&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.328&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0411&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Time of day on peak</td>
<td>-0.792&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.714&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.203&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.0709&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.334&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* statistically significant at 1%
*<sup>a</sup> statistically significant at 5%
*<sup>b</sup> small sample (<20 respondents)

## 6.5 Effort Factors in Relation to Travel Time

The second part of the survey is dedicated to the relation of the five attributes to travel time. The respondents were presented the most attractive environment and the worst environment (according to the signs of the pilot survey outcomes) with varying travel times. This part contained three choice sets with adapting travel time. The exact iterations were earlier illustrated in figure 31. The figure below presents the first question with Route A ‘5 minutes’ and Route B ‘9 minutes’. Route A presents the ‘worst environment’ with no right of way, parking place 200 meters to platform, not many people watching or walking on the street, many other bicyclists on the bike path and no trees. Route B has the opposite levels of the five attributes and is seen as the most attractive environment in this experiment.
The table below presents how many people ended at each switching point. To illustrate, 15 respondents answered 1=B;2=B;3=A and ended at switching point ‘11’ which indicates that they are willing to cycle 6 minutes extra for the attractive environment. These additional minutes can be seen as the price respondents are willing to pay for the extra utility provided by the attributes. The mean is 3.5 minutes with a standard deviation of 2.09. This large standard deviation indicates a wide variety in the outcomes and a distribution over all 8 possible outcomes as illustrated in figure 34.

Table 17 FINAL – the answers on Part II of the questionnaire (Travel Time)

<table>
<thead>
<tr>
<th>Switching point</th>
<th>-</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>total</th>
</tr>
</thead>
<tbody>
<tr>
<td># respondents</td>
<td>12</td>
<td>20</td>
<td>23</td>
<td>34</td>
<td>17</td>
<td>23</td>
<td>15</td>
<td>18</td>
<td>162</td>
</tr>
</tbody>
</table>

Figure 34 also illustrates female respondents have a higher mean (3.96 minutes) than male respondents (3.09 minutes) which indicates that women attach more value to the 5 effort attributes in relation to time than men. Considering level of education, highly educated (N=121) have an average additional time of 3.38 minutes, medium educated people of 2.96 (N=25) and low educated people (N=16) of 5 minutes. People who mostly cycle on peak (N=65) have an average additional time of 3.2 minutes and off peak people (N=22) 3.6 minutes. People living in dense areas (>1500 addresses/km2) (N=107) have an average of 3.38 minutes and people from rural areas (N=55) of 3.75 minutes.
6.6 Conclusion

The data retrieved from the experiment turned out to be useful for answering the three stated questions: (1) What are the weights of the attributes? (2) Do different individual and social characteristics systematically relate to the value respondents attach to certain attributes? (3) How do these attributes relate to travel time?

The MNL showed the two attributes out of the five which are most influential on people’s route choice: ‘bicycle parking’ and ‘right of way’. The presence of traffic lights influences people’s choice most negatively (-0.968) and nearby bicycle parking most positively (0.974). The presence of trees also increases the chance a person will take that route, but has a smaller impact (0.465) than right of way of bicycle parking. A crowded bicycle path decreases the chance a person will take that route (-0.328) but has less impact than the first three attributes. Social safety was found to have a value of 0.0435 but is insignificant. In other words, the value found cannot be confirmed with statistical certainty since randomness might play a role.

The MNL models with the inclusion of the personal characteristics showed bicycle route choice in access is clearly influenced by socio-demographics and habits. Since the sample is not representative for the Dutch population, one must be careful to draw conclusions based on these findings. Nevertheless, the retrieved values seem plausible and are a reason for further research.

The travel time analysis of the experiment showed the majority of the respondents indicated they would cycle more minutes for a route that contains the attributes that are perceived positive (no traffic lights, no crowded bicycle path, many people watching or walking on the street, close bicycle parking, trees present). Women have an average additional travel time of 3.96 minutes and men of 3.09 minutes. These additional travel can be seen as the price people are willing to pay for the extra utility provided by the attributes. However with these outcomes should be noted that the pressure of catching the train in real life might result in totally different choices than respondents gave in this SP situation.
CONCLUSION AND RECOMMENDATIONS

7.1 INTRODUCTION

The focus was in this thesis on the relationship between the urban environment and cycling in access of Dutch railway stations. The importance of the bicycle-train combination and the quality of good access and egress for a high-quality door-to-door journey has been repeatedly emphasized by many authors in the field of mobility and urban development. Still, studies about bicycling in access are quite scarce. Previous studies on cycling behaviour mainly focused on travel time or traffic safety while the impact of effort factors remain unclear. This thesis contributes to scientific literature by performing an online stated preference choice experiment and giving insights in the relative importance of urban environment factors in relation to each other and to travel time. Furthermore, the research conducted analysis on the influence of personal characteristics on the travel resistance in bicycle access which lead to interesting results and induces further research.

In this chapter, the conclusions of the research will be presented in section 7.2. Subsequently, the recommendation for practice and science are discussed in section 7.3.

7.2 CONCLUSIONS

The main question to be answered in this thesis is: ‘Which urban environment factors (with focus on effort) determine the quality of railway stations access by bicycle and how do travellers rate these factors?’

This main question is divided in sub questions that are answered throughout the thesis. These sub questions and their answers will be shortly described before answering the main question.
7.2.1 Answers to the Sub Questions

1) Which components and factors influence travel resistance of bicycling?
Many different factors influence the bikeability of routes towards a railway station. Socio-economic variables, psychological factors, natural environment and urban environment factors all influence how a person perceives the cycling resistance in access. The latter differs from the others in the sense that urban environment can be adjusted by decision-makers in order to improve access. The other types are hard or even impossible to influence by a decision-maker. The urban environment factors can be divided in the categories of: the experience, comfort, ease, speed and safety and reliability (see table 37). Most previous studies on bicycling focused on bicycle safety (especially foreign studies) and travel time. The gap in current literature is not so much which factors influence bikeability in access, but to what extent.

Figure 35 Overview of the factors put in the categories

2) How do existing instruments assess bikeability and what can we learn from them?
Current instruments that attempt to assess bikeability draw their factors from previous instruments or studies. Studies about instruments that assess bikeability or walkability often focus on the application of the instrument and possible ways of operationalizing the factors that are chosen. Extensive studies that used instruments to analyse existing cities or areas have been carried out what led to comparisons and rankings of areas in their level of bikeability or walkability. However, a crucial part seems to be lacking in most of these instruments: the factor’s weights. The consideration of the cyclist’s perception is lacking since the factors are not validated with the user: the cyclist. In other words, it is unclear what the relative importance or weights of the factors are. Applying weights to the factors in the instruments is crucial in order to get more reliable outcomes on which areas are most in need for improvement in bikeability for example. The few instruments that did determine the weights (BCI, BLOS & Bike ISI for bikeability and Park’s instrument for walkability) found major differences in importance between the attributes. This implies that knowledge on weights is important for efficient decision-making about the urban environment around railway stations.

