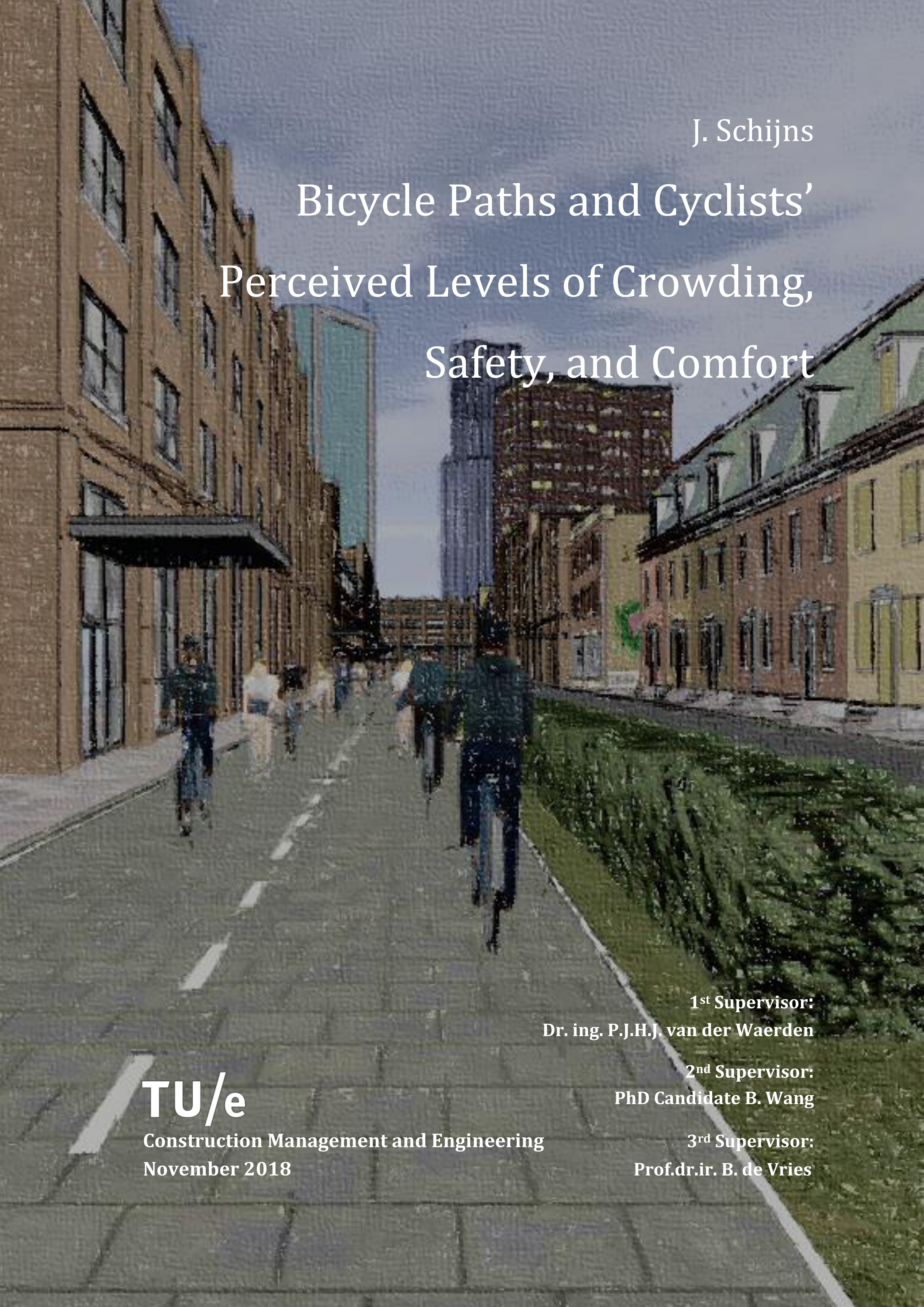


J. Schijns

Bicycle Paths and Cyclists' Perceived Levels of Crowding, Safety, and Comfort

1st Supervisor:
Dr. ing. P.J.H.J. van der Waerden

2nd Supervisor:
PhD Candidate B. Wang

3rd Supervisor:
Prof.dr.ir. B. de Vries

Construction Management and Engineering
November 2018

Colophon

Graduation thesis
In partial fulfilment of the requirements for graduation of the Master's degree Construction Management and Engineering

Name	J. Schijns
TU/e ID	0808057
E-mail address	j.schijns@student.tue.nl

Graduation committee:

1st Supervisor:	Dr. ing. P.J.H.J. van der Waerden
2nd Supervisor:	PhD Candidate B. Wang
3rd Supervisor/ chairman:	Prof.dr.ir. B. de Vries

Graduation date	21-11-2018
Graduation program	Construction Management and Engineering
Institute	Eindhoven University of Technology
Faculty	The Built Environment

Acknowledgements

After six months working on my biggest project so far, I am proud to finally present my official thesis and to (almost) fulfil the Master Construction Engineering Management at the TU/e. Before I go into detail about the content of this report, I would like to thank a bunch of people first.

I would like to thank Peter van der Waerden for the very personal help and guidance. In the beginning of my graduate project, I had difficulty choosing a clear subject and mostly because of Peter I found a subject that I have been working on with great pleasure all the time. Furthermore, our hour-long meetings were not only useful for my research, but also just pleasant (gezellig). I would also like to thank Ben Wang for his valuable contribution to the accompaniments.

Furthermore, I would like to thank all the people who have completed my survey. Each completed respondent is a valuable contribution to my research. In particular, I would like to thank Maastricht Bereikbaar for distributing my research to their respondent panel. Mostly because of this organization, a total of 1210 respondents fully completed the survey, which has certainly improved the quality of the research.

Finally, I want to thank all my friends and family, for their support during my study, but also for the interest in my graduation research. In particular, I want to thank my mother Marijke for fanatically distributing my survey.

Enjoy reading!

Jeffrey Schijns

Eindhoven, 2018

Summary

Recently it becomes increasingly more crowded on the cycle path, especially in high urban areas. About 10% of the cyclists have problems with this crowdedness. The increase in intensity of cyclists is due to a number of measures, such as the construction of many fast cycling routes, discouraging measures to reduce the use of the car in the city, and the availability of “OV-bicycle”. Furthermore new groups of people discover the bike, such as elderly people, people who traveled by bus or tram, and people with a non-western background. There are clearly people who sometimes find it too busy on the bike path and therefore decide to take a different mode of transport. It also appears that the intensity level has an influence on the safety and comfort experience of users. It is important to avoid that it becomes too crowded on a bicycle path and more people are going to trade in the bike for other means of transport such as the bus, or car.

Whether a bicycle path is crowded, is now determined on the basis of a few guidelines concerning the width of the bicycle path and bike intensity. If the bicycle path is too narrow for the measured intensity, the bicycle path is considered to be too crowded. However, it is questionable whether users also find it crowded on that bike path. According to the crowding definition it is inappropriate to determine the crowded level this way. Crowding is seen as a negative evaluation of density or number of encounters. This assessment is done with an opinion that the observed number is too high for the area that is occupied. Because crowding is a value judgement, it is often used as the term ‘Perceived crowding’. In terms of determining the perceived level of crowding, one need to know more about the setting, desired activity, and the individuals making the evaluation.

Measuring the perceived crowding, safety and comfort is seen as a cognitive complex task, which is hard to understand for the respondent. This can be the case when a large number of attributes is included in the research, which should be obtained by the respondent. The use of visuals can help in presenting a wide range of variables and can lower the cognitive complexity for the respondents. Several literature show that the best way to measure the perceived crowding, safety, and comfort is in a visual way. The chosen attributes based on literature are: intensity level of cyclists, level of duo cyclists in the same direction, level of duo cyclists in the other direction, land use, pedestrian level of activity, vegetation next to the bike path, intensity of car traffic, bike path width, and color of bike path. The stated preference experiment that was designed based on these attributes, was completed by 1,210 respondents. The respondents valuated for each profile the perceived level of crowding, safety, and comfort. The profiles were shown as short virtual videos (15 seconds). In the videos the perspective of a cyclists was shown on a two way bicycle path.

The results show that all the chosen attributes have a significant influence on the valuation of the perceived crowding, safety, and comfort. The intensity of the cyclists on the bike path has by far the biggest influence on the perceived level of all three dependent variables. Further the bike path width seems to be a very important contributor to the dependent variables. The rest of the attributes have a more varying role in terms of influence on the perceived level of crowding, safety, and comfort. The intensity of cars next to the bike path is for instance an important contributor to the perceived level of crowding, vegetation plays a bigger role in the valuation of the perceived level of safety, and the color and level of duo cycling are more important for the cyclists' perceived level of comfort. For each variable, it was checked whether there are differences between groups of respondents. The grouping of respondents was based on answers given on various questions. It has been found that there are significant differences between groups in the valuation of the dependent variables.

This results of this study can help, as an information source, in the search to the 'bicycle path of the future. Out of the results can be concluded that in order to minimize the perceived crowding and to maximize the perceived safety and comfort: the cyclist intensity should be low, all cyclists cycle behind each other, the cycle path is located downtown, there are no pedestrians next to the cycle path, bushes border the cycle path on one side, car traffic next to the cycle path should be minimalized, the cycle path width is on the other hand maximized and executed in the color red.

Samenvatting

De laatste jaren is het steeds drukker geworden op het fietspad, vooral in stedelijke gebieden. Ongeveer 10% van de fietsers heeft hier problemen mee. De toename in intensiteit van fietsers wordt veroorzaakt door een aantal gebeurtenissen, zoals de aanleg van vele snelle fietsroutes, ontmoedigende maatregelen om het gebruik van de auto in de stad en het succes van "OV-fiets". Bovendien ontdekken nieuwe groepen reizigers de fiets, zoals ouderen die langer fietsen, mensen die per bus of tram reizen en mensen met een niet-westerse achtergrond. Fietsgebruikers hebben duidelijk last van de drukte op fietspaden en kiezen daarom vaker voor een ander vervoersmiddel. Drukte lijkt ook van invloed op de veiligheids- en comfortbeleving van gebruikers van het fietspad. Het is belangrijk om te voorkomen dat het te druk wordt op een fietspad en dat meer mensen de fiets inruilen voor een ander vervoermiddel.

Of een fietspad druk is, wordt nu bepaald aan de hand van enkele richtlijnen gebaseerd op de breedte van het fietspad en de fietsintensiteit. Als het fietspad te smal is voor de gemeten intensiteit, wordt het fietspad als te druk beschouwd. Het is echter de vraag of gebruikers het ook daadwerkelijk druk vinden op dat fietspad. Volgens de definitie van drukte is het niet voldoende om zo het niveau van drukte te bepalen. Drukte wordt gezien als een negatieve evaluatie van een dichtheid of aantal ontmoetingen. Deze beoordeling is gebaseerd op een mening. Om het niveau van drukte te bepalen moet men meer weten over de locatie, de gewenste activiteit op die locatie en de personen die de betreffende situatie waarnemen.

Het meten van de waargenomen drukte, veiligheid en comfort wordt gezien als een complexe cognitieve taak, dat is een taak die moeilijk te begrijpen is voor de respondent. Dit kan het geval zijn wanneer een groot aantal attributen in het onderzoek is opgenomen. Het gebruik van beelden, en dus de variabelen in een visuele vorm uitvoeren, kan helpen bij het verlagen van de cognitieve complexiteit voor de respondenten. De gekozen attributen op basis van literatuur zijn: intensiteitsniveau van fietsers, mate van duo fietsers in dezlefde richting als de waarnemer, mate van duo fietsers in tegenovergestelde richting dan de waarnemer, grondgebruiksfunctie, voetgangers naast het fietspad, vegetatie naast het fietspad, intensiteit van autoverkeer , fietspad breedte en kleur van het fietspad. Het met behulp van de genoemde attributen ontwikkelde Stated Preference experiment was volledig ingevuld door 1210 respondenten. In elk profiel beoordeelden deze respondenten de ervaren drukte, veiligheid en comfort. De profielen zijn aan de respondenten gepresenteerd als korte virtuele video’s (15 seconden_. In deze video’s was het perspectief van de fietser weergeven op een twee-richting fietspad.

De resultaten laten zien dat alle gekozen attributen van invloed zijn op de waardering van de ervaren drukte, veiligheid en comfort. De intensiteit van de fietsers op het fietspad heeft veruit de grootste invloed op alle drie de afhankelijke variabelen. Verder lijkt de breedte van het fietspad een zeer belangrijke rol te spelen bij het bepalen van de afhankelijke variabelen. De rest van de attributen hebben een meer variërende rol qua invloed op de beleving van drukte, veiligheid en comfort van fietsers. De intensiteit van auto's naast het fietspad is bijvoorbeeld een belangrijke factor bij het bepalen van drukte, vegetatie speelt een grotere rol bij de waardering van het veiligheidsniveau en de kleur van het fietspad en de mate van naast elkaar fietsen zijn belangrijker bij het bepalen van het comfort level voor de fietser. Voor elke variabele werd gecontroleerd of er verschillen tussen groepen van respondenten waren. Er is vastgesteld dat er verschillen zijn tussen groepen in de waardering van de afhankelijke variabelen.

De resultaten van dit onderzoek kunnen als informatiebron helpen bij het zoeken naar het 'fietspad van de toekomst'. Uit de resultaten kan worden geconcludeerd dat om de ervaren drukte te minimaliseren en de ervaren veiligheid en comfort te maximaliseren: de intensiteit van de fietsers laag moet zijn, alle fietsers achter elkaar fietsen, het fietspad in het centrum van de stad ligt, er geen voetgangers naast het fietspad lopen, aan het fietspad struiken grenzen, het autoverkeer naast het fietspad geminimaliseerd wordt, de breedte van het fietspad daarentegen gemaximaliseerd wordt en uitgevoerd wordt in de kleur rood.

Abstract

Recently it has become increasingly more crowded on the cycle path in especially urban areas, this has a negative side. Recent research has shown that almost 10% of the cyclists have problems with busy cycle paths. About half of the cyclists choose sometimes a different route to avoid crowdedness and about one third of the cyclists leave the bike sometimes to choose other means of transport because of the crowded bicycle paths. It appears that the intensity level also has an influence on the safety and/or comfort experience of users. Measuring the perceived crowding, safety and comfort is seen as a cognitive complex task. The use of visual images can help in presenting a wide range of variables and can lower the cognitive complexity for the respondents. The chosen attributes based on literature are: intensity level of cyclists, level of duo cyclists in the same direction, level of duo cyclists in the opposite direction, land use, pedestrian level of activity, vegetation next to the bike path, intensity of car traffic, bike path width and color of bike path. A stated preference experiment was completed by 1210 respondents in which they valuated the perceived level of crowding, safety and comfort. In the video experiment was the perspective of a cyclists shown on a two way bicycle path. The results show that all the chosen attributes have a significant influence on the valuation of the perceived crowding, safety, and comfort. The intensity of the cyclists on the bike path and the bike path width have the biggest influence on the perceived level of all three dependent variables. The rest of the attributes have a more varying roll in terms of influence on the perceived level of crowding, safety, and comfort. This research may be seen as a contribution to crowding understandings on the bike path. This results of this study can help, as an information source, in the search to the 'bicycle path of the future. Out of the results can be concluded that in order to minimize the perceived crowding and to maximize the perceived safety and comfort: the cyclist intensity should be low, all cyclists cycle behind each other, the cycle path is located downtown, there are no pedestrians next to the cycle path, bushes border the cycle path on one side, car traffic next to the cycle path should be minimalized, the cycle path width is on the other hand maximized and executed in the color red.

Table of Contents

1. INTRODUCTION ... 18
1.1 Problem Definition ... 18
1.2 Research Question and Objective ... 19
1.3 Research Design ... 21
1.4 Societal relevance ... 21
2. LITERATURE REVIEW ... 22
2.1 Introduction ... 22
2.2 Understanding Crowding ... 22
2.2.1 Personal space ... 23
2.2.2 Neutral and personal crowding ... 23
2.2.3 Previous research about level of perceived crowding in other fields ... 25
2.3 Crowding on bicycle paths ... 26
2.3.1 Problematic places ... 28
2.3.2 Previous research about crowding on bike paths ... 30
2.4 Bicycle level of service ... 32
2.5 Attributes influencing bicyclist's perceived level of crowding ... 34
2.5.1 Traffic conditions on bicycle path ... 34
2.5.2 Surrounding bicycle path ... 34
2.5.3 Physical bicycle path conditions ... 35
2.5.4 Individual factors ... 36
2.6 Attributes influencing bicyclist's perceived level of safety ... 36
2.6.1 Traffic conditions on bicycle path ... 37
2.6.2 Surrounding bicycle path ... 37
2.6.3 Physical bicycle path conditions ... 38
2.6.4 Individual factors ... 38
2.7 Attributes influencing bicyclist's perceived level of comfort ... 39
2.7.1 Traffic conditions on bicycle path ... 39
2.7.2 Surrounding bicycle path ... 40
2.7.3 Physical bicycle path conditions ... 41
2.7.4 Individual factors ... 41

2.7.5 Overview found literature 41
2.8 Conclusion Literature Review 43
3. METHODOLOGY 44
3.1 Introduction 44
3.2 Choice modeling 44
3.2.1 Choosing a method 44
3.2.2 Utility theory 45
3.3 Towards visual presentation of attributes 46
3.3.1 Virtual Reality 48
3.3.2 Driving Simulator 49
3.4 Setting up Stated Preference Experiment 50
3.4.1 Problem refinement 51
3.4.2 Stimuli refinement 52
3.4.3 Experimental design considerations and generation 56
3.4.3 Choice set generation 58
3.4.4 Choice set randomization 60
3.5 Visualization of attributes 60
3.5.1 Environmental base 60
3.5.2 Process from text to visual 61
3.5.3 Static & dynamic attributes 63
3.6 Survey construction 67
3.7 Data collection and processing 69
4. RESULTS 72
4.1 Introduction 72
4.2 Descriptive Analysis 72
4.2.1 Respondents´ characteristics 72
4.2.2 Respondents' bike related characteristics 74
4.3 Model Estimation Perceived level of Crowding 77
4.3.1 Differences between groups in evaluating the perceived level of crowding 81
4.4 Model Estimation Perceived level of Safety 84
4.4.1 Differences between groups in evaluating the perceived level of safety 87
4.5 Model Estimation Perceived level of Comfort 90

4.5.1 Differences between groups in evaluating the perceived level of comfort 93
4.6 Discussion results 95
5. CONCLUSION 99
5.1 General Conclusion 99
5.2 Scientific relevance 102
5.3 Recommendations 103
BIBLIOGRAPHY 104
APPENDICES 113
Appendix A: Determination Factual Crowding 113
Appendix B: Fractional Factorial Design 114
Appendix C: Reference Bike Paths 115
Appendix D: Example Script in Vizard (Python as program language) 116
Appendix E: Visualized Attributes 123
Appendix F: Characteristics Respondents 131
Appendix G: Ordinal Regression Output Perceived Level of Crowding 135
Appendix H: Ordinal Regression Output Perceived Level of Safety 138
Appendix J: Attribute impact per group 142
Appendix K: Coefficients for predictor variables 154

List of Tables

-Table 1: A typology of crowding experiences (Stokols, 1976) 25
-Table 2: Level of Service for a Cycle Path regarding density determinant (Navin, 1994) 32
-Table 3: Service Volumes According to Hindrance Criterion (Botma, 1995) 33
-Table 4: Overview found literature 42
-Table 5: The most important advantages and disadvantages summarized for Stated and Revealed preference methods (Hensher, Rose, & Greene, 2005) and (Verschuren & Doorewaard, 2002) 45
-Table 6: Attributes and attribute levels 55
-Table 7: Orthogonal fractional factorial design with nine three level attributes 57
-Table 8: Design codes translated into attributes and levels 58
-Table 9: Design codes translated into attributes and levels 59
-Table 10: Overview of variables in questionnaire 68
-Table 11: Level of perceived crowding coefficients using ordinal regression 79
-Table 12: Level of safety coefficients using ordinal regression 85
-Table 13: Level of comfort coefficients using ordinal regression 91
-Table 14: Summary of all findings compared to literature findings 98
-Table 15: The most optimal scenario for each dependent variable 102

List of Figures

-Figure 1: Neutral and Personal varieties of crowding (Stokols, 1976) 24
-Figure 2: Number of trips (x 1,000) from/to/within Amsterdam by residents per working day by means of transport in period between 1986-2014 (Gemeente Amsterdam, 2015) 28
-Figure 3: Intensity heat map of cyclists observed in specific situation for the cities Utrecht, Amsterdam and Eindhoven (Bike Print, 2016) 30
-Figure 4: Extent in which bike path conditions contribute to the perceived level of crowding (Munckhof, Zengerink, & Avest, 2017) 35
-Figure 5: Four types of virtual reality methods 48
-Figure 6: The Experimental design process of a Stated Preference Research (Hensher, Rose, & Greene, 2005) 51
-Figure 7: The dependent variables in the stated preference experiment 52
-Figure 8: Conceptual framework 54
-Figure 9: The seven considered environmental bases (schematically viewed) 61
-Figure 10: The chosen base by the researcher (A) 61
-Figure 11: Fragment of a set-up of a scenario in a text file (with schematic environmental base) 62
-Figure 12: Schematic overview of the process from text to visual 62
-Figure 13: Intensity levels of cyclists: low (1000 cyclists/h), medium (2500 cyclists/h) and high (4000 cyclists/h) 63
-Figure 14: Levels of duo cyclists: low (0%), medium (40%), high (80%)............................... 64
-Figure 15: Land use levels: rural, in-town residential and high density............................... 64
-Figure 16: Levels of (pedestrian) activity: low (0 pedestrians), medium (10 pedestrians), high (30 pedestrians).. 65
-Figure 17: Vegetation levels: grass, trees and bushes... 65
-Figure 18: Intensity levels of car traffic: low (250 cars/h), medium (1000 cars/h), high (2000 cars/h) 65
-Figure 19: Bike path width levels: low (2.5m), medium (3.5m), high (4.5m)........................ 66
-Figure 20: Color bike path levels: red, gray/tiles and blue.. 66
-Figure 21: The visual explanation of level of crowding in the questionnaire 68
-Figure 22: Ratio gender (%) 73
-Figure 23: Ratio age (%) 73
-Figure 24: Ratio level of urbanity residential area (%) 74
-Figure 25: Ratio time period of cycle trip (%) 75
-Figure 26: Ratio most used bike type (%) 76
-Figure 27: Ratio of average bike use of the respondents, compared with national and regional averages (%) 77
-Figure 28: The relative impact of the attributes on the perceived level of crowding............ 80
-Figure 29: Attribute impact on perceived level of crowding per gender group 81
-Figure 30: Attribute impact on perceived level of crowding per age group 82
-Figure 31: Attribute impact on perceived level of crowding per experience group 83

-Figure 32: Attribute impact on perceived level of crowding per bike type group 83
-Figure 33: The relative impact of the attributes on the safety level 86
-Figure 34: Attribute impact on perceived level of safety per gender group 87
-Figure 35: Attribute impact on perceived level of safety per age group 88
-Figure 36: Attribute impact on perceived level of safety per experience group 89
-Figure 37: Attribute impact on perceived level of safety per bike type group 89
-Figure 38: Ranges of the impact on the comfort level 92
-Figure 39: Attribute impact on perceived level of comfort per gender group 93
-Figure 40: Attribute impact on perceived level of comfort per age group 94
-Figure 41: Attribute impact on perceived level of comfort per experience group 94
-Figure 42: Attribute impact on perceived level of comfort per bike type group 95

1. INTRODUCTION

1.1 Problem Definition

More and more people are living in cities. CBS (the Dutch Central Bureau of Statistics) expects that three-quarters of the total population growth in the Netherlands will take place in the large cities until 2030 (CBS, 2016). This substantial increase in population brings a number of challenges.

For example, the CROW, the knowledge center for bicycle policies of the Dutch authorities, predicts that without major measures many Dutch cities will clog up during the peak periods in five years. This is a doubling compared to the situation in 2016. According to CROW, this is because the focus of the Dutch government in recent years has been mainly on solving traffic jams on main roads. Little attention has been paid to the effects on urban accessibility. According to the CROW does solving these traffic jams with extra asphalt, bridges, and tunnels make little sense, since the maximum capacity of the urban road network has already been reached (Hijman, et al., 2016).

The large concentration of cars in cities also means that there is a lot of particulate matter present in cities. For example, in the Netherlands the concentrations of soot and heavy metals along busy streets are two to three times higher than elsewhere with health complaints and premature mortality as a result. Air pollution is one of the major causes of cancer deaths (Knol, 2014). The very poor air quality in the center of Eindhoven has stimulated the municipality to implement a radical plan on one of the most polluted streets to partially close the busy street for car traffic and to make more space available for bicyclists and pedestrians (Van Hoof, 2017). According to Leendert van Bree, policy researcher at the Netherlands Environmental Assessment Agency, a healthy city means a place where people can live long, healthy, and in a clean environment. This requires not only a policy and plans aimed at limiting health damage, but also action aimed at promoting health and well-being (Van Summeren, 2015). The increase of urban traffic congestion and pollution in the city centers has led to a growing need for mobility alternatives.

The bicycle is seen as a very sustainable and healthy way of mobility. In the Netherlands, this has also been seen in recent years as an important means to reduce the traffic on the roads. In the Netherlands, 61% of the inhabitants live within a radius of 15 km from their work. Only 25% of these people use the bicycle as a means of transport to get to their workplace (Fietssnelwegen, 2017). This is enough reason for the Dutch government to make cycling more attractive. For example, many fast-cycle routes have recently been created. Fast cycling routes ensure that cycling becomes an attractive mode of transport for larger distances (Lange, Talens, & Hulshof, 2017).

Nearly all big cities pay special attention to bikes in their cities and want to stimulate this transportation mode. For example, in Utrecht the bike gets priority within the design of all new public spaces. In the most recent accessibility vision of Utrecht, it is stated that there will be a good balance between accessibility, attractiveness, and quality of life. The bicycle is thereby seen as primary means of transport (Gemeente Utrecht, 2015). The city of Eindhoven also pays special attention to the bike. In recent years, the municipality invested a lot of money in improving the comfort for cyclists (Gemeente Eindhoven, 2009). There are also several pro-bike initiatives initiated by the Dutch government or organizations to stimulate bicycle usage instead of car usage. A specific example is ‘Trappers’ initiated by 20 organizations. The employees of these organizations got rewarded with points every time they biked to their work. They could exchange their points for a gift card. Research has shown that the bike usage rose with 13% (XTNT, 2009).

More recently, the bike is undergoing a true revival. Especially in urban areas the bike is regaining its popularity again. According to the KIM (Dutch Knowledge Institute for Mobility policy) the bike as transportation mean in 2015 is used 9% more in comparison with the year 2009 (Lange, Talens, & Hulshof, 2017). Last year the amount of sold bikes has risen again, after years of decline. The popularity of the bicycle is mainly due to the continuous growth of the amount of e-bikes. Almost a third of all new bikes are electrical (Termaat, 2018).

This growth has also a negative side. Recent research has shown that almost 10% of the cyclists have problems with busy cycle paths (Munckhof, Zengerink, & Avest, 2017). Antisocial behavior is often seen as the worst annoyance. Most cyclists experience crowding at locations in urban areas and in one third of the crowded cases it concerns a highly urban area. About half of the respondents choose sometimes a different route to avoid crowdedness and about one third of the cyclists leave the bike sometimes to choose other means of transport because of the crowded bicycle paths (Munckhof, Zengerink, & Avest, 2017).

It seems that the bike as a transportation mean is becoming its own enemy in especially urban areas. This could weaken the recent revival of the bike in the Dutch street scene.

1.2 Research Question and Objective

Earlier research mentioned that there is more research needed to understand what influences the perceived level of crowding (Munckhof, Zengerink, & Avest, 2017). The bicycle does not seem to be going down in its success yet in this research. Although, it is important to avoid that it becomes too crowded on a bicycle path and more people are going to trade in the bike for different means of transport. This can be quite challenging, with the still increasing number of cyclists in especially the very urban areas, but also on important bicycle routes. More and more initiatives are being developed to search for the 'bicycle path of the future'. This is especially true now that the bicycle is playing an increasingly important role in cities (Provinciale Staten, 2018).

Relatively not much research is executed regarding the perceived level of crowding. Usually, research is based on objective crowding, which is practically the intensity of the cyclists in relation to the width of the bike path. This is more executed as a guideline for planners. Though, it is in these cases unclear, whether cyclists experience such a cycle path as a crowded path and perhaps other attributes have an influence too in this experience. Since there are clearly people who sometimes find it too busy on the bike path and therefore take a different mode of transport, it appears that the intensity level also has an influence on the safety and/or comfort experience of users. It would be interesting to measure whether and to what extent the crowding on the cycle path affects these experiences. Eventually the following research question is composed:

"What is the influence of several bike path related attributes on the perceived level of crowding, safety and comfort?"

In order to be able to answer the above stated question, the following sub-questions are defined:

- **What is crowding?**
- **What is crowding on bicycle paths?**
- **What has previous research on crowding on bicycle paths demonstrated?**
- **How can the perceived crowding, safety and comfort for cyclists be measured?**
- **Which attributes influence the perceived crowding, safety and comfort by cyclists on bicycle paths?**

The objective of the research is to get more insight into the influence of attributes on the perceived level of crowding, safety, and comfort of bike paths. Special attention is paid to understanding of crowding on bike paths. Further the objective is to develop a simulation/animation which is credible for respondents. In a way that respondents can observe the real world in a controlled environment. At last, the researcher could advise authorities about important attributes influencing the perceived crowding, safety, and comfort based on findings of this research.

This research has a few limitations. First of all the researcher will make a selection of interesting attributes to be researched based on literature. This means that not all possible bike path related attributes will be researched. Due to time limitations and skill level of the researcher, the level of detail will be limited in the simulations. Last, is it important to mention that the research is mainly focused on situations of Dutch bicycle paths. Crowding on bicycle paths is something that occurs often in the Netherlands, in other countries this plays a more modest role.

1.3 Research Design

Crowding in general has been a topic in existing literature for quite a long time already. The first research question: “What is crowding?” will be answered using these sources. This will also possible provide for any theoretical components of crowding, which can be used later in the research. The general findings of crowding will be shown in paragraph 2.2. Crowding on bike paths is relatively less researched in a scientific way. The second research question “What is crowding on bicycle paths?”, will be answered using these limited scientific researches, but also other reports and findings. The goal of this part is to get a good insight in the crowding issue on the bike path and what the possible reasons are for the recent increase. Further is being researched on what places it occurs and how it is measured. The crowding findings based on the bike path are shown in paragraph 2.3. Next, will all the relevant attributes be stated, which might influence the bicyclist’s perceived level of crowding, safety and comfort. This is done to include afterwards the right attributes in the next phase of the research. These findings are shown in paragraph 2.5 to 2.7. To answer the next research question: “How can the perceived crowding, safety and comfort for cyclists be measured?”, a few sources have been reviewed. The researcher would like special attention for this, since respondents need to review a quite complex situation. These findings are shown in paragraph 3.2. Afterwards the stated preference experiment is constructed. In this step there is special attention for the visualization of the used attributes. After the data collection and processing are the results analyzed in chapter 4. With the help of these results is the main question: “What is the influence of several bike path related attributes on the perceived level of crowding, safety and comfort?” answered.

1.4 Societal relevance

Many people in Dutch society are involved in this topic, since a lot of Dutch people cycle often. Former research has proven that most of the cyclists face sometimes a crowded situation and about 10% of the population has problems with crowding on bike paths. This research could contribute to the bike path of the future. The researcher could advise institutions on how cyclists valuate the perceived crowding on bike paths and how to ensure that people do not change their bikes for another means of transport (with the perceived safety and comfort). This can therefore ensure that the bicycle remains a suitable alternative to the car for many people. Cities benefit from that, because there are fewer cars in the city.

2. LITERATURE REVIEW

2.1 Introduction

Before the researcher can start with the actual research, more information is needed to make appropriate decisions. This chapter provides a review of the current literature in the field of crowding on bike paths and several issues that are important regarding the topic and research. Paragraph 2.2 is about crowding in general, since there are some misconceptions what crowding exactly is. In this paragraph the concept of crowding and some different types in crowding are explained in more detail. Paragraph 2.3 is about crowding on bicycle paths. The first part of that paragraph will be about the cause of the bike usage growth. Followed by determining where the problematic places are. Furthermore attention is paid to previous researches about crowding on bike paths. The next paragraph will be about the principle of Bicycle Level of Service. In paragraph 2.5 all the relevant attributes will be introduced that might influence the bicyclist's perceived level of crowding. For the perceived level of safety this will be done in paragraph 2.6. Finally in paragraph 2.7 the relevant attributes that might influence the perceived level of comfort will be presented.

2.2 Understanding Crowding

In many cases the concept crowding is used incorrect. The concept is often mixed up with the concept of density, both concepts are not the same. The following is seen as the definition of density: "*Density is a descriptive term that refers to the number of people per unit area."* (Shelby, Vaske, & Heberlein, 1989).The definition of crowding is the following:

"Crowding is seen as a negative evaluation of a density or number of encounters" (Stokols, 1972)

Density can be measured by observing people or things and after that, compare these by the total area occupied. This measuring is relative objective. Crowding is a negative assessment of density. This assessment is done with an opinion that the observed number is too high for the area that is occupied. Because crowding is a value judgement, it is often used as the term 'Perceived crowding'. Shelby, Vaske & Heberlein (1989) state that to determine the perceived crowding you will need to know more about:

- the setting;
- the desired activity; and
- the individuals making the evaluation.

To give an example of the above, suppose there are 5 people in an area one day and 50 people the other day. Density is in the second day clearly higher, but is the area more crowded the other day? If the area is a big square in a city center it is both days not crowded, but if the area is a small front yard, it may be considered as crowded both days. The perceived crowding might be evaluated differently by various individuals. Regarding the previous example it might be that people who live in a small village evaluate the perceived crowding differently in comparison with people who live in cities.

2.2.1 Personal space

Shelby, Vaske & Heberlein (1989) also state that human crowding has a lot to do with personal space violations. This is an invisible and for each individual different amount of space, which indicates the preferred distance from others (Burgoon, 2006). Burgoon & Jones (1976) concluded that people do not tolerate extended physical contact with other people. Also people dislike being unnecessary close to other members of the species. Humans have a need for a certain degree of spatial insulation from other people.

Researchers talk about the normative distance, which is the distance that is acceptable for a given communication context in a certain situation. The communication context is based on several features (Burgoon, 2006):

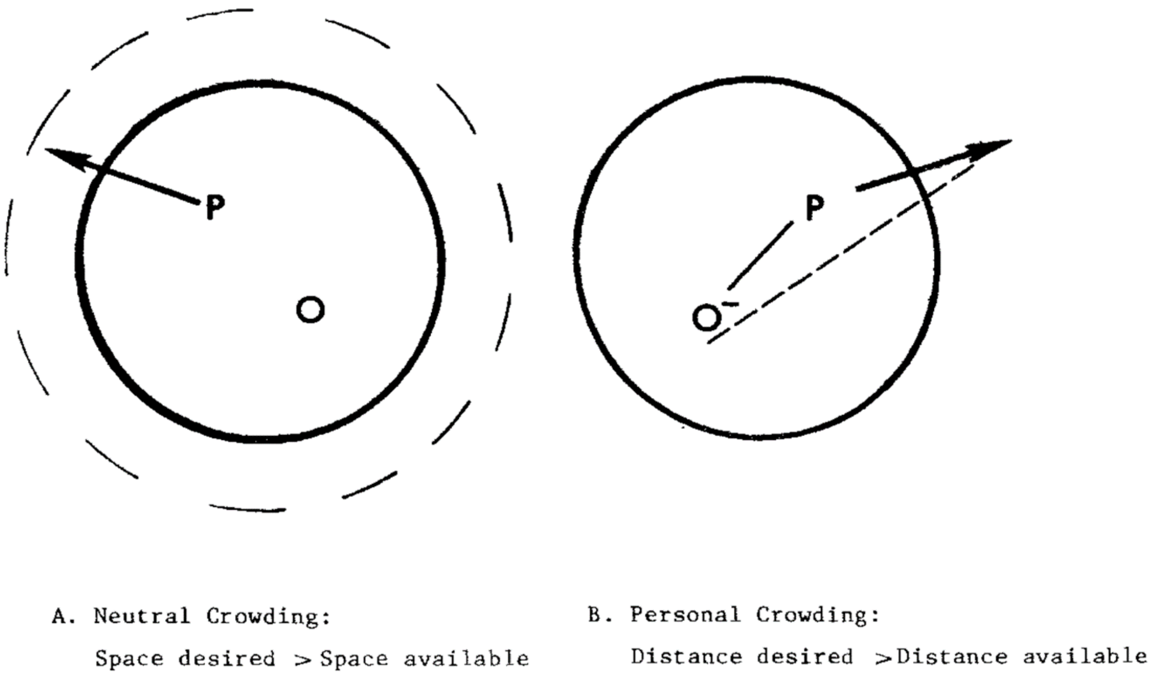
- Characteristics of the people who observe the situation, like gender, age and status.
- Characteristics of the interaction itself, like target of the interaction, formality and intimacy.
- Characteristics of the environment, includes the amount of space available, weather and other things which might have an influence on the behavior of people.

A research of differences in gender concerning spatial behavior indicates that females need on average less personal space in comparison with males. Females can also tolerate closer interpersonal contacts than males (Baxter, 1970).

The idea of a personal space gives a certain predictability and stability to an interaction between two or more people. A violation of the standard, which makes the situation less predictable, can cause a change in someone's sense of control (Seligman, 1975). The disability to control any activities and outcomes in situations with a high density may contribute to the perceived crowding. An experiment by Rodin, Solomon & Metcalf (1978), concludes that there is a causal relationship between the degree on which the activity can be controlled and the perceived level of crowding (Mueller, 1981).

2.2.2 Neutral and personal crowding

Stokols (1976) stated that there are differences in crowding. Neutral crowding is defined as interactions between person (P) and others (O), which are not directly derived from O, are not specifically pointed at P and are perceived by P as being unintended. On the other hand is personal crowding about interactions which derive directly from O are specifically pointed at P and the person perceives this as planned and intentionally by O. In figure 1 there are the varieties about the differences in kind of crowding shown schematically.