3) How to design an experiment in order to find answers on questions 3a, 3b, 3c?
The fifth chapter of this thesis is dedicated to this sub question. Finding relative importance’s, or weights, of factors can be done with several methods. For example rating, ranking or choice experiments. The latter is preferred since people are poor analysts of their own behaviour (Chorus, 2014). The first step
in this method is to select attributes since respondents are considered unable to handle more than 7 attributes in a choice set. The visual character of the attributes demands a visual approach of the experiment. It is yet unclear whether fictive pictures or real pictures would lead to more reliable results. An advantage of fictive pictures is that the attributes are easy to control. The literature review showed that personal characteristics (socio-demographics and habits) might influence the perception of travel resistance and should therefore be included in the experiment.

3a) What are the weights of the effort resistance factors?
Right of way (-0.968), Bicycle parking (0.974), Social Safety (0.0435), Vegetation (0.465), Bicycle lane volume (-0.328).

3b) Do different individual and social characteristics systematically relate to the value respondents attach to certain factors?
The analysis in section 6.4 confirm the expectation, which was based on the literature review, that personal characteristics influence travel resistance and thus route choice behaviour. The most outstanding finding is that people from rural areas (defined as less than 1500 addresses per km2), attach more value to the presence of trees and have a larger dislike for streets with crowded bicycle paths but tend to give less value to the distance between platform and parking place. Also gender, education and age have proved to be significant for some of the attributes. Habits seem to play a smaller, or at least a less clear, role in route choice than socio-demographic characteristics. From the analyse can be concluded that more frequent users of the bicycle-train combination, the ones who mainly commute with it, and the ones who travel on peak in general attach more value to attributes that influence the ease of access: right of way and distance between platform and bicycle parking. The ‘experience’ attribute of trees is relatively seen valued more by less frequent train users.

3c) How does the value of the effort factors relate to travel time?
The literature review gave the impression that within the components of travel resistance (time, effort & money) travel time is by far most important for travellers. However, the outcomes of the adaptive choice experiment presented slightly different results. On average, respondents are willing to cycle 8.5 minutes for an attractive environment compared to 5 minutes travel time through an unattractive area. Considering the female respondents, this is even almost 9 minutes. Thus, the five effort factors in the attractive alternative (trees, no traffic lights, 50 meters between parking and platform, many people watching or walking on the street and not a crowded bicycle path) are appreciated with on average 3.5 minutes additional travel time. These numbers imply that the used attributes do influence route choice in access.

7.2.2 Answer on the Main Question
Question: Which urban environment factors (with focus on effort) determine the quality of railway stations access by bicycle and how do travellers rate these factors?

The conducted literature review provided an overview of factors (with focus on effort) which might influence travel resistance in cycling to a railway station. According to the literature 5 types of urban environment factors influence a trip trip: the experience, comfort, ease, speed and safety and reliability. The experiment was limited in the amount of attributes but did do research into every type. The experience was represented by the attribute ‘vegetation’ and found to be of significant influence in route choice with an average weight of 0.465. The comfort was represented by ‘bicycle parking’ and was found to have a significant value of 0.974. Ease was represented by both ‘bicycle lane volume’ and ‘right of way’ with significant values of -0.328 and -0.968. Also the rating test confirms that ‘right of way’ and ‘bicycle parking’ are the most important of the five attributes in travel resistance in bicycle access of railway stations. Safety and reliability was represented by ‘social safety’ which found to have an insignificant value of 0.0435. Though, some of the analyses with interaction variables did find significant values for social safety. For example female value this attribute with 0.246. Insignificant values have
to be treated carefully when drawing conclusions, but the combination of the small value of the MNL (0.0435 for general and 0.246 for female) and the outcome of the rating test (2.02) do imply that the attribute of social safety, as put down in the experiment, does not play an important role in the route choice of bicycle access.

The last type of factors *speed* was not represented by a specific attribute, but was examined with the switching point part of the survey. The outcomes of that analysis indicate that the respondents are, on average, willing to cycle 3.5 minutes extra for the extra utility provided by the attributes of the most attractive environment. Thus, the expectation that *time* is far more important than *effort* in travel resistance is not confirmed by the outcomes of this thesis.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Name</th>
<th>Value</th>
<th>Std err</th>
<th>t-test</th>
<th>p-value</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right of way</td>
<td>B_LIGHT</td>
<td>-0.968</td>
<td>0.122</td>
<td>-7.94</td>
<td>0.00</td>
<td>4.11</td>
</tr>
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<td>Bicycle parking</td>
<td>B_PARK</td>
<td>0.974</td>
<td>0.0798</td>
<td>12.21</td>
<td>0.00</td>
<td>3.97</td>
</tr>
<tr>
<td>Social safety</td>
<td>B_SAFE</td>
<td>0.0435</td>
<td>0.0773</td>
<td>0.56</td>
<td>0.57</td>
<td>2.02</td>
</tr>
<tr>
<td>Vegetation</td>
<td>B_TREES</td>
<td>0.465</td>
<td>0.0593</td>
<td>7.84</td>
<td>0.00</td>
<td>2.98</td>
</tr>
<tr>
<td>Bicycle lane volume</td>
<td>B_VOLUME</td>
<td>-0.328</td>
<td>0.0593</td>
<td>-5.54</td>
<td>0.00</td>
<td>3.08</td>
</tr>
</tbody>
</table>

7.3 RECOMMENDATIONS

The research in this thesis has several limitations. That is because the conducted research was limited by time restrictions which required a narrow research scope. Moreover, the outcomes contain several uncertainties due to the explorative character of the experiment and the lack of existing knowledge on the subject. Still, the outcomes of the thesis can be used in practice as the next section will describe. Thereafter in the last section, the limitations of the experiment and recommendations for further research will be described.

7.3.1 RECOMMENDATIONS FOR PRACTICE

As said in the introduction, this thesis analysed bicycle access with the viewpoint of decision-makers in mind. The experiment was set up in such a way that it would give outcomes on factors that can be influenced and improved by decision-makers in order to improve access to railway stations. The outcomes of the experiment can be used in several ways in practice. Despite the small and explorative character of the experiment, the outcomes do clearly indicate that urban environment attributes are of importance in route choice and thus can decrease the disutility of a certain route. This implies that urban environmental measures are potential effective tools for decision-makers to improve the quality of the door-to-door railway journey by bike. It is therefore recommended to decision-makers who aim to improve cycling journeys to railway stations to take effort-factors into account in the design or redevelopment of the cycling routes to and from railway stations and of the areas around railway stations.