-Figure 1: Neutral and Personal varieties of crowding (Stokols, 1976)

Furthermore, there are differences in kind of environment where crowding takes place. We specify two different environments, primary and secondary environments. Primary environments are areas in which an individual spends a lot of time, the individual knows others on a personal basis and the individual executes a lot of personally important activities in this environment. Examples of primary environments are on the work floor and in someone's dwelling. Secondary environments are areas in which individuals cross others who are relatively anonymous. Examples of this type of environment are traveling to work and shopping in the shopping mall (Stokols, 1976). With secondary environments Stokols means public environments, where the needs for personal space will become less important for people who are using that area, in comparison with the needs of mutual-protection and physical-safety.

Table 1 shows the four different basic types of crowding classified on whether the situation is in a primary or secondary environment and if the crowding is on a personal or a neutral base. For each type is a description, possible consequences and example shown.

-Table 1: A typology of crowding experiences (Stokols, 1976)

		Primary	Secondary
Personal Thwarting	Antecedents:	Violation of spatial and social expectations in the context of continuous, personalized interaction	Violation of spatial and social expectations in the context of transitory, anonymous interaction
	Experience:	Rejection, hostility, alienation, high intensity, persistence and generalizability	Annoyance, reactance, fear, moderate intensity, low persistence and low generalizability, tendency toward "neutralization"
	Behavior:	Behavioral withdrawal, aggression, passive isolation	Self-defense, leave situation
	Example Situation:	Antagonistic suitemates occupying mutual living space	Approach by threatening strangers on a crowded street
Neutral Thwarting	Antecedents:	Violation of spatial expectations in the context of continuous, personalized interaction	Violation of spatial expectations in the context of transitory anonymous interaction
	Experience:	Annoyance, infringement, reactance, moderate intensity, persistence and low generalizability, tendency towards "personalization"	Annoyance, reactance, low intensity, persistence and generalizability
	Behavior:	Behavioral withdrawal, improve coordination with others, augmentation of psychological space	Improve coordination with others, augmentation of psychological space
	Example Situation:	Family confined to a small apartment	Attendance of a crowded concert, laboratory experiment

2.2.3 Previous research about level of perceived crowding in other fields

The perceived level of crowding has been studied quite a lot in a retail/shopping context. This also is valid for the field of tourism, recreation, and events. Most of this research into crowding has focused on the perceptions of the occupants and the effects crowding has on their behavior (Kim, Lee, & Sirgy, 2016). The perceived level of crowding is a lot researched in relation to pedestrians. Especially the pedestrian flow in urban environments is often the subject of crowding researches.

(Li, Kim, & Lee, 2009) specified two different crowding situations, these are human and spatial crowding and can result in different emotions for the occupants. With spatial crowding is meant the following: "*feelings of restricted physical body movement due to high spatial density*" (Li, Kim, & Lee, 2009). This kind of crowding can lead to negative emotions.

With human crowding the following is meant: *"feelings related to high human density reflective of social interactions*" (Li, Kim, & Lee, 2009). This kind of crowding is the crowdedness seen as wanted, for example at a concert. This kind of crowding leads in most of the cases to positive emotions.

2.3 Crowding on bicycle paths

Recently the bike is undergoing a true revival in the Netherlands. Especially in urban areas the bike is regaining its popularity again. According to the KIM (Dutch Knowledge Institute for Mobility policy) the bike as transportation mean in 2015 is used 9% more in comparison with the year 2009 (Lange, Talens, & Hulshof, 2017). Last year the amount of sold bikes has risen again, after years of decline. The popularity of the bicycle is mainly due to the continuous growth of the amount of e-bikes. Almost a third of all new bikes are electrical (Termaat, 2018). The bike is especially used in trips till 5 km. Fast cycling routes ensure that cycling becomes an attractive mode of transport for larger distances (Lange, Talens, & Hulshof, 2017). For example, recently the fast cycling route between Schiedam and Maassluis is completed. The path is part of the regional cycle route between Rotterdam and Hoek van Holland (Vlaardingen24, 2017). The bicycle will be a lot more attractive for people who live within cycling distance of their work in comparison with the car, with the renewed connection (Vlaardingen24, 2017). A lot of cities have policies that discourage the use of the car in the city center. Several specific measures are paid parking, less room in the city for cars and a ban of cars that exceed the pollution limit (Theeuwen, 2017).

This regained interest and share of the bicycle in the Dutch street scene is partly because new groups discover the bike as transportation means (Lange, Talens, & Hulshof, 2017):

• Elderly people continue to cycle for a longer period of time due to the availability of e-bikes. For seniors, cycling becomes more attractive because of the availability of E-bikes. E-bikes offer people faster travel with less physical effort. Additionally, it is important to mention that the age forecast has increased considerably in the Netherlands. People generally become older and live longer without any physical limitations. A recent research states that by 2040, people are on average 81 years when they start experiencing any physical limitations (De Zeeuw, 2018).

• People who used to travel by bus or tram more often choose the bike as transportation mean. This might be caused by price increases in public transport. In the past ten years the average prices for travelers in the public transport rose with almost 26 percent (Voermans, 2017). In the period from 2010 till 2017 the total distance that Dutch people travel by bus, tram and metro decreased with 3.5%. In the same period the total bike distance of Dutch people increased with 5.8% (CBS, 2018).

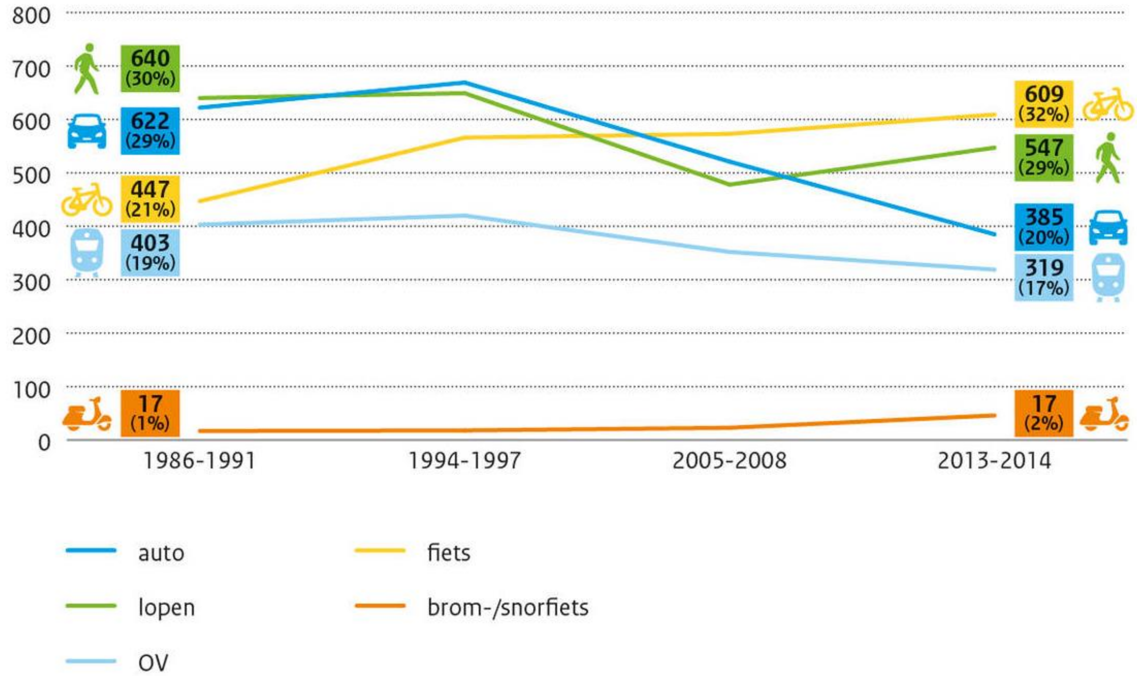
• Two-income families more often live in urban areas within cycling distance of a train station. Cycling from home to the station is very common in the Netherlands. Around 33% of train passengers do that. The bicycle thus brings the train within reach, especially for travelers who live one to three kilometers from a station (Fietsverkeer, 2003).

• Travelers use more often the ‘OV-bike’ to reach their final destination. The NS, the Dutch railroad company, started in 2008 with the ‘OV-bike’. Travelers can rent a special bike from a busy public transport hotspot for a relative cheap price. Last decade the usage of these bikes has grown largely. In 2017 a total of 3.2 million bike rides were executed on an ‘OV-bike’. This bike is often used by train travelers for their final part of their trip and is for instance an alternative for the bus or metro (Nederlandse Spoorwegen, 2018).

• More people with a non-western background discover the bicycle. The bicycle has still status problems among this group of the Dutch population and some people are not able, or are not allowed to cycle because of, for example, religious conviction. For people who are unexperienced in cycling, some organizations organize with success cycling lessons for several years already, specifically for non-western women (Harms L. , 2006).

• Primary school students go more often to a school outside the neighborhood, which is not within walking distance. In ten years the average distance to a primary school for students is increased by 100 meters in the Netherlands (CBS, 2015).

Figure 2 shows that bicycle use has increased by 36 percent since the mid-1980s for all journeys within Amsterdam. The car and public transport shares have declined in the same period (Harms L. , 2017). In Nijmegen the morning peak is so busy that it leads to a lot of bike congestion and irritations. Harriët Tiemens who is deputy mayor of mobility in Nijmegen says that the municipality of Nijmegen wants to eliminate the growing number of bicycle congestions in the city. Although she is pleased that more and more people are taking the bike in Nijmegen (De Gelderlander, 2016). Harms (2017) states that this ‘modal shift’ in these cities are partly due the changed composition of the population and the local anti-car policies. In the same time is the popularity of the bicycle in rural areas decreased. The population decline and the fewer number of facilities in the neighborhood might be a good reason why the bike is not that popular anymore in these regions.



-Figure 2: Number of trips (x 1,000) from/to/within Amsterdam by residents per working day by means of transport in period between 1986-2014 (Gemeente Amsterdam, 2015)

2.3.1 Problematic places

Recent research has shown that almost 10% of the cyclists have problems with busy cycle paths. Antisocial behavior is often seen as the worst annoyance. Especially the unnecessary cycling side by side is disliked by a lot of people. Most cyclists experience crowding at locations in urban areas and in 33% of the crowded cases it concerns a highly urban area (Munckhof, Zengerink, & Avest, 2017). When it is crowded on bicycle paths, cyclists find it annoying that they have to wait a long time at traffic lights. Unable to bike at the desired speed is also disliked by a serious amount of people. About half of the respondents choose a different route to avoid crowdedness. About 33% of the cyclists leave the bike sometimes at home to choose other means of transport because of the crowded bicycle paths (Munckhof, Zengerink, & Avest, 2017).

The busiest cycle paths are located in urban areas, mainly in large cities. Also some smaller municipalities have problems in their centers regarding crowded bicycling paths. Several touristic zones are experiencing crowding issues on their bike paths. It can also be quite crowded on connecting cycle routes between the centers of different cities. The moments of the largest crowds in urban areas are the (school) peak hours, where the morning peak is the most crowded. The most crowded bicycle paths in the urban area are located (Lange, Talens, & Hulshof, 2017):

• In the center of cities,

• At intersections and crossings for pedestrians, especially if there are long waiting times,

• On roads with limited width,

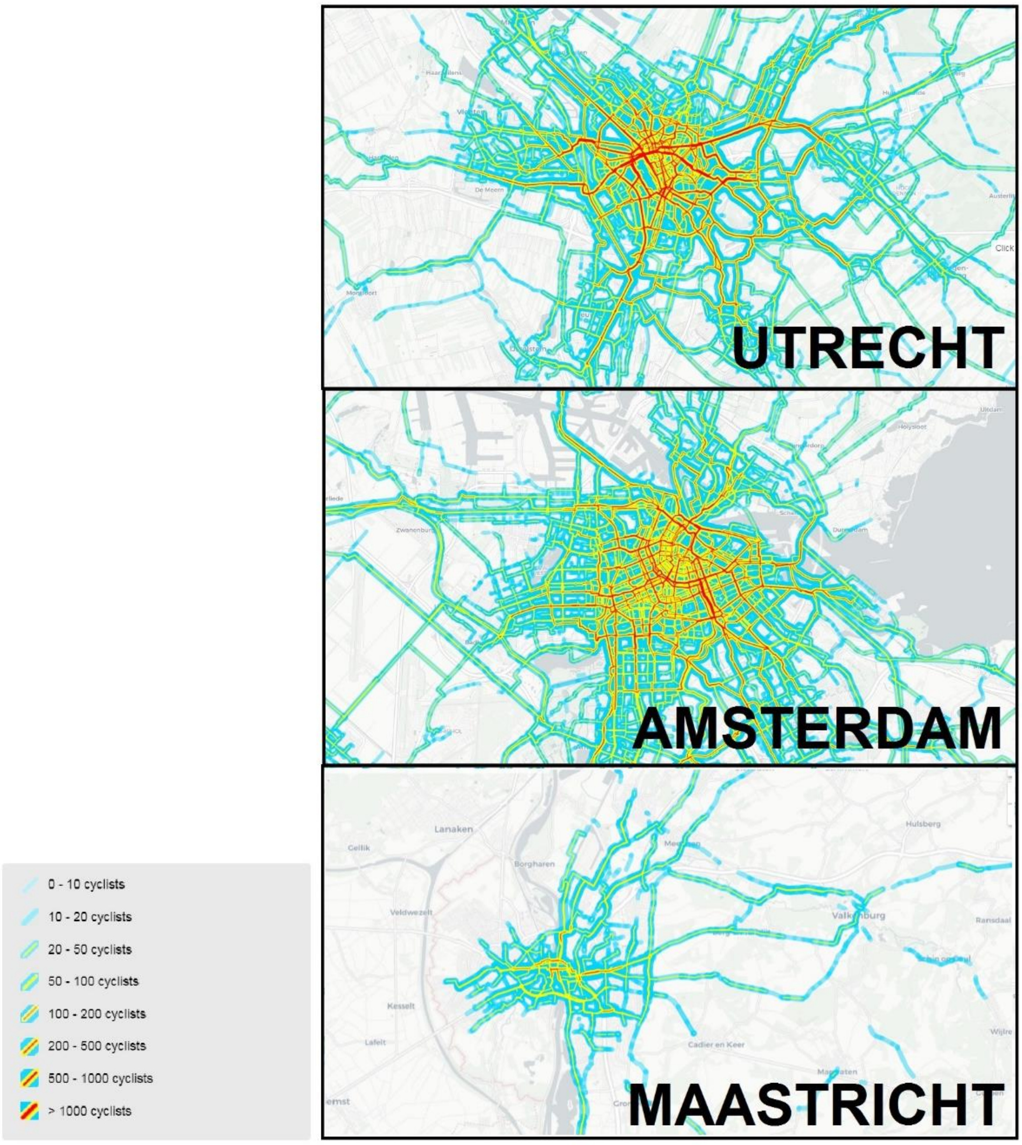
• In streets with many different usage functions (such as shopping, parking, walking, car-usage and bike-usage),

• On routes to stations and educational institutions,

• On connections such as bridges and tunnels over barriers such as rail, water or main traffic routes and especially when there are few such links.

The most problems occur in bigger cities. For example, in Nijmegen, Utrecht and Amsterdam the bicycle share increased strongly in relative and absolute amounts (Harms L. , 2017). The Dutch annual bike count week (Fietstelweek) has demonstrated that several locations in these cities have a very high bike usage intensity. This research demonstrated that this is also the case in the following cities: Groningen, Den Haag, Rotterdam and Eindhoven (Rottier, 2017). Figure 3 shows the intensity heat map for the Dutch cities: Utrecht, Amsterdam and Maastricht. These maps are retrieved from the bike count week research of 2016.

Whether a bicycle path is crowded, is now determined on the basis of a few guidelines concerning the width of the bicycle path and bike intensity. If the bicycle path is too narrow for the measured intensity, the bicycle path is considered to be too crowded. An example of such a determination is shown in Appendix A. However, it is questionable whether users also find it crowded on that bike path. According to paragraph 2.2, this is a wrong way to determine crowding, as crowding is more about the evaluation of density in a particular environment and is based on opinions of the users.



-Figure 3: Intensity heat map of cyclists observed in specific situation for the cities Utrecht, Amsterdam and Maastricht (Bike Print, 2016)

2.3.2 Previous research about crowding on bike paths

As described in paragraph 2.2.2, crowding on bike paths has been subject of several researches. Bryon & Neuts (2008) were one of the first researchers to specify the perceived crowding in urban environments, as found in Munckhof et al. (2017). The perceived crowding in urban environments is caused by three different types of factors (Bryon & Neuts, 2008):

• Physical factors, these are objective physical conditions in the environment such as the width of the bicycle path or the number of cyclists.

• Social factors, here it concerns the behavior of other people in the vicinity of the individual. If the behavior of these people to whom the individual is exposed does not meet his own standards and values, this leads to irritation.

• Individual factors, this can be linked to socio-demographic variables. Past experiences also play a role in how the individual experiences crowding. Each person perceives the situation in his or her own way.

Klinkers & van Hoorn (1987) have executed specific research concerning the perceived level of crowding among cyclists. This research was carried out on rural roads. The relationship between the cyclists' perceived level of crowding and the traffic intensity on rural roads in the vicinity of Zwolle was researched. The conclusion of the research was that the higher the intensity of the cyclists, the more crowded the respondents found it. These researchers also found some differences in the assessment of crowding among different sexes and age. More about this in paragraph 2.5.

Botma & Papendrecht (1992) carried out a simulation model concerning the quality of traffic flow on separate cycle paths. In this simulation the degree of nuisance for users of the bike path is encountered in maneuvers such as overtaking or meeting other bicycle users on the bike path. This research resulted in several interesting conclusions, concerning differences in speed and cycling next to each other, these conclusions will also be discussed further in paragraph 2.5.

In another study by de Groot-Mesken et al. (2015) attention is paid to crowding on the bike path in relation to the increasing unsafety on those paths. Particularly in big cities there is a lot of concern about the crowding on bike paths and how to deal with this. The research wanted to investigate, among other things, whether the behavior on more crowded bicycle paths is different than on more uncrowded paths and whether this manifests itself in conflicts. In the study, a cycle path is referred to a cycle path that is too narrow for the bike intensity. It has been established that the speed variation on more crowded bike paths is smaller. Unfortunately, the research could not prove whether crowded bike paths are less safe due to the research method used.

Munckhof et al. (2017) have investigated the crowding on bike paths most recently. With the help of a survey among 2,063 people, it was investigated which factors influence the perceived crowding among cyclists. The respondents were asked to remember a crowded situation they recently experienced and answer several questions with this past situation in their minds. The most important conclusion from the survey was that 10% of cyclists had serious problems with crowding on the bike path, as mentioned earlier in this chapter. Subsequently, 33% of the respondents sometimes take another mean of transport due the crowding on the bike paths. Other findings about the influencing factors will be discussed in paragraph 2.5. The authors of this research advise for a follow-up study to show the causality between subjective crowding versus objective crowding.

2.4 Bicycle level of service

The concept of level of service was introduced in the Highway Capacity Manual of 1965. "*The concept of LOS is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A LOS definition generally describes these conditions in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety*" (National Research Council, 1965).

First were bicyclists seen as an obstacle to the level of service for motorized traffic, but since 1990 is there also special attention for the bicycle level of service. The level of service for bicyclists are more pointed to the "quality of service" and measured by the perceived comfort, safety and ease of mobility. Important is that the quality of the traffic stream has to be assessed as experienced by the user (Performance & Analysis, n.d.).

There are many different ways to measure the bicycle level of service. Determinants which used often are: volume of bicyclists, width of bike path, mean speed, density of bicyclists on the bike path, type of bike path, path conditions and type of traffic (one-way or two-way) (Botma, 1995), (Johnson, 2014).

The bike paths which are determined, will get a score from A to F, in where A is the highest level of service and F is the lowest level of service for the bicyclists. For example, Navin (1994) suggests the following for the BLOS regarding the density on the bike path; at a LOS of A has each cyclists more than 9.3 m^2 space to occupy on the bike path, here the cyclist has total freedom to maneuver. The LOS ranges till LOS F, where the cyclists has less than 3.0 m^2 to occupy on the bike path and almost no freedom to maneuver. The rest of the suggested values are shown in table 2.

-Table 2: Level of Service for a Cycle Path regarding density determinant (Navin, 1994)

LOS	m^2 / bic	k bic / m^2
A	>9.3	0.11
B	>7.0	0.14
C	>4.7	0.25
D	>3.4	0.29
E	>3.0	0.33
F	≤3.0	0.33

The Florida DOT Q/LOS handbook states that bicycle volume does not have an effect on the Bicycle level of service. This is because bicycle volumes rarely reach a critical point in which thus volume affects the bicycle traffic flow, a delay or have an effect on the comfort of the cyclists. (State of Florida Department of Transportation, 2013) as found in (Johnson, 2014).

What does have a major influence on the BLOS is the frequency of hindrance perceived by the bicyclists. Botma (1995) states that there are three kinds of maneuvers on the bike path which can be specified:

- Passing a cyclist going in the same direction
- Meeting a cyclist going in the opposite direction
- Combination of passing and meeting

Every maneuver brings some discomfort, inconvenience and possible safety issues for the cyclists which are involved. This is specified as hindrance on the bike path. With a simulation model, can the frequency of all these maneuvers be determined. Botma (1995) developed a hindrance method for the bicycle level of service. With equation 2.1 the frequency of the passing on the bike path can be calculated.

$$F = 2Q\sigma/\{U\sqrt{\pi}\} \tag{2.1}$$

Where
F = Frequency of passing
U = the mean speed (default of 18 km⁄h)
σ = standard deviation of speed (default of 3 km⁄h)
Q= volume of bicycles (bicycles/h)

This leads to the following suggestions to determine the LOS for bike paths, as shown in table 3. With a 2-lane Botma (1995) means a path where bicyclists can cycle with two people next to each other. On a 3-lane path is this possible with three people.

-Table 3: Service Volumes According to Hindrance Criterion (Botma, 1995)

LOS	% with Hindrance over 1 km	Service volume (bic/h) (one way)	
		2-lane	3-lane
A	0-10	130	780
B	10-20	260	1560
C	20-40	520	3120
D	40-70	910	5460
E	70-100	1300	7800
F	100	---	---

2.5 Attributes influencing bicyclist's perceived level of crowding

In this paragraph all the relevant attributes will be stated that might influence the bicyclist's perceived level of crowding. This paragraph is divided in four sub paragraphs:

- Traffic conditions on bicycle path,
- Surrounding bicycle path,
- Physical bicycle path conditions,
- Individual factors.

2.5.1 Traffic conditions on bicycle path

The research of Klinkers & van Hoorn (1987) concluded that the higher the **intensity** of the cyclists is the more crowded the respondents find it.

The study by Botma & Papendrecht (1992) clearly showed that people experience a lot of annoyance when the **share of mopeds** increases on the bike path. The biggest annoyances concerning the mopeds are the speed differences, smell, and noise.

Furthermore, the same study showed that people experience a lot of annoyance when the **level of duo-cyclists** increases. This means that cyclists cycle more alongside each other. There was no difference in the proportion of duo bicycles and the lane in relation to the perceived annoyance. Munckhof, Zengerink, & Avest (2017) also state that the level of duo-cyclists on the bike path is the most important social contributor to the perceived level of crowding. Other important social contributors to the perceived level of crowding, according to this study, are: not going to the side, using mobile phones, overtaking without paying attention, and unexpected movements.

The **level of speed differences** is a less important social contributor to the perceived level of crowding. Though speed differences are a big issue on bike paths recently, due the popularity of E-bikes and racing bikes (Munckhof, Zengerink, & Avest, 2017). According to Martijn van Es of the Fietsersbond, the annoyances of race bikes have increased considerably in recent years and the infrastructure becomes overcrowded. This might be due Dutch professional cyclists who had recently successes in big tours (Van den Broek, 2018).

2.5.2 Surrounding bicycle path

As described in paragraph 2.2 the desired activity for a specific location, among other things, is important in the evaluation of the perceived crowding (Shelby, Vaske, & Heberlein, 1989). This is based on the perceiver's past experiences of that location (Bryon & Neuts, 2008). **Land use** plays an important role in specifying the location. Land use is seen as the function of a specific location, like residential and agricultural. So basically is it how humans use the location. Most of the times, the land use is clear to the observer due to its appearance.

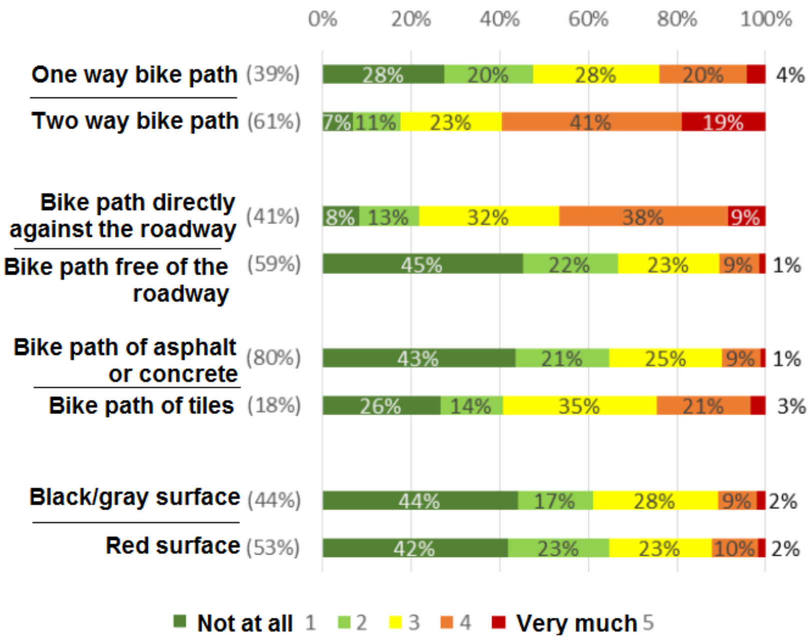
2.5.3 Physical bicycle path conditions

The results of Munckhof, Zengerink & Avest (2017) state that in the most crowding situations, the cyclists was cycling on a two-way bike path (in comparison with one-way bike paths) (figure 4). This might indicate that the **number of directions** is a relevant attribute to perceived level of crowding on bike paths.

The same research also states that cycling on a bike path next to the roadway may influence the level of the cyclist's perceived crowding, this in comparison with bike paths with no roadway near (figure 4). The **bike path type** might play a role in the perceived level of crowding.

Just like intensity level the **width of the bike path** is a major indicator of perceived crowding. Munckhof et al. (2017) found that more than 50% of the respondents think that width of a bike path contributes a lot to the perceived level of crowding on bike paths.

Bike paths are often red, but there are plenty cases where the bike path is gray (tiles) or black (asphalt). The previously mentioned research has shown that the **color of the bike path** makes no difference in perceived level of crowding (figure 4). At last, the same research found that there was an obvious difference between the **material of the bike path** and the perceived crowding.



-Figure 4: Extent in which bike path conditions contribute to the perceived level of crowding (Munckhof, Zengerink, & Avest, 2017)

2.5.4 Individual factors

Klinkers & van Hoorn (1987) have found in their research that there is a significant difference between men and women (**gender**) when evaluating the perceived level of crowding. Male respondents are more likely to evaluate situations as less crowded in comparison with the female respondents. Though, a research of differences in gender concerning spatial behavior indicates that females need on average less personal space in comparison with males as stated in paragraph 2.2.1. Females can also tolerate closer interpersonal contacts than males (Baxter, 1970).

Klinkers & van Hoorn (1987) concluded that there is a relationship between **age** and valuation of the perceived crowding on the bike path. Older cyclists evaluate the situation in their research as less crowded in comparison with younger cyclists. The border between 'older' and 'younger' was set on 51 years old. A possible explanation, according to the researchers, is a difference in observation and perception for the distinguished groups. It could be that older respondents are less critical about a situation in comparison with younger respondents.

Although the previous researches in this paragraph found that there is a significant relationship between age/gender and the valuation of the crowded situation, Botma & Papendrecht found that there was no significant difference in their research concerning the level of annoyance on the bike path and these two individual factors.

Finally, Krabbenborg et al. (2015) found that respondents from less populated urban areas (defined as fewer than 1500 addresses per km2) have a strong aversion to crowded cycle paths in comparison with respondents living in more populated urban areas. This might indicate that the **urbanity levels** of respondents' residential areas have an influence on the perceived level of crowding on people.

2.6 Attributes influencing bicyclist's perceived level of safety

Godefrooij (2018) sees a clear relationship between the perceived crowding on the bike path and the perceived safety by the cyclists. If it gets too crowded, it can lead to unsafe situations. In this paragraph all the relevant attributes will be stated, which might influence the bicyclist's level of safety. This paragraph is divided into four sub paragraphs:

- Traffic conditions on bicycle path,
- Surrounding bicycle path,
- Physical bicycle path conditions,
- Individual factors.

2.6.1 Traffic conditions on bicycle path

Lankhuijzen et al. (2016) mention that most people, who find it unsafe on the bike path blame the behavior of other road users. This could therefore be unnecessarily cycling next to each other, use of mobile telephone or other social contributors, like cycling on the wrong side of the bike path and overtaking without paying enough attention. The same research states that some cyclists experience annoyance by big groups of professional cyclists who pass by in a high velocity. For the cyclists in some cases this can be very surprising and can cause unsafe situations (Lankhuijzen, Ruijs, & Orsouw van, 2016). **Speed differences** might also cause unsafe situations for users of the bike path. Speed pedelecs can, according to a research, be quite dangerous when the capacity of the cycle path is already limited. This might be one of the reasons why at the moment it is not allowed anymore to use a speed pedelec on a regular bike path (Schepers & Voet, 2014). 'Normal' cyclists move on the bike path with a maximum speed of 19 km/h. An E-bike user can cycle with a maximum of 32 km/h which is clearly faster.

VVN, an organization that works for safe traffic in the Netherlands, believes that bicycle paths should be made more suitable for e-bikes. According to VVN, speed differences on the bike path between electric and normal bicycles cause often accidents (ANP, 2018).

On two-way cycle paths, which are often too narrow and where the cyclist needs to pay attention to cyclists from the other direction it is safer to cycle one behind the other. Safety problems only exist on routes with capacity problems (Lehner-Lierz, 2006). The **level of duo-cyclists** might influence the perceived safety. Duo-cyclists are two cyclists who bike next to each other.

2.6.2 Surrounding bicycle path

Cox et al. (2017) found that car drivers perceive roads in rural areas as less risky than roads in urban areas. This might indicate that car drivers feel less safe in urban areas. In most cases in urban areas there is more traffic on the road. This might cause this difference. It is not proven whether this difference also exists among bicycle users. An article in a newspaper mentions the dangers of cycling on rural roads, but this is more about cycling in rural areas with no separate bike paths (Brady, 2011). On the other hand Jaarsma (2011) states that rural roads are clearly more unsafe for cyclists. This might indicate that the **land use** based on urbanity can influence the perceived safety by the cyclists.

Research about subjective safety showed that cyclists feel particularly threatened by **motorized traffic**. This is remarkable while most (serious) accidents in cycling happen with no other traffic users involved (unilateral accidents). These specific accidents can occur for example because of an obstacle on the road or bike path. But related to the subjective safety it appears that cyclist are hardly afraid for this kind of accidents (Christmas et al., 2010, as cited in Schepers & van der Voet, 2014).

Evans-Cowley & Akar (2013) stated that cyclists may feel safer with the presence of **pedestrians** on the street. They conducted a research in which adult students viewed a series of paired slides of images of city streets. After that the participants were asked to choose which image from the pair they preferred based on which street they would prefer to ride a bicycle. The more pedestrians were seen, the more likely the scenario was chosen. The same research concludes that **trees** next to street give some mixed results concerning the likelihood of being chosen. This might be mostly because of safety perceptions, as stated by the authors. Trees, which were a bit set back from the streets were more likely to be chosen by cyclists in comparison with the scenario with no trees. On the other hand, scenarios in which the trees were closer and denser trees to the cyclist were less likely to be chosen. This might be because of the decreasing visibility for the cyclists.

2.6.3 Physical bicycle path conditions

De Groot-Mesken et al. (2015) mention that too narrow bike paths lead to unsafe situations for the cyclists. Another research states that bike paths with a high intensity and a limited **bike path width** play a big role in unsafe situations among the cyclists. There is also a possibility that cyclists will move more to the edge of the bike path, which, depending on the type of roadside or sidewalk, results in additional safety risks (De Goede, Obdeijn, & Van der Horst, 2013). For some cyclists, the width of the bike path is reason for dissatisfaction. On narrow bike paths, the scooters and e-bikes will come close to the cyclists at a higher speed and since there is limited space available in this kind of bike paths, this can cause an unsafe feeling for the cyclists (WoW, 2017).

As mentioned in the previous paragraph most of the bike accidents happen with no other traffic users involved. It has been found that approximately half of this kind of accidents is (partly) related to one or more infrastructure-related factors. A loose tile is often mentioned as a possible cause (Schepers et al., 2009). The **material of the bike path** might be an indicator for the perceived safety by the cyclists.

2.6.4 Individual factors

DeJoy (1992) states that males tend to take more risks concerning driving behavior in comparison with females. "*There were clear gender differences in the ratings of accident likelihood and seriousness*" (DeJoy, 1992). This research might indicate that males feel safer on the road, regarding their risk-taking behavior. Although, it is not with certainty to say whether **gender** differences have influence on the perceived level of safety on the bike path, since this research is based on car drivers.

Shigematsu et al. (2009) concludes that there is a significant difference between **age** groups concerning the perceived safety of pedestrians. In this research the youngest age group (between 20 and 39 years old) perceived the situation as most safe and the oldest age group (76 years old and older) perceived the situations as least safe. Again it is not with certainty to say that this difference also occurs among cyclists, since this research is only based on pedestrians.

People who live in rural areas tend to take much more risks in traffic. This concludes a research which compared the behavior of car drivers who lived in rural areas and car drivers who lived in urban areas. The result might indicate that people who live in rural areas feel more secure and safe in a car (Rakauskas, Ward, & Gerberich, 2009). It is not certain whether this is also the case on a bicycle. The **urbanity levels** of respondents' residential areas might influence the way they perceive the level of safety on the bike path.

2.7 Attributes influencing bicyclist's perceived level of comfort

In this paragraph all the relevant attributes will be stated, which might influence the bicyclist's level of comfort. This paragraph is divided in four sub paragraphs:

- Traffic conditions on bicycle path,
- Surrounding bicycle path,
- Physical bicycle path conditions,
- Individual factors.

2.7.1 Traffic conditions on bicycle path

The **intensity** of bicyclists on the bike path is found to have a negative impact on the bicyclist's perceived level of comfort. "*Bicyclists do not like to ride in heavy amounts of bicycle traffic because high bicycle flow rate increases disturbances among bicycles*" (Li, Wang, Zhang, Lu, & Ragland, 2011). Bai et al. (2015) state that bicyclists are more likely to have a low level of comfort as the volume of the amount of bicyclists increases on the bike path.

In a recent bicycle research in collaboration with the municipality of Rotterdam it is shown that residents with an ordinary bike feel less comfortable because of the presence of vehicles with a higher velocity. It is forbidden to ride mopeds on bike paths, but according to the residents this rule is often violated. The residents of Rotterdam also experience dangerous situations due to the rise of the e-bike, which decreases their comfort on the bike path (Groenendijk, Olde Kalter, & Sturm, 2017). Another research states that the e-bikes are very popular in urban areas and because of their greater speed and limited space available on the bike path are causing unsafe and uncomfortable situations for other users of the bike path (De Goede, Obdeijn, & Van der Horst, 2013). It seems that **speed differences** on the bike path play a big role in the cyclists' perceived comfort.

The research by Botma & Papendrecht (1992) has shown that cycling next to each other can cause major nuisance for the other users of the bike path. This study shows a significant relationship between the **level of duo-cyclists** and the perceived nuisance.

2.7.2 Surrounding bicycle path

Lee, Jennings & El-Geneidy (2010) stated that cyclists are more likely to choose for bike paths along residential, water and industry environments. On the other side they choose less likely for bike paths along commercial, park and recreation areas. A commercial area is a street where a lot of commercial buildings are located, for example restaurants, shops and offices. A commercial area is mostly an area with a lot potential conflicts with other traffic such as motor vehicles. This kind of environments is also more likely to be busy. This might be a reason why cyclists prefer not to choose cycling in a commercial area. This is also the case for paths next to highways and major roads. This might indicate that the **land use** based on urbanity can influence the perceived comfort by the cyclists.

The amount of **pedestrians** next to the bike path is an attribute to consider. Lee, Jennings & El-Geneidy (2010) state that cyclist are less likely to choose for a route with a strong commercial land use share. Streets which are used commercially are often more crowded on the street, but also next to it. This might indicate that the level of pedestrians next to the bike path can have a negative contribution to the users' perception of comfort. Tough, another research states that the presence of pedestrians has a positive effect on the experienced comfort for cyclists (Krabbenborg, Annema, & Snellen, 2015). This is also concluded by another research by Evans-Cowley et al. (2013), which says that "*the presence of pedestrians on the street may give a sense of safety and security to bicyclists*".

The use of **vegetation,** especially the presence of trees and shrubs, has positive effects on preference. Residents respond with a relative low preference to landscapes that contain only grass vegetation. The use of grass as vegetation has little effect on preferences (Ulrich, 1986). In this research trees came out as the most preferred vegetation. Another research about the factors influencing the desirability of a street for bicycling, states that a street with trees has overall a positive effect on the likelihood to be chosen by cyclists. This is in comparison with streets without any vegetation. Though, this depends on the position of the tree, as described in paragraph 2.5.2 (Evans-Cowley & Akar, 2013).

As described earlier in this paragraph cyclists try to avoid roads with high **car intensity** (Lee, Jennings, & El-Geneidy, 2010). Another research found that the more visible vehicles, the least the likelihood of choosing this situation. This indicates that the increasing traffic intensity has a possible negative effect of the comfort of bicyclists (Evans-Cowley & Akar, 2013). At last, van Overdijk (2016) stated that the traffic speed has a negative effect on cyclist's perceived level of comfort.

2.7.3 Physical bicycle path conditions

Sener et al. (2009) found that bicyclists prefer to bike on a shared roadway, open to both bicyclists and motor vehicles, in comparison with a separated bike lane. This might indicate that bicyclists like to have more maneuvering room and not wants to be "*boxed*". Though several other researchers conclude the opposite; Broach et al. (2012) and Li et al. (2011) state that bicyclists prefer to ride on a separated path. The **type of the bike path** might have a major influence on the perceived level of comfort by the bicyclist.

The **width** of the bicycle path has a positive relation with the perceived level of comfort for the bicyclist. Wider paths provide more space for cycling (Li, Wang, Zhang, Lu, & Ragland, 2011). This is also stated by Bai et al. (2015). Just like the previous possible attribute stated Sener et al. (2009) the opposite; the width showed no statistically significant differences in preferences between a narrower and a wider bike path.

The **color** of the bike path might influence the perceived comfort of bicyclists. Nowadays most of the bike paths in the Netherlands are red. Though Danish and Canadian research state that blue and green bike paths are the most appropriate ones, especially due safety reasons. In Copenhagen most of the bike paths are because of this blue (Verkeer in Beeld, 2015). Color can play a role on emotions, behavior and functioning, because the brain associating a color with certain concepts. A single color however can have multiple associations. The color red may be associated with negative concepts such as danger and fear. The color blue is associated with safety, softness and calmness (Hill & Barton, 2005) as found in (Luttels, 2013).

2.7.4 Individual factors

Krabbenborg et al. (2015) stated that people who live in rural areas tent to have a strong preference for routes with trees, in comparison with people who live in more urban areas. The **urbanity levels** of respondents' residential areas might influence the way they perceive the level of comfort on the bike path.

Males prefer lower car intensities next to the route, in comparison with females (Sener, Eluru, & Bhat, 2009). Although, it is not with certainty to say whether **gender** differences have influence on the perceived level of comfort on the bike path in the Netherlands, since this research is based on cycling in Texas.

2.7.5 Overview found literature

Table 4 shows an overview of all found literature, corresponding to the possible included attributes and the three dependent variables.

-Table 4: Overview found literature

Attribute Group	Attributes	Perceived level of crowding	Perceived level of safety	Perceived level of comfort
Traffic conditions on bike path	**Intensity level of cyclists**	(Klinkers & van Hoorn, 1987)		(Li, Wang, Zhang, Lu, & Ragland, 2011), (Bai, Liu, Li, & Wang, 2015)
	Share of mopeds	(Botma & Papendrecht, 1992)	(WoW, 2017)	(Groenendijk, Olde Kalter, & Sturm, 2017)
	Level of duo cyclists	(Botma & Papendrecht, 1992),(Munckhof, Zengerink, & Avest, 2017)	(Lehner-Lierz, 2006)	(Botma & Papendrecht, 1992)
	Level of speed differences	(Munckhof, Zengerink, & Avest, 2017) (Van den Broek, 2018)	(Lankhuijzen, Ruijs, & Orsouw van, 2016)	(De Goede, Obdeijn, & Van der Horst, 2013)
Surrounding bike path	**Land Use**	(Shelby, Vaske, & Heberlein, 1989), (Bryon & Neuts, 2008)	(Cox, Beanland, & Filtness, 2017), (Brady, 2011)	(Lee, Jennings, & El-Geneidy, 2010)
	Level of pedestrian activity		(Evans-Cowley & Akar, 2013)	(Lee, Jennings, & El-Geneidy, 2010), (Krabbenborg, Annema, & Snellen, 2015), (Evans-Cowley & Akar, 2013)
	Vegetation		(Chirstmas, Helman, Buttress, & Newman, 2010)	(Ulrich, 1986), (Evans-Cowley & Akar, 2013)
	Intensity Car Traffic		(Chirstmas, Helman, Buttress, & Newman, 2010)	(Lee, Jennings, & El-Geneidy, 2010), (Evans-Cowley & Akar, 2013), (Van Overdijk, 2016)
Physical bike path conditions	**Width Bike Path**	(Munckhof, Zengerink, & Avest, 2017)	(Groot-Mesken, Vissers, & Duivenvoorden, 2015), (De Goede, Obdeijn, & Van der Horst, 2013)	(Li, Wang, Zhang, Lu, & Ragland, 2011) (Bai, Liu, Li, & Wang, 2015), (Sener, Eluru, & Bhat, 2009)
	Bike path type	(Munckhof, Zengerink, & Avest, 2017)		(Sener, Eluru, & Bhat, 2009), (Broach, Dill, & Gliebe, 2012), (Li, Wang, Zhang, Lu, & Ragland, 2011)
	Color of Bike Path	(Munckhof, Zengerink, & Avest, 2017)	(Schepers, Brinker den, & Ormel, 2009)	(Hill & Barton, 2005), (Luttels, 2013)
Individual factors	**Gender**	(Klinkers & van Hoorn, 1987), (Baxter, 1970)	(DeJoy, 1992)	(Sener, Eluru, & Bhat, 2009)
	Age	(Klinkers & van Hoorn, 1987), (Botma & Papendrecht, 1992)	(Shigematsu, et al., 2009)	
	Urbanity level of respondents residential area	(Krabbenborg, Annema, & Snellen, 2015)	(Rakauskas, Ward, & Gerberich, 2009)	(Krabbenborg, Annema, & Snellen, 2015)

2.8 Conclusion Literature Review

In this chapter the definition of crowding is defined. This crowding assessment is done with an opinion that the observed number is too high for the area that is occupied. Because crowding is a value judgement, it is often used as the term 'Perceived crowding'. Furthermore, the state of crowding on bike paths in the Netherlands is explained. The increase in intensity of cyclists is due a number of measures. Also new groups discovered the bike. If the bicycle path is too narrow for the measured intensity, the bicycle path is considered to be too crowded. However, it is questionable whether users also find it crowded on that bike path. According to the general definition of crowding, is this a wrong way to determine crowding, as crowding is more about the evaluation of density in a particular environment and is based on opinions of the users. A bicycle level of service determination might be more appropriate to measure the "quality of service". Though, this is still based on factual data, which is still no opinion of users. The few researches who paid attention to the actual perceived crowding found several things. The perceived crowding in urban environments is caused by physical, social and individual factors. Individual factors play also a role in the valuation of the perceived safety and comfort. This chapter included all the relevant attributes, which might influence the bicyclist's perceived level of crowding, safety and comfort.

3. METHODOLOGY

3.1 Introduction

After all the relevant literate is reviewed, includes this chapter a description of the working method used. The theories, methods and techniques to achieve to goal of the research are explained elaborately. Paragraph 3.2 is about choosing an appropriate method and the utility theory. In the next paragraph the researcher will explain why he chose for visualization of the attributes. Paragraph 3.4 is about all the taken steps of constructing an appropriate stated preference experiment. Next the researcher explains what choices he made in visualize the attributes and how he did visualize the attributes. The last two paragraphs are about the construction of the survey and the data collection.

3.2 Choice modeling

Individuals make choices every day and different influences affect these choices. If a decision maker is placed in a position where the individual needs to make several decisions, researchers can investigate mutual relations between the choices. Hensher et al. (2005) state that making a choice set is a very complex and time consuming process. Before starting with constructing the choice set, it is important to figure out what influences the choice of individuals. That is why the researcher already conducted an extensive literature research in order to find the most influential attributes regarding the topic. The results of this literature review are shown in paragraphs 2.4, 2.5, and 2.6.

3.2.1 Choosing a method

To answer the main research question a *Stated Preference (SP) experiment or Revealed Preference (RP) experiment* will be executed. The following is meant by a SP experiment: the researcher will setup a specific situation, to which the respondent needs to react. This will be in a 'controlled' environment and will be a hypothetical situation (Verschuren & Doorewaard, 2002). With a RP experiment the following is meant: the researcher will obtain all data from the real world in which respondents act in their natural behavior (Hensher, Rose, & Greene, 2005).

Stated Preference experiments have several pros and cons. This strategy has often a very high level of internal validity. This could help in demonstrating causal relations. The researcher can adjust the research environment for the respondents, what could help with demonstrating the effects of various factors. The external validity of SP experiments might be a problem. Since respondents are not in their natural environment, they might experience the situation differently. At last these kinds of experiments might cost a lot of time to set up, but this depends on the chosen method (Verschuren & Doorewaard, 2002).

Revealed Preference experiments also have several pros and cons. The external validity in these kinds of researches is very high. Since the data is obtained in the real world it is likely that respondents will act and experience the research in a natural way. The data could be very detailed. Therefore, the researcher could learn more about the subject in depth. It may be more challenging than other methods to document this kind of researches. The biggest con of this kind of researches is the lack of influence on factors like weather, intensity and behavior of other users. Because of this feature it might be harder to demonstrate causal relations. Additionally, the researcher is limited to collect only data in existing circumstances (Hensher, Rose, & Greene, 2005).

In table 3 the most important advantages and disadvantages are summarized. Overall the researcher will choose for the Stated Preference experiment. This will be the best choice for seeking causal relations which is the goal of this research. Furthermore, it would be harder to research the potential attributes with a revealed preference experiment.

-Table 5: The most important advantages and disadvantages summarized for Stated and Revealed preference methods (Hensher, Rose, & Greene, 2005) and (Verschuren & Doorewaard, 2002)

Stated Preference	Revealed Preference
-High level of internal validity	-External validity is very good
-Adjusting research environment	-Very detailed data
-Risk on low external validity	-Harder to document observations
-Might cost a lot of time to set up	-No influence on a lot of factors

3.2.2 Utility theory

The utility theory is based on individuals' preferences. Each individual will have different preferences. The utility theory tries to explain the individuals' observed behavior and choices (Saylordotorg, n.d.). The behavior of individuals trying to choose their most preferred alternative is referred to as 'utility-maximization' as stated in Louviere et al. (2000). The utility U_{iq} stands for choosing alternative *i* by individual *q*, this is shown in equation (1). V_{iq} is the 'systematic observed value for utility' and ε_{iq} stand for the unobserved factors.

$$U_{iq} = V_{iq} + \varepsilon_{iq} \tag{1}$$

The observed value of the utility is never equal to U_{iq} since there is an unobserved utility value (ε_{iq}). The unobserved utility factor is unknown and will be treated as a random factor. The observed value of utility (V_{iq}) of alternative *i* for individual *q* can be explained as a function of *k* variables *x* with all the parameter estimates (β) in equation (2) (Hensher, Rose, & Greene, 2015), as found by Overdijk (2016).

$$V_{iq} = f(x_{iqk}, \beta) \tag{2}$$

Hensher et al. (2015) as found by Overdijk (2016) state that the previous equation can be translated to a common used linear function for the observed value of utility. This is shown in equation (3):

$$V_{iq} = \sum_{k=1}^{k} \beta_k \, x_{iqk} \tag{3}$$

The observed utility (V_{iq}) in this equation is equal to the sum of all the parameter estimates (β_k) multiplied with the attribute variable (x_{iqk}).

After knowing the utility of all the attributes and the utility of a specific alternative, the probability that individual q chooses for alternative I instead of alternative j can be calculated. This can be calculated using equation (4) (Train, 2002), as found by Overdijk (2016):

$$P_{iq} = prob\left(U_{iq} > U_{jq} \; \forall \, j \neq i\right) \tag{4}$$

3.3 Towards visual presentation of attributes

Arentze et al. (2003) stated that in the past few years, a number of design strategies have been suggested to reduce the respondents' burden. This burden is defined as the degree to which respondents obtain a survey research as difficult, emotionally stressful, or time consuming. Some characteristics of the survey which can cause this are (Lavrakas, 2008):

- Interview length,
- Cognitive complexity of the task,
- Required respondent effort,
- Frequency of being interviewed,

In this paragraph the researcher wants to focus on the cognitive complexity of the task and how to reduce the complexity for the respondents using a visual presentation of the attributes.

A cognitive complex task is a task which is hard to understand for the respondent. This can be the case when a large number of attributes is included in the research, which should be obtained by the respondent. Sometimes it is hard to imagine a situation with only written attributes, this is called a text-only experiment. *"A possible solution to this potential problem is to add pictorial or visual information to a verbal presentation of attribute profiles and, thus, aid subjects in constructing and maintaining vivid representations of alternatives in working memory"* (Arentze, Borgers, Timmermans, & DelMistro, 2003). Further these researchers found that respondents failed to keep the attributes well balanced in a consistent way and that unbalanced situation influenced their decision-making in the text-only experiment. Caussade et al. (2005) found that Stated Preference experiments with more than six attributes are confusing and too hard to process for the respondent. Another research concludes that the use of visual images can help in presenting a wide range of variables. This way the variables are easy to understand and could act reasonable and credible for unbuilt environments. This research is based on several high quality images of virtual environments. More than 80% of the respondents found these images realistic. Further this researcher states that the use of virtual environments holds potential for use within environmental studies (Davies, Laing, & Scott, 2002).

Hibbard & Peters (2003) concluded that comprehension, motivation, and the actual use of the information are increased when the cognitive complexity is reduced. This happens when the respondent is moved closer to the actual experience, for instance with visual support.

Nevertheless, visualization of attributes also gets some criticism. The visualization should not take the overhand in the research. How something is visualized, can have a major influence on the respondents' choices and might affect results (Patterson, Darbani, Rezaei, Zacharias, & Yazdizadeh, 2017). It is also not clear whether people will experience a real world situation different from a computer screen. Fitch & Handy (2017) executed research on the difference between respondents receiving the information on a video and respondents who are actually experiencing it on the bike in the real world. In this research the respondents needed to evaluate the perceived safety and comfort on the bike. The results showed that 'video-participants' responded slightly more negative compared to the bicyclists. The video participants reported 10-15% lower on average for their experienced comfort/safety.

Since the problem is based on an observation issue, it is likely that more than five attributes are included in this research and the goal of the researcher to minimize the respondent's burden, will the researcher strive to show the attributes in an approachable visual way. Virtual reality could help to minimize the cognitive complexity for the respondents.

3.3.1 Virtual Reality

Virtual reality is an artificial, computer-based simulation of a real environment or situation presented to the user, which can help in reducing the cognitive complexity. It allows the user to believe that they are experiencing a real-life situation by simulating their vision or/and their hearing. Virtual Reality uses technology to create and simulate a non-existent reality in order to generate the imaginary reality or to create simulations of specific situations (Piekarski & Thomas, 2002).

Virtual reality models include existing or imaginary environments. Not always all the info in the model can be received by the user, nor mimics the model perfectly the natural setting. A virtual environment gives the user access to information at any place and time. Thus Virtual reality can be used in any location and the user will receive the exact same information and features through the virtual environment (Schoenmakers, 2017)

Jacobson (1993) stated that there are four different kinds of virtual reality. These types are shown in figure 5:

- Immersive virtual reality (see figure 5A) is a virtual reality system which uses stereoscopic goggles that provide the 3D imagery.

- Desktop virtual reality (see figure 5B) is a program on the computer that simulates a real-life or an imaginary environment in 3D, what is displayed on a screen. This type of virtual reality is especially suitable for projects with smaller budgets.

- Projection virtual reality (see figure 5C) creates a virtual reality experience via projections. This type of virtual reality is suitable if users need to experience the environment in a group.

- Simulation virtual reality (see figure 5D) is an interactive virtual environment. The users can besides moving freely change things in this environment or operate a vehicle. In paragraph 3.3.2 simulators in general will be discussed.

-Figure 5: Four types of virtual reality methods

As found by Schoenmakers (2017) virtual reality is used in different forms of research already. Previous researches are especially in the field of neuroscientists, to simulate natural events and social interactions. Furthermore virtual reality is often used in the field of psychological issues. A specific experiment where virtual reality is used as tool is a research about the effects of being in the virtual environment, concerning the respondents' stress levels. Davies et al. (2002) used virtual reality to measure the likelihood of the respondent to choose for a specific neighborhood.

3.3.2 Driving Simulator

A driving simulator is used to mimic the real world or a non-existing situation and let the receiver believe that he/she is driving for real in this environment. The receiver operates a vehicle, which moves faster than walking. Blana (1996) specified several advantages of using a driving simulator compared to field research:

- The versatility is considered by Blana (1996) as the most important advantage of driving simulators. In a driving simulator it is relatively easy to economically change the situation. This is especially useful when testing new and not existing technologies. In field researches this is often not possible, or very expensive. In a driving simulator new developments can be included at reduced cost.
- Experimental control and measurement is seen as another important advantage. "*Simulators make it possible to control experimental conditions over a wider range than field tests and can be easily changed from one condition to another*" (Blana, 1996). This might come in handy in terms of experimental design characteristics. It is difficult to achieve an exact same situation for respondents in the real world, concerning for instance weather and traffic situations. Furthermore it is easier to measure the performance in a driving simulator.
- Safety is found as another important reason to use a driving simulator. Simulators provide a very safe environment for driving research. There is no danger to drive virtually for the respondent. In field research this is not always the case and it is sometimes impossible to get approval of instances to execute an experiment in the real world.

Blana (1996) found also several disadvantages of using a driving simulator compared to field research:

- The validity issue is the most important disadvantage of a driving simulator. It is still impossible to replace the real world in all its complexity. It is always the question to what extent the behavior of the respondent in the simulator corresponds to that in the real world.
- The relative high costs of driving simulators are another disadvantage. Though there is a wide variety of simulator types. PCs can provide already reasonable and credible visuals. PC simulators are called low-cost simulator, because of the relative low costs to make them. On the other hand very complex simulators are extremely expensive.
- And finally simulator sickness is considered as an important disadvantage for simulators. "*Simulator sickness can vary widely among individuals who experience it*

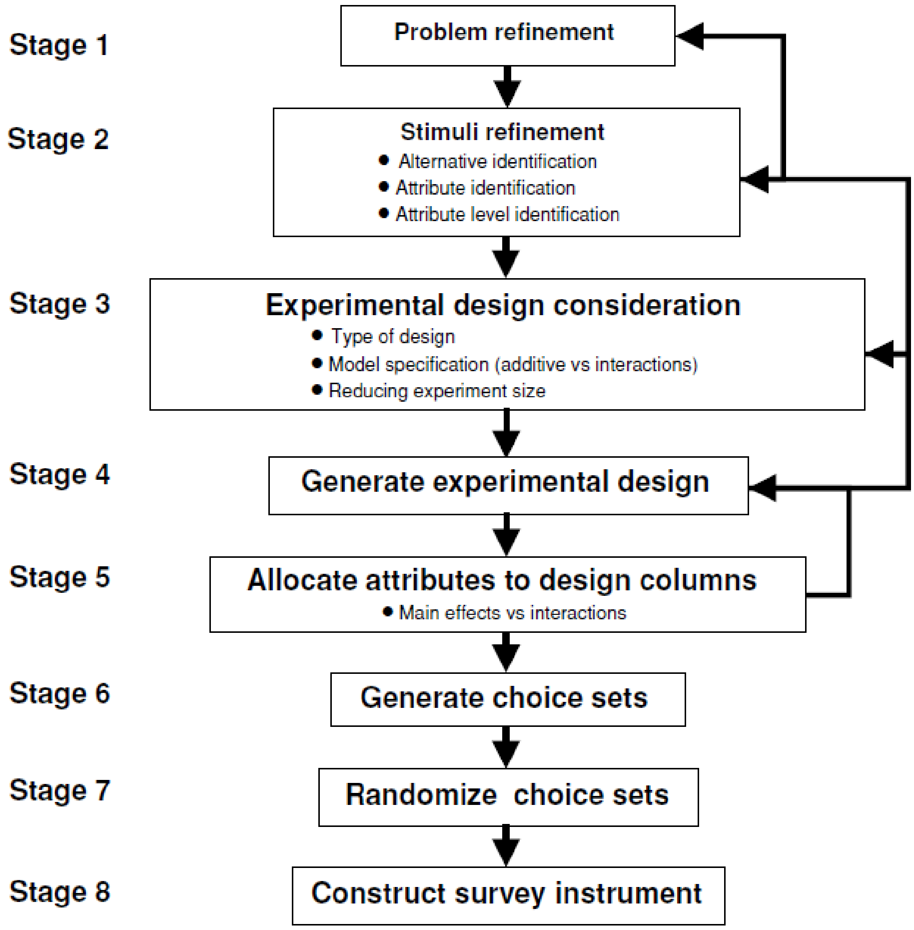
> *and among simulators that induce it*” (Blana, 1996). The respondent is in this case sick because of the exposure in the virtual environment and the symptoms are similar to the regular motion sickness symptoms. Possible symptoms are headache, stomach awareness and disorientation.

Simulators are already used for a long time. The most well-known simulators are flight simulators in which pilots learn to fly an aircraft. Simulators are often used as research tool, for example in a recent research where the drivers’ behavior is observed when driving together with an automated vehicle on the highway (Schoenmakers, 2018)

NHTV Breda University of Applied Sciences developed in the past three years a virtual reality bike simulator. It has been developed to answer knowledge and design related questions in the field of cycling. In this bike simulator the visuals are controlled by the user’s physical efforts and steering movements. The virtual environment is shown in a Head Mounted Display. This type simulator is especially suitable for asking users about the cycling experience in the experiment (Klinkenberg, 2017).

3.4 Setting up Stated Preference Experiment

The researcher will conduct a stated preference experiment. Hensher, Rose & Greene (2005) developed a clear roadmap to setup an appropriate SP Experiment. In figure 6 the overall process is shown. This process will begin with the problem refinement in stage 1, to ensure that the problem is well understood. The next stage is the stimuli refinement, the researcher should decide which alternatives, attributes and attribute levels will be used. The next steps are mainly about making choices to construct the survey instrument. This also includes making a full factorial design.

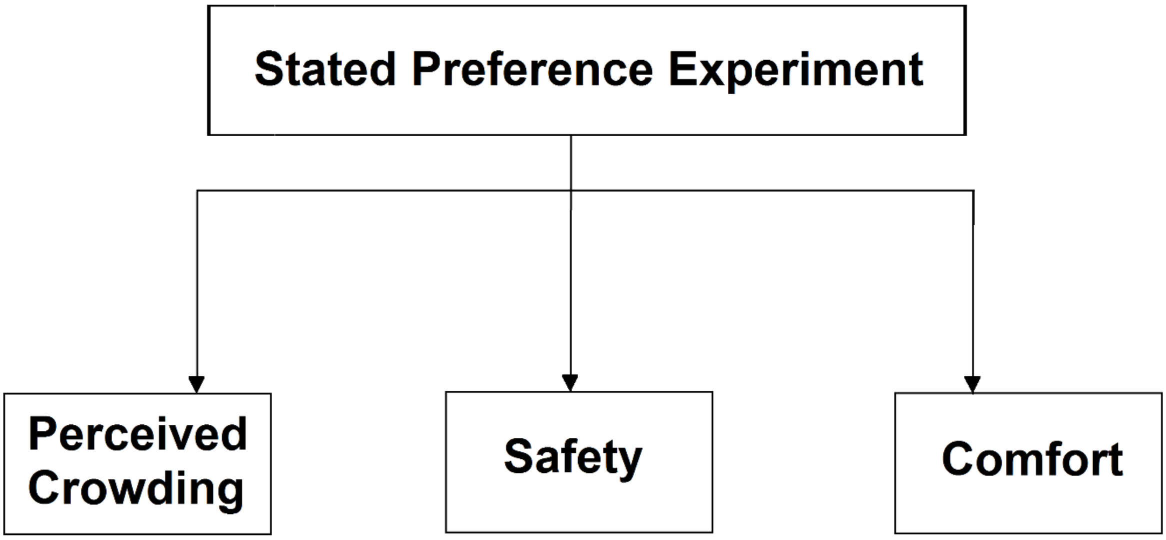


-Figure 6: The Experimental design process of a Stated Preference Research (Hensher, Rose, & Greene, 2005)

3.4.1 Problem refinement

The research question in paragraph 1.2 concerning what attributes influence the perceived crowding on the bike path has been answered in paragraph 2.4 theoretically. Now it is important to see to what extent these attributes influence the perceived crowding. Having a clear understanding of the research problem is very important. The main problem was the increasing crowding on several bike paths causing cyclists to find those situations uncomfortable and/or unsafe, which could lead to a change of transportation means by these cyclists.

Since increasing crowding causes possible safety and comfort issues, it is also important to figure out if the previous mentioned attributes influence the safety and comfort perception of the cyclists. In figure 7 the dependent variables are shown.



-Figure 7: The dependent variables in the stated preference experiment

3.4.2 Stimuli refinement

The second stage in constructing a stated preference experiment according to Hensher et al. (2005), concerns the stimuli refinement. This *"involves defining the universal but finite list of alternatives to decision makers within the context being studied"* (Hensher, Rose, & Greene, 2005). First the list of alternatives needs to be refined. As explained in the previous paragraph, this research focuses on the extent relevant attributes influence the perceived crowding, safety, and comfort. For the experiment is a selection of alternatives made. An alternative is in this case a certain traffic situation on a bike path.

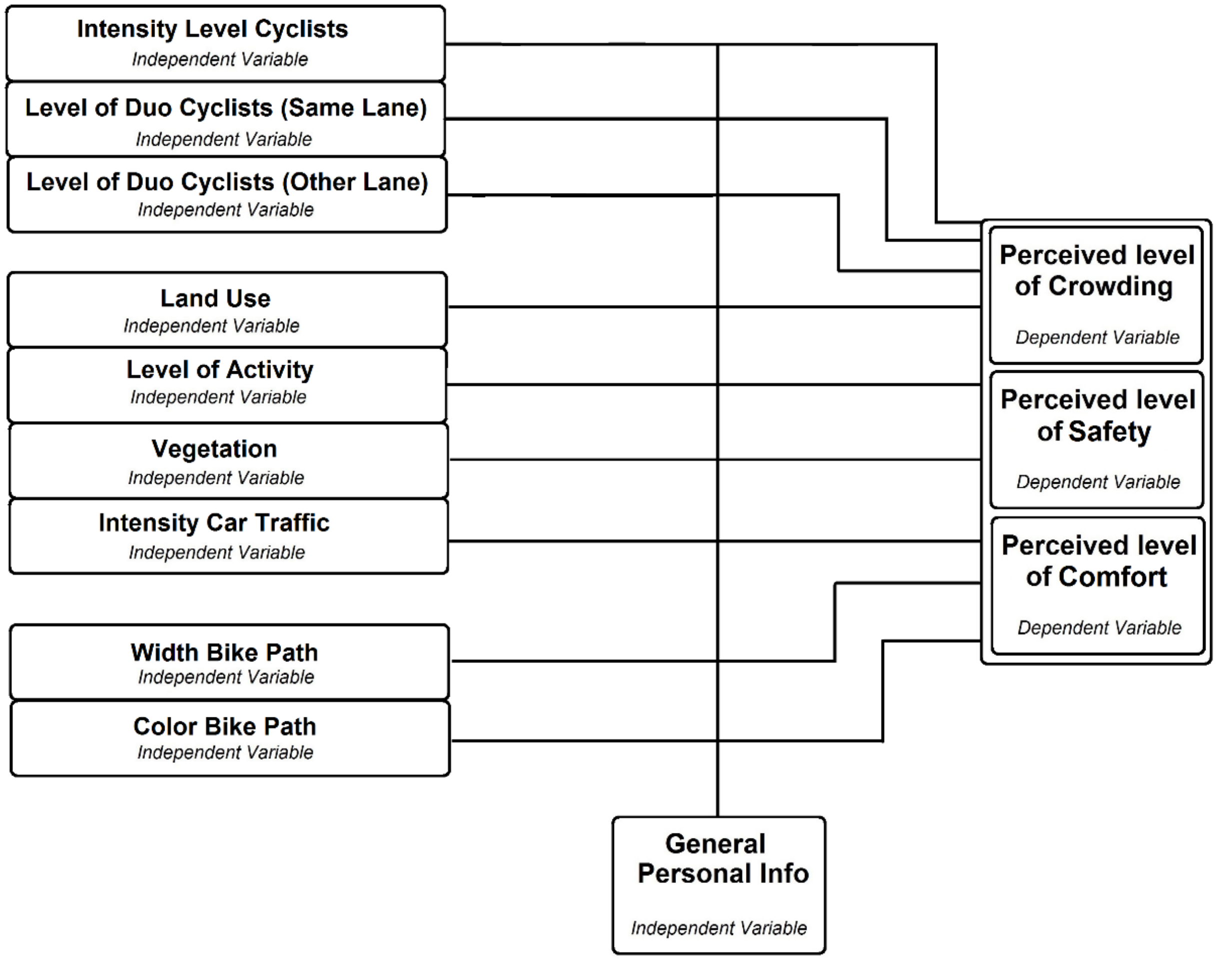
After defining the alternatives, the attributes will be selected and defined. These attributes describe the alternatives. Each attribute is described by a number of levels. In this research it is chosen to define three levels per attribute. This is done in order to allow the observation of both linear and non-linear effects. It also creates more accuracy. Furthermore the range important of the levels is important. It is best to maximize the range of the attribute levels, although the levels should be realistic for the respondent. Finally, Hensher et al. (2005) states that ambiguity and correlations between attributes should be avoided.

In this research, each alternative is described by 9 attributes. These alternatives vary, as mentioned previously, over three levels. In the experiment, some influences are set as 'fixed'. These influences might affect the dependent variable, but are in all the alternatives the same. Some of these fixed influences will be further explained in paragraph 3.5. The researcher chose to only use one '**bicycle path type',** since this means that the researcher needs to design only one environmental model base for the alternatives. Regarding time limitations the researcher can only make one environmental model base, since this is very time consuming. The researcher chose for a two-way bike path near a road. According to the research of Munckhof et al. (2017) this type bike path is an important contributor to the perceived crowding. Next the '**car velocity' is** fixed, although Overdijk (2016) stated that this can affect the perceived crowding of cyclists. The '**weather**' is also fixed. The experiment takes place on a clear and sunny day. The '**bike velocity'** is also fixed, all the bikes in the experiment bike with the same velocity (13.7 km/h). This means that the possible attribute 'difference in speed' cannot be included. The researcher assumed that this was too time consuming to construct in the virtual environment. Though, many literature sources stated that this possible attribute had a large influence.

Next the researcher will discuss all the included attributes.

First, '**intensity level**' is included in the research, since this is regarded in several literature sources as an important contributor to the three dependent variables. The height of the levels is based on the intensity level of one of the most crowded bike paths of the Netherlands, namely in Utrecht. Next, the **'level of duo cyclists'** is included because this is also regarded by several sources as an important contributor. The researcher chose to split this attribute in two attributes: '**level of duo cyclists same direction**' and '**level of duo cyclists opposite direction'**. The range varies from zero percent at the lowest level to eighty percent at the highest level. The attribute **'land use'** is the next attribute which will be included in the research. These levels will be based on rural, in-town residential and high density themes. The land use types will be further explained in the next paragraph. The attribute **'level activity'** is also included in the research and relates to the amount of pedestrians next to the road/bike path. Next, the attribute **'vegetation'** will be added to the research. The defined levels will be: grass, trees, and bushes. **'Intensity car traffic'** will be included, since this is also stated as possible contributor to the dependent variables. Furthermore, the variable **'width bike path'** and **'color of bike path'** are included into the research.

This leads to the following conceptual framework:



-Figure 8: Conceptual framework

All the included attributes are shown with more detailed information in table 6.

-Table 6: Attributes and attribute levels

Attribute Group	Column	Attributes	Levels	
Traffic conditions on bike path	**A**	Intensity level of cyclists	Low	1000 cyclists/h
			Medium	2500 cyclists/h
			High	4000 cyclists/h
	B	Level of duo cyclists (same direction)	Low	0%
			Medium	40%
			High	80%
	C	Level of duo cyclists (opposite direction)	Low	0%
			Medium	40%
			High	80%
Surrounding bike path	**D**	Land Use	Rural	Few houses and a lot room for greenery
			In-town residential	Single family homes that are close together
			High density	High rise buildings and environment which is used commercially
	E	Level of Pedestrian Activity	Low	0 activities
			Medium	20 activities
			High	40 activities
	F	Vegetation	Grass	
			Trees	
			Bushes	
	G	Intensity Car Traffic	Low	250 cars/h
			Medium	1000 cars/h
			High	2000 cars/h
Physical bike path conditions	**H**	Width Bike Path	Low	2,5 meter
			Medium	3,5 meter
			High	4,5 meter
	I	Color of Bike Path	Red	Red asphalt
			Gray	Gray tiles
			Blue	Blue asphalt

3.4.3 Experimental design considerations and generation

There are a number of different types of designs available. The most general type of design is the full factorial design that is defined as "*a design in which all possible treatment combinations are enumerated."* (Hensher, Rose, & Greene, 2005). A full factorial design would contain 19,683 treatment combinations, as shown in equation (5).

$$Maximal\ number\ of\ treatment\ combinations = 3^9 = 19{,}683 \qquad (5)$$

This amount of treatment combination is for the respondents impossible to evaluate. Therefore, the researcher decided to use a fractional factorial design. This is a "*design in which we use only a fraction of the total number of treatment combinations*" (Hensher, Rose, & Greene, 2005). It is not recommended to randomly select a number of treatment combinations, because this could cause statistically inefficient designs. Hensher et al. (2005) mentioned further that it is important to use an orthogonally design. "*Orthogonality is a mathematical constraint requiring that all attributes be statically independent of one another"* (Hensher, Rose, & Greene, 2005). Further this design type allows the estimation of main effects independently.

As mentioned previously the researcher will use an orthogonal fractional factorial design. The design which will be used is shown in table 7. There are in total 27 treatment combinations in this design. This quantity is acceptable in view of the intended visualization of the attributes.

-Table 7: Orthogonal fractional factorial design with nine three level attributes

	A	B	C	D	E	F	G	H	I
1	0	0	0	0	0	0	0	0	0
2	0	0	1	1	2	1	2	1	2
3	0	0	2	2	1	2	1	2	1
4	0	1	0	0	0	1	1	2	2
5	0	1	1	1	2	2	0	0	1
6	0	1	2	2	1	0	2	1	0
7	0	2	0	0	0	2	2	1	1
8	0	2	1	1	2	0	1	2	0
9	0	2	2	2	1	1	0	0	2
10	1	0	0	1	1	1	1	1	1
11	1	0	1	2	0	2	0	2	0
12	1	0	2	0	2	0	2	0	2
13	1	1	0	1	1	2	2	0	0
14	1	1	1	2	0	0	1	1	2
15	1	1	2	0	2	1	0	2	1
16	1	2	0	1	1	0	0	2	2
17	1	2	1	2	0	1	2	0	1
18	1	2	2	0	2	2	1	1	0
19	2	0	0	2	2	2	2	2	2
20	2	0	1	0	1	0	1	0	1
21	2	0	2	1	0	1	0	1	0
22	2	1	0	2	2	0	0	1	1
23	2	1	1	0	1	1	2	2	0
24	2	1	2	1	0	2	1	0	2
25	2	2	0	2	2	1	1	0	0
26	2	2	1	0	1	2	0	1	2
27	2	2	2	1	0	0	2	2	1

3.4.3 Choice set generation

The next step is to combine the attributes and their levels to the design codes shown in table 5. This way the alternatives will become more readable and interpretable. Between the combinations are no unrealistic combinations. In table 8 is shown which attributes represent which design code. Appendix B shows all the detailed 27 treatment combinations. Table 9 show how the alternatives correspond to a theoretical bicycle level of service rating, based on density and hindrance on the bike path. These BLOS-levels are calculated by the formulas stated in paragraph 2.4. The alternatives range in this case from level A to F.

-Table 8: Design codes translated into attributes and levels

Column	Attribute	0	1	2
A	Intensity level of cyclists	1000 cyclists/h	2500 cyclists/h	4000cyclists/h
B	Level of duo cyclists (same direction)	0%	40%	80%
C	Level of duo cyclists (opposite direction)	0%	40%	80%
D	Land Use	Rural	In-town residential	High density
E	Level of Pedestrian Activity	0 activities	10 activities	30 activities
F	Vegetation	Grass	Trees	Bushes
G	Intensity Car Traffic	250 cars/h	1000 cars/h	2000 cars/h
H	Width Bike Path	2.5 meter	3.5 meter	4.5 meter
I	Color of Bike Path	Red	Gray/tiles	Blue

-Table 9: Theoretical bicycle level of service rating for the scenarios

Scenario	Intensity level of cyclists	Width Bike Path	BLOS Regarding Density	BLOS Regarding Hindrance
1	Low	Low	A	E
2	Low	Medium	A	C
3	Low	High	A	B
4	Low	High	A	B
5	Low	Low	A	E
6	Low	Medium	A	C
7	Low	Medium	A	C
8	Low	High	A	B
9	Low	Low	A	E
10	Medium	Medium	A	D
11	Medium	High	A	C
12	Medium	Low	B	F
13	Medium	Low	B	F
14	Medium	Medium	A	D
15	Medium	High	A	C
16	Medium	High	A	C
17	Medium	Low	B	F
18	Medium	Medium	A	D
19	High	High	B	D
20	High	Low	D	F
21	High	Medium	C	E
22	High	Medium	C	E
23	High	High	B	D
24	High	Low	D	F
25	High	Low	D	F
26	High	Medium	C	E
27	High	High	B	D

3.4.4 Choice set randomization

Each respondent will obtain nine choice tasks. This means that three respondents are needed to complete the entire fractional factorial design of 27 sets. Appendix B, as mentioned before, shows all the detailed choice alternatives. Hensher et al. (2005) state that there might exist some learning in obtaining the choice tasks, the choices made in later choice tasks could be not the same in terms of the utility or preferences in comparison with earlier choice tasks. Further, respondents could get bored towards the end of the survey, which may affect the accuracy of respondents' choices. Randomization of the choice tasks could help in the previous mentioned issues. Each respondent obtains nine choice tasks, but for each respondent a unique set of tasks is created. An online survey platform can easily randomize the choice tasks. The platform makes sure that each choice task is obtained about the same time in total.