The found values show a clear preference for the routes with the attributes ‘bicycle parking’ (0.974) and ‘right of way’ (routes with no right of way have a negative preference of -0.968). Bicycle parking can be improved by reducing the distance from parking to platform. Spreading the bicycle parking spots along the different platform entrances seems therefore more attractive than one large central bicycle parking. Bicycle parking direct below (or above) the platforms with entrances to all platforms seems ideal considering this attribute. Improving the ‘right of way’ can be done by making the route more fluent and by diminishing the amount of required stops. Measures are, for example, implementation of a green wave (adapting the traffic lights in the favour of bicyclists) or creation of priority lanes for bicyclists. The analysis of the personal characteristics in relation to the five attributes is also interesting for practice. These insights provide more detailed information on how to improve areas around railway station than
the general found values do. To illustrate, the analysis revealed that people from rural areas attach more value to the presence of vegetation than people from urban areas. Thus, for station development in rural areas the presence of trees is relatively seen more important than of the stations in urban areas.

Despite the fact that ‘vegetation’, ‘bicycle lane volume’ and ‘social safety’, have received lower weights, they might still be useful measures in improving bikeability. Further research with for example a cost-benefit analysis would give more insight into the efficiency of potential measures. When for example the improvement of bicycle parking is 4 times as expensive as the improvement of the vegetation, it would be more efficient to spend the money and time on vegetation in order to reduce travel resistance (since bicycle parking is only about twice as important as vegetation is).

The values found in this thesis can also be used to improve current instruments that assess bikeability. For example, the pyramid of Scheltema assigns equal weights to the four different layers of the pyramid (attractiveness, comfort, directness & safety). However, the values of this thesis indicate that attractiveness (presented by vegetation) should weigh less in the assessment of bikeability than comfort and directness (presented by bicycle parking, right of way). Assessing bicycle routes with this instrument will lead to other outcomes once weights are assigned to the layers. Improvement of instruments like this will lead to more reliable outcomes on which routes are most in need for improvement and if decision-makers use these improved instruments they can make more efficient choices.

7.3.2 Recommendations for Science
In the previous section already several recommendations for further research were mentioned. In this section, more recommendations for further research are given.

Zoom in on the factors
Previous scientific studies did do research into many different factors that influence bicycle resistance. However, a broad overview on how all of these factors influence bikeability in access is still lacking. Incorporating all these factors in a choice experiment is not desirable since it would lead to too complex choice sets for the respondents. Using factor analysis or a categorization, as this thesis did, are manners to diminish the amount of factors into groups of factors. A next step in research would be to zoom in into these groups.

To illustrate: the group ‘bicycle parking’ was found to be important in travel resistance, but how exactly bicycle parking has to be improved can be further investigated. How bicyclists rate the ‘distance to platform’ in relation to other parking characteristics such as ‘amount of free parking places’ or ‘guarded parking’ has not been investigated in this thesis. It is the author’s expectation that ‘distance to platform’ would be leading in the traveller’s preferences. Yet, follow-up research into the preferences of bicyclists to different types of parking places at stations would give more reliable outcomes and recommendations on how to plan bicycle parking.

The respondents
The survey of this thesis gathered 162 completed questionnaires. A larger group of respondents will lead to a more reliable result and weights. Moreover, the sample of respondents showed a bias towards highly educated people while youngsters (under 15 years) and elderly (older than 65 years) were underrepresented compared to the Dutch average. When the sample is proportionally taken from a random group of people, the outcome will be more reliable. It was decided not to make a proportional selection of respondents due to high time and costs involved. Another approach of selecting a sample would be to only take frequent train users who cycle to the station. A disadvantage of this approach would be that the outcomes will precisely tell what current users find important in the urban environment of access, but that the opinions of potential users are excluded. Because of that, it is recommended to use a sample that represents the Dutch average.
The visualized alternatives

A challenge that remains is the right visualization of the attributes. Not often before visual stated choice experiments were conducted and research on the (dis)advantages of the use of visualisations in choice experiments is scarce. That made the design of the alternatives in this experiment explorative. An advantage of the visualisations that came forward, is that many respondents liked the choice sets and found the pictures very clear. Since surveys are often experienced as boring and unpleasant, the use of pictures could improve this. Another advantage is that some attributes are hard to describe in words (such as ‘crowded bicycle path’) but are easy to visualize. These advantages indicate that visualized alternatives are interesting for choice experiments and are therefore recommended to be further developed.

Also some disadvantages and limitations of the applied method came forward. The attribute of ‘social safety’ was found to be very difficult to clearly visualize with the used method. The visualizations were made with fictive pictures in order to keep control on the attributes, but this might not be the most suitable method for attributes that appeal strongly to individuals feelings and perceptions. It proved to be difficult to capture an unsafe feeling in a fictive picture. Probably these kind of attributes require a different approach with for example pictures or films of real streets. Perhaps even more suitable is to use Revealed Preference data in order to investigate social safety.

Thus, the use of visualizations in choice experiments is expected to have potential but needs further development and research. It is therefore recommended to compare types of choice experiments (fictive visual survey, realistic visual survey, survey with video, survey with text etc.) with each other in order to find out which type of survey fits which kind of attributes best. A first suggestion is to use ‘eye tracking’ in order to see how respondents look at (the aspects of) images and investigate how that differs from real-life situations.

Travel time analysis

Some respondents indicated that they were confused by the adaptive choice experiment (Part II: travel time in the survey). In this part, the respondents were informed that the shown travel time indicated the total time in minutes between home and the parking place. However, a few respondents commented on this question and emphasized that the presence of traffic lights does influence (extend) the travel time. It was the aim of the author to measure the effect of required stops purely in effort terms, not in extra travel time. Clearly, not all respondents understood the question in the same manner and therefore the outcomes of the adaptive choice experiment have to be treated carefully. It is recommended in following experiments to be more clear about what the presented travel time exactly is.

Moreover, the outcomes indicated that people are willing to cycle on average 3.5 minutes extra for the positive attributes. However, it might be that the stress of catching the train in real life will lead to shorter additional travel times than found in this SP experiment. Therefore, it would be interesting to investigate the additional travel time with for example Revealed Data.

Model estimations

The retrieved data was analysed with a Multinomial Logit Model due to its user friendliness. Most more advanced models such as Mixed Multinomial Logit or Latent Class models require more respondents in order to get reliable outcomes and were therefore less suitable for the experiment in this thesis. However, these models might improve the model fit and could probably give more precise information on the influence of individual characteristics and the continuous heterogeneity. It is therefore recommended to estimate and compare other models with each other in future experiments (with more respondents). The results of the different models can be compared to each other in seek of the best model fit and most reliable weights.
Modal shift
It has not been researched in this thesis whether people would actually make more use of the bicycle-train combination if the urban environment is made more attractive. This could be researched by assigning effort-resistance values to links in regional travel models and test whether the outcomes improve the model’s ability to predict the train use. Here, it must be noted that causing a modal shift towards rail might be desirable from a policy perspective, but that also without an increase in train use the improvements of urban environment can be called a success since it diminishes the travel resistance of exiting cyclists.