3.5 Visualization of attributes

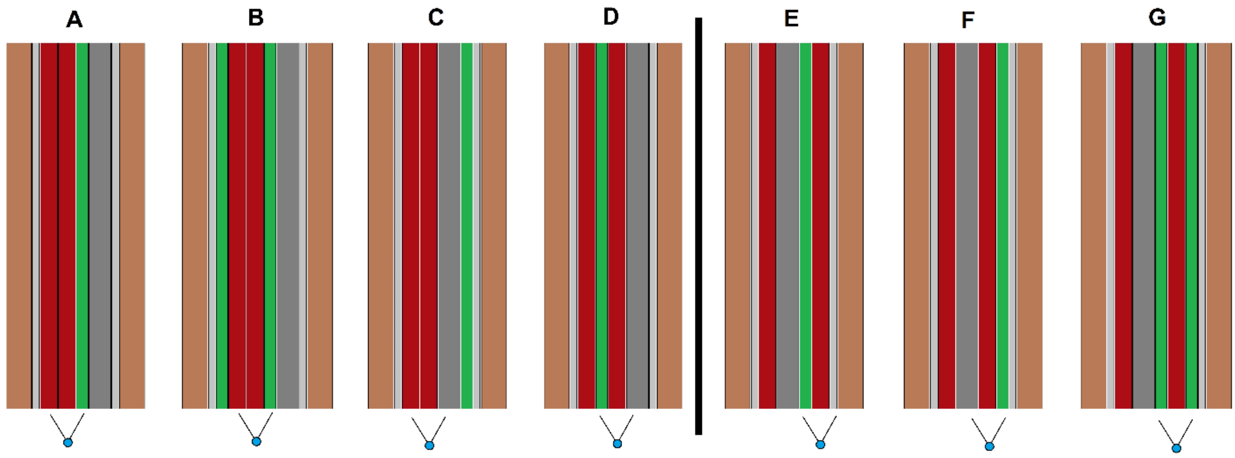
3.5.1 Environmental base

First, the researcher decided to use only one environmental base in the experiment (see before). Due to time limitations the researcher could only make a limited number of bases, since this is very time consuming task. According to the researcher it is important to choose an environmental base:

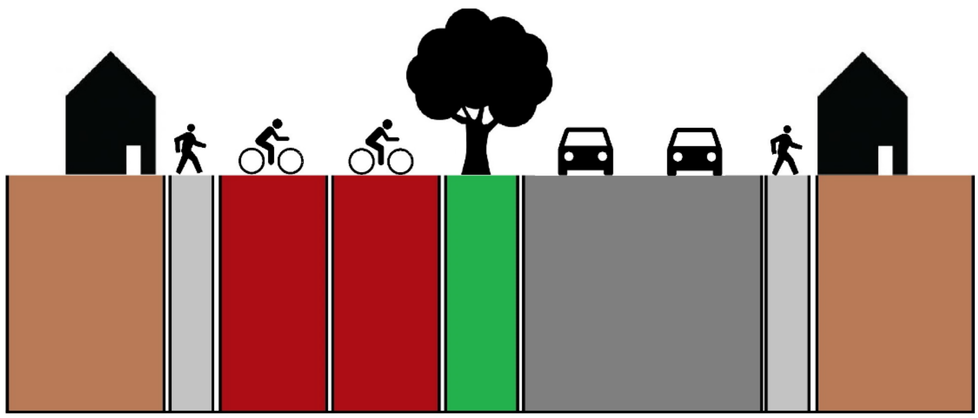
- Which occurs often in the real world,
- Where the receiver is sufficiently exposed to all variables,
- That can be easily executed.

Figure 9 shows all the considered environmental bases. The bases consist of a land use type (brown), bicycle path with both directions (red), pavement (light gray), vegetation strip (green) and roadway (dark gray). This figure shows the arrangement schematically, the proportions in terms of size are not correct yet. The blue circle with the arrow shows the intended viewpoint of the receiver/respondent. The bases A to D show a two-way bicycle path and the bases E to G show a one-way bicycle path on each side of the road. In Appendix C some reference bike paths are shown. The bases B and D are not considered ideal by the researcher, since they are located too far away from the pavement, as a result of which the attribute 'activity of the pedestrians' is probably not well perceived by the receiver / respondent.

This also applies for base C, regarding the vegetation strip. The bases E, F and G are a one-way bike path and therefore less suitable for measuring several attributes (like the level of duo cycling in the opposite direction). Base A is preferred by the researcher, since all attributes can be observed in a balanced way. Furthermore, this basis also regularly occurs in the real world. The researcher therefore chooses base A for all the 27 scenarios (see Figure 10).



-Figure 9: The seven considered environmental bases (schematically viewed)



-Figure 10: The chosen base by the researcher (A)

3.5.2 Process from text to visual

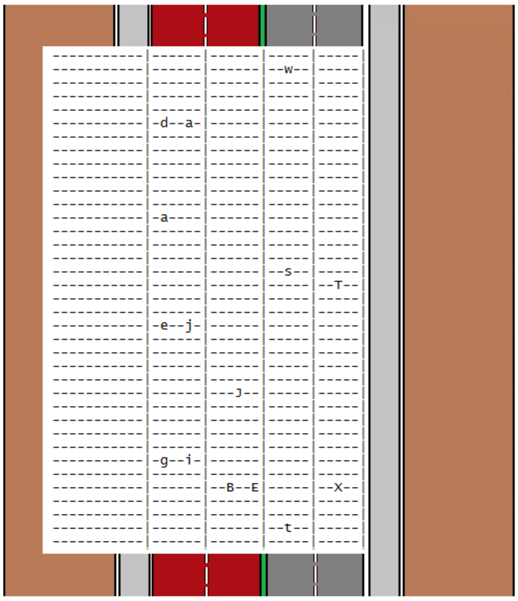
The total compositions of the 27 scenarios are made in several programs. In this sub paragraph the way how the scenarios are modeled is briefly described. In figure 12 an overview of the process is shown.

First, all static attributes are modeled in SketchUp. SketchUp is a program in which 3D objects can be drawn. All the static attributes, land use, vegetation, color, and width, are modeled in its scenario, based on the fractional factorial design as shown in appendix B. The researcher used partly pre-modeled land use and vegetation elements, but spend a lot of time in composing the scenarios. All the scenarios are saved as a DAE document.

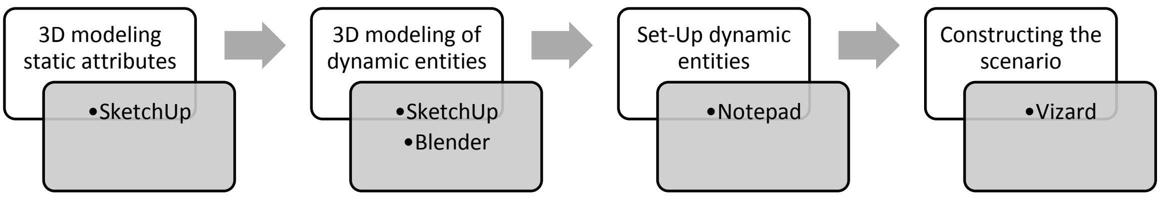
The dynamic attributes consist of dynamic entities, like pedestrians, cyclists, and cars. These are modeled in SketchUp and Blender, another 3D-modeling program with more features. In the experiment there are three different looking pedestrians, ten different looking cyclists and eight different looking cars. All the dynamic entities are saved as a DAE document.

Next, for all the scenarios a specific set-up is made based on the intensity level of cyclists, the level of duo cyclists, and the intensity of the car traffic. Each letter corresponds later to a dynamic entity. In figure 11 an example is shown of such a set-up to make it more clear what schematic environmental base is added. The letters A to J correspond to a cyclist moving in the same direction as the receiver/respondent. The letters a to j stand for the cyclists who are moving in the opposite direction. The letters S to Z correspond to cars moving in the same direction as the receiver/respondent. The letters s to z stand for the cars which are moving in the opposite direction.

The next phase is set up in Vizard. Vizard is a comprehensive, Python based virtual reality development platform. In this program all former phases are brought together into 27 scenarios. The script which is used is shown in appendix D. Afterwards are all the scenarios recorded, with the help of screen recording software.



-Figure 11: Fragment of a set-up of a scenario in a text file (with schematic environmental base)



-Figure 12: Schematic overview of the process from text to visual

3.5.3 Static & dynamic attributes

In terms of visualization, there are two types of attributes, as already mentioned in the previous section:

• Static attributes are attributes that do not move;

• Dynamic attributes are attributes that do move.

Almost all static attributes will be modeled in SketchUp. For the dynamic attributes a more complex process is required in combination with the programs SketchUp (https://www.sketchup.com/), Blender (https://www.blender.org/) and Vizard (https://www.worldviz.com/vizard). As described in the previous sub section. Below, all choices regarding the visualization are explained. This is also supported by pictures of the relevant attributes and the different levels. A larger copy of these images can be found in appendix E.

Dynamic attribute: **Intensity level of cyclists**

At the lowest level, the intensity is 1000 cyclists/h. This value can actually be described as pretty high. It is so high because the respondents only see 15 seconds of the situation. In a very low intensity of 100 cyclists per hour the respondent would not observe a passing cyclist. Now the respondent will pass 5 cyclists at the lowest level in the experiment of 15 seconds. In the medium level this the respondents will pass 10 cyclists, with an intensity of about 2500 cyclists/h. At the highest level the intensity has almost doubled again, to 4000 cyclists/h and 17 passing cyclists in 15 seconds. Figure 13 shows the levels visually. A larger copy of these images can be found in appendix E.

-Figure 13: Intensity levels of cyclists: low (1000 cyclists/h), medium (2500 cyclists/h) and high (4000 cyclists/h)

Dynamic attribute: **Level of duo cyclists**

This attribute is divided into two separate attributes, namely the degree of cycling next to each other in the same bicycle direction and in the opposite bicycle direction. At the lowest level, no one cycles side by side; the degree of cycling next to each other at this level is 0%. At the medium level, 40% of cyclists cycle side by side and in the highest level, 80% of cyclists cycle side by side. Figure 14 shows the levels visually.

-Figure 14: Levels of duo cyclists: low (0%), medium (40%), high (80%)

<u>Static attribute: **Land use**</u>

The researcher found it very important that respondents could see at a glance in what kind of environment, in terms of land use type, they cycle. The chosen land use types must therefore be particularly clear, so that there is no confusion. This is done with the land use types: rural, in-town residential and high density.

"*A rural area can be defined as a surrounding area that has a low population density and no built environment*" (Schoenmakers, 2017). The option of no buildings at all is not considered as an option. So the researcher has chosen to use a few buildings in the visualization of this type, also to give the idea that few people live in the area. The second land use type is mainly focused on the function of living. The respondent is in a residential area and this is clearly reflected in this variant. For the visualization of the high density level, the height of the buildings was mainly used. Building height says a lot about the kind of environment. Rural zones contain more often lower buildings in comparison with higher density zones (Cheng, 2009). Furthermore, the respondent should especially get the idea to cycle in the center of a city. Figure 15 shows the levels visually. A larger copy of these images can be found in appendix E.

-Figure 15: Land use levels: rural, in-town residential and high density

<u>Dynamic attribute: **Level of activity**</u>

This attribute contains the level of activity of pedestrians next to the bike path/road way. The environmental base consists of two different pavements for pedestrians. In all scenarios the pavement is 1.65m wide. At the least crowded level there is no activity at all on the sidewalk. At the medium level there are, equally distributed over the 2 sidewalks, a total of 10 pedestrians who use the sidewalk and at the highest level a total of 30 pedestrians use the sidewalks. Most pedestrians walk forwards or backwards, but there are also some pedestrians who conduct another activity, such as picking up something or waving. Figure 16 shows the levels visually. A larger copy of these images can be found in appendix E.

-Figure 16: Levels of (pedestrian) activity: low (0 pedestrians), medium (10 pedestrians), high (30 pedestrians)

<u>Static attribute: **Vegetation**</u>

For the vegetation attribute, the levels grass, trees, and bushes are visualized. These are all levels that occur frequently around bicycle paths in the Netherlands. In all variants, the vegetation strip is 2m wide and, like all other attributes, must look credible. In fact, the same grass was used at every vegetation level. At the 'tree' level there is a distance of 15m between the trees. The bushes are 1.15 m wide and show an opening after 18 m. Figure 17 shows the levels visually.

-Figure 17: Vegetation levels: grass, trees and bushes

<u>Dynamic attribute**: Intensity car traffic**</u>

In all scenarios, the roadway is 7m wide. Car traffic comes from two directions and all cars drive at a speed of 30 km/h. At the least crowded level, the intensity is 250 cars/h. This means in 4 seconds that the respondent sees about 1 car per driving direction. At the medium level the intensity is 1000 cars/h, which amounts to more than 4 cars per 15 seconds. At the busiest level the intensity has been considerably increased, to show a clear difference, to 2000 cars/h. This amounts to more than 8 cars per 15 seconds per direction that the respondent can see. Figure 18 shows the levels visually.

-Figure 18: Intensity levels of car traffic: low (250 cars/h), medium (1000 cars/h), high (2000 cars/h)

Static attribute: **Width bike path**

The lowest value of the width, level low, the bike path is 2.5m wide. Here, the respondent must get the idea that it is a fairly tight cycle path. Furthermore, it was very important at this level that two bikes can cycle next to each other per driving direction. Now there is 1.25m space per direction. An average cyclist is 0.60m - 0.65m wide, so this would theoretically have to fit with two cyclists side by side. However, it must be added that the average distance of 0.25m between the cyclists has not been included. The medium level is 3.5m wide. This should be for the respondent looks as a not too tight but also not too wide bike path. The highest level is 4.5m wide. For the respondent's look it should be a fairly wide bike path. Figure 19 shows the levels visually.

-Figure 19: Bike path width levels: low (2.5m), medium (3.5m), high (4.5m)

Static attribute: **Color bike path**

The attribute color includes of the colors: red, gray and blue. This attribute also needed to look as realistic as possible. Therefore, for the level red, a realistic color red is sought which is often used for cycle paths. Oxid red is often used as a color for red cycle paths in the Netherlands. The gray level varies not only in color but also in structure. The ilusion is aroused that the bike path is not smooth concrete, but consists of tiles. These types of cycle paths also occur regularly in the Netherlands. Blue cycle paths hardly occur in the Netherlands, but they are often used in Scandinavian countries. Figure 20 shows the levels visually. A larger copy of these images can be found in appendix E.

-Figure 20: Color bike path levels: red, gray/tiles and blue

3.6 Survey construction

This is the last stage of constructing a stated choice experiment according to Hensher et al. (2005). This instrument should be suitable for the research. It is very important that the respondents have a good understanding of the questions. This paragraph describes how the online survey is structured and what is asked to the respondent. Since the researcher finds it very important that everyone can answer the questionnaire, the questionnaire starts with the question which **language** the respondent prefers; English or Dutch.

Next, in the **introduction of the questionnaire**, the respondent is informed about the goal and content of the questionnaire. Further the introduction mentioned the three parts of the questionnaire, the estimated time needed to answer all the questions, and it informs the respondents that all the information gathered is confidential and anonymous. As an extra note for respondents using a smartphones is being recommended to tilt the phone, for optimal presentation of the survey.

The first part of the questionnaire is looking at the respondent's '**cycling experience'**. Questions are included like, how often the respondent uses the bike as a transportation mean, but also at what time of the day the respondent uses the bike. Further is asked on what types of bike paths the respondent usually rides his/her bike and what bike type is used in most of the cases. Finally, with some photos the respondent is asked how often he/she has been in a crowded situation and an uncrowded situation on a bike path. The respondent can also choose the option that he or she never cycles for each question in this part. The researcher decided that these respondents are allowed to participate in the entire questionnaire, since they can still observe a situation and give an opinion.

The second part of the questionnaire concerns the '**video experiment'** and starts with a clear introduction for the respondent. In that introduction the respondent is informed about the nine videos and the length of 15 seconds for each video. Further the situation is briefly described, namely the videos take place on a (virtual) bike path, where the perspective of a cyclist is shown and in each video the researcher diversifies the bike path, road and surrounding area. Finally, the respondent is invited to watch each video carefully with the eye at the full picture and rate for each situation the perceived level of crowding, safety and comfort. To make sure the respondent has a good understanding of what is meant by 'level of crowding', a figure is shown with the same pictures of the first part of the questionnaire (uncrowded vs crowded). This figure is shown here below in figure 21. The respondents can rate in each video the variables using a five point scale.

-Figure 21: The visual explanation of level of crowding in the questionnaire

The last part of the questionnaire focuses on the '**personal information'**. In this part demographic questions are asked to the respondent. Hensher et al. (2005) advise that demographic questions are preferred in the last section of the questionnaire. These are mainly questions that the respondent can answer easily, like gender and age. Further the respondent is asked about the living area, based on the level of urbanization and the country in which the respondent biked mostly. Finally the respondent is asked on what kind of device he/she filled in the questionnaire. In table 10 is an overview shown of all the variables in the questionnaire, classified in parts.

-Table 10: Overview of variables in questionnaire

Part	Variables
I: Cycling experience	Transportation mean bike
	Bike type
	Cycle period
	Type of cycle path
	Experience in crowded situations
	Experience in uncrowded situations
II: Video experiment	Perceived level of crowding x9
	Perceived level of safety x9
	Perceived level of comfort x9
III: Personal information	Gender
	Age
	Most cycled country
	Level of urbanity residential area
	Device

3.7 Data collection and processing

After the construction of the survey it is important to consider the data collection and processing. This is very important for the quality of the research. It is not completely clear what number of respondents for the research is needed, as stated by Hensher et al. (2005). Though, an assumption can be made of the total needed respondents. There are 27 profiles in the research which should be obtained by the respondents. Overdijk (2015) estimates that with this amount of profiles a total of 1080 observations should be reached as an absolute minimum. The respondents obtain each nine profiles. With this information added to the minimum of 1080 observations, the minimum number of respondents is estimated on 120 people. The researcher decides, because of this intended quantity, to distribute the research online and with a video experiment instead of a VR-experiment. In the case of a virtual reality experiment the respondents need to come to the lab. The intended amount of respondents would probably not be reached in this case, due to time limitations. The questionnaire can be filled in by anyone. There is no specific group defined. The researcher chose for this, because cycling is done by almost everyone in the Netherlands. Although, it might be more appropriate, regarding the research problem, to ask specific vulnerable people to answer the survey exclusively. Since these vulnerable groups (elderly people and young children) are generally difficult to reach, no pre-selection was made of the respondents.

The respondents are reached in several ways:

-Own Network, these respondents are reached through social media (like Facebook, LinkedIn and Instagram), mail or verbal communication.

-Maastricht Bereikbaar has distributed the survey among 3,500 members of their panel. These people all live in the vicinity of the Dutch city Maastricht. Maastricht Bereikbaar works with a large number of partners to keep Maastricht and its surroundings permanently accessible. Maastricht Bereikbaar structurally encourages other travel and working behavior among commuters, visitors and freight traffic. They stimulate innovative researches to improve accessibility in their region (Maastricht Bereikbaar, n.d.).

-Employees of Open Universiteit are reached through mail or verbal communication. Most of these people live in the vicinity of the Dutch city Heerlen.

-CROW Fietsberaad placed the link of the questionnaire on their homepage. CROW Fietsberaad is the knowledge center for bicycle policies of the Dutch authorities. One of their main goals is the stimulation of the use of the bicycle as main means of transport. In order to achieve that, they distribute knowledge, publications and magazines through their website. CROW-Fietsberaad provides information for anyone who is directly or indirectly involved in the development and implementation of bicycle policies (CROW-Fietsberaad, n.d.).

After all the data is collected, the researcher can start with processing the data. The online questionnaire will be exported to the statistical software SPSS. The questionnaires are all checked whether these are completely filled in. Uncomplete questionnaires will be deleted, this is also the case for respondents who do not answer consequently regarding their past cycle experience.

After checking the data, the analysis of descriptive statistics will be executed. This way it is clear who answered the questionnaire. The sample will be compared to data of the Dutch population. This is all described in the next chapter.

4. RESULTS

4.1 Introduction

This chapter shows all the results of the conducted analyses on the stated preference data. After all questionnaires have been filled in, the analyses can be executed. In paragraph 4.2 the descriptive statistics will be presented. The analyses are carried out using IBM SPSS Statistics 23 software. After the data is carefully described in that paragraph, the data will be used for further analyses. In the paragraphs 4.3 to 4.5 the estimated models for the three dependent variables will be presented. For each variable, it will be checked whether there are differences between groups of respondents. The distinction of groups is based on the characteristics gender, age, crowding experience on the bike path and bike type use.

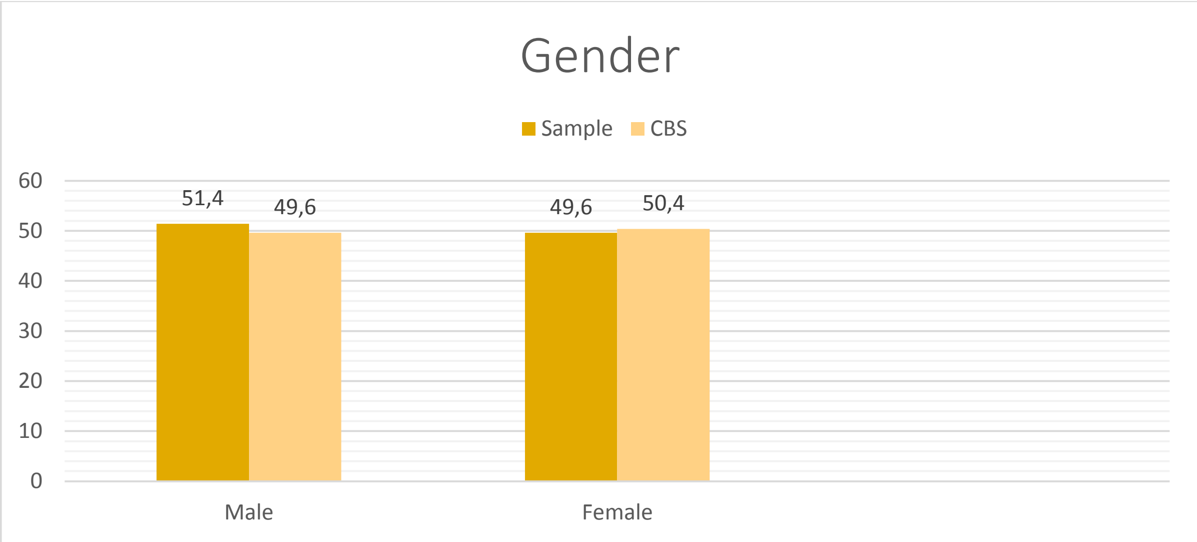
4.2 Descriptive Analysis

In total, 2,025 respondents started with the questionnaire. Only 1,215 respondents completed the questionnaire. This is a completion rate of 60.0%. The data of the 810 respondents who did not filled in the questionnaire completely are not included in the final data set. No questions were asked using an open answer option. This means that there are no extreme values filled in. Most respondents filled in the questionnaire using a desktop computer or laptop (71.9%). The smartphone is used by 19.3% of the respondents and 8.8% used a tablet. Four respondents were not consequent regarding their view on ´never cycling´ and because of this they are not included in the final data set. At last, one specific case is deleted because this case was a test case from the organization Maastricht Bereikbaar.

4.2.1 Respondents´ characteristics

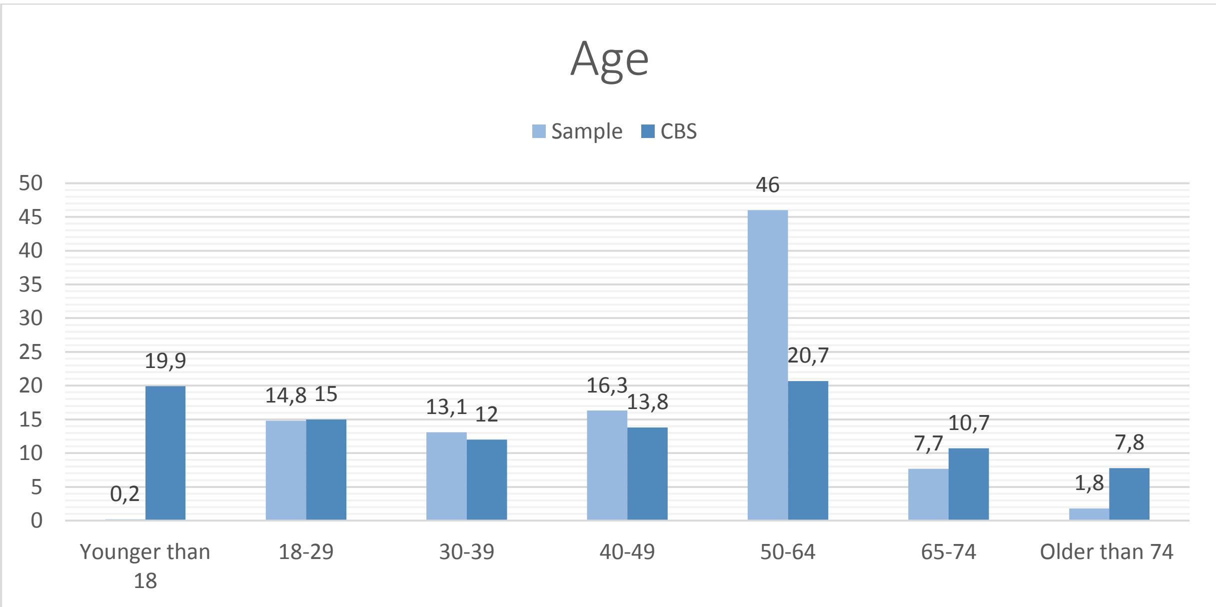
The very last part of the questionnaire contained several questions about the respondents´ personal characteristics. In this part there are questions asked such as: 'what is your gender?' and 'which of the following answers explains best your living environment?'. The descriptive statistics will be presented in this paragraph. The characteristics of the sample will be compared with the entire population of the Netherlands. In this way it can be seen if the respondents represent the entire population of the Netherlands. The data which is used to present the entire population is retrieved from the Central Bureau of Statistics (CBS) and the Traveling Research in the Netherlands (OViN). The detailed tables can be found in appendix F.

Figure 22 shows the ratio between males and females who filled in the questionnaire. This ratio is compared with data of the entire Dutch population. It appears that the ratios are quite similar. However, males are slightly over-presented in the current data set.



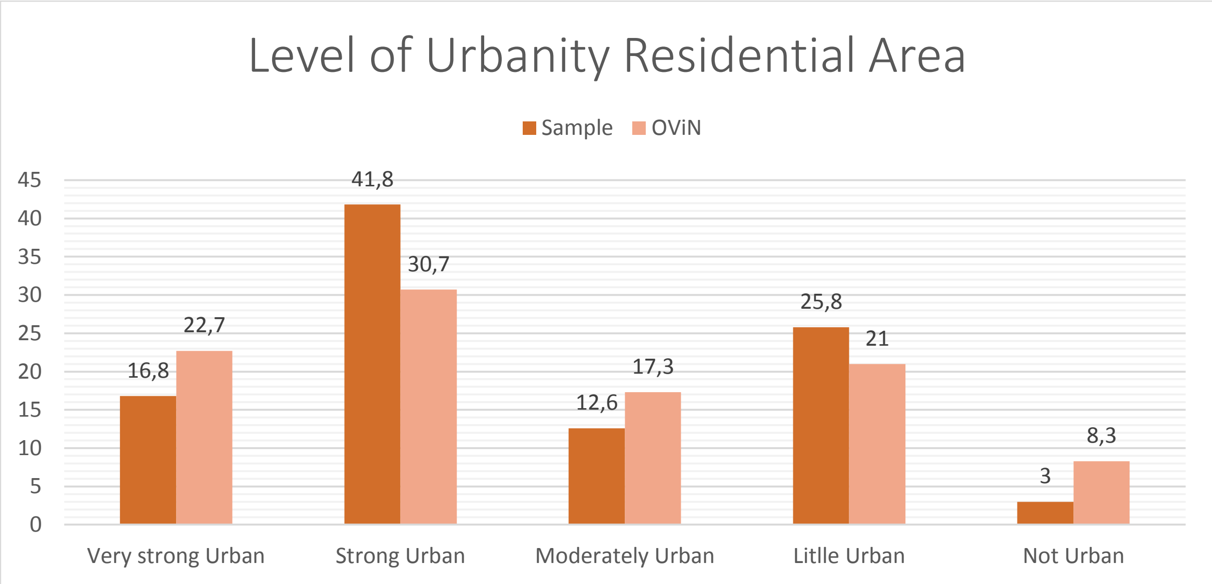
-Figure 22: Ratio gender (%)

Figure 23 presents the ratio between the different age groups of the respondents in the data set. This data is also compared with data of the entire Dutch population as presented by the CBS. The age group of 50 till 64 years old is extremely over-represented. This age group is compared to the general Dutch population double in its size. This is mostly caused by the respondents who found this questionnaire via Maastricht Bereikbaar. Approximately, 53% of the respondents of Maastricht Bereikbaar filled in this age category. Further it can be noticed that the age groups of 30 till 39 and 40 till 49 years old are slightly over-represented. The 'edge' age groups of younger than 18 years old and older than 74 years old are clearly under-represented in the data set.



-Figure 23: Ratio age (%)

Figure 24 shows the ratio between the urbanity levels of respondents' residential areas and information retrieved from the OViN data, which represents the Dutch population. In the figure it can be seen that people who live in strongly urbanized areas are over-represented in the data set. This is also the case for people who live in a less urbanized residential area. The other groups (very strong urbanized, moderately urbanized and not urbanized) are slightly under-represented.



-Figure 24: Ratio level of urbanity residential area (%)

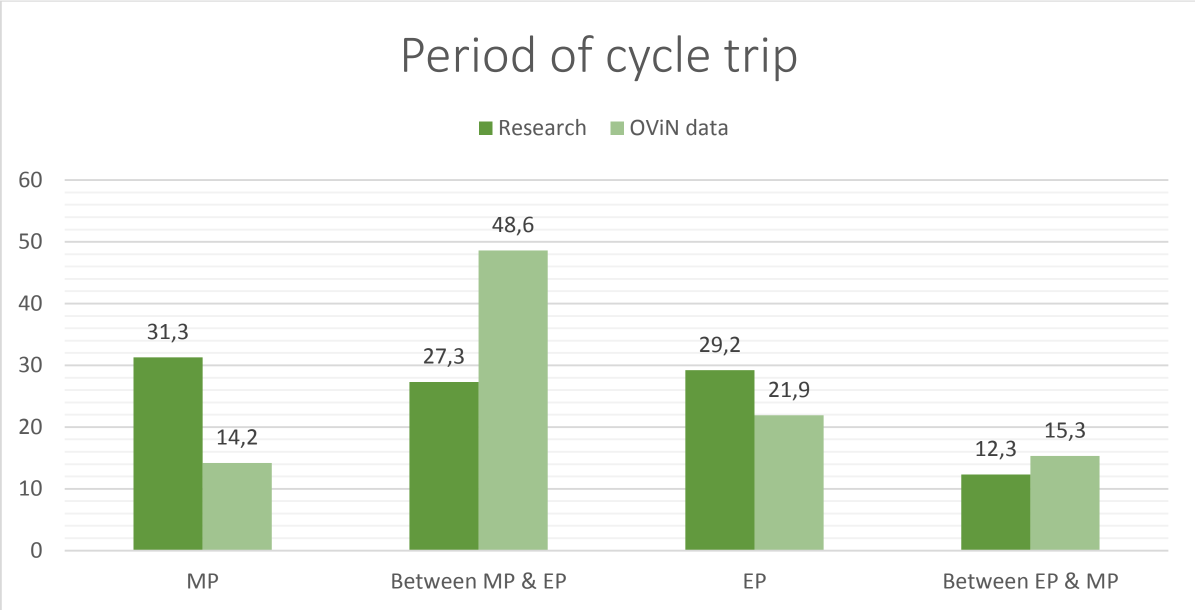
Regarding the living situation of the respondents, it is very important to state that most of the respondents live in the Dutch province Limburg and more specifically the South of Limburg. This is because most of the researcher's network is in this area and almost all the respondents from the panel of Maastricht Bereikbaar live close to the city of Maastricht, which is located in the South of Limburg. The researcher has not included the question in which municipality the respondent lives.

4.2.2 Respondents' bike related characteristics

The first part of the questionnaire contained several questions about the respondent's cycle experience. In this part questions are asked such as: 'On average how often do you use the bike as a transportation means?' and 'When you cycle, in what period(s) of times this mostly takes place?'. The descriptive statistics will be stated in this paragraph and the characteristics of the sample will be compared with the OViN data, which represents the travel behavior of the Dutch population. The detailed tables can be found in appendix F. Most of the respondents have their biggest share of cycle experience in the Netherlands (95%), the other 5% has most of his/her cycle trips elsewhere or never biked before. About 40% of the respondents experienced once or more a very crowded situation on the bike path, the other 60% never experienced a very crowded situation on the bike path.

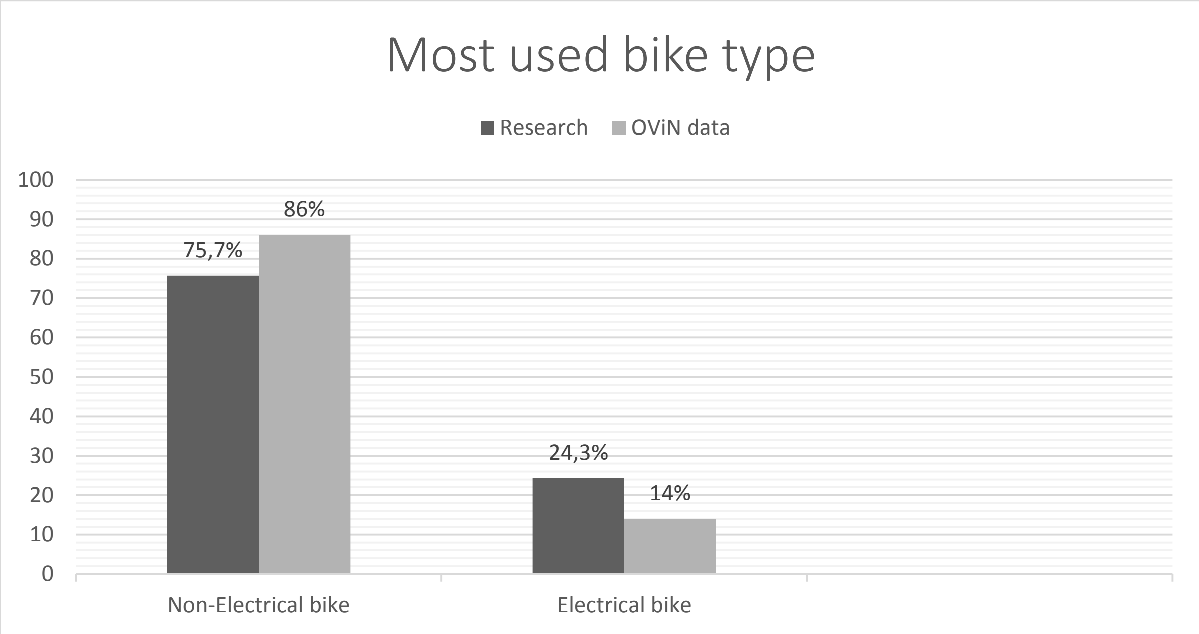
In figure 25 the respondents' period of cycle trip are compared with OViN data. The value 'MP' stands for morning peak (7:00 - 9:00 hours) and the value 'EP' stands for evening peak

(16:30 – 18:30 hours). It is clear that the people who cycle in a peak period (morning and evening peak) are over-represented and people who cycle on off-peak times are under-represented in the data set. A note about this comparison is that respondents were allowed to choose more than one category. The percentage is generated by comparing it with all the given 1,913 answers.



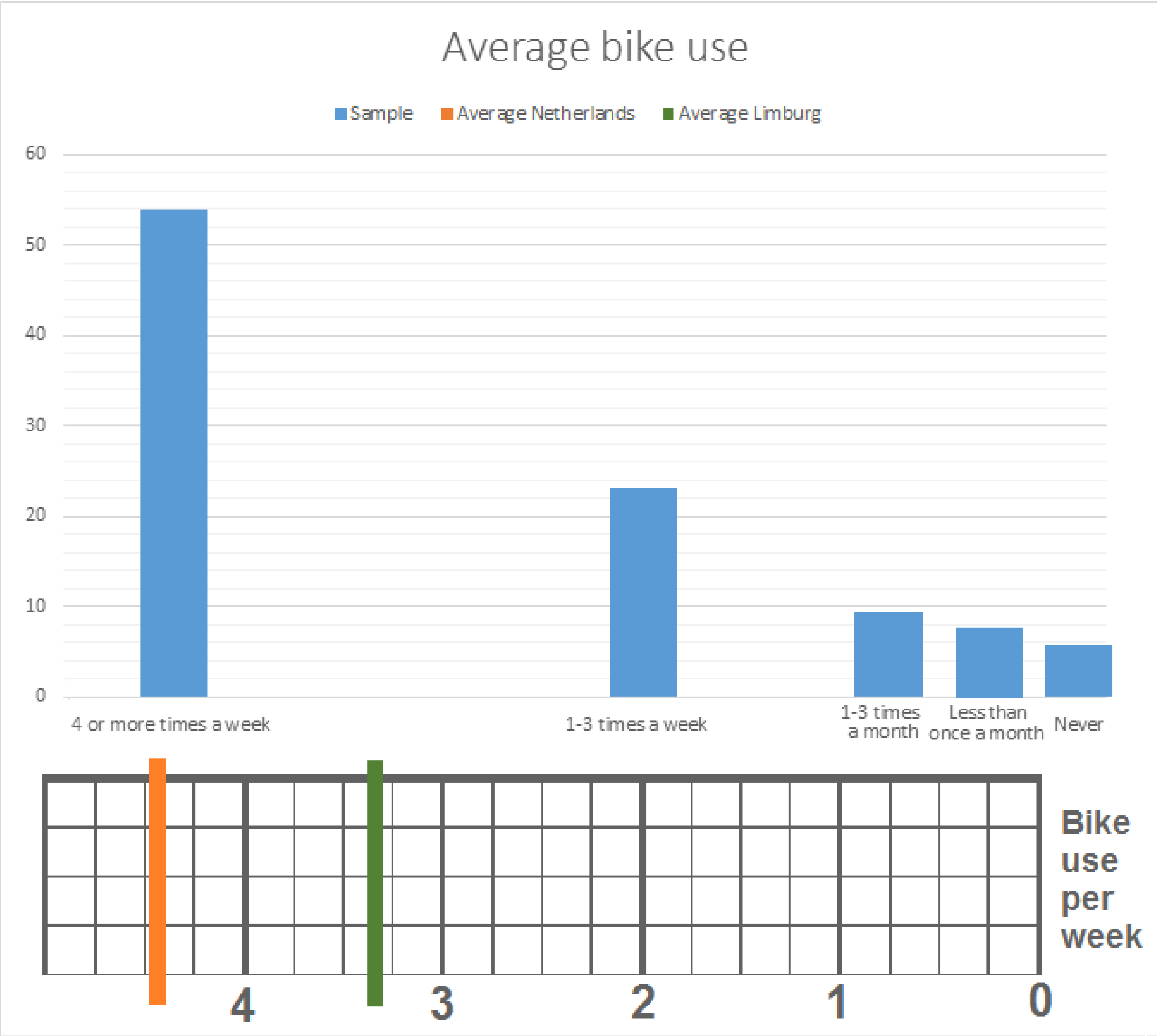
-Figure 25: Ratio time period of cycle trip (%)

Figure 26 shows the ratio between respondents' most used bike type. This ratio is compared to the ratio in the OViN data. In this case, a non-electrical bike is equal to a 'normal' bike in which category the mountain bike and race bike are included. Since OViN data only makes a distinction between non-electrical bikes and electrical bikes there is chosen for this division. In the figure below can be seen that electrical bike users are over-represented in the data set. This means that non-electrical bike users are relatively under-represented.