Applicability outside the Netherlands
The experiment used images based on Dutch streets and was filled in by Dutch-speaking people living in the Netherlands. Not many foreign countries have similar cycling conditions and culture as in the Netherlands. The values found in this thesis are therefore probably not direct transferable to other countries. It is therefore recommended to adjust the experiment for use in other countries. The images of the streets should be based on standard local streets. Moreover, the attributes should be selected with the cycling culture of the particular country in mind. For example, in the US a focus on safety factors should be logical since the cycle safety is relatively low in that country and therefore probably important in cycle resistance.
The interviews for the attribute derivation:
Anco Hoen – PBL
Danielle Snellen - PBL
Hans Nijland – PBL
Herbert Tiemens (bicycle expert)- Provincie Utrecht

The photos used in the survey:
8 photos (from left to right, top to bottom) of bicycle parkings in the survey were retrieved on 2015-05-21 from the following websites:
1: https://www.verkeerinbeeld.nl/nieuwe-fietsenstalling-noordzijde-rotterdam-centraal-open
2: http://www.fransmensonides.nl/fotoarchief2010_1.htm
3: http://www.ovmagazine.nl/fotoreportage/station-breda-scoort-met-bus/
5: http://www.fransmensonides.nl/fotoarchief2010_1.htm
7: unknown
8: https://www.google.nl/search?q=fietsparkeren+station&hl=nl&source=lnms&tbm=isch&sa=X&ei=5GeWVeDnQHOyQO8uJagBw&ved=0CAgQ_AUoAg&biw=1284&bih=866#hl=nl&tbm=isch&q=fiets+parkeren+den+hag&imgrc=ltpd25mH-4OoBM%3A

The literature used:


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APPENDICES

Read Guide:
Part [A] contains documents of the Pilot survey design,
part [B] documents of the final survey design,
part [C] the analyses of the personal characteristics,
part [D] contains the conducted (final) survey.

[A1] PILOT SURVEY: NGENE SYNTAX

Design
;alts = alt1, alt2
;rows = 8
;orth = seq
;foldover
;model:
U(alt1) = b0 + b1 * veget[0,1] + b2 * vol[0,1] + b3 * light[0,1] + b4 * park[0,1] + b5 * safe[0,1]/
U(alt2) = b1 * veget + b2 * vol + b3 * light + b4 * park + b5 * safe$

[A2] PILOT SURVEY: NGENE DESIGN

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### [A3] Pilot Survey: Underpinnings of the Respondents' Choices in Keywords

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### [B1] Final Survey: NGENE Syntax

Design

;alts = alt1, alt2
;rows = 12
;eff = (mnl,d)

;model:

\[ U(alt1) = b_0 + b_1[0.865] \times \text{trees}[0,1] + b_2[-0.680] \times \text{volume}[0,1] + b_3[-2.34] \times \text{light}[0,1] + b_4[1.4] \times \text{park}[0,1] + b_5[1.47] \times \text{safe}[0,1]/ \]

\[ U(alt2) = b_1 \times \text{trees} + b_2 \times \text{volume} + b_3 \times \text{light} + b_4 \times \text{park} + b_5 \times \text{safe} \]

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// Logit model
// Two alternatives
// SP data

[ModelIDDescription]
"pilot of the logit model for a route choice with 2 unlabeled alternatives:"

[DataFile]
$COLUMNS = 15

[Choice]
choice

[Beta]
// Name Value LowerBound UpperBound Status (0=variable, 1=fixed)
B_TREES 0 -10 10 0
B_VOLUME 0 -10 10 0
B_LIGHT 0 -10 10 0
B_PARK 0 -10 10 0
B_SAFE 0 -10 10 0

[Utilities]
// Id Name Avail linear-in-parameter expression (beta1*x1 + beta2*x2 + ... )
1 A1 avail1 B_TREES * alt1_trees + B_VOLUME * alt1_volume + B_LIGHT * alt1_light + B_PARK * alt1_park + B_SAFE * alt1_safe
2 A2 avail2 B_TREES * alt2_trees + B_VOLUME * alt2_volume + B_LIGHT * alt2_light + B_PARK * alt2_park + B_SAFE * alt2_safe

[Expressions]
// Define here arithmetic expressions for name that are not directly
// available from the data
one = 1

[Model]
// $MNL stands for "multinomial logit model",
$MNL

// $COLUMNS = 15

Cycling to a Railway Station
### [C] INTERACTIONS WITH PERSONAL CHARACTERISTICS

**Note:** the interaction variables that are found to be statistically insignificant are marked red.

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<tr>
<th>Main effects</th>
<th>Value</th>
<th>Std err</th>
<th>t-test</th>
<th>p-value</th>
<th>Final log L</th>
<th>Ad rho sq</th>
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<th>p-value</th>
<th>Final log L</th>
<th>Ad rho sq</th>
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**Interactions * SAFE**

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<td>-1.46</td>
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**Train use never/rarely**

| Train use 1-4 times a month           | 0.133       | 0.132          | 1.01    | 0.31    |
| Train use 1-3 times a week            | -0.0360     | 0.110          | -0.33   | 0.74    |
| Train use >3 times a week             | -0.0450     | 0.101          | -0.44   | 0.66    |
| Travel purpose both                   | 0.194       | 0.152          | 1.28    | 0.20    |
| Travel purpose recreation             | -0.0799     | 0.122          | -0.66   | 0.51    |
| Travel purpose work/school            | -0.143      | 0.0850         | -1.69   | 0.09    |
| Bicycle in access never/not often     | 0.139       | 0.108          | 1.28    | 0.20    |
| Bicycle in access often/always        | -0.184      | 0.0835         | -2.21   | 0.03    |

**Time of day both**

| Time of day off peak                  | -0.0707     | 0.141          | -0.50   | 0.62    |
| Time of day on peak                   | -0.0411     | 0.147          | -0.28   | 0.78    |
| Time of day on peak                   | -0.334      | 0.0922         | -3.63   | 0.00    |
Enquête: fietsen naar het station

Deze enquête is onderdeel van mijn afstudeeronderzoek uitgevoerd voor de TU Delft en het Planbureau voor de Leefomgeving. Het onderzoek gaat over fietsroutes van huis naar het treinstation. De vragenlijst bestaat uit 12 onderdelen en duurt 5 à 10 minuten. In het eerste en tweede deel krijgt u hypothetische situaties te zien en wordt u gevraagd welk alternatief u zou kiezen. In het derde deel van de vragenlijst worden u enkele vragen over persoonlijke kenmerken en fietsgebruik gesteld. Alle informatie die u geeft is vertrouwelijk en wordt alleen voor dit afstudeeronderzoek gebruikt.

Alvast bedankt voor het meedoen!

Lizet Krabbenborg
Master student TU Delft

* Required

Deel 1: Fietsroutes

Dit onderdeel bestaat uit 12 vragen waarin steeds uit twee alternatieven kan worden gekozen. Elk alternatief stelt een route van uw huis naar het station voor. De reistijd van beide opties is even lang. Met reistijd wordt bedoeld de tijd van huis tot de fietsparkeerplaats. De alternatieven kunnen verschillen in de hoeveelheid groen langs de weg (vegetatie), drukte van het fietspad; aantal keer verplicht stoppen, afstand van de fietsparkeerplaats tot perron en het aantal mensen dat op straat loopt of uitzij op straat heeft. De twee alternatieven waaruit u kunt kiezen worden behalve in woorden, ook uitgelegd in de plaatjes eronder.

Door op ‘Route A’ of op ‘Route B’ te klikken geeft u antwoord. U gaat door naar de volgende vraag door op ‘Doorgaan’ te klikken.

Deel 1: Fietsroutes

Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reistijd. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

1. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.

☐ Route A: vegetatie aanwezig; rustig fietspad; vaak stoppen; fietsparkeerplaats 50 meter van het perron; weinig mensen die op straat lopen of uitzij op straat hebben

☐ Route B: vegetatie afwezig; druk fietspad; weinig stoppen; fietsparkeerplaats 200 meter van het perron; veel mensen die op straat lopen of uitzij op straat hebben

Survey: cycling to the station

This survey is part of my graduation project conducted for the TU Delft and Planbureau voor de Leefomgeving. The research concerns bicycle routes from home to the railway station. The questionnaire consists of 3 parts and takes about 5-10 minutes. In the first and second part hypothetical situations will be presented and you will be asked which alternative you would choose. In the third part of the questionnaire some question about personal characteristics and bicycle use will be asked. All information you will give is confidential and will only be used for this thesis.

Thanks for participating!

Lizet Krabbenborg
Master student TU Delft

Part 1: Cycle routes

This part consists of 12 questions with choice from 2 alternatives. Each alternative represents a route from your house to the station. The travel time of each alternative is equal. With travel time is meant the time between home to the bicycle parking place. The alternatives can differ in the amount of green along the road (vegetation), crowdedness on the bicycle path, amount of required stops, distance between bicycle parking place and platform and the amount of people that walk or watch on the street. The two alternatives are presented in both text and pictures.

You will give an answer by clicking on ‘route A’ or ‘route B’. You will continue to the next question by clicking on the continue button.

Part 1: Cycle routes

Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

1. Which route would you prefer?

Route A: vegetation present; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; few people watching or walking on the street

Route B: vegetation absent; crowded bicycle path; few stops; bicycle parking 200 meters to platform; many people watching or walking on the street
Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reisduur. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

2. Naar welke route zou uw voorkeur uitgaan? *
   Mark only one oval.

- Route A: Vegetatie afwezig; rustig fietspad; vaak stoppen; fietsparkeren 50 meter van het perron; veel mensen die op straat lopen of op straat hebben.
- Route B: Vegetatie aanwezig; druk fietspad; weinig stoppen; fietsparkeren 200 meter van het perron; weinig mensen die op straat lopen of op straat hebben.

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

1. Which route would you prefer?

Route A: vegetation absent; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; many people watching or walking on the street
Route B: vegetation present; crowded bicycle path; few stops; bicycle parking 200 meters to platform; few people watching or walking on the street

Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reisduur. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.
Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reistijd. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

4. Naar welke route zou uw voorkeur uitgaan?
Mark only one oval.
- Route A: vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeren 200 meter van het perron; weinig mensen die op straat lopen of uitkijk of straat hebben
- Route B: vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeren 50 meter van het perron; veel mensen die op straat lopen of uitkijk of straat hebben

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform.

3. Naar welke route zou uw voorkeur uitgaan?
Mark only one oval.
- Route A: vegetation absent; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; many people watching or walking on the street
- Route B: vegetation present; crowded bicycle path; few stops; bicycle parking 200 meters to platform; few people watching or walking on the street

3. Which route would you prefer?
Route A: vegetation absent; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; many people watching or walking on the street
Route B: vegetation present; crowded bicycle path; few stops; bicycle parking 200 meters to platform; few people watching or walking on the street

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ.

4. Naar welke route zou uw voorkeur gaan?
Mark only one oval.
- Route A: vegetation absent; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; many people watching or walking on the street
- Route B: vegetation present; crowded bicycle path; few stops; bicycle parking 200 meters to platform; few people watching or walking on the street

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ.
Deel 1: Fietsroutes

Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reistijd. Veel mensen op de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

6. Naar welke route zou uw voorkeur gaan? *

Mark only one oval.

☐ Route A: vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; veel mensen die op straat lopen of uitkijk of straat hebben

☐ Route B: vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; weinig mensen die op straat lopen of uitkijk of straat hebben

Part 1: Cycle routes

Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

6. Which route would you prefer?

Route A: vegetation absent; crowded bicycle path; few stops; bicycle parking 200 meters to the platform; many people watching or walking on the street

Route B: vegetation present; quiet bicycle path; frequent stops; bicycle parking 50 meters to platform; few people watching or walking on the street
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform. This distance is presented in the textboxes at the bottom of the pictures.

7. Which route would you prefer?
Route A: vegetation present; quiet bicycle path; frequent stops; bicycle parking 50 meters to the platform; many people watching or walking on the street.
Route B: vegetation absent; crowded bicycle path; few stops; bicycle parking 200 meters to platform; few people watching or walking on the street.

8. Which route would you prefer?
Route A: vegetation absent; crowded bicycle path; few stops; bicycle parking 200 meters to the platform; few people watching or walking on the street.
Route B: vegetation present; quiet bicycle path; frequent stops; bicycle parking 50 meters to platform; many people watching or walking on the street.
Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fiest om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reistijd. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

9. Naar welke route zou uw voorkeur gaan? *
Mark only one oval.
- Route A: vegetatie aanwezig; druk fietspad; weinig stoppen; fietsparkeerplaats 200 meter van het perron; veel mensen die op straat lopen of ute zijn in de straat hebben
- Route B: vegetatie afwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; weinig mensen die op straat lopen of ute zijn in de straat hebben

Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fiest om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reistijd. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

10. Naar welke route zou uw voorkeur gaan? *
Mark only one oval.
- Route A: vegetatie aanwezig; druk fietspad; vaak stoppen; fietsparkeerplaats 50 meter van het perron; weinig mensen die op straat lopen of ute zijn in de straat hebben
- Route B: vegetatie afwezig; rustig fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; veel die op straat lopen of ute zijn in de straat hebben