-Figure 26: Ratio most used bike type (%)

In figure 27 the distributions of the categories of average bike use of the respondents in the data set are presented. These distributions are compared with the averages on national and regional level retrieved from CBS data. The national bike use average is 4.5 bike trips per week. If we obtain the distribution from a national perspective, it shows that about half of the respondents meet this value. It cannot be said with absolute certainty, but from a national perspective the distribution is on average. However, since most of the respondents live in the South of Limburg and the average bike use is significantly lower in this province, we obtained it also from a regional perspective. The average bike use in Limburg is 3.3 bike trips per week. In this case, more than half of the respondents in the data set bikes more than average. From a regional perspective it is likely that the average in the data set is higher than the common use.



-Figure 27: Ratio of average bike use of the respondents, compared with national and regional averages (%)

4.3 Model Estimation Perceived level of Crowding

The output presented in Appendix G, shows that the model used 10,890 observations in total, since all 1,210 respondents evaluated 9 observations. The case processing summary validates that each independent variable level has been distributed in equal amounts among the respondents. The moderate level is the most often selected level as the perceived level of crowding by the respondents. In this case ordinal regression is applied, since the dependent variable (perceived level of crowding) is an ordinal variable.

When looking at the log-likelihood of the intercept Only-model and the final model, it is clear that the final model performs significantly better than the intercept Only-model. The intercept Only-model has a log-likelihood of 7,703.900. The final model which is shown in Appendix G has a log-likelihood of 755.882. This value is closer to zero, which is a good sign (Moore, Notz, & Flinger, 2013). With the values of the log-likelihood of the previous two models the rho-squared index can be calculated. The value of the rho–squared index can range from zero to one. This value summarizes the proportion of variance in the dependent variable associated with the independent variables. The larger this value the more variation is explained by the model. In this case, Cox and Snell's rho-squared value is equal to 0.472. This method has however a theoretical maximum value of less than one, for an even "perfect" model. Nagelkerke's rho-squared method is an adjusted version of the Cox and Snell's rho-squared value and changes the scale of the statistic to cover the full range from zero to one (Pseudo R-Squared Measures, n.d.). The Nagelkerke's adjusted rho-squared value is 0.503. This value is seen as a very good model fit (Ortúzar & Willumsen, 2011). Another way to provide information about the model performance is the chi-squared test.

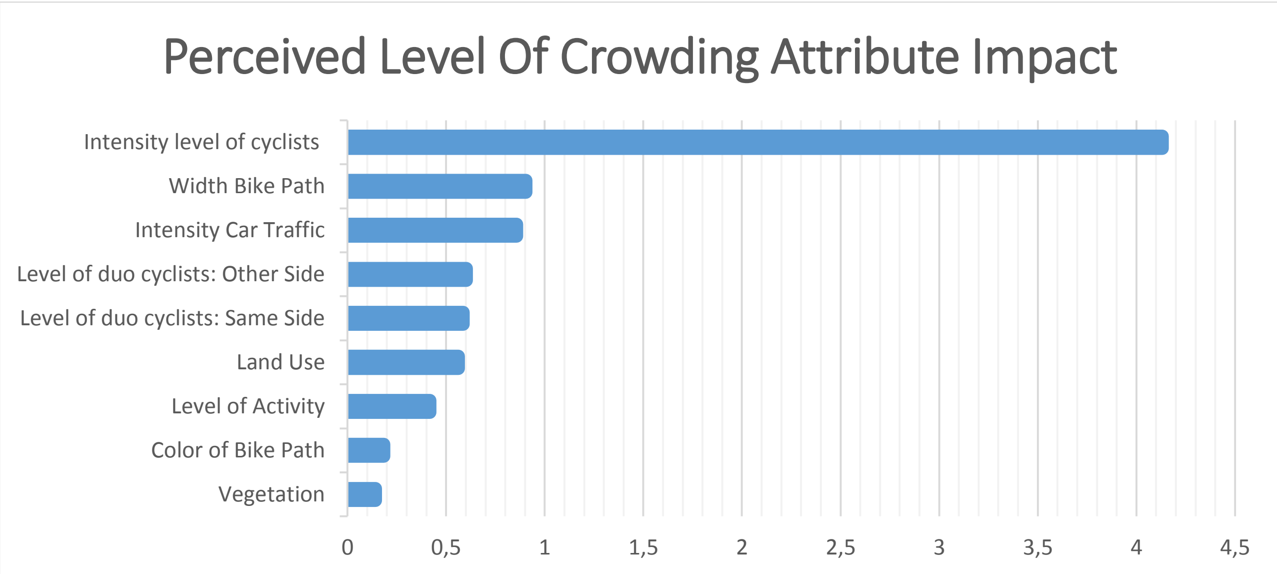
The value of this test is calculated by subtracting the log-likelihood of the final model from the log-likelihood of the constant only model, multiplied by -2. This gives a value of 6,948.018. A critical upper-tail value of the chi-squared distribution according to chi-squared tables for 18 degrees of freedom and a confidence interval of 99.95% is 44.434 (Chi-Square Distribution (Upper Tail) Critical Values, n.d.). Since the value of 6,948.018 is greater than the value of 44.434, the hypothesis that the final model does not perform better than the null model is being rejected. Dummy coding is used to represent the effect of the independent attributes.

-Table 11: Level of perceived crowding coefficients using ordinal regression

Threshold	Level	Beta	Sign.
Level of perceived crowding	Very Low / Low	-7.070	0.000
	Low / Moderate	-4.343	0.000
	Moderate / High	-1.967	0.000
	High / Very High	0.957	0.000
Attribute	**Level**	**Beta**	**Sign.**
Intensity level of cyclists	Low	-4.131	0.000
	Medium	-2.334	0.000
	High	0	-
Level of duo cyclists: Same Direction	Low	-0.586	0.000
	Medium	-0.146	0.001
	High	0	-
Level of duo cyclists: Opposite Direction	Low	-0.602	0.000
	Medium	-0.066	0.143
	High	0	-
Land Use	Rural	0.562	0.000
	In-town residential	0.475	0.000
	High Density	0	-
Level of Activity	Low	-0.417	0.000
	Medium	-0.309	0.000
	High	0	-
Vegetation	Grass	-0.013	0.782
	Trees	0,142	0.002
	Bushes	0	-
Intensity Car Traffic	Low	-0.857	0.000
	Medium	-0.604	0.000
	High	0	-
Width Bike Path	Low	0.904	0.000
	Medium	0.479	0.000
	High	0	-
Color of Bike Path	Red	-0.184	0.000
	Gray/Tiles	-0.055	0.222
	Blue	0	-

Table 11 shows the ordered log-odds (logit) regression coefficients of the attribute levels which influence the perceived level of crowding on the bike path. For one unit increase in the independent variable, the dependent variable is expected to change in its regression coefficient in the ordered log-odds scale. The other variables will be held constant (Ordered Logistic Regression, SPSS Annotated Output, n.d.). In this case the lower the value of the estimated coefficient, the higher the probability on a low rating for the level of crowding on the bike path, which means a positive evaluation. If the intensity level of bicyclists increases is it more likely that respondents rate the situation as a higher level of crowding. This is also the case with an increasing level of duo cyclists, a higher level of pedestrian activity next to the bike path and a higher intensity level of cars next to the bike path. Further it is found that the wider the bike path, the more likely it is that the respondent rates the situation as a lower level of crowding.

A remarkable finding is that rural and in-town residential environments are more likely to be rated as more crowded than high density environments. Another noteworthy finding is that the presence of trees next to the bike path increases the rating of crowded in comparison with the use of bushes, although this difference is minimal. Red bike paths are more likely to be rated as a low level of crowdedness than blue bike paths, but also this difference is only minor. The medium level of duo cyclists in the opposite direction, the grass vegetation next to the bike path and the gray bike paths are insignificant at 95% confidence interval.



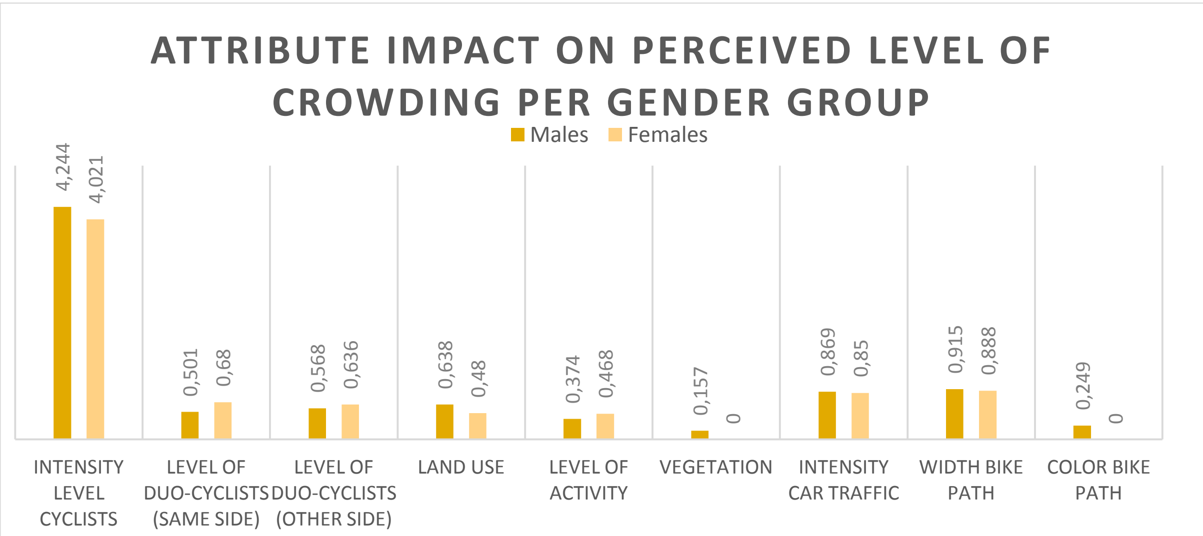
-Figure 28: The relative impact of the attributes on the perceived level of crowding

The intensity level of cyclists has clearly the strongest relation with the perceived level of crowding. The relation of this attribute is positive and has a relative impact of 4.1 on the total utility of a situation. Next, at some distance follows the width of the bike path as second strongest relation with the perceived level of crowding. This effect is negative and has a relative impact of 0.9 on the total utility of a situation. The third strongest relation between the dependent variable is the intensity of car traffic, with a positive direction and a relative impact of 0.9 on the total utility of a situation. The rest of the relative impacts of the attributes on the perceived level of crowding are shown in figure 28. In appendix K are the coefficients for the predictor variables shown in a graph.

4.3.1 Differences between groups in evaluating the perceived level of crowding

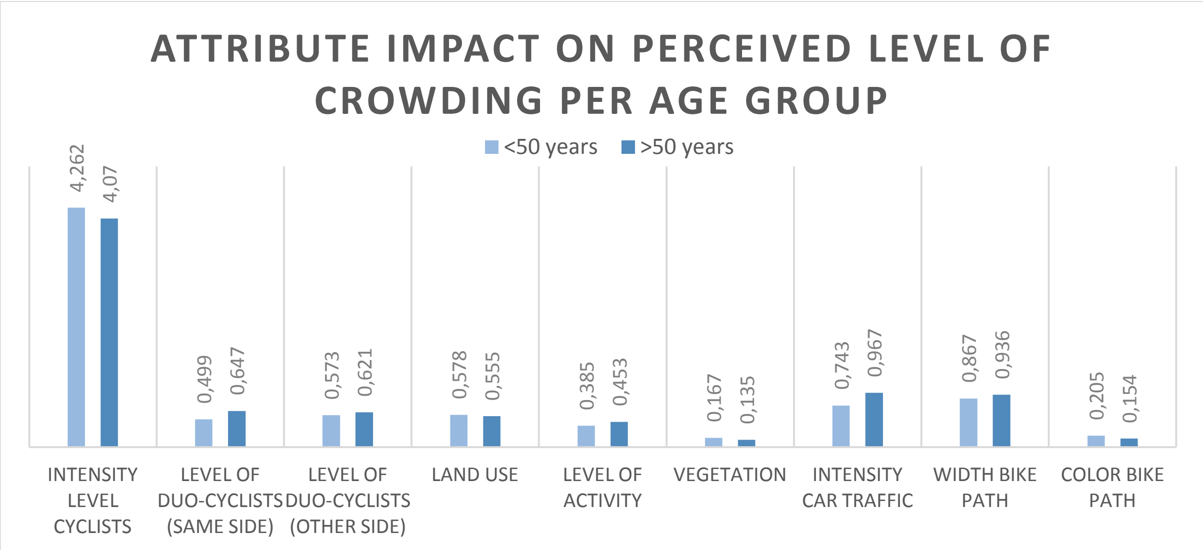
There are no differences between the groups when looking at the effects of the variables on the dependent variable. So this means that for all different groups all effects have the same direction. Among females, there are no significant differences on the valuation of the perceived level of crowding when looking at the color of the bike path. This is also the case concerning the vegetation next to the bike path. Among males there are significant differences in the valuation of the perceived level of crowding for both attributes color of bike path and vegetation). Concerning the color of the bike path and the vegetation next to the bike path among the group who cycles most of the time on an e-bike there are no significant differences regarding the valuation of the perceived level of crowding. In the group who cycles on 'normal' bikes there are significant differences in the valuation of the perceived level of crowding for these two attributes.

Males are more sensitive for the intensity level of cyclists, the land use surrounding the bike path, the vegetation next to the bike path, and the color of the bike path than females. This means that among males these attributes have a greater relative impact on the perceived level of crowding. Females are more sensitive for the level of duo cyclists on both sides and the level of pedestrians' activity next to the bike path compared to males. Figure 29 shows the specific differences in attribute impact on the dependent variable per gender group.



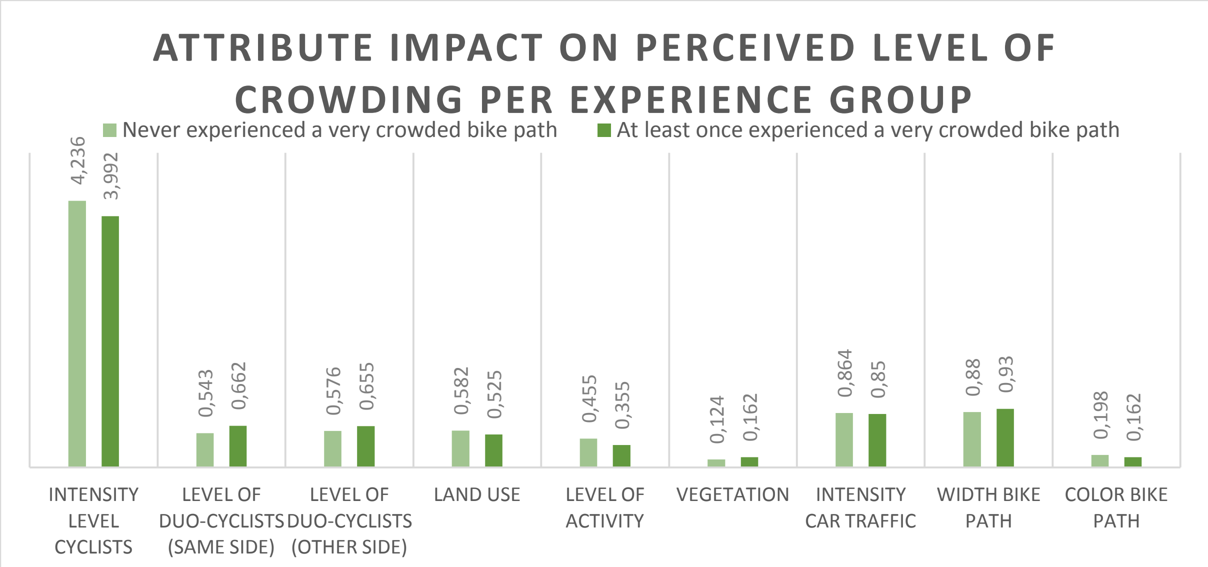
-Figure 29: Attribute impact on perceived level of crowding per gender group

The group of 50 years and older is more sensitive for the level of duo cyclists on both sides in, level of pedestrians' activity, intensity of car traffic next to the bike path and the width of the bike path in comparison with the group of younger than 50 years. The relative impact among people younger than 50 years is greater for the intensity level of cyclists and the bike path color in comparison with the 'older' group. So the relative impact of these two attributes on the perceived level of crowding is larger. Figure 30 shows the specific differences in attribute impact on the dependent variable per age group.



-Figure 30: Attribute impact on perceived level of crowding per age group

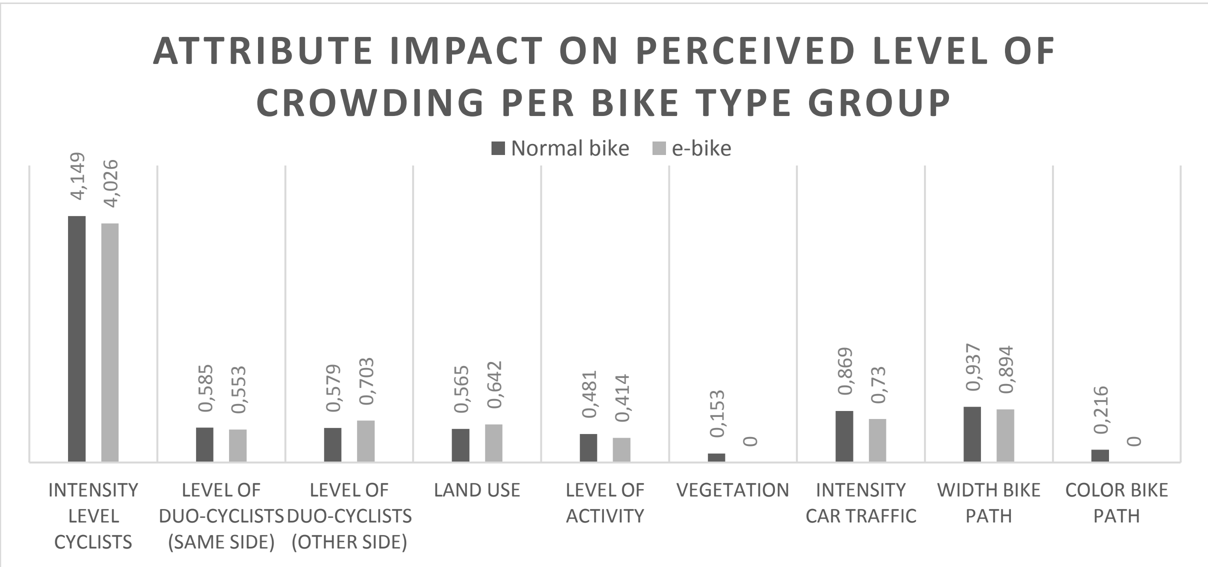
For people who have experienced a very crowded situation on the bike path at least once the level of duo cyclists on both sides does matter more in comparison with people who never faced a very crowded situation on the bike path. People who never faced a very crowded situation on the bike path are more sensitive for the intensity level of cyclists and the activity level of pedestrians in comparison with people who have at least once experienced a very crowded bike path. Figure 31 shows the specific differences in attribute impact on the dependent variable per crowding experience group.



-Figure 31: Attribute impact on perceived level of crowding per experience group

People who ride a non-electrical bike are more sensitive for the intensity level of cyclists, the activity level of pedestrians, the vegetation next to the bike path, the intensity level of cars and the bike path color in comparison with people who ride an e-bike most of the times. Among the group who ride most of the time on an e-bike does the level of duo cyclist in the opposite direction and the land use surrounding the bike path matters more in comparison with people who ride a non-electrical bike. Figure 32 shows the specific differences in attribute impact on the dependent variable per bike type use group.

In Appendix J are all the estimated coefficients and significance values shown.



-Figure 32: Attribute impact on perceived level of crowding per bike type group

4.4 Model Estimation Perceived level of Safety

The output presented in Appendix H shows that the model used 10,890 observations in total, since all 1,210 respondents evaluated 9 observations. In this case ordinal regression is applied, since the dependent variable (perceived level of safety is an ordinal variable). When looking at the log-likelihood of the intercept Only-model and the final model, the final model performs significantly better than the intercept Only-model. The intercept Only-model has a log likelihood of 3,338.322. The final model which is shown in Appendix H has a log-likelihood of 731.544. With the values of the log likelihood of the previous two models the rho-squared index can be calculated. This index summarizes the proportion of variance in the dependent variable associated with the independent variables (Pseudo R-Squared Measures, n.d.). Cox and Snell's rho-squared value is in equal to 0.213. The Nagelkerke's adjusted rho-squared value is 0.231. This value is seen as a moderate model fit (Ortúzar & Willumsen, 2011). The Chi-Square test gives a value of 2,606.778. A critical upper-tail value of the chi-squared distribution according to chi-squared tables for 18 degrees of freedom and a confidence interval of 99.95% is 44.434 (Chi-Square Distribution (Upper Tail) Critical Values, n.d.). Since the value of 2,606.778 is greater than the value of 44.434, the hypothesis that the final model does not perform better than the null model is being rejected. Dummy coding is used to represent the effect of the independent attributes.

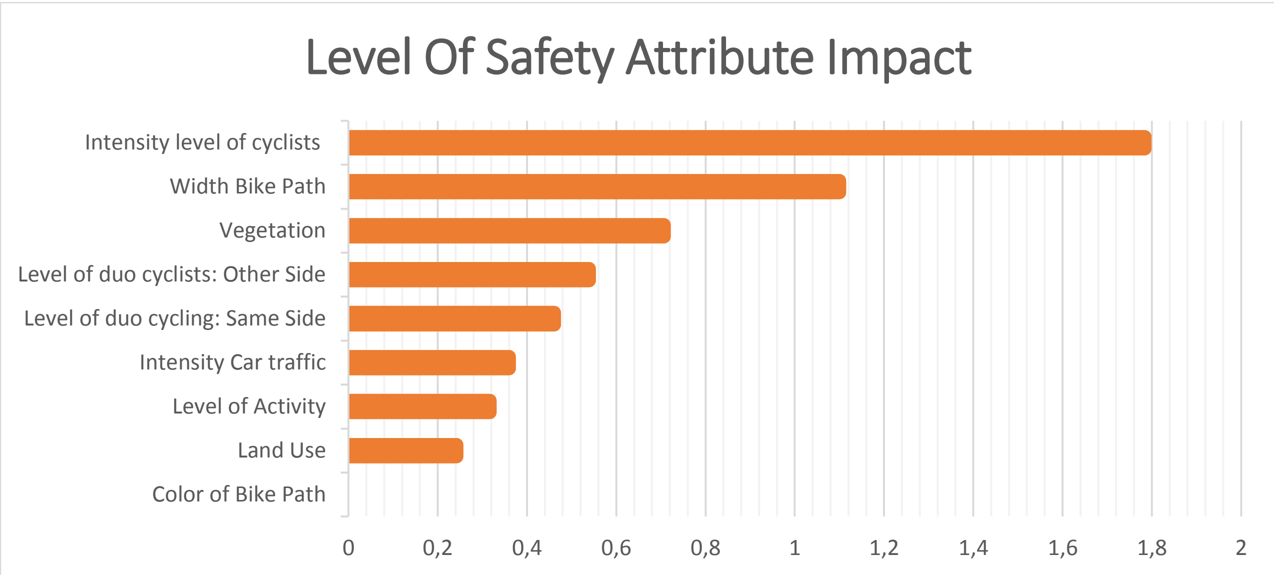
-Table 12: Level of safety coefficients using ordinal regression

Threshold	Level	Beta	Sign.
Level of safety	Very Low / Low	-2.986	0.000
	Low / Moderate	-1.055	0.000
	Moderate / High	1.088	0.000
	High / Very High	4.347	0.000
Attribute	**Level**	**Beta**	**Sign.**
Intensity level of cyclists	Low	1.784	0.000
	Medium	1.110	0.000
	High	0	-
Level of duo cyclists: Same Direction	Low	0.461	0.000
	Medium	0.138	0.002
	High	0	-
Level of duo cyclists: Opposite Direction	Low	0.539	0.000
	Medium	0.053	0.230
	High	0	-
Land Use	Rural	-0.064	0.157
	In-town residential	-0.242	0.000
	High Density	0	-
Level of Activity	Low	0.317	0.000
	Medium	0.180	0.000
	High	0	-
Vegetation	Grass	-0.707	0.000
	Trees	-0.557	0.000
	Bushes	0	-
Intensity Car Traffic	Low	0.360	0.000
	Medium	0.300	0.000
	High	0	-
Width Bike Path	Low	-1.100	0.000
	Medium	-0.445	0.000
	High	0	-
Color of Bike Path	Red	0.085	0.056
	Gray/Tiles	-0.065	0.146
	Blue	0	-

Table 12 shows the ordered log-odds (logit) regression coefficients of the attribute levels which influence the safety level on the bike path.

If the intensity level of bicyclists increases it is more likely that respondents rate the situation with a lower level of safety. This is also the case with an increasing level of duo cyclists, a higher level of pedestrian activity next to the bike path and a higher intensity level of cars next to the bike path. These attributes have all a negative impact on the perceived level of safety valuation. Further it is found that the wider the bike path, the more likely it is that the respondent rates the situation as a higher level of safety. This attribute has a positive impact on the perceived level of safety valuation.

An interesting finding is that high density environments are more likely to be rated as safer in comparison with in-town residential environments. The use of grass or presence of tree vegetation next to the bike path increases the chance to be rated as unsafe in comparison with the use of bushes, this is a very clear difference as seen in table 12. The high and medium levels of car intensity show little differences regarding the rating of safety. The medium level of cycling next to each other in the opposite direction, the rural area environment and both gray and red bike paths are insignificant at 95% confidence interval.



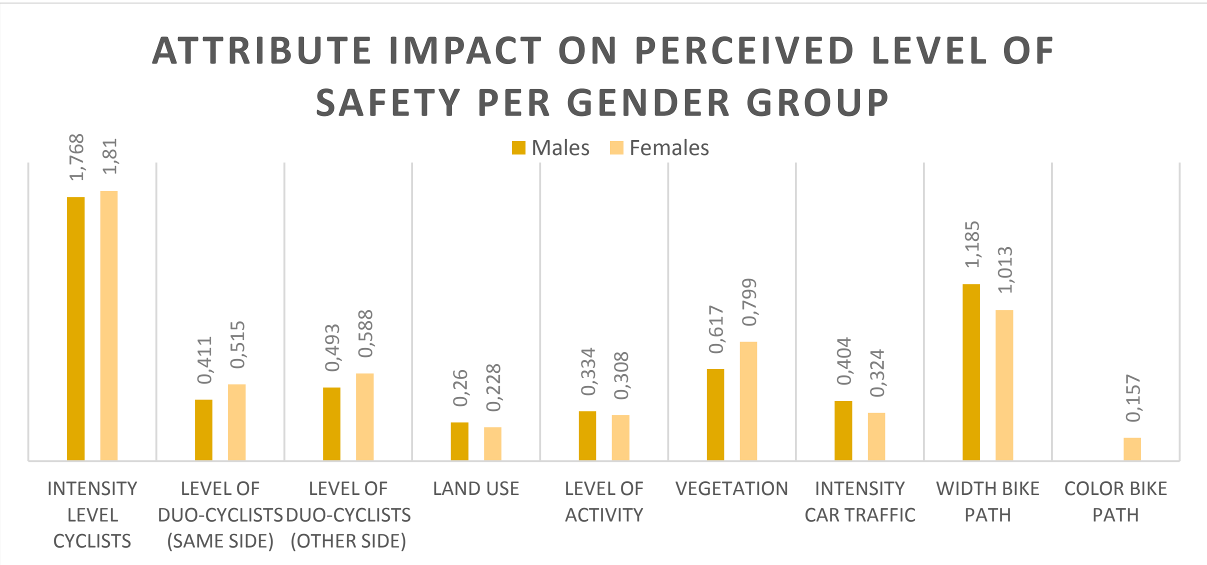
-Figure 33: The relative impact of the attributes on the safety level

The intensity level of cyclists has clearly the strongest relation with the perceived level of safety. The relation of this attribute is positive and has a relative impact of 1.8 on the total utility of a situation. Next, at a good distance follows the width of the bike path as second strongest relation with the perceived level of safety. This effect is negative and has a relative impact of 1.1 on the total utility of a situation. Remarkable here is that the difference between the impacts of the first two variables is not as big as with the perceived level of crowding. The third strongest relation between the dependent variable is the vegetation, with a relative impact of 0.7 on the total utility of a situation. The vegetation has clearly a bigger influence on the perceived level of safety than it has on the perceived level of crowding. The rest of the relative impacts of the attributes on the perceived level of safety is shown in figure 33. In appendix K are the coefficients for the predictor variables shown in a graph.

4.4.1 Differences between groups in evaluating the perceived level of safety

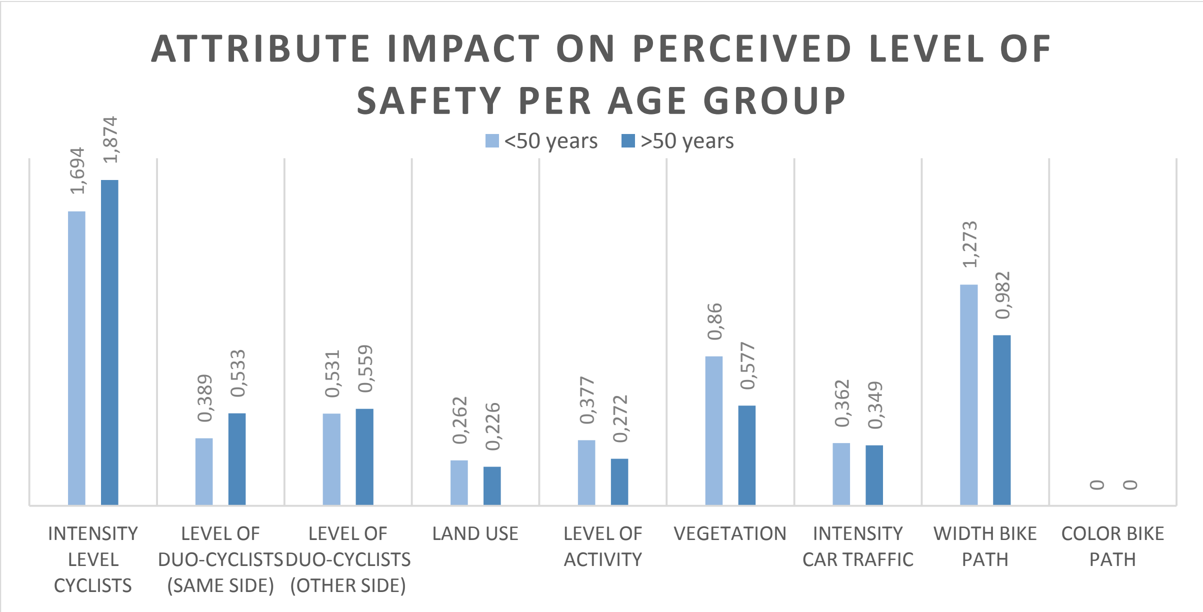
There are no differences between the groups when looking at the effects of the variables on the dependent variable. So this means that for all different groups all effects have the same direction. Among males, there are no significant differences on the valuation of the perceived level of safety when looking at the color of the bike path. Among females there are significant differences in the valuation of the perceived level of safety for this attribute. Concerning the color of the bike path for all the other compared groups are no significant differences in the valuation of the perceived level of safety found. Among the group who rides most of the times an e-bike are there no significant differences found in the valuation of the perceived level of safety for the vegetation levels.

Females are more sensitive for the intensity level of cyclists, the level of duo cyclists on both sides, the vegetation next to the bike path and the color of the bike path than males. This means that these attributes have a greater relative impact on the perceived level of safety among females. Males are more sensitive for the car intensity and the bike path width compared to females. Figure 34 shows the specific differences in attribute impact on the dependent variable per gender group.



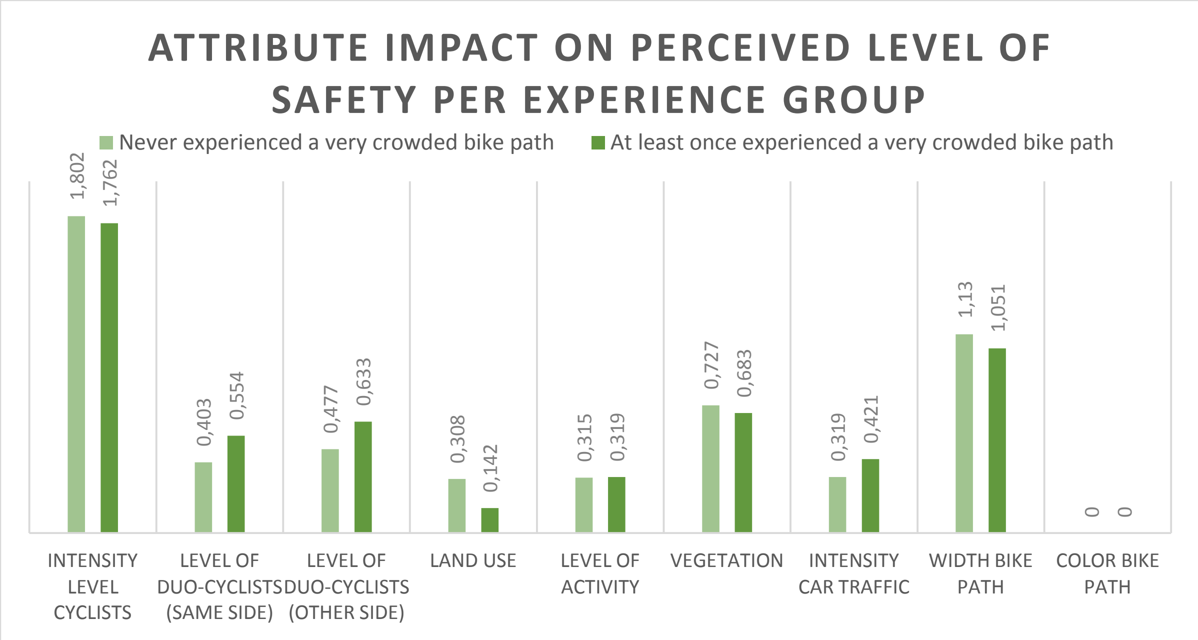
-Figure 34: Attribute impact on perceived level of safety per gender group

The group of 50 years old or older is more sensitive for the intensity level of cyclists and the level of duo cyclists on the same side in comparison with the group of younger than 50 years old. The relative impact among people younger than 50 years old is greater for the activity level of pedestrians, the vegetation next to the bike path and the width of the bike path in comparison with the 'older' group. So the relative impact of these two attributes on the perceived level of safety is larger. Figure 35 shows the specific differences in attribute impact on the dependent variable per age group.



-Figure 35: Attribute impact on perceived level of safety per age group

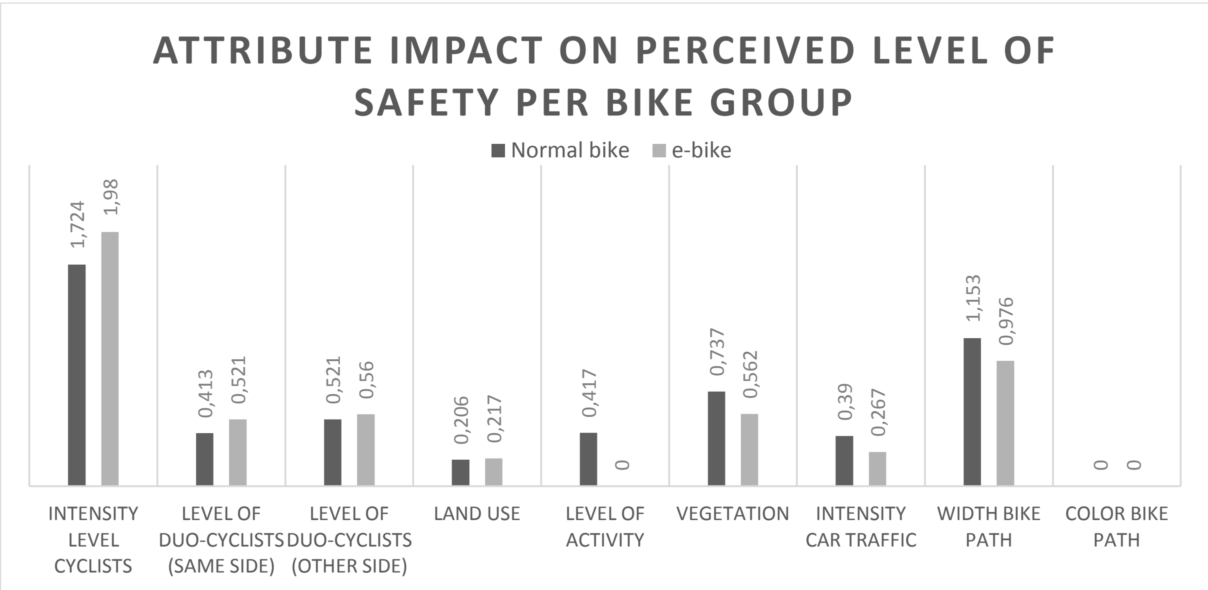
For people who have experienced at least once a very crowded situation on the bike path does the level of duo cyclists on both sides and the car intensity matter more in comparison with people who never faced a very crowded situation on the bike path. The relative impact among people who never faced a very crowded situation on the bike path is greater for the land use surrounding the bike path and the bike path width in comparison with people who have at least once experienced a very crowded bike path. Figure 36 shows the specific differences in attribute impact on the dependent variable per crowding experience group.



-Figure 36: Attribute impact on perceived level of safety per experience group

People who ride a non-electrical bike are more sensitive for the activity level of pedestrians, the vegetation next to the bike path and the intensity level of cars in comparison with people who ride an e-bike most of the times. Among the group who ride most of the time on an e-bike do the intensity level of cyclists and the level of duo cyclist on the same side matter more in comparison with people who ride a non-electrical bike. Figure 37 shows the specific differences in attribute impact on the dependent variable per bike type use group.

In Appendix J are all the estimated coefficients and significance values shown.



-Figure 37: Attribute impact on perceived level of safety per bike type group

4.5 Model Estimation Perceived level of Comfort

The output presented in Appendix I shows us again that the model used 10,890 observations in total. In this case ordinal regression is applied, since the dependent variable (perceived level of comfort) is an ordinal variable When looking at the log likelihood of the intercept Only-model and the final model, it is clear that the final model performs better than the intercept Only-model. The intercept Only-model has a log likelihood of 3,736.258. The final model which is shown in Appendix I has a log-likelihood of 697.932. This value is closer to zero, which is says that the final model is indeed better than the previous (Moore, Notz, & Flinger, 2013). Cox and Snell's rho-squared value is in this case 0.243. The adjusted rho-squared value is 0.263. This value is seen as a good model fit by Ortúzar &

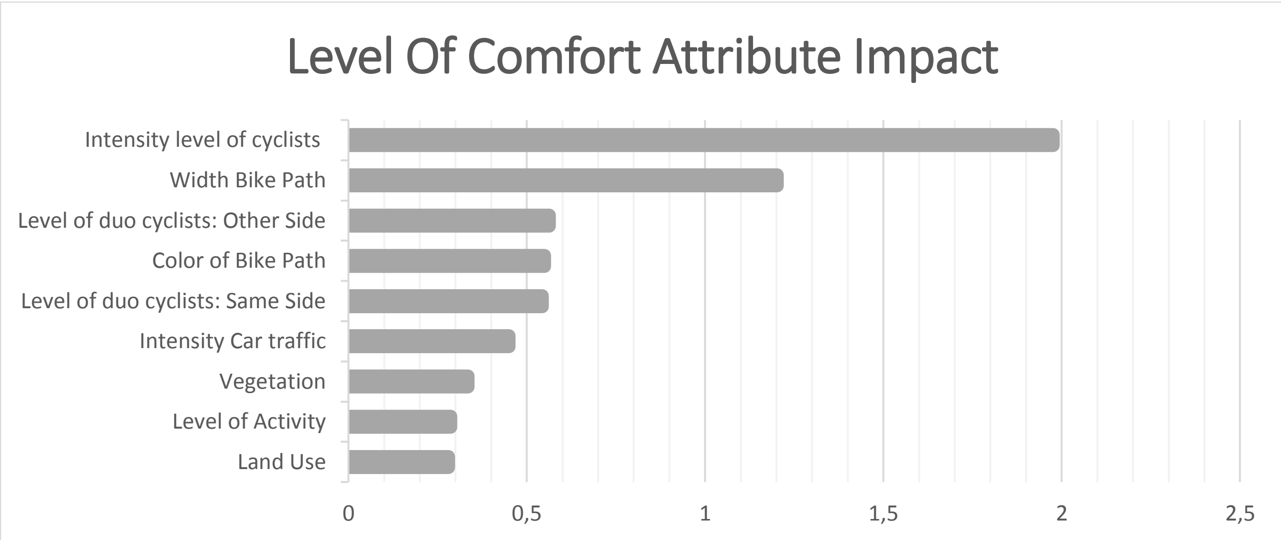
Willumsen (2011). Another way to provide information about the model performance is the chi-squared test. This gives a value of 3,038.327. A critical upper-tail value of the chi-squared distribution according to chi-squared tables for 18 degrees of freedom and a confidence interval of 99.95% is 44.434 (Chi-Square Distribution (Upper Tail) Critical Values, n.d.). Since the value of 3,038.327 is greater than the value of 44.434, the hypothesis that the final model does not perform better than the null model is being rejected. Dummy coding is used to represent the effect of the independent attributes.

-Table 13: Level of comfort coefficients using ordinal regression

Threshold	Level	Beta	Sign.
Level of comfort	Very Low / Low	-2.620	0.000
	Low / Moderate	-.705	0.000
	Moderate / High	1.496	0.000
	High / Very High	4.615	0.000
Attribute	**Level**	**Beta**	**Sign.**
Intensity level of cyclists	Low	1.976	0.000
	Medium	1.236	0.000
	High	0	-
Level of duo cyclists: Same Direction	Low	0.543	0.000
	Medium	0.222	0.000
	High	0	-
Level of duo cyclists: Opposite Direction	Low	0.563	0.000
	Medium	0.052	0,243
	High	0	-
Land Use	Rural	-0.111	0.013
	In-town residential	-0.280	0.000
	High Density	0	-
Level of Activity	Low	0.287	0.000
	Medium	0.088	0.046
	High	0	-
Vegetation	Grass	-0.278	0.000
	Trees	-0.335	0.000
	Bushes	0	-
Intensity Car Traffic	Low	0.450	0.000
	Medium	0.369	0.000
	High	0	-
Width Bike Path	Low	-1.202	0.000
	Medium	-0.566	0.000
	High	0	-
Color of Bike Path	Red	0.127	0.004
	Gray/Tiles	-0.428	0.000
	Blue	0	-

Table 13 shows the ordered log-odds (logit) regression coefficients of the attribute levels which influence the perceived level of comfort on the bike path. In this case it holds that the higher the value of the estimated coefficient, the higher the probability on a higher rating for the comfort level. If the intensity level of bicyclists increases is it more likely that respondents rate the situation as less comfortable. This is also the case with an increasing level of duo cyclists, a higher level of pedestrian activity next to the bike path and a higher intensity level of cars next to the bike path. These attributes have, just like with the perceived level of safety, a negative influence on the dependent variable. Further is found that the wider the bike path, the more likely it is that the respondent rates situation as a higher level of comfort.

A remarkable finding is that rural and in-town residential environments are more likely to be rated as less comfortable than high density environments. Another noteworthy finding is that the use of gray tiles for the bike path is likely to be rated less comfortable, where the red bike path is likely to be rated as more comfortable. The medium level of cycling next to each other in the same direction is again insignificant at 95% confidence interval.



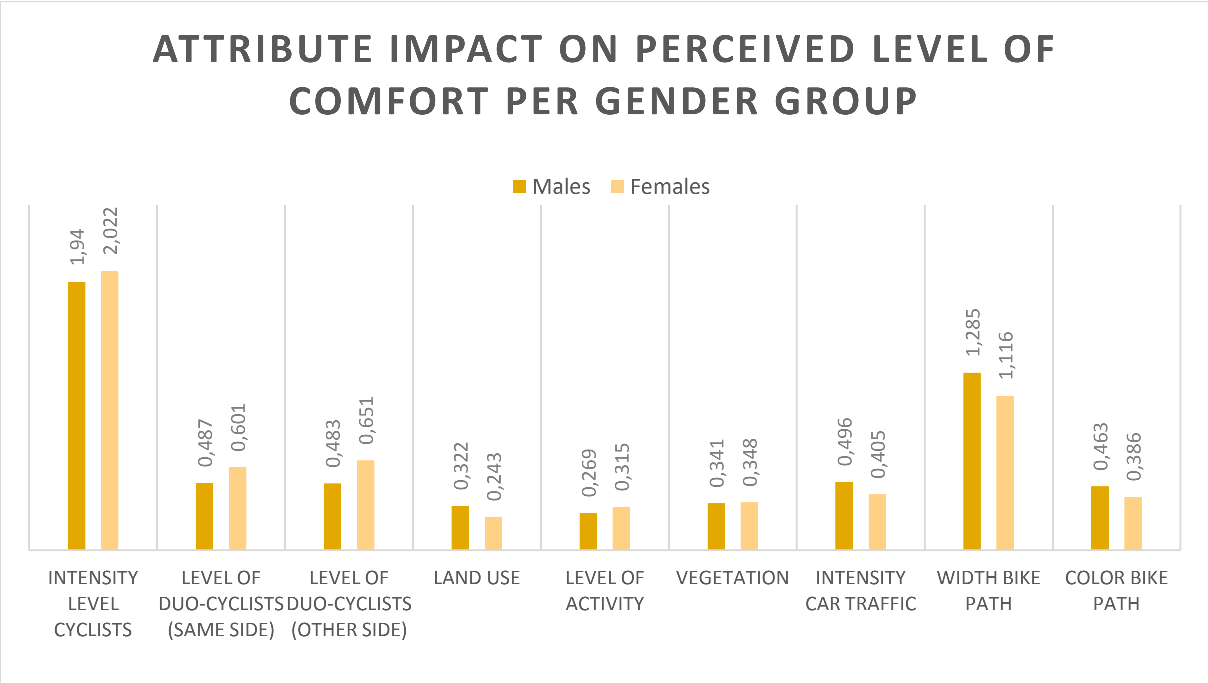
-Figure 38: Ranges of the impact on the comfort level

The intensity level of cyclists has clearly the strongest relation with the perceived comfort level. The relation of this attribute is negative and has a relative impact of 1.9 on the total utility of a situation. Next, at a good distance follows the width of the bike path as second strongest relation with the perceived level of crowding. This effect is positive and has a relative impact of 1.2 on the total utility of a situation. The third strongest relation between the dependent variable is the level of duo cycling in the opposite direction, with a negative direction and a relative impact of 0.6 on the total utility of a situation. The rest of the relative impacts of the attributes on the perceived level of comfort are shown in figure 38. In appendix K are the coefficients for the predictor variables shown in a graph.

4.5.1 Differences between groups in evaluating the perceived level of comfort

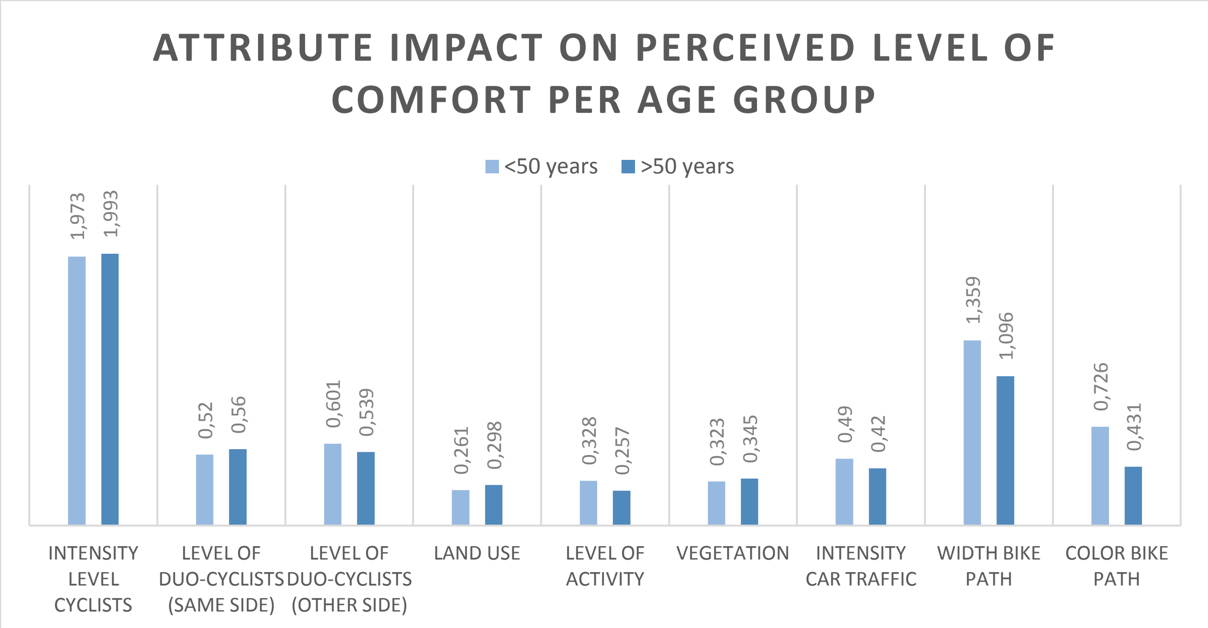
There are no differences between the groups when looking at the effects of the variables on the dependent variable. So this means that for all different groups all effects have the same direction. Among e-bike users, there are no significant differences on the valuation of the perceived level of comfort when looking at the activity level of pedestrians. Among cyclists who do not use an e-bike are there significant differences in the valuation of the perceived level of comfort for this attribute.

Females are more sensitive for the intensity level of cyclists and the level of duo cyclists on both sides compared with males. This means among females that these attributes have a greater relative impact on the perceived level of safety. Males are more sensitive for the land use surrounding the bike path, the car intensity, the bike path width and the color of the bike path compared to females. Figure 39 shows the specific differences in attribute impact on the dependent variable per gender group.



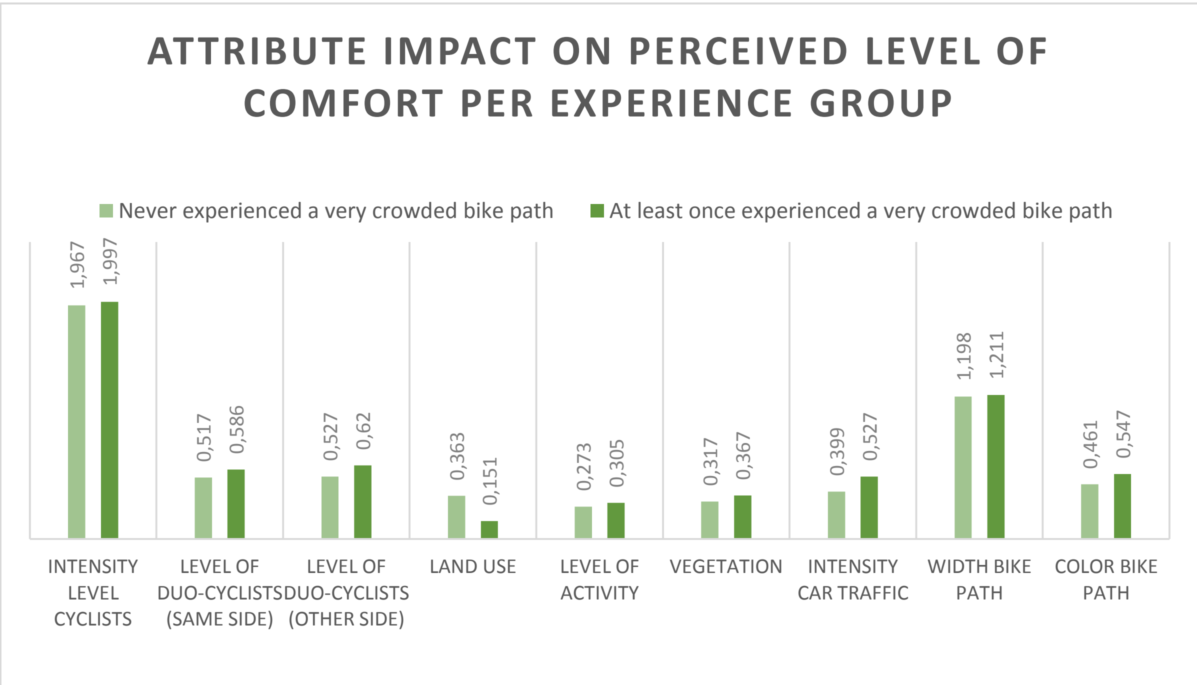
-Figure 39: Attribute impact on perceived level of comfort per gender group

The relative impact among people younger than 50 years old is greater for the level of duo cyclists in the opposite direction, the activity level of pedestrians, the car intensity, the bike path width and the color of the bike path compared to the 'older' group. So the relative impact of these attributes on the perceived level of comfort is larger. Figure 40 shows the specific differences in attribute impact on the dependent variable per age group.



-Figure 40: Attribute impact on perceived level of comfort per age group

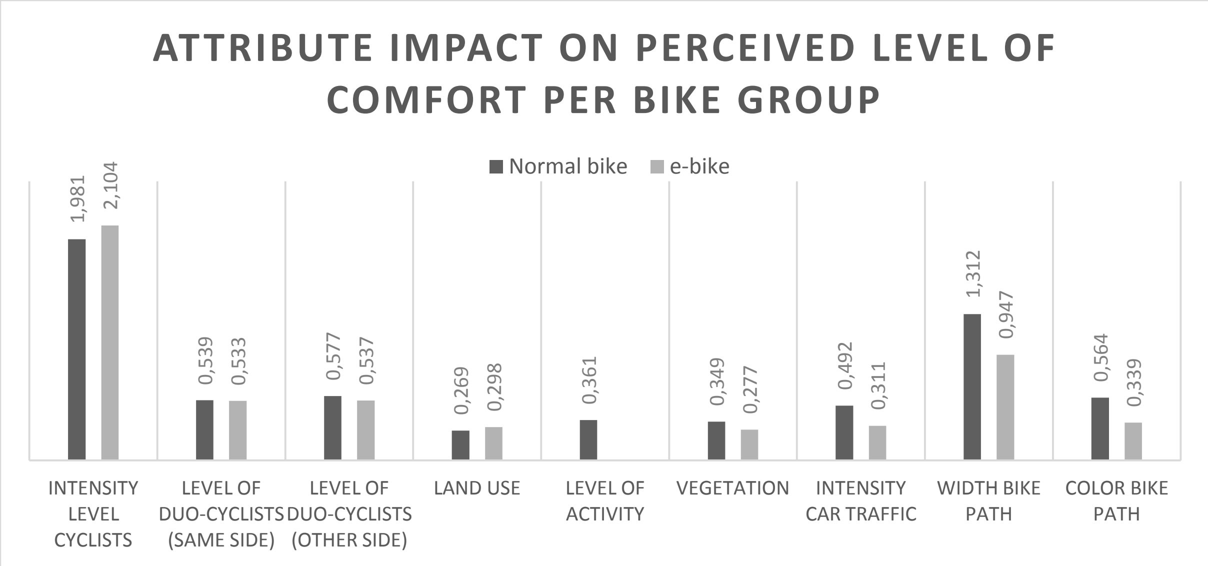
For people who have experienced at least once a very crowded situation on the bike path does the level of duo cyclists on both sides, the car intensity and the bike path color matter more compared to people who never faced a very crowded situation on the bike path. The relative impact among people who never faced a very crowded situation on the bike path is greater for the land use surrounding the bike path in comparison with people who have at least once experienced a very crowded bike path. Figure 41 shows the specific differences in attribute impact on the dependent variable per crowding experience group.



-Figure 41: Attribute impact on perceived level of comfort per experience group

People who ride a non-electrical bike are more sensitive for the activity level of pedestrians, the vegetation next to the bike path, the intensity level of cars, the bike path width and the color of the bike path compared to people who ride an e-bike most of the times. Among the group who ride most of the time on an e-bike does the intensity level of cyclists matter more in comparison with people who ride a non-electrical bike. Figure 42 shows the specific differences in attribute impact on the dependent variable per bike type use group.

In Appendix J are all the estimated coefficients and significance values shown.



-Figure 42: Attribute impact on perceived level of comfort per bike type group

4.6 Discussion results

This chapter showed the results of the analyses carried out on the stated preference data. The required amount of respondents of the questionnaire, which is set in chapter 3, was reached. Though, some groups are over presented in the experiment, like the group of respondents who are 50 to 64 years old and the group of e-bike users. Further, the results show that all the in chapter 2 chosen attributes have a significant influence on the valuation of the perceived crowding, safety, and comfort. Except for the color of the bike path, that does not lead to a significant difference in the valuation of the perceived level of safety. The intensity of the cyclists on the bike path has by far the biggest influence on the perceived level of all three dependent variables. Further, the bike path width seems to be a very imported contributor to the dependent variables. The other attributes have a more varying role in terms of influence on the perceived level of crowding, safety, and comfort. The intensity of cars next to the bike path is for instance an important contributor to the perceived level of crowding and vegetation plays a bigger role in the valuation of the perceived level of safety. For each attribute, it was checked whether there are differences between groups of respondents, which could be distinguished out of the answers given in the questionnaire. It was found that there are differences between groups in the valuation of the dependent variables. As stated before the sample is not entirely representative for the Dutch population. People younger than 18 and people who are older than 76, are under-represented in the sample. Especially the 'elderly' group is seen as a vulnerable group in terms of safety on the bike path. It could be that this 'elderly' group is more critical on unsafe situations and this could lead to a stronger relation between the dependent variables and the attributes. In terms of level of urbanity of the respondents' residential area the 'not-urban' group is the most under-represented in the sample. These people are most of the time not used to crowding, which could lead to more sensitivity for the intensity variables. Furthermore, most respondents live in South-Limburg. This location has relatively not much problems with bicycle crowding, the only exception is the center of Maastricht as can be seen in figure 3. If more people living in a big city elsewhere in the Netherlands participated, could this lead to other results. At last, people who are cycling most of the time in off-peak periods are under-represented. In off-peak periods the intensity on the bike paths is clearly lower. So, this means that this group is less exposed to crowding on bike paths. This could lead again to more sensitivity for the intensity variables.

The findings of the cyclist intensity stroke with the findings in literature. Regarding the results, the intensity of cyclists has a positive effect on the level of perceived crowding of cyclists, this is also stated by Klinkers & van Hoorn (1987). The same intensity has a negative effect on the cyclist's perceived comfort, which is also concluded by Li et al. (2011) and Bai et al. (2015). The findings regarding the influence of the level of duo-cyclists on the dependent variables also correspond with the findings from literature. The results show that the level of duo-cyclists has a positive effect on the perceived level of crowding, as also stated by Munckhof et al. (2017). This attribute has a negative effect on the perceived level of safety in this research. This is also concluded by Lehner-Lierz (2006). The research by Botma & Papendrecht (1992) has shown that cycling next to each other can cause major comfort issues for the other users of the bike path. The results of this research also show that people find it less comfortable when there are more people cycling next to each other. Further this research found that respondents are more sensitive for the level of duo cyclist in the opposite direction, compared to the level of duo cyclists on the same bicycle lane. Since this is never researched before this statement cannot be compared.

The land use surrounding the bicycle path also influences the three dependent variables. It seems that the desired activity for a specific location is indeed important for the evaluation of the perceived crowding, as stated by Shelby et al. (1989). Rural environments were evaluated as more crowded, followed by the in-town residential environment and the high density (downtown) environment. Jaarsma (2011) states that rural roads are more unsafe for cyclists in comparison with high density environments, but this study shows that there is no difference in the evaluation of safety between these two environments. The results show that respondents evaluate the high density environment as more comfortable, in comparison with the other two levels. This does not correspond to the findings of Lee et al. (2010), which indicated that people do not like to cycle in these kinds of environments. Concerning the presence and activity level of pedestrians influencing the perceived safety of cyclists are some uncertainties. Evans-Cowley & Akar (2013) stated that cyclists may feel safer with the presence of pedestrians on the street. The more pedestrians were seen, the more likely the scenario was chosen. But in this research it appears that respondents find it more unsafe when more pedestrians are seen by the respondents. This uncertainty is also the case in evaluating the perceived comfort of the cyclists. Krabbenborg et al. (2015) stated that the presence of pedestrians has a positive effect on the experienced comfort for cyclists. Though, this research concludes the opposite: the more pedestrians there are the lower the level of comfort for the cyclists. The results of this research stroke more with the findings of Lee et al. (2010), who state that cyclists are less likely to choose for a route with a strong commercial land use share. Streets which are used commercially are often more crowded on the street, but also next to it. This might indicate that the level of pedestrians next to the bike path can have a negative contribution to the users' perception of comfort. The results of this research show that cyclists valuate the situation as more unsafe when only grass is used. Further it is seen that trees are seen as more unsafe, compared to the use of bushes. This is also stated before by Evans-Cowley & Akar (2013). Trees which are closer to the bicycle path and which are denser were less likely to be chosen. This might be because of the decreasing visibility for the cyclists. This results show that the car intensity has a negative influence on the cyclists perceived level of safety, this is also concludes by Christmas et al. (2010). This attribute also has a negative influence on the perceived level of comfort by the cyclists, which is also stated by Lee et al. (2010), Evans-Cowley & Akar (2013) and Overdijk (2016).

These results also show that the bike path width is a major indicator for the perceived level of crowding, which is also stated by Munckhof et al. (2017). De Groot-Mesken et al. (2015) mention that too narrow bike paths lead to unsafe situations for the cyclists. Another research by De Goede et al. (2013) stated that bike paths with a high intensity and a limited bike path width play a big role in unsafe situations among the cyclists. This has also been shown in the current study. The bike path width has a negative influence on the perceived level of comfort, which is also stated by Li et al. (2011) and Bai et al. (2015). There is one source found that did not show a statistically significant influence of the bike path width on the experienced safety (Sener et al., 2009). Munckhof et al. (2017) state that color of the bike path makes no difference in the perceived level of crowding. The result of this research shows though a difference in the evaluation of red bike paths in comparison with the other two levels. The results also show that respondents evaluate the gray/tiles bike path as less comfortable in comparison with the other two levels. This finding strokes with the findings of Schepers et al. (2009). Further red bike paths are seen as more comfortable than blue bike paths. This could be explained because Dutch people are more familiar with red colored bike paths. In table 14 is a summary shown where all findings are compared with the literature findings.

-Table 14: Summary of all findings compared to literature findings

Attribute Group	Attributes	Perceived level of crowding	Perceived level of safety	Perceived level of comfort
Traffic conditions on bike path	Intensity level of cyclists			
	Level of duo cyclists			
Surrounding bike path	Land Use			
	Level of pedestrian activity			
	Vegetation			
	Intensity Car Traffic			
Physical bike path conditions	Width Bike Path			
	Color of Bike Path			

Validated by literature (54%)	Mixed validation views by literature (13%)	Invalidated by literature (13%)	No literature found (20%)

5. CONCLUSION

5.1 General Conclusion

The objective of the research was to get more insight in the influence of attributes to the perceived level of crowding, safety and comfort of cyclists, as stated in chapter 1. There was special attention paid to understanding crowding in general and on the bike path in particular. Further the objective of this research was to develop a simulation/animation which is credible for respondents. It should be done in a way that respondents could easily relate the simulation to the real world. The main research question was:

"What is the influence of several bike related attributes on the perceived level of crowding, safety and comfort?"

In order to be able to answer this question, several sub-questions have to be answered.

- ***"What is crowding?"***

Crowding is seen as a negative evaluation of density or number of encounters, as stated in chapter 2. This assessment is done with an opinion that the observed number of occupants is too high for the area that is occupied. Because crowding is a value judgement, it is often used as the term 'Perceived crowding'. In terms of determining the perceived level of crowding, one need to know more about the setting, desired activity, and the individuals making the evaluation. Further crowding has a lot to do with personal space violations. This is an invisible and for each individual different amount of space, which indicates the preferred distance from others.

- ***"What is crowding on bicycle paths?"***

Recently it has become increasingly more crowded on the cycle path, especially in high urban areas. About 10% of the cyclists have problems with this. The increase in intensity of cyclists is due to a number of measures, such as the construction of many fast cycling routes, discouraging measures to reduce car use in the city, and the availability of "OV-bicycle". Furthermore new groups discovered the bike, such as elderly people, people who traveled by bus or tram, and people with a non-western background. Most crowded bicycle paths are located in the center of cities, at intersections and crossings for pedestrians, on roads with a limited width, in streets with many different usage functions, and on routes to stations and educational institutes. Whether a bicycle path is crowded, is now determined on the basis of a few guidelines concerning the width of the bicycle path and bike intensity. If the bicycle path is too narrow for the measured intensity, the bicycle path is considered to be too crowded. However, it is questionable whether users also find it crowded on that bike path. According to paragraph 2.2, this is a wrong way to determine crowding, as crowding is more about the evaluation of density in a particular environment and is based on opinions of the users. A bicycle level of service determination might be more appropriate to measure the "quality of service" which obtains the comfort, safety, and ease of mobility for users. Though, this is still based on factual data, which is still no opinion of users.

- ***"What has previous research on crowding on bicycle paths demonstrated?"***

The few researches who paid attention to the actual perceived crowding found several things. The perceived crowding in urban environments is caused by physical, social, and individual factors, as shown in paragraph 2.3. Another research found that the higher the intensity of the cyclists, the more crowded the respondents found it. Further, it has been established that the speed variation on more crowded bike paths is smaller and about one third of the cyclists sometimes take another mean of transport due the crowding on the bike paths. The same researchers also stated that the level of duo-cyclists on the bike path is the most important social contributor to the perceived level of crowding. Just like intensity level the width of the bike path is a major indicator of perceived crowding.

- ***"How can the perceived crowding, safety and comfort for cyclists be measured?"***

Measuring the perceived crowding, safety, and comfort is seen as a cognitive complex task that is a task which is harder to understand for the respondent. This can be the case when a large number of attributes is included in the research, which should be obtained by the respondent. Sometimes it is hard to imagine a situation with only attributes in a text-only experiment, as stated in chapter 3. Another research found that text-only Stated Preference experiments with more than six attributes are confusing and too hard to process for the respondent. The use of visual images can help in presenting a wide range of variables and can lower the cognitive complexity for the respondents. This result shows that the best way to measure the perceived crowding, safety, and comfort is in a visual way. In where a virtual research has the preference over a field research, since in virtual environments the researcher will have total experimental control.

- ***"Which attributes influence the perceived crowding, safety and comfort by cyclists on bicycle paths?"***

As stated in several different literatures, it seems that the **intensity level of cyclists** has a significant influence on the perceived level of crowding. In this research it is demonstrated that besides it has significant influence on the perceived crowding, safety and comfort, it also has the largest impact on these dependent variables. It has a positive effect on the perceived crowding; the higher the intensity, the higher the perceived crowding. For safety and comfort, it has a negative effect; the higher the intensity, the lower the perceived safety and comfort by the cyclist. The **bike path width** has also a significant influence on the perceived level of crowding, safety, and comfort, stated by several researchers. In this research it is demonstrated that this is true. Bike path width is the second most important contributor to the dependent variables. The width has a negative effect on the perceived crowding; the wider the path, the lower the perceived crowding. For safety and comfort, it has a positive effect; the wider the path, the lower the perceived safety and comfort on the bike path. The intensity level and bike path width are most of the times used to determine the objective crowding. It is correct that these are important variables to determine whether the cyclists feel crowdedness on the bike path, but there are also other important variables which contribute to this experience.

The **intensity of car traffic** is especially for the perceived level of crowding an important contributor. This has also a significant influence on the perceived level of safety and comfort, but with less relative impact. It has a positive effect on the perceived crowding; the higher the intensity, the higher the perceived crowding. For safety and comfort, it has a negative effect; the higher the intensity, the lower the perceived safety and comfort by the cyclist. The **level of duo cyclists** has a significant influence on all three dependent variables. The level of duo cyclists has, compared to the other attributes, a medium impact on the perceived crowding, safety and comfort. The respondents are more sensitive for the level of duo cyclist in the opposite direction, compared to the level of duo cyclists in the same direction. This is probably cause respondents are more exposed to that direction. It has a positive effect on the perceived crowding; the higher the level of cycling next to each other, the higher the perceived crowding. For safety and comfort, it has a negative effect.

Vegetation next to the bike path has a significant influence on the perceived level of crowding, safety, and comfort. It has a high impact on the perceived safety, compared to the other researched attributes. On the perceived crowding and comfort this attribute has a quite low impact. Compared to the other levels, scenarios with trees were evaluated as more crowded and bushes as less crowded. For the perceived safety it is clear that respondents prefer a separation between the road way and the bike path, since the grass level is evaluated as less safe, compared to the other two levels. For the perceived comfort the bushes are evaluated as most comfortable and the trees as least comfortable. **The color of the bike path** has only a significant influence on the perceived crowding and comfort. On the perceived safety this attribute has no influence. The color has a low impact on the perceived crowding, compared to the other included attributes. For the perceived comfort the impact is medium. Red bike paths were evaluated as less crowded compared to the blue bike paths. Further the respondents evaluated red bike paths as more comfortable and gray/tiles were evaluated clearly as less comfortable. The **pedestrians' level of activity** next to the bike path has on all three dependent variables a significant influence. It has a low impact on the perceived crowding, safety, and comfort compared to the other researched attributes. The level of activity has a positive effect on the perceived crowding; the more activity by the pedestrians, the higher the perceived crowding. For safety and comfort, it has a negative effect; the more activity by the pedestrians, the lower the perceived safety and comfort on the bike path. The **land use** surrounding the bicycle path has also on all three dependent variables a significant influence. It has a medium impact on the perceived crowding, compared to the other researched attributes. On the perceived safety and comfort this attribute has a quite low impact. The high density level is evaluated the most positively, followed by respectively the in-town residential level and the rural level. This confirms the in chapter 2 stated argument, that individuals make their crowding decision on info about the setting and the desired activity in that setting. It has been found that there are differences between groups in the valuation of the dependent variables.

In table 15 are the most optimal scenarios shown for each dependent variable.

-Table 15: The most optimal scenario for each dependent variable

Attribute Group	Attributes	Perceived level of crowding	Perceived level of safety	Perceived level of comfort
Traffic conditions on bike path	Intensity level of cyclists	1000 cyclists/h	1000 cyclists/h	1000 cyclists/h
	Level of duo cyclists	0%	0%	0%
Surrounding bike path	Land Use	High density	High density & Rural	High density
	Level of pedestrian activity	0 activities	0 activities	0 activities
	Vegetation	Bushes	Bushes	Bushes
	Intensity Car Traffic	250 cars/h	250 cars/h	250 cars/h
Physical bike path conditions	Width Bike Path	4.5 meter	4.5 meter	4.5 meter
	Color of Bike Path	Red	None	Red

5.2 Scientific relevance

There is not yet much scientific research in the area of the perceived crowding among cyclists. Most of the former researches are done using data that is gathered in the field or based on the respondents' memory of a crowded situation. In the study of Munckhof et al. (2017), it is suggested that a follow-up study can be carried out into the relationship between different attributes and the perceived level of crowding in a controlled situation. This has not yet been implemented and provides a gap in scientific knowledge about the subject of bicycle crowding. By examining the relationship in a controlled situation, certain attributes, which may have had an influence on the results of Munckhof et al. (2017), can be checked.

For the perceived safety and comfort more researches are available. Though, most of these researches are text or picture based. The researcher has tried to visualize the real world as well as possible, which also benefits external validity.

5.3 Recommendations

Out of the results can be concluded that in order to minimize the perceived crowding and to maximize the perceived safety and comfort: the cyclist intensity should be low, all cyclists cycle behind each other, the cycle path is located downtown, there are no pedestrians next to the cycle path, bushes border the cycle path on one side, car traffic next to the cycle path should be minimalized, the cycle path width is on the other hand maximized and executed in the color red. This information can help, as information source, in the search to the 'bicycle path of the future. For example, it is not recommended that an intended important bicycle route is located next to a busy road, since car intensity has a major influence on the cyclist's perceived crowding.

However, there are a few gaps in the research that could be carried out by another study.

- The questionnaire was mainly filled in by people who live in South-Limburg. A region that relatively does not have many problems with crowding on cycle paths. This could have affected the results of this research, since the respondents are less familiar with crowding on bike paths. In a follow-up study, it is interesting to ask people who also live in a busy city and afterwards compare the results with this research.
- This study was made with VR technology, but not really implemented in VR. The respondents viewed a 15 seconds video, but cannot cycle freely in this study. It might be interesting to let the respondents do the research entirely in VR/Simulator. So that the cognitive complexity becomes even less for the respondents.
- With the results cannot directly be said that the attributes influence the willingness to bike in the specific situation. This is not measured in the research and willingness contains of several other crucial indicators. Though, the results of this study can be included in a mode choice model, as described in Overdijk (2017). With the help of a mode choice model can conclusions be drawn about the influence of the attributes on willingness to bike.
- In a follow-up study it is advisable to also include other attributes. The researcher unfortunately could not include the speed differences on the bike path in the research, since this was too time consuming to carry out convincingly. That while that is seen by some sources as an important contributor. Furthermore, it is also interesting to take along other types of cycle paths, such as on and off-street single lane cycle paths.

BIBLIOGRAPHY

Amerom, M. v. (2018, May 2017). *Nederlanders zijn een onafhandelijk fietsvolkje*. Retrieved March 8, 2018, from Kennislink: https://www.nemokennislink.nl/publicaties/nederlanders-zijn-een-onafhankelijk-fietsvolkje/

ANP. (2018, May 31). *Meer fietsdoden door e-bike.* Retrieved September 19, 2018, from Tweewieler: https://www.tweewieler.nl/elektrische-fietsen/nieuws/2018/04/meer-fietsdoden-door-e-bike-10134447

Arentze, T., Borgers, A., Timmermans, H., & DelMistro, R. (2003). Transport stated choice responses: effects of task complexity, presentation format and literacy. *Transportation Research Part E, 39*, 229-244.

Baarda, B. (2009). *Dit is onderzoek! Handleiding voor kwantitatief en kwalitatief onderzoek.* Groningen/Houten: Noordhoff Uitgevers.

Bai, L., Liu, P., Li, Z., & Wang, W. (2015). *Factors Affecting Comfort Perception of Cyclists Considering Mixed Traffic Flow in 1 Bicycle Lanes.* Transportation Research Board.

Baxter, J. (1970). Interpersonal spacing in natural settings. *Sociometry, 33*, 444-456.

Bike Print. (2016). Retrieved October 15, 2018, from http://www.bikeprint.nl

Blana, E. (1996). *A Survey of Driving Research Simulators around the World.* University of Leeds, Institute for Transport Studies.

Botma, H. (1995). Method to Determine Level of Service for Bicycle Paths and Pedestrian-Bicycle Paths. *Transportation Research Record 1502*, 38-44.

Botma, H., & Papendrecht, J. H. (1992). *Kwaliteit afwikkeling op vrijliggende fietspaden, toepassingen van een hindermodel.* TU Delft, Faculteit der Civiele Techniek, Delft.

Brady, N. (2011, June 13). *The many dangers of rural cycling.* Retrieved September 19, 2018, from The Guardian: https://www.theguardian.com/environment/bike-blog/2011/jun/13/dangers-rural-cycling-bike-blog

Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. *Transportation Research Part A: Policy and Practice, 46*(10), 1730-1740.

Bruheze, A. A., & Vervaart, F. (1999). *Bicycle traffic in practice and policy in the twentieth century.*

Bryon, J., & Neuts, B. (2008). *Crowding and the tourist experience in an urban environment: a structural equation modeling approach.* Leuven.

Burgoon, J. K. (2006, March). A communication model of personal space violations: Explication and an initial test. *Human Communication Research, 4*(2), 129 - 142.

Burgoon, J. K., & Jones, S. B. (1976, December). Toward a theory of personal space expectations and their violations. *Human Communication Research, 2*(2), 131-146.

Caussade, S., Ortuzar de Dios, J., Hensher, D. A., & Rizzia, L. I. (2005). Assessing theinfluence of design dimensions on stated choice experiment estimates. *Transportation Research Part B,, 39*, 621-640.

CBS. (2015). *Nabijheid voorzieningen onderwijs*. Retrieved March 10, 2018, from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/70072ned/table?ts=1520778951729

CBS. (2016, September 12). *PBL/CBS prognose: Groei steden zet door.* Retrieved September 4, 2018, from CBS: https://www.cbs.nl/nl-nl/nieuws/2016/37/pbl-cbs-prognose-groei-steden-zet-door

CBS. (2018, July 3). *Totale reizigerskilometers in Nederland per jaar; vervoerwijzen, regio's.* Retrieved September 13, 2018, from CBS: http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=83497ned&D1=0&D2=a&D3=0,5-16&D4=a&HDR=T,G3&STB=G1,G2&VW=T

Cheng, V. (2009). *Understanding density and high density.* Technische Universität München.

Chirstmas, S., Helman, S., Buttress, S., & Newman, C. (2010). Cycling, Safety and Sharing theRoad: Qualitative Research withCyclists and Other Road Users. *Road Safety Web Publication, 17*.

Chi-Square Distribution (Upper Tail) Critical Values. (n.d.). Retrieved September 8, 2018, from http://www.public.iastate.edu/~vardeman/stat328/328%20chi-square%20table.pdf

Cox, J. A., Beanland, V., & Filtness, A. J. (2017, February). Risk and safety perception on urban and rural roads: Effects of environmental features, driver age and risk sensitivity. *Traffic Injury Prevention, 18*(3).

CROW-Fietsberaad. (n.d.). *Over CROW-Fietsberaad, Doelstellingen en uitgangspunten*. Retrieved April 6, 2018, from CROW-Fietsberaad Kenniscentrum voor fietsbeleid: http://www.fietsberaad.nl/?section=fietsberaad&lang=nl

Davies, A., Laing, R., & Scott, S. (2002). *Combining visualisation and choice experiments in built environment.* THe Robert Gordon University, Aberdeen.

De Gelderlander. (2016, May 20). *Nijmegen wil af van fietsfiles*. Retrieved March 11, 2018, from De Gelderlander: https://www.gelderlander.nl/default/nijmegen-wil-af-van-fietsfiles~adaed5c1/

De Goede, M., Obdeijn, C., & Van der Horst, A. R. (2013). *Conflicten op fietspaden - fase 2.* TNO, Behavioural and Societal Sciences.

De Zeeuw, H. (2018, March 19). *CBS: Nederlanders steeds ouder en langer gezond.* Retrieved September 13, 2018, from Nieuwe Rotterdamsche Courant: https://www.nrc.nl/nieuws/2018/03/19/nederlanders-worden-steeds-ouder-en-blijven-langer-gezond-a1596180

DeJoy, D. M. (1992). An Examination of Gender Differences in Traffic Accident Risk Perception. *Accident Analysis & Prevention, 24*(3), 237-246.

Evans-Cowley, J. S., & Akar, G. (2013). *StreetSeen: Factors Influcencing the Desirability of a Street for Bicycling.* Washington.

Fietsersbond. (2015, May 23). *Het ontstaan van een fietsnatie*. Retrieved March 8, 2018, from Fietsersbond: https://www.fietsersbond.nl/nieuws/het-ontstaan-van-een-fietsnatie/

Fietssnelwegen. (2017). Retrieved September 4, 2018, from https://www.fietssnelwegen.nl/Links/675%20km%20Fietssnelwegen.pdf

Fietsverkeer. (2003, October). *Fiets miskend flexibel natransport van de trein: van station naar bestemming.*

Fitch, D. T., & Handy, S. L. (2017). *The Relationship between experienced and imagined bicycling comfort and safety.* University of California at Davis, Institute of Transportation Studies, Davis.

Gemeente Amsterdam. (2015). *Amsterdamse thermometer van de Bereikbaarheid.*

Gemeente Eindhoven. (2009). *Actieplan fiets Eindhoven.*

Gemeente Utrecht. (2015). *Actieplan Utrecht fietst.* Milieu en Mobiliteit/Realisatie Mobiliteit.

Godefrooij, H. (2018). *Passen al die fietsers nog op het fietspad?* Retrieved September 19, 2018, from DTV consultants: https://dtvconsultants.nl/actueel/passen-al-die-fietsers-nog-op-het-fietspad/

Groenendijk, L., Olde Kalter, M. J., & Sturm, J. (2017). *Het ontwikkelen, Implementeren en Evalueren van fietsbeleid in Rotterdam gebaseerd op de wensen van de Rotterdamse Fietsers.* Rotterdam.

Groot-Mesken, J. d., Vissers, L., & Duivenvoorden, C. (2015). *Stedelijke mobiliteit op het fietspad - Observaties van aantallen, kenmerken, gedrag en conflicten van.* Stichting Wetenschappelijk Onderzoek Verkeersveiligheid , Den Haag.

Harms, L. (2006). *Anders onderweg: De mobiliteit van allochtonen en autochtonen vergeleken.* Ministerie van Verkeer en Waterstaat, Den Haag. Retrieved September 13, 2018, from http://www.fietsberaad.nl/library/repository/bestanden/document000176.pdf

Harms, L. (2017, May 4). *Sterke groei van het fietsgebruik? Ja en nee!* Retrieved March 10, 2018, from Kennisinstituut voor Mobiliteitsbeleid: https://www.kimnet.nl/actueel/weblogs/weblog/2017/blog-sterke-groei-van-het-fietsgebruik-ja-en-nee

Hensher, D. A., Rose, J. M., & Greene, W. H. (2005). *Applied Choice Analysis - A Primer.* Cambridge.

Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). *Applied Choice Analysis (Second Edi).* Cambridge University Press.

Hibbard, J., & Peters, E. (2003). Supporting Informed Consumer Health Care Decisions: Data presentation approaches that facilitate the use of information in choice. *Annual Review of Public Health, 24*, 413-433.

Hijman, R., Bekhuis, F., De Vries, J., Van der Waard, J., Hilbers, H., Burgmeijer, J., . . . Van de Riet, O. (2016). *Meer bereiken met een brede blik op mobiliteit Overzicht van trends en ontwikkelingen voor integraal mobiliteitsbeleid.* CROW.

Hill, R. A., & Barton, R. A. (2005). Psychology: red enhances human performance in contests. *Nature, 435*(7040), 293-300.

Jaarsma, R., Louwerse, W. J., Dijkstra, A., Vries, J. R., & Spaas, J. P. (2011). Making minor rural road networks safer: The effects of 60 km/h-zones. *Accident Analysis and Prevention 43*, 1508 - 1515.

Jacobson, L. (1993). Welcome to the virtual world. *On the cutting edge of technology*, 69-79.

Johnson, P. C. (2014). *Bicycle Level of Service: Where are the Gaps in Bicycle Flow Measures?* Portland State University, Civil and Environmental Engineering.

Kim, D., Lee, C., & Sirgy, M. J. (2016). Examing the Differenctial Impact of Human Crowding Versus Spatial Crowding on Visitors Satisfaction at a Festival. *Journal of Travel & Tourism Marketing, 33*(3), 293-312.

Klinkenberg, A. (2017, June 27). *CycleSpex.* Retrieved September 27, 2018, from Fietscommunity: http://www.fietscommunity.nl/projecten/cycle-spaces/

Klinkers, P. M., & van Hoorn, A. (1987). *Druktebeleving van fietsene recreanten, een onderzoek op plattelandswegen in de omgeving van Zwolle.* Instituut voor cultuurtechniek en waterhuishouding, Wageningen.

Knol, A. (2014). *Luchtvervuiling en de gevolgen voor onze gezondheid.* Milieudefensie.

Krabbenborg, L., Annema, J. A., & Snellen, D. (2015). *De invloed van bebouwde omgeving op fietsen in voortransport.* Antwerpen.

Lange, M. d., Talens, H., & Hulshof, R. (2017). *Drukte op fietspaden: een inventarisatie van knelpunten, maatregelen en ideeën.* Fietsberaad CROW.

Lankhuijzen, R., Ruijs, K., & Orsouw van, M. (2016). *Drukte op fietspaden in Zeeland, eindrapport.* XTNT, Utrecht.

Lavrakas, P. J. (2008). *Encyclopedia of Survey Research Methods.* London: SAGE Publications.

Lee, B. H., Jennings, L., & El-Geneidy, A. M. (2010). *How does land use influence cyclist route choice? A geospatial analysis of commuter routes and cycling facilities.* University of Vermont, School of Engineering and Transportation Research Center.

Lehner-Lierz, U. (2006). Naast elkaar fietsen, mag het en gebeurt het buiten Nederland? *Fietsverkeer*.

Lesisz, R. (2004). *Honderd jaar fietsen in Nederland 1850-1950 over het begin van de fietscultuur.* University of Wroclaw. Retrieved from http://fietspadenstichting.nl/honderd%20jaar%20fietscultuur.pdf

Li, J. T., Kim, J., & Lee, S. Y. (2009). An empirical examination of perceived retail crowding, emotions and retail outcomes. *The Service Industries Journal, 29*(5), 635-652.

Li, S., Wang, W., Zhang, Y., Lu, J., & Ragland, D. R. (2011). *Exploring Factors Influencing Bicyclists' Perception of Comfort on Bicycle Facilities.* Transportation Research Board.

Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). Uncovering the contribution of travel time reliability to dynamic route choice using real-time loop data. *Transportation Research Part A: Policy and Practice, 38*(6), 435-453.

Luttels, K. C. (2013). *Het effect van de kleuren rood en groen op onderhandelingen na gebruik van een prime.* Tilburg University, Geesteswetenschappen.

Maastricht Bereikbaar. (n.d.). *Organisatie*. Retrieved October 4, 2018, from Maastricht Bereikbaar: https://www.maastrichtbereikbaar.nl/nl/over-ons/organisatie

Moore, D. S., Notz, W. I., & Flinger, M. A. (2013). *The basic practice of statistics* (6 ed.). New York: W. H. Freeman and Company.

Mueller, C. W. (1981). *The perception of crowding.* Iowa State University, Iowa.

Munckhof, L. v., Zengerink, L., & Avest, R. t. (2017). *Over drukte valt te twisten - Druktebeleving op het fietspad verkennen en onderzoeken.* Retrieved from http://www.fietsberaad.nl/library/repository/bestanden/CROW-Fietsberaadpublicatie_Over_drukte_valt_te_twisten_22_september_2017__2_.pdf

National Research Council. (1965). *Special Report 87: Highway Capacity Manual.* Washington D.C.

Navin, F. P. (1994). Bicycle Traffic Flow: Experimental Results ancl Comparisons. *ITEJournal,, 64*(3), 31-36.

Nederlandse Spoorwegen. (2018, January 5). *Recordaantal ritten met de OV-fiets*. Retrieved September 15, 2018, from NS: https://nieuws.ns.nl/recordaantal-ritten-met-de-ov-fiets-in-2017/

Ordered Logistic Regression, SPSS Annotated Output. (n.d.). Retrieved September 8, 2018, from Institute for Digital Research and Education: https://stats.idre.ucla.edu/spss/output/ordered-logistic-regression/

Ortúzar, J. D., & Willumsen, L. G. (2011). *Modeling Transport (Fourth Edition).* London: John Wiley &.

Patterson, Z., Darbani, J. M., Rezaei, A. R., Zacharias, J., & Yazdizadeh, A. (2017). Comparing text-only and virtual reality discrete choice experiments of neighbourhood choice. *Landscape and Urban Planning, 157*, 63-74.

Performance & Analysis. (n.d.). Retrieved October 10, 2018, from Pedestrian an Bicycle Information Center: http://www.pedbikeinfo.org/planning/analysis.cfm

Piekarski, W., & Thomas, B. H. (2002). *Unifying Augmented Reality and Virtual Reality User Interfaces.* University of South Australia.

Provinciale Staten. (2018, July 13). *'FIETSPAD VAN DE TOEKOMST' LANGS DE N225*. Retrieved October 22, 2018, from Provincie Utrecht: https://www.provincie-utrecht.nl/@332329/fietspad-toekomst-langs-n255/

Pseudo R-Squared Measures. (n.d.). Retrieved September 3, 2018, from IBM Knowledge Center: https://www.ibm.com/support/knowledgecenter/en/SSLVMB_23.0.0/spss/tutorials/plum_germcr_rsquare.html

Rakauskas, M. E., Ward, N. J., & Gerberich, S. G. (2009). Identification of differences between rural and urban safety cultures. *Accident Analysis & Prevention, 41*(5), 931-937.

Rodin, J., Solomon, S., & Metcalf, J. (1978). Role of control in mediating perceptions of density. *Journal of Personality and Social Psychology*, 564-578.

Rottier, J. P. (2017, November 11). *Nieuwe resultaten fietstelweek: 1 op de 5 deelnemers vindt fietsen onveilig*. Retrieved April 10, 2018, from Verkeersnet: https://www.verkeersnet.nl/fiets/24928/nieuwe-resultaten-fietstelweek-1-op-5-deelnemers-vindt-fietsen-onveilig/

Saylordotorg. (n.d.). *Utility Theory*. Retrieved September 29, 2018, from Saylordotorg: https://saylordotorg.github.io/text_risk-management-for-enterprises-and-individuals/s07-01-utility-theory.html

Schepers, P., & Van der Voet, M. (2014). Effecten van mogelijke gedragsregels voor speedpedelecs.

Schepers, P., Den Brinker, B., & Ormel, W. (2009). Enkelvoudige fietsongevallen. Hoe te voorkomen? Nieuwe infrastructuuroplossingen voor een omvangrijk probleem. *Verkeerskunde, 7*.

Schoenmakers, M. J. (2017). *The use of Virtual Reality in a Stated Choice Experiment concerning Autonomous Vehicles.* Technical University Eindhoven, The Build Environment.

Schoenmakers, M. J. (2018). *Automated Vehicles and Infrastructure Design An insight into the implications of a dedicated lane for Automated Vehicles on the highway in the Netherlands.* Eindhoven University of Technology, The Built Environment.

Seligman, M. E. (1975). *Helplessness: On depression, development and death.* San Fransisco: Freeman.

Sener, I. N., Eluru, N., & Bhat, C. R. (2009). An analysis of bicycle route choice preferences in Texas, US. *Transportation, 36*, 511-539. doi:10.1007/s11116-009-9201-4

Shelby, B., Vaske, J. J., & Heberlein, T. A. (1989). Comparative analysis of crowding in multiple locations: Results from fifteen years of reseresearch. *Leisure Sciences, 11*, 269-291.

Shigematsu, R., Sallis, J. F., Conway, T. L., Saelens, B. E., Frank, L. D., Cain, K. L., . . . King, A. C. (2009). *Age Differences in the Relation of Perceived Neighborhood Environment to Walking.* San Diego State University, Department of Psychology, San Diego.

State of Florida Department of Transportation. (2013). *Ouality/ Level of Service Handbook.* State of Florida Department of Transportation, Florida.

Stokols, D. (1972). On the distinction between density and crowding: some implications for future research. *Phychological Review, 79*(3), 275-277.

Stokols, D. (1976, March). The experience of crowding in primary and secondary environments. *Environment and Behavior, 8*(1), 49-86.

Termaat, G. (2018, March 2). *Fietsverkoop in 2017 voor eerst weer gestegen*. Retrieved March 11, 2018, from Telegraaf: https://www.telegraaf.nl/financieel/1739346/fietsverkoop-in-2017-voor-eerst-weer-gestegen

Theeuwen, M. (2017, October 3). *Eindhoven moet auto uit groot deel binnenstad weren om luchtvervuiling terug te dringen*. Retrieved April 4, 2018, from Algemeen Dagblad: https://www.ad.nl/eindhoven/eindhoven-moet-auto-uit-groot-deel-binnenstad-weren-om-luchtvervuiling-terug-te-dringen~a8e541e5/

Train, K. (2002). *Discrete Choice Methods with Simulation.* Cambridge University Press.

Transportation Research Board. (2017). *TRB's Mission and Services*. Retrieved April 6, 2018, from TRB: http://www.trb.org/AboutTRB/MissionandServices.aspx

Ulrich, R. S. (1986). *Human Responses to Vegetation and Landscapes.* University of Delaware, Department of Geography. Amsterdam: Elsevier Sience.

Van den Broek, M. (2018, August 5). *Dumoulin-effect zorgt voor meer drukte en ergernis op fietspaden.* Retrieved September 19, 2018, from NOS: https://nos.nl/artikel/2244613-dumoulin-effect-zorgt-voor-meer-drukte-en-ergernis-op-fietspaden.html

Van Hoof, R. (2017, February 8). *Vestdijk Eindhoven gaat dicht voor doorgaand verkeer: 'Luchtkwaliteit in centrum dramatisch slecht'.* Retrieved September 5, 2018, from Omroep Brabant: https://www.omroepbrabant.nl/nieuws/225095/Vestdijk-

Eindhoven-gaat-dicht-voor-doorgaand-verkeer-Luchtkwaliteit-in-centrum-dramatisch-slecht

Van Overdijk, R. P. (2016). *The influence of comfort aspects on route-and mode-choice decisions of cyclists in the Netherlands.* Technical Universtiy Eindhoven, The Built Environment.

Van Summeren, F. (2015, July 6). *De stad van de toekomst en mobiliteit: kansen en bedreigingen.* Retrieved September 4, 2018, from Studiecentrum voor Bedrijf en Overheid: https://blog.sbo.nl/milieu-ro/ruimtelijke-ordening/de-stad-van-de-toekomst-en-mobiliteit-kansen-en-bedreigingen/

Verkeer in Beeld. (2015, March 25). *Groene of blauwe fietspaden voor meer veiligheid?* Retrieved September 24, 2018, from Verkeer in Beeld: https://www.verkeerinbeeld.nl/nieuws/250315/groene-of-blauwe-fietspaden-voor-meer-veiligheid

Verschuren, P., & Doorewaard, H. (2002). *Het Ontwerpen van een Onderzoek.* Utrecht: Lemma.

Vlaardingen24. (2017, November 27). *Snelfietspad Rivierzone klaar*. Retrieved March 11, 2018, from https://www.vlaardingen24.nl/nl/nieuws/nieuws/snelfietspad-rivierzone-klaar/19546

Voermans, T. (2017, March 14). *Prijs treinrit in 8 jaar explosief gestegen*. Retrieved March 11, 2018, from Het Parool: https://www.parool.nl/binnenland/prijs-treinrit-in-8-jaar-explosief-gestegen~a4474094/

WoW. (2017). *Onderzoek fietsweggebruikers, Gemeente, Provincie, Waterschap, Rijkswaterstaat.* Wegbeheerders Ontmoeten Wegbeheerders.

XTNT. (2009, April 2). *Overzicht campagnes in het fietsbeleid.* Retrieved September 6, 2018, from CROW: https://www.crow.nl/mobiliteit-en-gedrag/bibliotheek/kennisdocumenten/overzicht-campagnes-in-het-fietsbeleid?parenturl=/Mobiliteit-en-Gedrag/Bibliotheek

APPENDICES

Appendix A: Determination Factual Crowding

-Table: Actual width of bike path compared to adiced width, if bike path is too narrow it is classified as too crowded (Groot-Mesken, Vissers, & Duivenvoorden, 2015)

Municipality	Street	1 or 2 directions	Intensity (bic/h)	Adviced width	Actual width	Crowded?
Amsterdam	De Clerqustraat	1	758	4	2	Yes
	Weesperstraat	1	467	3	2.1	Yes
	Geldersekade	2	461	3.5 to 4	3.9	No
	Piet Heinkade	2	206	3.5 to 4	3.5	No
The Hague	Prinsegracht	1	720	3	2	Yes
	Laan van Meerdervoort	1	85	2	2.1	No
	Laan van Hoornwijck	2	304	4	2.7	Yes
	Waalsdorperweg	2	97	3	3.5	No

Appendix B: Fractional Factorial Design

Scenario	Intensity level of cyclists	Level of duo cycling (same side)	Level of duo cycling (other side)	Land Use	Level of Activity	Vegetation	Intensity Car Traffic	Width Bike Path	Color of Bike Path
1	Low	Low	Low	Rural	Low	Grass	Low	Low	Red
2	Low	Low	Medium	In-town residential	High	Trees	High	Medium	Blue
3	Low	Low	High	High density	Medium	Bushes	Medium	High	Gray
4	Low	Medium	Low	Rural	Low	Trees	Medium	High	Blue
5	Low	Medium	Medium	In-town residential	High	Bushes	Low	Low	Gray
6	Low	Medium	High	High density	Medium	Grass	High	Medium	Red
7	Low	High	Low	Rural	Low	Bushes	High	Medium	Gray
8	Low	High	Medium	In-town residential	High	Grass	Medium	High	Red
9	Low	High	High	High density	Medium	Trees	Low	Low	Blue
10	Medium	Low	Low	In-town residential	Medium	Trees	Medium	Medium	Gray
11	Medium	Low	Medium	High density	Low	Bushes	Low	High	Red
12	Medium	Low	High	Rural	High	Grass	High	Low	Blue
13	Medium	Medium	Low	In-town residential	Medium	Bushes	High	Low	Red
14	Medium	Medium	Medium	High density	Low	Grass	Medium	Medium	Blue
15	Medium	Medium	High	Rural	High	Trees	Low	High	Gray
16	Medium	High	Low	In-town residential	Medium	Grass	Low	High	Blue
17	Medium	High	Medium	High density	Low	Trees	High	Low	Gray
18	Medium	High	High	Rural	High	Bushes	Medium	Medium	Red
19	High	Low	Low	High density	High	Bushes	High	High	Blue
20	High	Low	Medium	Rural	Medium	Grass	Medium	Low	Gray
21	High	Low	High	In-town residential	Low	Trees	Low	Medium	Red
22	High	Medium	Low	High density	High	Grass	Low	Medium	Gray
23	High	Medium	Medium	Rural	Medium	Trees	High	High	Red
24	High	Medium	High	In-town residential	Low	Bushes	Medium	Low	Blue
25	High	High	Low	High density	High	Trees	Medium	Low	Red
26	High	High	Medium	Rural	Medium	Bushes	Low	Medium	Blue
27	High	High	High	In-town residential	Low	Grass	High	High	Gray

Appendix C: Reference Bike Paths

Appendix D: Example Script in Vizard (Python as program language)

```
import viz
import vizfx
import vizact

viz.setMultiSample(4)
viz.go()
#Enable full screen anti-aliasing (FSAA) to smooth
edges
viz.setMultiSample(4)
viz.go()
#Increase the Field of View BELANGRIJK VOOR
BELEVING
viz.MainWindow.fov(60)
#viewpositie
#viz.MainView.setPosition([-5,1.7,35])
#viz.MainView.setEuler([180,0,0])
#vizact.onkeydown(' ', viz.MainView.velocity,
[0,0,3.8 ]  )

#cartest
moveForward = vizact.move(0,0,6.5,25)
car1 = viz.addChild('car1.dae')
car2 = viz.addChild('car2.dae')
car3 = viz.addChild('car3.dae')
car4 = viz.addChild('car4.dae')
car5 = viz.addChild('car5.dae')
car6 = viz.addChild('car6.dae')
car7 = viz.addChild('car7.dae')
car8 = viz.addChild('car8.dae')
car1.visible(viz.OFF)
car2.visible(viz.OFF)
car3.visible(viz.OFF)
car4.visible(viz.OFF)
car5.visible(viz.OFF)
car6.visible(viz.OFF)
car7.visible(viz.OFF)
car8.visible(viz.OFF)

cyc1 = viz.addChild('cyclist1.dae')
cyc2 = viz.addChild('cyclist2.dae')
cyc3 = viz.addChild('cyclist3.dae')
cyc4 = viz.addChild('cyclist4.fbx')
cyc5 = viz.addChild('cyclist5.fbx')
cyc6 = viz.addChild('cyclist6.fbx')
cyc7 = viz.addChild('cyclist7.fbx')
cyc8 = viz.addChild('cyclist8.fbx')
cyc9 = viz.addChild('cyclist9.fbx')
cyc10 = viz.addChild('cyclist10.dae')

cyc1.visible(viz.OFF)
cyc2.visible(viz.OFF)
cyc3.visible(viz.OFF)
cyc4.visible(viz.OFF)
cyc5.visible(viz.OFF)
cyc6.visible(viz.OFF)
cyc7.visible(viz.OFF)
cyc8.visible(viz.OFF)
cyc9.visible(viz.OFF)
cyc10.visible(viz.OFF)

#avatars
dude11 = viz.addAvatar('vcc_male.cfg')
dude11.setPosition ([-2.8,0.1,25])
dude11.setEuler( 270, 0, 0 )
dude11.state(1) #looping idle animation
female = viz.addAvatar('vcc_female.cfg')
female.setPosition ([-2.8,0.1,20])
female.setEuler( 300, 0, 0 )
female.state(9) #looping idle animation
dude9 = viz.addAvatar('vcc_male.cfg')
dude9.setPosition ([-2.8,0.1,10])
dude9.setEuler( 200, 0, 0 )
dude9.state(10) #looping idle animation
female5 = viz.addAvatar('vcc_female.cfg')
female5.setPosition ([-2.4,0.1,9])
female5.setEuler( 300, 0, 0 )
female5.state(9) #looping idle animation

dude6 = viz.addAvatar('vcc_male.cfg')
dude6.setPosition ([-2.8,0.1,5])
dude6.setEuler( 270, 0, 0 )
dude6.state(1) #looping idle animation
dude2 = viz.addAvatar('vcc_male2.cfg')
dude2.setPosition ([-2.8,0.1,0])
dude2.setEuler( 270, 0, 0 )
dude2.state(1) #looping idle animation
female8 = viz.addAvatar('vcc_female.cfg')
female8.setPosition ([-2.4,0.1,-15])
```

```
female8.setEuler( 300, 0, 0 )
female8.state(1) #looping idle animation
dude = viz.addAvatar('vcc_male.cfg')
dude.setPosition ([-2.8,0.1,-50])
dude.setEuler( 270, 0, 0 )
dude.state(1) #looping idle animation
female7 = viz.addAvatar('vcc_female.cfg')
female7.setPosition ([-2.4,0.1,-57])
female7.setEuler( 300, 0, 0 )
female7.state(1) #looping idle animation
dude7 = viz.addAvatar('vcc_male2.cfg')
dude7.setPosition ([-2.8,0.1,-60])
dude7.setEuler( 270, 0, 0 )
dude7.state(1) #looping idle animation
dude10 = viz.addAvatar('vcc_male.cfg')
dude10.setPosition ([-2.8,0.1,-55])
dude10.setEuler( 270, 0, 0 )
dude10.state(3) #looping idle animation
female2 = viz.addAvatar('vcc_female.cfg')
female2.setPosition ([-2.8,0.1,-70])
female2.setEuler( 300, 0, 0 )
female2.state(1) #looping idle animation
dude8 = viz.addAvatar('vcc_male2.cfg')
dude8.setPosition ([-2.8,0.1,-85])
dude8.setEuler( 270, 0, 0 )
dude8.state(1) #looping idle animation
dude3 = viz.addAvatar('vcc_male2.cfg')
dude3.setPosition ([-2.8,0.1,-100])
dude3.setEuler( 270, 0, 0 )
dude3.state(1) #looping idle animation
dude21 = viz.addAvatar('vcc_male.cfg')
dude21.setPosition ([-2.8,0.1,-135])
dude21.setEuler( 270, 0, 0 )
dude21.state(1) #looping idle animation
dude12 = viz.addAvatar('vcc_male.cfg')
dude12.setPosition ([-16.2,0.1,20])
dude12.setEuler( 90, 0, 0 )
dude12.state(4) #looping idle animation
female4 = viz.addAvatar('vcc_female.cfg')
female4.setPosition ([-16.2,0.1,10])
female4.setEuler( 90, 0, 0 )
female4.state(1) #looping idle animation
dude16 = viz.addAvatar('vcc_male.cfg')
dude16.setPosition ([-16.2,0.1,4])
dude16.setEuler( 90, 0, 0 )
dude16.state(1) #looping idle animation
dude4 = viz.addAvatar('vcc_male.cfg')
dude4.setPosition ([-16.2,0.1,-0])
dude4.setEuler( 90, 0, 0 )
dude4.state(4) #looping idle animation
female3 = viz.addAvatar('vcc_female.cfg')
female3.setPosition ([-16.2,0.1,-7])
female3.setEuler( 90, 0, 0 )
female3.state(3) #looping idle animation
dude22 = viz.addAvatar('vcc_male2.cfg')
dude22.setPosition ([-16.2,0.1,-14])
dude22.setEuler( 90, 0, 0 )
dude22.state(1) #looping idle animation
dude5 = viz.addAvatar('vcc_male2.cfg')
dude5.setPosition ([-16.2,0.1,-15])
dude5.setEuler( 90, 0, 0 )
dude5.state(1) #looping idle animation
dude13 = viz.addAvatar('vcc_male.cfg')
dude13.setPosition ([-16.2,0.1,-25])
dude13.setEuler( 90, 0, 0 )
dude13.state(1) #looping idle animation

dude14 = viz.addAvatar('vcc_female.cfg')
dude14.setPosition ([-16.2,0.1,-30])
dude14.setEuler( 90, 0, 0 )
dude14.state(1) #looping idle animation
dude17 = viz.addAvatar('vcc_male.cfg')
dude17.setPosition ([-16.2,0.1,-65])
dude17.setEuler( 90, 0, 0 )
dude17.state(3) #looping idle animation
dude19 = viz.addAvatar('vcc_male2.cfg')
dude19.setPosition ([-16.2,0.1,-65])
dude19.setEuler( 90, 0, 0 )
dude19.state(1) #looping idle animation
dude18 = viz.addAvatar('vcc_male.cfg')
dude18.setPosition ([-16.2,0.1,-75])
dude18.setEuler( 90, 0, 0 )
dude18.state(1) #looping idle animation
female3 = viz.addAvatar('vcc_female.cfg')
female3.setPosition ([-16.2,0.1,-80])
female3.setEuler( 90, 0, 0 )
female3.state(1) #looping idle animation
dude15 = viz.addAvatar('vcc_female.cfg')
dude15.setPosition ([-16.2,0.1,-85])
dude15.setEuler( 90, 0, 0 )
dude15.state(1) #looping idle animation
dude20 = viz.addAvatar('vcc_male2.cfg')
dude20.setPosition ([-16.2,0.1,-140])
dude20.setEuler( 90, 0, 0 )
```

```
dude20.state(1) #looping idle animation

walkfront = vizact.walkTo([-2.8,0.1,50])
walkback = vizact.walkTo([-2.8,0.1,-120])
walkotherfront = vizact.walkTo([-16.2,0.1,50])
walkotherback = vizact.walkTo([-16.2,0.1,-120])
dude.runAction(walkfront)
dude2.runAction(walkback)
dude6.runAction(walkback)
dude3.runAction(walkfront)
dude7.runAction(walkfront)
female7.runAction(walkfront)
female3.runAction(walkotherfront)
dude5.runAction(walkotherback)
female4.runAction(walkotherfront)
female5.runAction(walkback)
dude11.runAction(walkfront)
dude12.runAction(walkotherfront)
dude16.runAction(walkotherfront)
dude13.runAction(walkotherback)
dude14.runAction(walkotherback)
dude15.runAction(walkotherback)
dude18.runAction(walkotherback)
dude19.runAction(walkotherback)
dude20.runAction(walkotherfront)
dude21.runAction(walkfront)
female8.runAction(walkback)

# Add sky options
#day = viz.addChild('sky_night.osgb')
sky = viz.add(viz.ENVIRONMENT_MAP,'sky.jpg')
skybox = viz.add('skydome.dlc')
skybox.texture(sky)
light = vizfx.addDirectionalLight(color=viz.WHITE,
euler=(0,90,0))
light1 = vizfx.addDirectionalLight(color=viz.WHITE,
euler=(90,0,0))
light2 = vizfx.addDirectionalLight(color=viz.WHITE,
euler=(270,0,0))

house = viz.addChild('s5low.dae')
#house = vizfx.addChild('house.osgb')
house.setPosition([0,0,100])

#snelheid fietsers
moveBike = vizact.move(0,0,3.8,20)

#opstellen fietsers dmv map and let them move
map = []
with open('opstelling5.txt') as inputfile:
  for line in inputfile:
    map.append(line.strip())

map_height = len(map)
map_width = len(map[0])
for i in range(map_height):
        map[i] = map[i] + ' ' * (map_width -
len(map[i]))

for x in range (map_width):
        for y in range(map_height):
                if map[y][x]== 'a':
                        block = cyc1.clone()
                        block.setPosition (-
x*0.15-2.00,0.08,y-200)
                        block.add(moveBike)

for x in range (map_width):
        for y in range(map_height):
                if map[y][x]== 'A':
                        block = cyc1.clone()
                        block.setPosition (-
x*0.15-2.00,0.08,y-200)
                        block.setEuler( 180, 0, 0 )
                        block.add(moveBike)

for x in range (map_width):
        for y in range(map_height):
                if map[y][x]== 'b':
                        block = cyc2.clone()
                        block.setPosition (-
x*0.15-2.00,0.08,y-200)
                        block.add(moveBike)

for x in range (map_width):
        for y in range(map_height):
                if map[y][x]== 'B':
                        block = cyc2.clone()
                        block.setPosition (-
x*0.15-2.00,0.08,y-200)
                        block.setEuler( 180, 0, 0 )
                        block.add(moveBike)
```

```
for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'c':
						block = cyc3.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'C':
						block = cyc3.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)
						block.setEuler( 180, 0, 0 )
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'd':
						block = cyc4.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'D':
						block = cyc4.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.setEuler( 180, 0, 0 )
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'e':
						block = cyc5.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'E':
						block = cyc5.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.setEuler( 180, 0, 0 )
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'f':
						block = cyc6.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'F':
						block = cyc6.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.setEuler( 180, 0, 0 )
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'g':
						block = cyc7.clone()
						block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
						block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
				if map[y][x]== 'G':
						block = cyc7.clone()
```

```
				block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
				block.setEuler( 180, 0, 0 )
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'h':
				block = cyc8.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'H':
				block = cyc8.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
				block.setEuler( 180, 0, 0 )
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'i':
				block = cyc9.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'I':
				block = cyc9.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)

		block.setScale([0.01,0.01,0.01])
				block.setEuler( 180, 0, 0 )
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'j':
				block = cyc10.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)
				block.add(moveBike)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'J':
				block = cyc10.clone()
				block.setPosition (-
x*0.15-2.00,0.08,y-200)
				block.setEuler( 180, 0, 0 )
				block.add(moveBike)

#setting up the cars and let them move
for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'z':
				block = car1.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'Z':
				block = car1.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'y':
				block = car2.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
```

```
			if map[y][x]== 'Y':
				block = car2.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'x':
				block = car3.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'X':
				block = car3.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'w':
				block = car4.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'W':
				block = car4.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'v':
				block = car5.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'V':
				block = car5.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'u':
				block = car6.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'U':
				block = car6.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 't':
				block = car7.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'T':
				block = car7.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
```

```
			if map[y][x]== 's':
				block = car8.clone()
				block.setPosition (-
x+20.2,0,y-250)
				block.add(moveForward)

for x in range (map_width):
		for y in range(map_height):
			if map[y][x]== 'S':
				block = car8.clone()
				block.setPosition (-
x+21,0,y-250)
				block.setEuler( 180, 0, 0 )
				block.add(moveForward)


#view from bike

box2=viz.addChild('cyclist3.dae')
box2.setScale(0.01,0.01,0.01)
box2.setPosition([-5.5,1.72,35])
box2.setEuler(( 180, 0, 0 ))

box2.add(moveBike)

link1=viz.link(box2,viz.MainView)
```

Appendix E: Visualized Attributes


Car intensity level= low


Car intensity level= medium


Car intensity level= high


Color of bike path= red


Color of bike path= gray/tiles


Color of bike path= blue


Level of duo cycling=low


Level of duo cycling=medium


Level of duo cycling=high


Intensity of cyclists=low


Intensity of cyclists=medium


Intensity of cyclists=high


Land use=rural


Land use=in-town residential


Land use=high density


Vegetation=grass


Vegetation=trees


Vegetation=bushes


Bike path width=low


Bike path width=medium


Bike path width=high

Appendix F: Characteristics Respondents

transportation_mean

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4+ times per week	654	54,0	54,0	54,0
	1 - 3 times per week	280	23,1	23,1	77,2
	1 â€“ 3 times per month	112	9,3	9,3	86,4
	Less than once per month	94	7,8	7,8	94,2
	Never	70	5,8	5,8	100,0
	Total	1210	100,0	100,0	

BIke_type

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Normal bike (mountain bike incl.)	808	66,8	66,8	66,8
	E-bike (speed pedelec incl.)	278	23,0	23,0	89,8
	Race bike	54	4,5	4,5	94,2
	I never bike	70	5,8	5,8	100,0
	Total	1210	100,0	100,0	

Morning_peak

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	612	50,6	50,6	50,6
	True	598	49,4	49,4	100,0
	Total	1210	100,0	100,0	

Btwn_Mor_Eve

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	689	56,9	56,9	56,9
	True	521	43,1	43,1	100,0
	Total	1210	100,0	100,0	

Evening_peak

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	652	53,9	53,9	53,9
	True	558	46,1	46,1	100,0
	Total	1210	100,0	100,0	

Btwn_Eve_Mor

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	975	80,6	80,6	80,6
	True	235	19,4	19,4	100,0
	Total	1210	100,0	100,0	

NeverBikePeriod

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	1106	91,4	91,4	91,4
	True	104	8,6	8,6	100,0
	Total	1210	100,0	100,0	

Roadway

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	753	62,2	62,2	62,2
	True	457	37,8	37,8	100,0
	Total	1210	100,0	100,0	

BPonRoadway

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	655	54,1	54,1	54,1
	True	555	45,9	45,9	100,0
	Total	1210	100,0	100,0	

OWBPsep

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	648	53,6	53,6	53,6
	True	562	46,4	46,4	100,0
	Total	1210	100,0	100,0	

TWBPsep

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	877	72,5	72,5	72,5
	True	333	27,5	27,5	100,0
	Total	1210	100,0	100,0	

NeverBikePath

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	1131	93,5	93,5	93,5
	True	79	6,5	6,5	100,0
	Total	1210	100,0	100,0	

Uncrowded_sit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	164	13,6	13,6	13,6
	Rarely	471	38,9	38,9	52,5
	Sometimes	314	26,0	26,0	78,4
	Often	236	19,5	19,5	97,9
	Very often	25	2,1	2,1	100,0
	Total	1210	100,0	100,0	

Crowded_sit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	730	60,3	60,3	60,3
	Rarely	278	23,0	23,0	83,3
	Sometimes	131	10,8	10,8	94,1
	Often	61	5,0	5,0	99,2
	Very often	10	,8	,8	100,0
	Total	1210	100,0	100,0	

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	622	51,4	51,4	51,4
	Female	588	48,6	48,6	100,0
	Total	1210	100,0	100,0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Younger than 18 years	3	,2	,2	,2
	18 to 29 years old	179	14,8	14,8	15,0
	30 to 39 years old	159	13,1	13,1	28,2
	40 to 49 years old	197	16,3	16,3	44,5
	50 to 64 years old	557	46,0	46,0	90,5
	65 to 74 years old	93	7,7	7,7	98,2
	Older than 74 years	22	1,8	1,8	100,0
	Total	1210	100,0	100,0	

Country

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I never biked before	7	,6	,6	,6
	Australia	1	,1	,1	,7
	Belgium	29	2,4	2,4	3,1
	China	1	,1	,1	3,1
	Denemark	1	,1	,1	3,2
	Germany	8	,7	,7	3,9
	France	1	,1	,1	4,0
	Ireland	1	,1	,1	4,0
	Israel	1	,1	,1	4,1
	Mexico	1	,1	,1	4,2
	Micronesia	1	,1	,1	4,3
	Nauru	1	,1	,1	4,4
	Netherlands	1149	95,0	95,0	99,3
	Nepal	1	,1	,1	99,4
	Nicaragua	2	,2	,2	99,6
	New Zeeland	2	,2	,2	99,8
	Nigeria	1	,1	,1	99,8
	Norway	1	,1	,1	99,9
	Spain	1	,1	,1	100,0
	Total	1210	100,0	100,0	

Country_new

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never biked before	7	,6	,6	,6
	Not in the Netherlands	54	4,5	4,5	5,0
	In the Netherlands	1149	95,0	95,0	100,0
	Total	1210	100,0	100,0	

Living

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	City center	203	16,8	16,8	16,8
	Suburb of city	506	41,8	41,8	58,6
	Bigger village (more than 15.000 inhabitants)	153	12,6	12,6	71,2
	Smaller village (less than 15.000 inhabitants)	312	25,8	25,8	97,0
	City center	36	3,0	3,0	100,0
	Total	1210	100,0	100,0	

Device

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Computer / laptop	870	71,9	71,9	71,9
	Smartphone	234	19,3	19,3	91,2
	Tablet	106	8,8	8,8	100,0
	Total	1210	100,0	100,0	

Appendix G: Ordinal Regression Output Perceived Level of Crowding

Case Processing Summary

		N	Marginal Percentage
Perceived level of crowding	Very Low	398	3,7%
	Low	2429	22,3%
	Moderately	3618	33,2%
	High	3549	32,6%
	Very High	896	8,2%
Intensity_level_cylists	Low	3631	33,3%
	Medium	3652	33,5%
	High	3607	33,1%
Level_CNE_sameside	Low	3647	33,5%
	Medium	3618	33,2%
	High	3625	33,3%
Level_CNE_otherside	Low	3621	33,3%
	Medium	3642	33,4%
	High	3627	33,3%
Land_use	Rural	3565	32,7%
	In-town residential	3658	33,6%
	High density	3667	33,7%
Level_of_activity	Low	3613	33,2%
	Medium	3661	33,6%
	High	3616	33,2%
Vegetation	Grass	3600	33,1%
	Trees	3658	33,6%
	Bushes	3632	33,4%
Intensity_car_traffic	Low	3648	33,5%
	Medium	3622	33,3%
	High	3620	33,2%
Width_bike_path	Low	3597	33,0%
	Medium	3638	33,4%
	High	3655	33,6%
Color_bike_path	Red	3657	33,6%
	Gray	3623	33,3%
	Blue	3610	33,1%
Valid		10890	100,0%
Missing		0	
Total		10890	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	7703,900			
Final	755,882	6948,018	18	,000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	267,463	86	,000
Deviance	273,310	86	,000

Link function: Logit.

Pseudo R-Square

Cox and Snell	,472
Nagelkerke	,503
McFadden	,229

Link function: Logit.

Parameter Estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Threshold	[Level of perceived crowding = 1]	-7,070	,109	4173,205	1	,000	-7,284	-6,855
	[Level of perceived crowding = 2]	-4,343	,094	2122,155	1	,000	-4,527	-4,158
	[Level of perceived crowding = 3]	-1,967	,085	537,342	1	,000	-2,134	-1,801
	[Level of perceived crowding = 4]	,957	,085	127,747	1	,000	,791	1,123
Location	[Intensity_level_cylists=low]	-4,131	,061	4550,983	1	,000	-4,251	-4,011
	[Intensity_level_cylists=medium]	-2,334	,052	1981,956	1	,000	-2,437	-2,231
	[Intensity_level_cylists=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_sameside=low]	-,586	,046	164,478	1	,000	-,676	-,497
	[Level_CNE_sameside=medium]	-,146	,045	10,384	1	,001	-,234	-,057
	[Level_CNE_sameside=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_otherside=low]	-,602	,046	172,634	1	,000	-,692	-,512
	[Level_CNE_otherside=medium]	-,066	,045	2,142	1	,143	-,155	,023
	[Level_CNE_otherside=high]	0[a]	.	.	0	.	.	.
	[Land_use=Rural]	,562	,046	149,334	1	,000	,472	,652
	[Land_use=In-town residential]	,475	,045	109,941	1	,000	,386	,563
	[Land_use=High Density]	0[a]	.	.	0	.	.	.

[Level_of_activity=low]	-,417	,046	82,267	1	,000	-,507	-,327
[Level_of_activity=medium]	-,309	,046	45,737	1	,000	-,399	-,220
[Level_of_activity=high]	0[a]	.	.	0	.	.	.
[Vegetation=grass]	-,013	,045	,076	1	,782	-,101	,076
[Vegetation=trees]	,142	,045	9,870	1	,002	,053	,231
[Vegetation=bushes]	0[a]	.	.	0	.	.	.
[Intensity_car_traffic=low]	-,857	,046	348,267	1	,000	-,947	-,767
[Intensity_car_traffic=medium]	-,604	,046	173,124	1	,000	-,694	-,514
[Intensity_car_traffic=high]	0[a]	.	.	0	.	.	.
[Width_bike_path=low]	,904	,046	381,195	1	,000	,813	,994
[Width_bike_path=medium]	,479	,046	110,087	1	,000	,390	,569
[Width_bike_path=high]	0[a]	.	.	0	.	.	.
[Color_bike_path=red]	-,184	,045	16,477	1	,000	-,273	-,095
[Color_bike_path=gray/tiles]	-,055	,045	1,489	1	,222	-,144	,034
[Color_bike_path=blue]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Appendix H: Ordinal Regression Output Perceived Level of Safety

Case Processing Summary

		N	Marginal Percentage
Perceived level of crowding	Very Low	387	3,6%
	Low	1602	14,7%
	Moderately	4274	39,2%
	High	4194	38,5%
	Very High	433	4,0%
Total		10890	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	3338,322			
Final	731,544	2606,778	18	,000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	199,626	86	,000
Deviance	219,929	86	,000

Link function: Logit.

Pseudo R-Square

Cox and Snell	,213
Nagelkerke	,231
McFadden	,095

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[Level of perceived safety = 1]	-2,986	,092	1042,280	1	,000	-3,167	-2,804
	[Level of perceived safety = 2]	-1,055	,081	171,465	1	,000	-1,212	-,897
	[Level of perceived safety = 3]	1,088	,081	181,394	1	,000	,930	1,247
	[Level of perceived safety = 4]	4,347	,095	2087,566	1	,000	4,160	4,533
Location	[Intensity_level_cylists=low]	1,784	,048	1394,499	1	,000	1,691	1,878
	[Intensity_level_cylists=medium]	1,110	,045	597,249	1	,000	1,021	1,199
	[Intensity_level_cylists=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_sameside=low]	,461	,045	104,723	1	,000	,373	,549
	[Level_CNE_sameside=medium]	,138	,045	9,548	1	,002	,050	,225
	[Level_CNE_sameside=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_otherside=low]	,539	,045	142,664	1	,000	,451	,628
	[Level_CNE_otherside=medium]	,053	,044	1,439	1	,230	-,034	,140
	[Level_CNE_otherside=high]	0[a]	.	.	0	.	.	.
	[Land_use=Rural]	-,064	,045	2,006	1	,157	-,152	,025
	[Land_use=In-town residential]	-,242	,045	29,575	1	,000	-,330	-,155
	[Land_use=High Density]	0[a]	.	.	0	.	.	.
	[Level_of_activity=low]	,317	,045	49,336	1	,000	,229	,406
	[Level_of_activity=medium]	,180	,044	16,513	1	,000	,093	,267
	[Level_of_activity=high]	0[a]	.	.	0	.	.	.
	[Vegetation=grass]	-,707	,045	241,700	1	,000	-,796	-,618
	[Vegetation=trees]	-,557	,045	151,945	1	,000	-,646	-,469
	[Vegetation=bushes]	0[a]	.	.	0	.	.	.
	[Intensity_car_traffic=low]	,360	,045	65,067	1	,000	,273	,448
	[Intensity_car_traffic=medium]	,300	,045	44,665	1	,000	,212	,388
	[Intensity_car_traffic=high]	0[a]	.	.	0	.	.	.
	[Width_bike_path=low]	-1,100	,046	571,106	1	,000	-1,190	-1,010
	[Width_bike_path=medium]	-,445	,045	96,341	1	,000	-,534	-,356
	[Width_bike_path=high]	0[a]	.	.	0	.	.	.
	[Color_bike_path=red]	,085	,045	3,650	1	,056	-,002	,173
	[Color_bike_path=gray/tiles]	-,065	,045	2,115	1	,146	-,153	,023
	[Color_bike_path=blue]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Appendix I: Ordinal regression output perceived level of Comfort

Case Processing Summary

		N	Marginal Percentage
Level of perceived comfort	Very Low	489	4,5%
	Low	1826	16,8%
	Moderately	4387	40,3%
	High	3763	34,6%
	Very High	425	3,9%
Valid		10890	100,0%
Missing		0	
Total		10890	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	3736,258			
Final	697,932	3038,327	18	,000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	171,822	86	,000
Deviance	174,677	86	,000

Link function: Logit.

Pseudo R-Square

Cox and Snell	,243
Nagelkerke	,263
McFadden	,107

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Level of perceived comfort = 1]	-2,620	,090	857,058	1	,000	-2,796	-2,445
	[Level of perceived comfort = 2]	-,705	,080	77,815	1	,000	-,862	-,549
	[Level of perceived comfort = 3]	1,496	,081	340,339	1	,000	1,337	1,655
	[Level of perceived comfort = 4]	4,615	,097	2266,042	1	,000	4,425	4,805
Location	[Intensity_level_cylists=low]	1,976	,048	1674,624	1	,000	1,882	2,071
	[Intensity_level_cylists=medium]	1,236	,046	731,885	1	,000	1,147	1,326
	[Intensity_level_cylists=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_sameside=low]	,543	,045	146,329	1	,000	,455	,630
	[Level_CNE_sameside=medium]	,222	,044	25,046	1	,000	,135	,309
	[Level_CNE_sameside=high]	0[a]	.	.	0	.	.	.
	[Level_CNE_otherside=low]	,563	,045	157,243	1	,000	,475	,652
	[Level_CNE_otherside=medium]	,052	,044	1,362	1	,243	-,035	,139
	[Level_CNE_otherside=high]	0[a]	.	.	0	.	.	.
	[Land_use=Rural]	-,111	,045	6,169	1	,013	-,199	-,023
	[Land_use=In-town residential]	-,280	,044	39,941	1	,000	-,367	-,193
	[Land_use=High Density]	0[a]	.	.	0	.	.	.
	[Level_of_activity=low]	,287	,045	40,613	1	,000	,199	,375
	[Level_of_activity=medium]	,088	,044	3,966	1	,046	,001	,175
	[Level_of_activity=high]	0[a]	.	.	0	.	.	.
	[Vegetation=grass]	-,278	,045	38,401	1	,000	-,365	-,190
	[Vegetation=trees]	-,335	,045	56,575	1	,000	-,423	-,248
	[Vegetation=bushes]	0[a]	.	.	0	.	.	.
	[Intensity_car_traffic=low]	,450	,045	101,804	1	,000	,362	,537
	[Intensity_car_traffic=medium]	,369	,045	68,357	1	,000	,282	,457
	[Intensity_car_traffic=high]	0[a]	.	.	0	.	.	.
	[Width_bike_path=low]	-1,202	,046	681,104	1	,000	-1,293	-1,112
	[Width_bike_path=medium]	-,566	,045	156,933	1	,000	-,654	-,477
	[Width_bike_path=high]	0[a]	.	.	0	.	.	.
	[Color_bike_path=red]	,127	,045	8,138	1	,004	,040	,215
	[Color_bike_path=gray/tiles]	-,428	,045	91,865	1	,000	-,515	-,340
	[Color_bike_path=blue]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Appendix J: Attribute impact per group

Level of perceived Crowding: Gender

		Female		Male	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived crowding = 1]	-7,078	,000	-7,090	,000
	[Level of perceived crowding = 2]	-4,350	,000	-4,359	,000
	[Level of perceived crowding = 3]	-1,954	,000	-1,999	,000
	[Level of perceived crowding = 4]	,985	,000	,930	,000
Location	[Intensity_level_cylists=low]	-4,021	,000	-4,244	,000
	[Intensity_level_cylists=medium]	-2,221	,000	-2,446	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	-,680	,000	-,501	,000
	[Level_CNE_sameside=medium]	-,229	,000	-,070	,268
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	-,636	,000	-,568	,000
	[Level_CNE_otherside=medium]	-,068	,301	-,062	,327
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	,480	,000	,638	,000
	[Land_use=In-town residential]	,384	,000	,556	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	-,468	,000	-,374	,000
	[Level_of_activity=medium]	-,368	,000	-,260	,000
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	,025	,704	-,050	,429
	[Vegetation=trees]	,127	,050	,157	,013
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	-,850	,000	-,869	,000
	[Intensity_car_traffic=medium]	-,596	,000	-,619	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	,888	,000	,915	,000
	[Width_bike_path=medium]	,512	,000	,449	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	-,120	,066	-,249	,000
	[Color_bike_path=gray/tiles]	-,004	,948	-,109	,084
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Safety: Gender

		Female		Male	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived safety = 1]	-2,951	,000	-3,009	,000
	[Level of perceived safety = 2]	-1,066	,000	-1,034	,000
	[Level of perceived safety = 3]	1,047	,000	1,148	,000
	[Level of perceived safety = 4]	4,337	,000	4,386	,000
Location	[Intensity_level_cylists=low]	1,810	,000	1,768	,000
	[Intensity_level_cylists=medium]	1,105	,000	1,120	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,515	,000	,411	,000
	[Level_CNE_sameside=medium]	,186	,004	,090	,148
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,588	,000	,493	,000
	[Level_CNE_otherside=medium]	,100	,119	,008	,892
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,075	,245	-,049	,434
	[Land_use=In-town residential]	-,228	,000	-,260	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,308	,000	,334	,000
	[Level_of_activity=medium]	,178	,005	,187	,003
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,799	,000	-,617	,000
	[Vegetation=trees]	-,569	,000	-,543	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,324	,000	,404	,000
	[Intensity_car_traffic=medium]	,209	,001	,393	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,013	,000	-1,185	,000
	[Width_bike_path=medium]	-,416	,000	-,475	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,157	,015	,021	,735
	[Color_bike_path=gray/tiles]	-,067	,296	-,060	,336
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Comfort: Gender

		Female		Male	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived comfort = 1]	-2,435	,000	-2,790	,000
	[Level of perceived comfort = 2]	-,624	,000	-,777	,000
	[Level of perceived comfort = 3]	1,585	,000	1,429	,000
	[Level of perceived comfort = 4]	4,763	,000	4,497	,000
Location	[Intensity_level_cylists=low]	2,022	,000	1,940	,000
	[Intensity_level_cylists=medium]	1,260	,000	1,220	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,601	,000	,487	,000
	[Level_CNE_sameside=medium]	,281	,000	,163	,008
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,651	,000	,483	,000
	[Level_CNE_otherside=medium]	,107	,093	-,003	,962
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,119	,064	-,101	,106
	[Land_use=In-town residential]	-,243	,000	-,322	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,315	,000	,269	,000
	[Level_of_activity=medium]	,126	,045	,056	,363
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,348	,000	-,209	,001
	[Vegetation=trees]	-,327	,000	-,341	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,405	,000	,496	,000
	[Intensity_car_traffic=medium]	,264	,000	,471	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,116	,000	-1,285	,000
	[Width_bike_path=medium]	-,509	,000	-,621	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,172	,008	,090	,147
	[Color_bike_path=gray/tiles]	-,386	,000	-,463	,000
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Crowding: Age

		Age<50 years		Age>=50 years	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived crowding = 1]	-7,199	,000	-7,004	,000
	[Level of perceived crowding = 2]	-4,486	,000	-4,248	,000
	[Level of perceived crowding = 3]	-2,107	,000	-1,858	,000
	[Level of perceived crowding = 4]	,836	,000	1,100	,000
Location	[Intensity_level_cylists=low]	-4,262	,000	-4,070	,000
	[Intensity_level_cylists=medium]	-2,486	,000	-2,240	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	-,499	,000	-,647	,000
	[Level_CNE_sameside=medium]	-,056	,405	-,212	,001
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	-,573	,000	-,621	,000
	[Level_CNE_otherside=medium]	-,018	,789	-,095	,120
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	,578	,000	,555	,000
	[Land_use=In-town residential]	,520	,000	,449	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	-,385	,000	-,453	,000
	[Level_of_activity=medium]	-,258	,000	-,353	,000
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,065	,342	,044	,471
	[Vegetation=trees]	,167	,013	,135	,027
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	-,743	,000	-,967	,000
	[Intensity_car_traffic=medium]	-,549	,000	-,658	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	,867	,000	,936	,000
	[Width_bike_path=medium]	,451	,000	,498	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	-,205	,002	-,154	,012
	[Color_bike_path=gray/tiles]	-,107	,118	,005	,937
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Safety: Age

		Age<50 years		Age>=50 years	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived safety = 1]	-3,372	,000	-2,696	,000
	[Level of perceived safety = 2]	-1,322	,000	-,832	,000
	[Level of perceived safety = 3]	,747	,000	1,389	,000
	[Level of perceived safety = 4]	4,082	,000	4,623	,000
Location	[Intensity_level_cylists=low]	1,694	,000	1,874	,000
	[Intensity_level_cylists=medium]	1,096	,000	1,136	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,389	,000	,533	,000
	[Level_CNE_sameside=medium]	,126	,059	,155	,010
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,531	,000	,559	,000
	[Level_CNE_otherside=medium]	,034	,609	,077	,195
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	,018	,790	-,131	,032
	[Land_use=In-town residential]	-,262	,000	-,226	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,377	,000	,272	,000
	[Level_of_activity=medium]	,244	,000	,137	,021
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,860	,000	-,577	,000
	[Vegetation=trees]	-,598	,000	-,517	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,362	,000	,349	,000
	[Intensity_car_traffic=medium]	,361	,000	,247	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,273	,000	-,982	,000
	[Width_bike_path=medium]	-,622	,000	-,321	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,109	,104	,083	,169
	[Color_bike_path=gray/tiles]	-,055	,419	-,065	,276
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Comfort: Age

		Age<50 years		Age>=50 years	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived comfort = 1]	-2,717	,000	-2,549	,000
	[Level of perceived comfort = 2]	-,827	,000	-,611	,000
	[Level of perceived comfort = 3]	1,321	,000	1,642	,000
	[Level of perceived comfort = 4]	4,562	,000	4,687	,000
Location	[Intensity_level_cylists=low]	1,973	,000	1,993	,000
	[Intensity_level_cylists=medium]	1,270	,000	1,219	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,520	,000	,560	,000
	[Level_CNE_sameside=medium]	,202	,002	,237	,000
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,601	,000	,539	,000
	[Level_CNE_otherside=medium]	,094	,158	,025	,671
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,058	,391	-,157	,009
	[Land_use=In-town residential]	-,261	,000	-,298	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,328	,000	,257	,000
	[Level_of_activity=medium]	,038	,569	,131	,027
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,278	,000	-,274	,000
	[Vegetation=trees]	-,323	,000	-,345	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,490	,000	,420	,000
	[Intensity_car_traffic=medium]	,450	,000	,303	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,359	,000	-1,096	,000
	[Width_bike_path=medium]	-,741	,000	-,437	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,148	,028	,121	,044
	[Color_bike_path=gray/tiles]	-,578	,000	-,310	,000
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Crowding: Crowded experience

		Crowded experience = never		Crowded experience = sometimes or more	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived crowding = 1]	-7,174	,000	-6,973	,000
	[Level of perceived crowding = 2]	-4,470	,000	-4,206	,000
	[Level of perceived crowding = 3]	-2,053	,000	-1,882	,000
	[Level of perceived crowding = 4]	,816	,000	1,173	,000
Location	[Intensity_level_cylists=low]	-4,236	,000	-3,992	,000
	[Intensity_level_cylists=medium]	-2,393	,000	-2,254	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	-,543	,000	-,662	,000
	[Level_CNE_sameside=medium]	-,170	,004	-,109	,130
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	-,576	,000	-,655	,000
	[Level_CNE_otherside=medium]	-,035	,553	-,132	,070
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	,582	,000	,525	,000
	[Land_use=In-town residential]	,492	,000	,447	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	-,455	,000	-,355	,000
	[Level_of_activity=medium]	-,302	,000	-,332	,000
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,011	,856	-,019	,795
	[Vegetation=trees]	,124	,033	,162	,025
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	-,864	,000	-,850	,000
	[Intensity_car_traffic=medium]	-,605	,000	-,617	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	,880	,000	,930	,000
	[Width_bike_path=medium]	,521	,000	,404	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	-,198	,001	-,162	,024
	[Color_bike_path=gray/tiles]	-,060	,307	-,056	,440
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Safety: Crowded Experience

		Crowded experience = never		Crowded experience = sometimes or more	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived safety = 1]	-2,976	,000	-3,036	,000
	[Level of perceived safety = 2]	-1,156	,000	-,903	,000
	[Level of perceived safety = 3]	,993	,000	1,237	,000
	[Level of perceived safety = 4]	4,263	,000	4,486	,000
Location	[Intensity_level_cylists=low]	1,802	,000	1,762	,000
	[Intensity_level_cylists=medium]	1,122	,000	1,092	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,403	,000	,554	,000
	[Level_CNE_sameside=medium]	,113	,048	,174	,014
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,477	,000	,633	,000
	[Level_CNE_otherside=medium]	,014	,803	,110	,118
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,092	,114	-,022	,753
	[Land_use=In-town residential]	-,308	,000	-,142	,046
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,315	,000	,319	,000
	[Level_of_activity=medium]	,195	,001	,162	,022
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,727	,000	-,683	,000
	[Vegetation=trees]	-,541	,000	-,586	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,319	,000	,421	,000
	[Intensity_car_traffic=medium]	,271	,000	,354	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,130	,000	-1,051	,000
	[Width_bike_path=medium]	-,456	,000	-,427	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,081	,162	,094	,187
	[Color_bike_path=gray/tiles]	-,031	,590	-,116	,104
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Comfort: Crowded Experience

		Crowded experience = never		Crowded experience = sometimes or more	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived comfort = 1]	-2,627	,000	-2,632	,000
	[Level of perceived comfort = 2]	-,796	,000	-,567	,000
	[Level of perceived comfort = 3]	1,380	,000	1,678	,000
	[Level of perceived comfort = 4]	4,629	,000	4,633	,000
Location	[Intensity_level_cylists=low]	1,967	,000	1,997	,000
	[Intensity_level_cylists=medium]	1,250	,000	1,217	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,517	,000	,586	,000
	[Level_CNE_sameside=medium]	,231	,000	,212	,003
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,527	,000	,620	,000
	[Level_CNE_otherside=medium]	,032	,579	,084	,235
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,125	,031	-,087	,217
	[Land_use=In-town residential]	-,363	,000	-,151	,032
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,273	,000	,305	,000
	[Level_of_activity=medium]	,091	,110	,085	,228
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,314	,000	-,230	,001
	[Vegetation=trees]	-,317	,000	-,367	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,399	,000	,527	,000
	[Intensity_car_traffic=medium]	,351	,000	,406	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,198	,000	-1,211	,000
	[Width_bike_path=medium]	-,560	,000	-,574	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,101	,080	,167	,018
	[Color_bike_path=gray/tiles]	-,461	,000	-,380	,000
	[Color_bike_path=blue]	0[a]	.	0[a]	.

Level of perceived Crowding: Bike Type

		Normal bike		E-bike	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived crowding = 1]	-7,135	,000	-6,859	,000
	[Level of perceived crowding = 2]	-4,372	,000	-4,112	,000
	[Level of perceived crowding = 3]	-1,954	,000	-1,931	,000
	[Level of perceived crowding = 4]	,948	,000	1,054	,000
Location	[Intensity_level_cylists=low]	-4,149	,000	-4,026	,000
	[Intensity_level_cylists=medium]	-2,352	,000	-2,200	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	-,585	,000	-,553	,000
	[Level_CNE_sameside=medium]	-,108	,051	-,197	,038
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	-,579	,000	-,703	,000
	[Level_CNE_otherside=medium]	-,010	,854	-,143	,134
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	,565	,000	,642	,000
	[Land_use=In-town residential]	,522	,000	,367	,000
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	-,481	,000	-,414	,000
	[Level_of_activity=medium]	-,380	,000	-,249	,009
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,022	,698	-,028	,770
	[Vegetation=trees]	,153	,006	,081	,386
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	-,869	,000	-,730	,000
	[Intensity_car_traffic=medium]	-,635	,000	-,511	,000
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	,937	,000	,894	,000
	[Width_bike_path=medium]	,476	,000	,533	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	-,216	,000	-,113	,236
	[Color_bike_path=gray/tiles]	-,102	,068	,004	,963
	[Color_bike_path=blue]	0[a]	.	0[a]	.

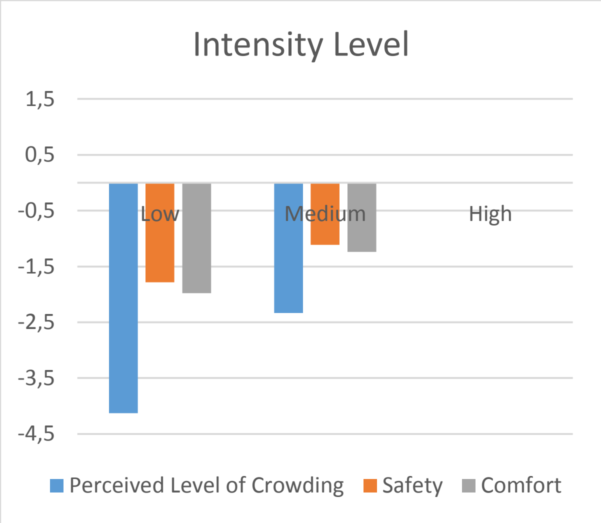
Level of perceived Safety: Bike Type

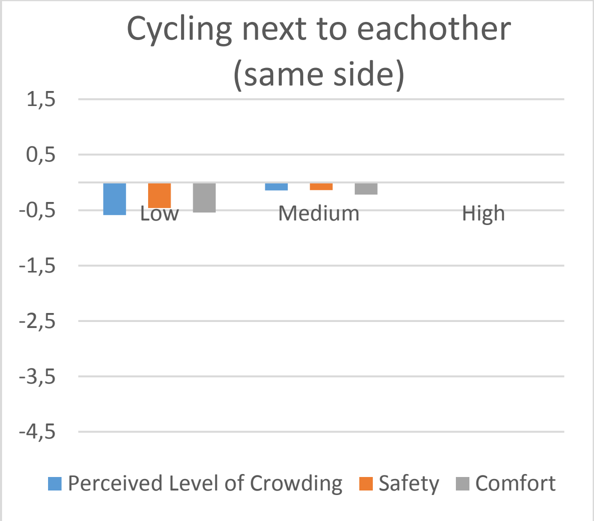
		Normal bike		E-bike	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived safety = 1]	-3,104	,000	-2,907	,000
	[Level of perceived safety = 2]	-1,159	,000	-,892	,000
	[Level of perceived safety = 3]	,978	,000	1,352	,000
	[Level of perceived safety = 4]	4,234	,000	4,677	,000
Location	[Intensity_level_cylists=low]	1,724	,000	1,980	,000
	[Intensity_level_cylists=medium]	1,054	,000	1,189	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,413	,000	,521	,000
	[Level_CNE_sameside=medium]	,116	,033	,178	,057
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,521	,000	,560	,000
	[Level_CNE_otherside=medium]	,016	,768	,142	,128
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,005	,923	-,217	,021
	[Land_use=In-town residential]	-,206	,000	-,199	,034
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,417	,000	,145	,125
	[Level_of_activity=medium]	,248	,000	,040	,669
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,737	,000	-,562	,000
	[Vegetation=trees]	-,614	,000	-,460	,000
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,390	,000	,267	,004
	[Intensity_car_traffic=medium]	,387	,000	,059	,530
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,153	,000	-,976	,000
	[Width_bike_path=medium]	-,480	,000	-,398	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,079	,147	,099	,292
	[Color_bike_path=gray/tiles]	-,065	,238	-,047	,613
	[Color_bike_path=blue]	0[a]	.	0[a]	.

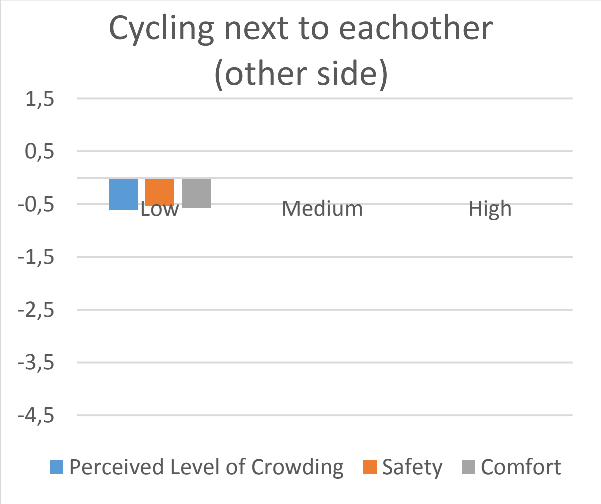
Level of perceived Comfort: Bike Type

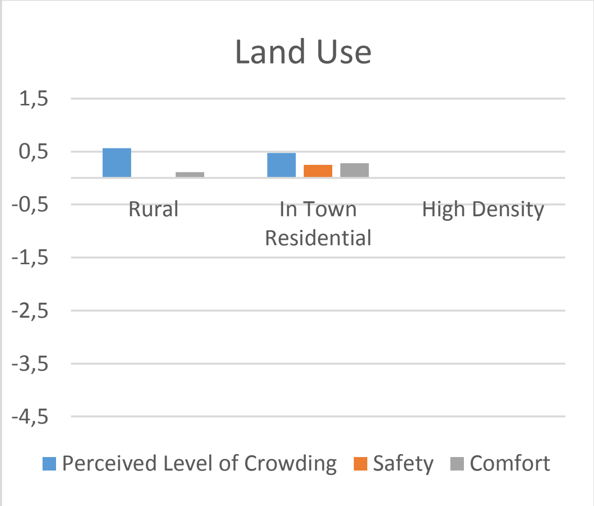
		Normal bike		E-bike	
		Estimate	Sig.	Estimate	Sig.
Threshold	[Level of perceived comfort = 1]	-2,766	,000	-2,523	,000
	[Level of perceived comfort = 2]	-,792	,000	-,516	,002
	[Level of perceived comfort = 3]	1,444	,000	1,691	,000
	[Level of perceived comfort = 4]	4,614	,000	4,630	,000
Location	[Intensity_level_cylists=low]	1,981	,000	2,104	,000
	[Intensity_level_cylists=medium]	1,253	,000	1,266	,000
	[Intensity_level_cylists=high]	0[a]	.	0[a]	.
	[Level_CNE_sameside=low]	,539	,000	,533	,000
	[Level_CNE_sameside=medium]	,198	,000	,256	,006
	[Level_CNE_sameside=high]	0[a]	.	0[a]	.
	[Level_CNE_otherside=low]	,577	,000	,537	,000
	[Level_CNE_otherside=medium]	,013	,808	,066	,477
	[Level_CNE_otherside=high]	0[a]	.	0[a]	.
	[Land_use=Rural]	-,064	,242	-,258	,006
	[Land_use=In-town residential]	-,269	,000	-,298	,001
	[Land_use=High Density]	0[a]	.	0[a]	.
	[Level_of_activity=low]	,361	,000	,177	,058
	[Level_of_activity=medium]	,092	,091	,123	,184
	[Level_of_activity=high]	0[a]	.	0[a]	.
	[Vegetation=grass]	-,287	,000	-,196	,034
	[Vegetation=trees]	-,349	,000	-,277	,003
	[Vegetation=bushes]	0[a]	.	0[a]	.
	[Intensity_car_traffic=low]	,492	,000	,311	,001
	[Intensity_car_traffic=medium]	,426	,000	,175	,058
	[Intensity_car_traffic=high]	0[a]	.	0[a]	.
	[Width_bike_path=low]	-1,312	,000	-,947	,000
	[Width_bike_path=medium]	-,621	,000	-,461	,000
	[Width_bike_path=high]	0[a]	.	0[a]	.
	[Color_bike_path=red]	,123	,025	,129	,167
	[Color_bike_path=gray/tiles]	-,441	,000	-,339	,000
	[Color_bike_path=blue]	0[a]	.	0[a]	.

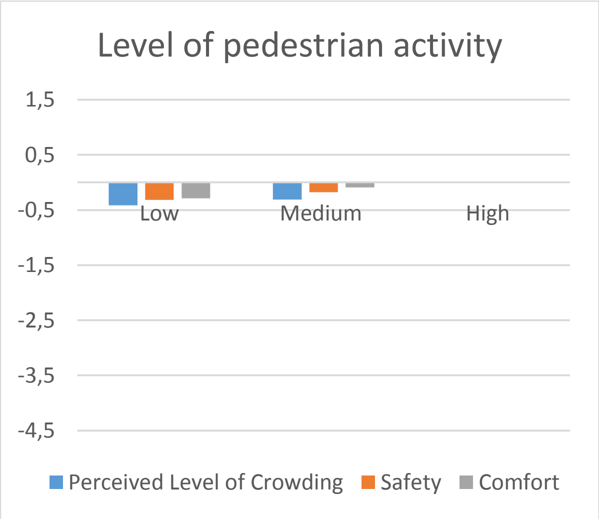
Appendix K: Coefficients for predictor variables

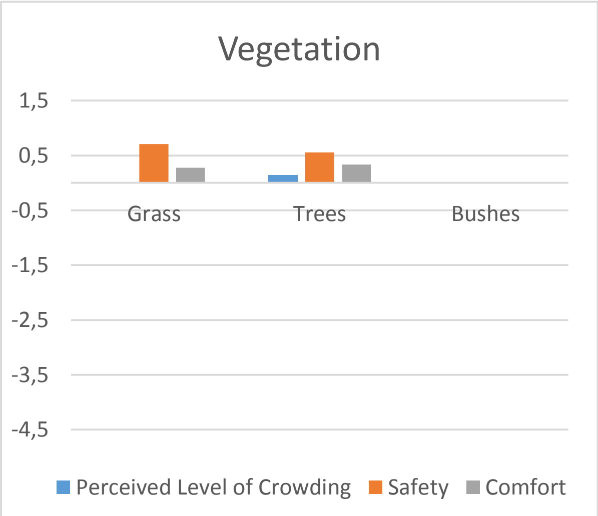


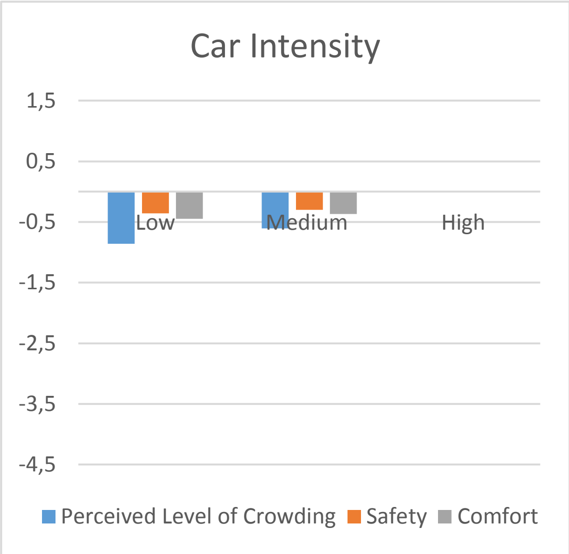


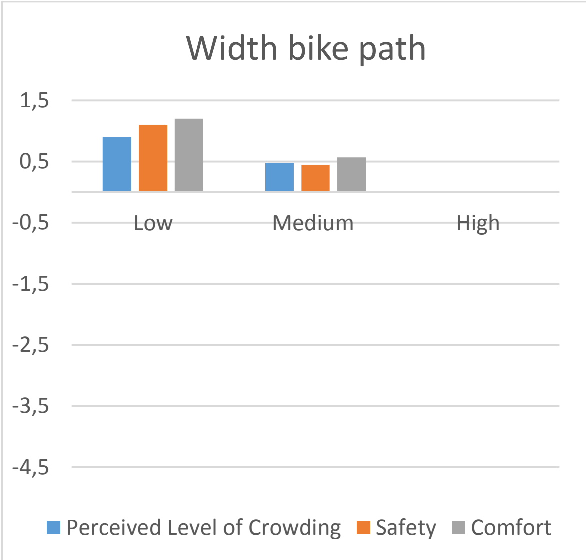


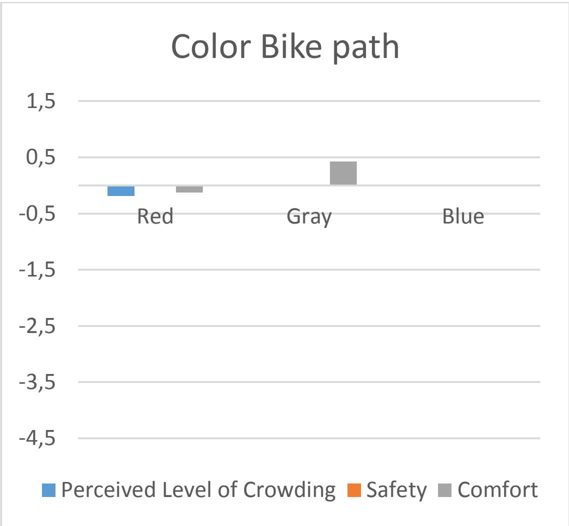







Car Intensity
1,5
0,5
-0,5
-1,5
-2,5
-3,5
-4,5
Low
Medium
High
Perceived Level of Crowding
Safety
Comfort


Width bike path
1,5
0,5
-0,5
-1,5
-2,5
-3,5
-4,5
Low
Medium
High
Perceived Level of Crowding
Safety
Comfort


Color Bike path
1,5
0,5
-0,5
-1,5
-2,5
-3,5
-4,5
Red
Gray
Blue
Perceived Level of Crowding
Safety
Comfort