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

9. Which route would you prefer?
Route A: vegetation present; crowded bicycle path; few stops; bicycle parking 200 meters to the platform; many people watching or walking on the street
Route B: vegetation absent; quiet bicycle path; few stops; bicycle parking 50 meters to platform; few people watching or walking on the street

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

10. Which route would you prefer?
Route A: vegetation present; crowded bicycle path; frequent stops; bicycle parking 50 meters to the platform; few people watching or walking on the street
Route B: vegetation present; quiet bicycle path; frequent stops; bicycle parking 200 meters to platform; many people watching or walking on the street
Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reisduur. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

11. Naar welke route zou uw voorkeur gaan? *
   Mark only one oval.
   - Route A: vegetatie afwezig; druk fietspad; weinig stoppen; fietsparkeren 50 meter van het perron; weinig mensen die op straat lopen of uitkijk of straat hebben
   - Route B: vegetatie aanwezig; rustig fietspad; vaak stoppen; fietsparkeren 200 meter van het perron; veel mensen die op straat lopen of uitkijk of straat hebben

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

11. Which route would you prefer?

Route A: vegetation absent; crowded bicycle path; few stops; bicycle parking 50 meters to the platform; few people watching or walking on the street
Route B: vegetation present; quiet bicycle path; frequent stops; bicycle parking 200 meters to platform; many people watching or walking on the street

Deel 1: Fietsroutes
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein te pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen niet in reisduur. Wel kunnen de routes verschillen in de afstand van de fietsparkeerplaats tot het perron, deze afstand staat in de tekst weergegeven onder de plaatjes.

12. Naar welke route zou uw voorkeur gaan? *
   Mark only one oval.
   - Route A: vegetatie aanwezig; rustig fietspad; vaak stoppen; fietsparkeren 200 meter van het perron; veel mensen die op straat lopen of uitkijk of straat hebben
   - Route B: vegetatie afwezig; druk fietspad; weinig stoppen; fietsparkeren 50 meter van het perron; weinig mensen die op straat lopen of uitkijk of straat hebben

Part 1: Cycle routes
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do not differ in travel time. The routes can differ in the distance between bicycle parking place and platform, this distance is presented in the textboxes at the bottom of the pictures.

12. Which route would you prefer?

Route A: vegetation present; quiet bicycle path; frequent stops; bicycle parking 200 meters to the platform; many people watching or walking on the street
Route B: vegetation absent; crowded bicycle path; few stops; bicycle parking 50 meters to platform; few people watching or walking on the street
Deel 2: Reistijd


Deel 2: Reistijd

Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

13. **Naar welke route zou uw voorkeur uitgaan?**

   Mark only one oval.

   - [ ] Route A: reistijd van 5 minuten; vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeeren 200 meter van het perron; weinig mensen die op straat lopen of uitkijk op straat hebben

   - [ ] Route B: reistijd van 9 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeeren 50 meter van het perron; veel mensen die op straat lopen of uitkijk op straat hebben

Part 2: Travel time

This part consists of 3 questions. Similar to previous questions, you can choose between two alternative cycle routes to the station. Though, now the alternatives also differ in travel time. The presented travel time stands for the time between your home and the bicycle parking place. The travel time differ per question. You are asked to choose the route of your preference.

Part 2: Travel time

Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do differ in travel time.

1. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street

Route B: travel time of 9 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street

Part 2: Travel time

Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do differ in travel time.

2. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street

Route B: travel time of 7 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street

Deel 2: Reistijd

Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

14. **Naar welke route zou uw voorkeur uitgaan?**

   Mark only one oval.

   - [ ] Route A: reistijd van 5 minuten; vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeeren 200 meter van het perron; weinig mensen die op straat lopen of uitkijk op straat hebben

   - [ ] Route B: reistijd van 7 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeeren 50 meter van het perron; veel mensen die op straat lopen of uitkijk op straat hebben

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Deel 2: Reistijd
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

2. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.

☐ Route A: reistijd van 5 minuten; vegetatie afwezig; duidelijk fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; weinig mensen die op straat lopen of uitzijk op straat hebben  Skip to question 18.

☐ Route B: reistijd van 11 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; veel mensen die op straat lopen of uitzijk op straat hebben  Skip to question 19.

3. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.

☐ Route A: reistijd van 5 minuten; vegetatie afwezig; duidelijk fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; weinig mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."

☐ Route B: reistijd van 6 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; veel mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."

Part 2: Travel time
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do differ in travel time.

2. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street
Route B: travel time of 11 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street

3. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street
Route B: travel time of 6 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street
Deel 2: Reistijd
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

17.
3. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.
☐ Route A: reistijd van 5 minuten; vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; weinig mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."
☐ Route B: reistijd van 8 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; veel mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."

Deel 2: Reistijd
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakken naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

18.
3. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.
☐ Route A: reistijd van 5 minuten; vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeerplaats 200 meter van het perron; weinig mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."
☐ Route B: reistijd van 10 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeerplaats 50 meter van het perron; veel mensen die op straat lopen of uitzijk op straat hebben  Skip to "Deel 3: Persoonlijke informatie."

Part 2: Travel time
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do differ in travel time.

3. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street
Route B: travel time of 8 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street
Deel 2: Reistijd
Stelt u zich voor dat u op een doordeweekse ochtend naar het station fietst om er de trein de pakkens naar uw werk of school. De volgende routes (route A en route B) zijn de enige opties beschikbaar. De routes verschillen in reistijd.

19. Naar welke route zou uw voorkeur uitgaan? *
Mark only one oval.
- Route A: reistijd van 5 minuten; vegetatie afwezig; druk fietspad; vaak stoppen; fietsparkeren 200 meter van het perron; weinig mensen die op straat lopen of uitkijk op straat hebben
- Route B: reistijd van 12 minuten; vegetatie aanwezig; rustig fietspad; weinig stoppen; fietsparkeren 50 meter van het perron; veel mensen die op straat lopen of uitkijk op straat hebben

Deel 3: Persoonlijke informatie
In dit laatste deel worden nog enkele vragen gesteld over uw persoonlijke kenmerken. Zoals al eerder genoemd: alle informatie wordt vertrouwelijk behandeld. Wilt u toch een vraag niet invullen, klik dan op ‘Doorgaan’ voor de volgende vraag.

Deel 3: Persoonlijke informatie

20. Wat is uw geslacht? *
Mark only one oval.
- Man
- Vrouw

Part 2: Travel time
Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. The following routes (Route A and Route B) are the only options available. The routes do differ in travel time.

3. Which route would you prefer?

Route A: travel time of 5 minutes; vegetation absent; crowded bicycle path; frequent stops; bicycle parking 200 meters to the platform; few people watching or walking on the street
Route B: travel time of 12 minutes; vegetation present; quiet bicycle path; few stops; bicycle parking 50 meters to platform; many people watching or walking on the street

Part 3: Personal Information
In this last part several questions about your personal characteristics are asked. As stated before: all information will be treated confidentially. Still, if you do not want to answer a question, you can click on ‘continue’ for the next question.

Part 3: Personal Information

1. What is your gender?
   Male
   Female
Deel 3: Persoonlijke informatie

21. Wat is uw leeftijd?
   Mark only one oval.
   
   [ ] jonger dan 15 jaar
   [ ] 15-24 jaar
   [ ] 25-44 jaar
   [ ] 45-64 jaar
   [ ] 65 of ouder

Deel 3: Persoonlijke informatie

22. Wat is uw hoogst voltooide opleiding?
   Mark only one oval.
   
   [ ] Basisschool
   [ ] VMBO/MAVO
   [ ] HAVO
   [ ] VWO
   [ ] MBO
   [ ] Bachelor
   [ ] Master
   [ ] PhD
   [ ] Other: ____________________________

Deel 3: Persoonlijke informatie

23. Wat is uw postcode?
   ____________________________

Deel 3: Persoonlijke informatie

Part 3: Personal Information

2. What is your age?
   younger than 15 years
   15-24 years
   25-44 years
   45-64 years
   65 or older

Part 3: Personal Information

3. What is your highest completed education?
   
   primary school
   VMBO/MAVO
   HAVO
   VWO
   MBO
   Bachelor
   Master
   PhD
   Other: ____________________________

Part 3: Personal Information

4. What is your postal code?
   ____________________________

Part 3: Personal Information
5. Wat is de samenstelling van uw huishouden?
Mark only one oval.
- Alleenwonend (ook kamer in studentenhuizen)  
- Tweepersoonshuishouden zonder (thuiswonende) kinderen  
  Skip to question 26.
- Gezin met 1 of meer thuiswonende kinderen  
  Skip to question 26.
- Eenoudergezin met 1 of meer thuiswonende kinderen  
  Skip to question 26.
- Other: ____________________________  
  Skip to question 26.

Deel 3: Persoonlijke informatie

6. Wat is uw jaarlijkse bruto inkomen?
Mark only one oval.
- Geen inkomen  
- Minder dan €10000  
  Skip to question 27.
- €10000 - €20000  
  Skip to question 27.
- €20000 - €30000  
  Skip to question 27.
- €30000 - €40000  
  Skip to question 27.
- €40000 - €50000  
  Skip to question 27.
- Meer dan €50000  
  Skip to question 27.

Deel 3: Persoonlijke informatie

6. Wat is het jaarlijkse bruto inkomen van uw partner en u samen?
Mark only one oval.
- Geen inkomen
- Minder dan €10000
- €10000 - €20000
- €20000 - €30000
- €30000 - €40000
- €40000 - €50000
- Meer dan €50000

Deel 3: Persoonlijke informatie

Part 3: Personal Information

5. What is your type of household?
Living alone (also chamber in studenthouse)
Two person household without (home living) children
Family with 1 or more home living children
One parent family with 1 or more home living children
Other:

Part 3: Personal Information

6. What is your annual gross income?
No income
Less than €10000
€10000 - €20000
€20000 - €30000
€30000 - €40000
€40000 - €50000
More than €50000

Part 3: Personal Information

6. What is the gross annual income of you and your partner together?
No income
Less than €10000
€10000 - €20000
€20000 - €30000
€30000 - €40000
€40000 - €50000
More than €50000
7. Wat is uw huidige werksituatie?
   Mark only one oval.
   ○ Student
   ○ Werkend (meer dan 25 uur per week)
   ○ Werkend (minder dan 25 uur per week)
   ○ Werkloos, op zoek naar een baan
   ○ Werkloos, niet op zoek naar een baan
   ○ Met pensioen
   ○ Arbeidsongeschikt
   ○ Other: ____________________________

Deel 3: Persoonlijke informatie

8. Hoe vaak reist u met de trein?
   Mark only one oval.
   ○ Meer dan 3 keer per week
   ○ 1 tot 3 keer per week
   ○ een paar keer (1-4 keer) per maand
   ○ zelden
   ○ nooit   Skip to question 33.

Deel 3: Persoonlijke informatie

9. Wat is doorgaans het doel van uw treinreis?
   Mark only one oval.
   ○ altijd of meestal werk/school
   ○ altijd of meestal recreatie (winkelen, op visite etc.)
   ○ beide even vaak
   ○ Other: ____________________________

Deel 3: Persoonlijke informatie

10. Van de keren dat u vanuit huis naar het treinstation gaat, hoe vaak gebruikt u de fiets als vervoermiddel?
    Mark only one oval.
    ○ Altijd / bijna altijd
    ○ Meestal wel
    ○ Meestal niet   Skip to question 33.
    ○ Nooit   Skip to question 33.

7. What is your current occupation?

   Student
   Working (more than 25 hrs a week)
   Working (less than 25 hrs a week)
   Unemployed, looking for a job
   Unemployed, not looking for a job
   Retired
   Unfit for work
   Other...

Part 3: Personal Information

8. How often do you travel by train?

   More than 3 times a week
   1-3 times a week
   a few times (1-4) per month
   rarely
   never

Part 3: Personal Information

9. What is generally the purpose of your train trip?

   Always or often work/school
   Always or often recreation (shopping, visiting etc.)
   Both equally
   Other...

Part 3: Personal Information

10. Of the times you go from home to the railway station, how often do you use the bicycle as access mode?

    Always/ almost always
    Mostly
    Not often
    Never
Deel 3: Persoonlijke informatie

31. Wanneer u naar een station fietst, wanneer doet u dat doorgaans?
   Mark only one oval.
   □ altijd of meestal in de spits (tussen 06:00-09:00 en 17:00-19:00)
   □ altijd of meestal buiten de spits
   □ beide even vaak

Deel 3: Persoonlijke informatie

32. Hoe vaak varieert uw fietsroute wanneer u naar het station fietst?
   Mark only one oval.
   □ nooit
   □ meestal niet
   □ meestal wel
   □ altijd

Einde enquête
Hartelijk dank voor het invullen van de enquête! Heeft u nog tijd voor enkele extra vragen? Klik dan op doorgaan. Wil u nu liever stoppen? Druk dan op ‘niet doorgaan’ en druk vervolgens op de blauwe knop om de antwoorden in te leveren.

33. Mark only one oval.  Stop filling out this form.
   □ Niet doorgaan
   □ Doorgaan

Part 3: Personal Information

11. When you cycle to the station, when do you do that normally?
   Always or mostly on peak (between 06:00-09:00 and 17:00-19:00)
   Always or mostly off peak
   Both equally

Part 3: Personal Information

12. How often do you vary your cycle route when you cycle to the station?
   never
   not often
   most of the times
   always

End of the Survey
Thank you very much for filling in the survey! Do you still have time for a few extra questions? Then click on continue. Do you prefer to quit? Then click on ‘not continue’ and thereafter click on the blue button in order to submit the answers.

Extra Vraag
In dit extra onderdeel wordt u gevraagd de volgorde van belangrijkheid aan te geven aan 5 factoren die een rol kunnen spelen in de keuze van de fietsroute van huis naar station. De factoren zijn: vegetatie (groen langs de weg); aantal keer stoppen; drukte van het fietspad; aantal mensen dat op straat loopt en op straat uittikt; afstand tussen fietsparkeerplek en perron. Eerst zullen deze factoren gepresenteerd worden, daarna wordt u gevraagd de belangrijkheid aan te geven.

Extra Vraag
Hieronder wordt de factor ‘vegetatie’ weergegeven. Kijk even rustig naar de 4 plaatjes boven en de 4 plaatjes onder om de verschillen in u op te nemen. Probeer bij elk van deze plaatjes te bedenken of u een sterk voorkeur heeft voor de af- of aanwezigheid van de vegetatie.

Extra Vraag
In this extra part you will be asked to rate the level of importance in five factors that might play a role in the route choice of the cycle route from home to the station. The factors are: vegetation (green along the road); amount of stops; crowdedness on the cycle path; the amount of people that watch or walk on the street; the distance between the bicycle parking and the platform. First, the factors will be presented to you, thereafter you will be asked to rate the importance.

Extra Vraag
Below the factor ‘vegetation’ is visualized. Please take your time to look at the 4 pictures on the top and the 4 pictures at the bottom in order to record the differences. Try already to imagine whether you have a (strong) preference for the presence or absence of vegetation.
Vegetatie: afwezig

Vegetatie: aanwezig

Extra Vraag
Hieronder wordt de factor 'aantal keer stoppen' weergegeven. Kijk u even rustig naar de 4 plaatjes boven en de 4 plaatjes onder om de verschillen in u op te nemen. Probeer hierbij alvast te bedenken of u een (sterke) voorkeur heeft voor de plaatjes boven/onder of dat de factor u misschien niet zo veel uitmaakt.

Extra question
Below the factor ‘amount of stops’ is visualized. Please take your time to look at the 4 pictures on the top and the 4 pictures at the bottom in order to record the differences. Try already to imagine whether you have a (strong) preference for the pictures on top/bottom or that is does not matter to you.
Stoppen: vaak

Stoppen: weinig

Extra Vraag
Hieronder wordt de factor ‘drukte van het fietspad’ weergegeven. Kijkt u even rustig naar de 4 plaatjes boven en de 4 plaatjes onder om de verschillen in u op te nemen. Probeer hierbij alvast te bedenken of u een (sterke) voorkeur heeft voor de plaatjes boven/onder of dat de factor u misschien niet zo veel uitmaakt.

Extra question
Below the factor ‘crowdedness on the cycle path’ is visualized. Please take your time to look at the 4 pictures on the top and the 4 pictures at the bottom in order to record the differences. Try already to imagine whether you have a (strong) preference for the pictures on top/on bottom or that is does not matter to you.
**Extra Vraag**

Hieronder wordt de factor 'aantal mensen dat op straat loopt of op straat uitkijkt' weergegeven. Kijk even rustig naar de 4 plaatjes boven en de 4 plaatjes onder om de verschillen in u op te nemen. Probeer hierbij alvast te bedenken of u een (sterke) voorkeur heeft voor de plaatjes bovenonder of dat de factor u misschien niet zo veel uitmaakt.

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**Extra question**

Below the factor 'amount of people walking or watching on the street' is visualized. Please take your time to look at the 4 pictures on the top and the 4 pictures at the bottom in order to record the differences. Try already to imagine whether you have a [strong] preference for the pictures on top/on bottom or that is does not matter to you.
Aantal mensen dat op straat loopt of uittikt: veel mensen

Extra Vraag
Hieronder wordt de factor 'afstand tussen parkeerplaats fiets en het perron' weergegeven. Kijk u even rustig naar de 4 plaatjes boven en de 4 plaatjes onder om de verschillen in u op te nemen. Probeer hierbij alvast te bedenken of u een (sterke) voorkeur heeft voor de plaatjes boven/onder of dat de factor u misschien niet zo veel uitmaakt.

Extra vraag
Below the factor 'distance between the bicycle parking and the platform' is visualized. Please take your time to look at the 4 pictures on the top and the 4 pictures at the bottom in order to record the differences. Try already to imagine whether you have a (strong) preference for the pictures on top/on bottom or that is does not matter to you.
Parkeerplaats fiets: 50 meter tot perron

Parkeerplaats fiets: 200 meter tot perron

Extra Vraag

U heeft nu de volgende 5 factoren gezien:
- vegetatie (afwezig/aanwezig)
- aantal keer stoppen (weinig/vaak)
- fietspad (druk/ruzig)
- aantal mensen dat op straat loopt of uitzijt (veel/weinig mensen)
- afstand parkeerplek tot perron (50 meter of 200 meter)

Stelt u zich voor dat u op een doordeweekse ochtend naar het station fiets om er de trein te pakken naar uw werk of school. Hoe belangrijk vindt u de genoemde factoren tijdens

Extra question

You have seen the following 5 factors:
- vegetation (present/absent)
- amount of stops (few/often)
- cycle path (quiet/crowded)
- amount of people walking or watching on the street (few/many people)
- distance between parking place and platform (50 or 200 meters)

Imagine it is a weekday and you are cycling to the railway station in order to catch the train to your school or work. How important do you find the mentioned factors during
uw rit naar het station? Geef hieronder aan hoe belangrijk u de factoren vindt op een schaal van 1 tot 5. Dus, als u het bijvoorbeeld erg belangrijk vindt of er wel of geen bomen staan in de straat, geef dan ‘vegetatie’ een 5.

34. Vegetatie
    Mark only one oval.
    1  2  3  4  5
    onbelangrijk □□□□□ belangrijk

35. Aantal keer stoppen
    Mark only one oval.
    1  2  3  4  5
    onbelangrijk □□□□□ belangrijk

36. Drukte op het fietspad
    Mark only one oval.
    1  2  3  4  5
    onbelangrijk □□□□□ belangrijk

37. Aantal mensen dat op straat loopt of op straat uitkijkt
    Mark only one oval.
    1  2  3  4  5
    onbelangrijk □□□□□ belangrijk

38. Afstand parkeerplek tot perron
    Mark only one oval.
    1  2  3  4  5
    onbelangrijk □□□□□ belangrijk

Hieronder kunt u eventuele opmerkingen zetten:

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39. Below, you may write any comments if you like: