Primary Rules On The Way To Primary Schools

“An assessment on the role of car speed reduction policy on creating a subjectively safe and encouraging environment for cyclists in the school zones.”

TU Delft

M.W. Tem Temi

Royal HaskoningDHV
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Written by: M.W. (Marc) Tem Temi

Student number: 4432916

Supervision committee:

Dr.Ir. A.	Gavriilidou	TU Delft
Dr.	J.A. Annema	TU Delft
Ing. T.	Te Lintel Hekkert	Royal Haskoning DHV
Ir.	L. Rijsman	Royal Haskoning DHV

Chaired by:

Dr.Ir. W.	Daamen	TU Delft

PREFACE

As I leave the throne vacant for the next contestants, I leave the principality of knowledge to enter the kingdom of applied practices. I do this with delight and pride for the work I have done in my graduation period, as well as the hard effort I have put in throughout my academic career. Having said that, I must devote this chapter to the people who served in my court as advisors and benefactors, making the last chapter of my scholarly book one of the greatest highlights of my life.

I must begin by thanking Dr. Alexandra Gavriilidou for acting as my first supervisor and providing the guidance I sought in the various pathways I was taking in the universe of active mode behaviour analysis. There is no greater mentor I could have asked for, even though it was by chance that you became my supervisor. Second, I would like to thank Dr. Jan Anne Annema, who was the supervisor I chose before learning about the topic of the thesis. Dr. Annema's excitement is unrivalled, and the assurance he provided that everything will be fine sooner or later boosted my confidence and provided the adrenaline rush that I so needed to complete the various tasks I assigned myself to accomplish. Finally, I must thank Dr. Winnie Daamen, with whom I had few interactions but who supplied me with such specific comments with tops and tips, especially at my greenlight meeting, that helped shape the report into what it is today.

I must express my gratitude to the team at Royal HaskoningDHV, where I completed my graduation internship. I want to start by thanking everyone in the mobility group in Rotterdam, without exception, for their unwavering support from the first day I walked into the office to the last. I want to thank Ing. Thomas te Lintel Hekkert in particular for being a patron to me and providing unconditional support to whatever suggestion I made on the topic without any interference or involvement in deciding the course of the study. I would also like to thank Thomas for consistently promoting my work within the organization and for his critical role in spreading the survey and encouraging people to complete it. In addition, I must express my appreciation to Ir. Lotte Rijsman, who provided guidance and practical advice on a range of situations that arose.

Moving away from professional and academic institutions, I need to highlight some individuals who made substantial contributions to the success of my tale and had a huge impact on my wellness and high spirits in the past few months. Ir. Stavros Xanthopoulos was in the front of the line, spearheading these auxiliary cohorts. I had no idea when I started the thesis that I would have to use programming languages to analyse the outcomes. If I had known, I would have selected a different topic altogether. However, I was really fortunate to have Stavros by my side, who committed his free time, even while being on holiday in Berlin, to have video calls with me to explain how the coding worked. Furthermore, I could always rely on Stavros for improvement ideas because he was constantly truthful and did not exaggerate about the things I was presenting. I would also like to thank Ir. Nejc Geržinič, who spent several hours providing guidance on the survey design technique. Moreover, I would like to thank everyone in the Thesis Room, Limousine Club,

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I can not end my preface without mentioning the role of my parents, Ani and Wasken, who were like the cannon and gunpowder that allowed me to breach the walls I doubted I could crack. Their unfaltering love and unending support were exactly what I needed at the end of the day, and they provided without reservation. I'd also want to thank my sister Jbeed for her assistance in spreading the survey and being there for me in the last stressful weeks of the thesis. I am incredibly blessed to have a loving family who has been by my side through the good and the bad times.

Finally, I would like to thank my partner Denise Campbell for her support and affection throughout the thesis, not only with emotional support but also with practical assistance. Thank you love for accompanying me on the streets to share the survey with parents and the general public and for helping me take creative pictures for the beginnings of each chapter. No matter how gloomy the days had become, I could always count on your smile to lift my spirits.

Marc Wartan Tem Temi

SUMMARY

According to statistics, the highest percentage of fatal traffic accidents in the Netherlands happen on distribution roads with a 50 km/hour speed limit (Ministerie van Infrastructuur en Waterstaat, 2022). A road type that is frequently found in urban areas in the Netherlands. Combining that with data showing an increase in the number of cyclists involved in fatal traffic accidents, where this group ranks as the top category of people who die in traffic accidents in the country (Centraal Bureau voor de Statistiek, 2021c). Additionally, children between the ages of 8 and 14 represent the majority of people in the Netherlands who receive first aid treatment following a bicycle crash and are increasingly involved in collisions with motor vehicles (VeiligheidNL, 2014). As a result, the Dutch government authorized a proposal to lower the speed limit for cars inside Dutch cities to 30 km/hour (Tweede Kamer Der Staten-Generaal, 2020). This choice was mainly justified by the need to make school zones safer and more cycle encouraging. Even though there is enough evidence to support the goal that lowering the speed limit will reduce the severity of crashes (Alnawmasi & Mannering, 2022; Renski et al., 1999; SWOV, 2018b), it is still unclear and unidentified the effect of this policy as an encouraging factor for cycling.

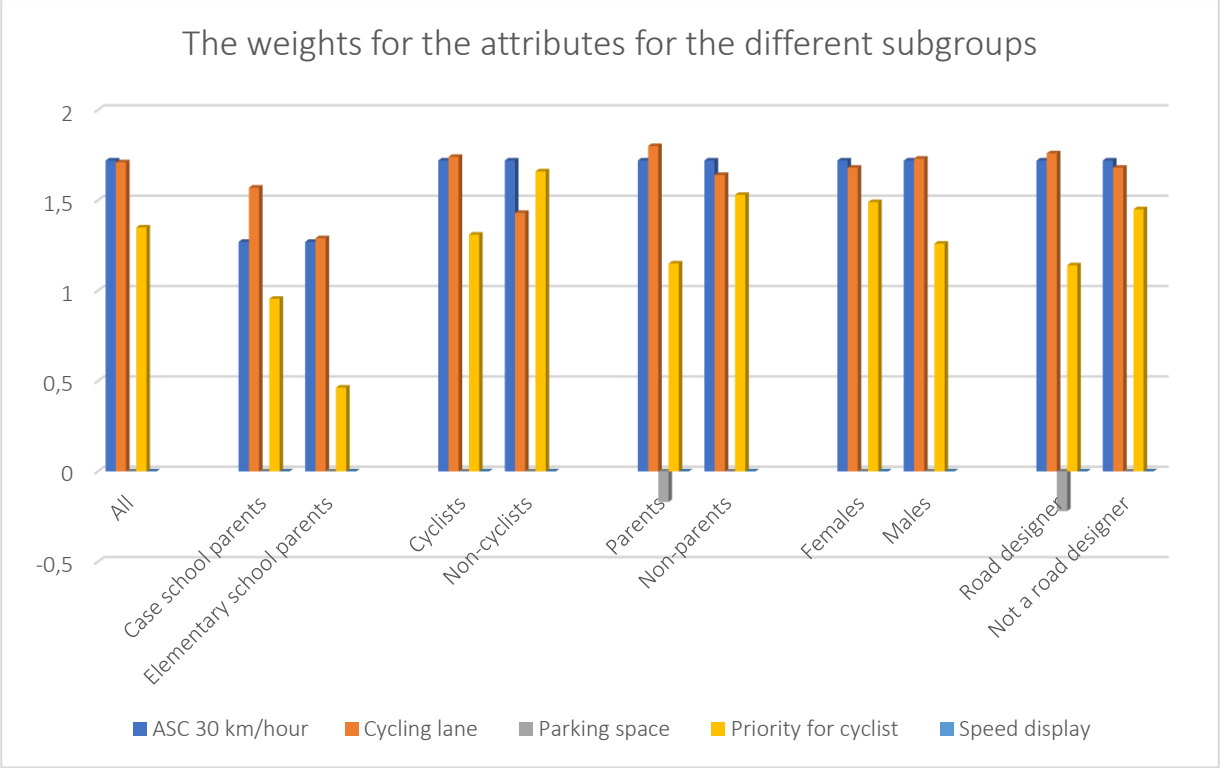
The introduction of lowering of the speed limit on the distribution roads in the Netherlands created a new concept of such roads called the distribution roads 30 (denoted by GOW30). This type of roads does not yet exist in the Netherlands and the elements that need to be included in this road type are still unclear and a major discussion point. In this research, a quantitative analysis is done based on a stated preferences experiment on the weights of the different elements on the roads with respect to the subjective safety perception. Next to the whole sample, the preferences of distinct groups have been studied in this study. Groups that are the most involved in this matter which according to the literature have different preferences to the different elements of the infrastructure. These groups are males and females, parents, road designers and cyclists. As this study focuses on the physical attributes of the road which are difficult to describe in words especially when coexisting in a single environment and because the use of visuals is shown to improve the validity and reliability of the parameters (Holmes et al., 2017; Steine et al., 2005), the use of images is utilized in this study. However, there are worries regarding potential bias caused by inadvertent information in the photographs, as well as possible discrepancies in attribute level perception when displayed graphically. Therefore, several changes were carried out during the image production phase to alleviate the challenges. Distracting characteristics have been eliminated. Furthermore, similar roads are sought to the road that is considered the base road next to the example school which incorporate the various features need to be researched to increase the believability of the method. These roads, or portions of them, are then included into the basic image which is deemed by the pilot study to increase the realism of the process. Additionally, the respondent is asked to state their supposed change in cycling behaviour after reducing the speed for cars on the road to 30 km/hour. This is done to investigate the attitude of the different groups of the population towards this new policy and their willingness to cycle more following the implementation of it. Finally, in order to compare the method of trade-off filled choice set questions with

the direct approach of preferences inquiry, respondents are given the option of selecting or stating the measure that, in their opinion, makes roads safer for children to cycle on surrounding school zones. This is also done to reflect on the importance of the measures that are mentioned in the study that need to be included in school areas but were not incorporated in the choice situations.

In this study, children are set as the focus point of the experiment to enhance the importance of the safety in the survey for the respondents as children are vulnerable group in the society (Paul, 2019). A case school is chosen that is in a proximity to a dangerous distribution road with 50 km/hour speed limit (which is donated by GOW50). The choice for this case is in two folds. One, to create a believable storyline for the respondents with recognizable distinct elements and the second reason is to study the travel behaviour around dangerous GOW50 roads and the attitude of this distinct group of people with similar one in the public. The survey is sent in May 2022 with an online survey that was spread inside various organisations and to different individuals. In total, 486 respondents completed the survey, of which 441 responses were kept to be analysed after taking out the outliers and the responses that did not provide any useful insights. Responses from people under the age of 18 are eliminated for privacy reasons and because the subject of the choice experiment is adolescence which is consider to differ the results intended to investigate by the approach set.

The attribute levels are dummy coded as the levels are set to be binary either existent or not with no additional steps in between. The MNL model is used to investigate the directions of the parameters and the differences in the preferences of the different subgroups. The MNL model however does not capture the taste heterogeneity and panel effect which occurs when several similar choices are given to the respondents. For that reason, an ML model is made to investigate the effects on the values calculated with the MNL model and to give recommendations on further research on which method should be utilized when stated choice experiments based on the strategy set for this study are going to be deployed.

According to the findings of the MNL approach, different persons have varying preferences for certain traits. For some attributes there is a strong and significant preference towards and for others there are none. For the whole sample, separated cycling lanes, speed limit of 30 km/hour and priority for crossing for cyclists are preferred while the removal of parked vehicles and parking spaces, and speed displays do not play any role in the feeling that safer roads have been created to cycle on around schools. As the questions are asked about the safety of children, the values of the parameters and the preferences are considered accordingly. Children are considered as a vulnerable group in society and there is, and society tries to protect them (Paul, 2019). Therefore, the results of this research are when the safety aspect is amplified.



There are also significant differences found for the different subgroups of people. Unlike the study done by Aldred et al (2016), that states that women prefer the segregation of cyclists from motorized vehicles, the results of this research show that there is no significant difference towards this aspect between both genders.

Most notably, two groups are found to have significant distaste towards the existence of parked vehicles and parking spaces next to schools. These groups are the road designers and parents while other groups did not have significant distaste towards this attribute. Interestingly, the groups of parents who have children attending primary schools in specific did not have a significant distaste for this attribute too compared to the group that is a parent in general. This could be due to the limited number of respondents that are a part of these groups to produce a significant parameter for this attribute.

Taking the performance of the different models into consideration, only two models had better adjusted rho value than the base model. These models are the parents and the road designers' groups. Combining the two models together did not improve the performance significantly. The only model that did perform better with the Likelihood Ratio Test is the model containing the dummy variables of road designers and non-road designers that interact with the variables set for the attributes. The model of the ML model with panel structure does perform better than the MNL model having a lower BIC value than the MNL model. It is clear to observe that the values for the preferences of the different attributes rise with the ML model. That being said, the direction of the parameters and the Difference between the values of the parameters does not largely change. This leads to the conclusion that the ML model with the panel data structure does perform better and explain the choice behaviour better than the MNL model however, the MNL model does

give valuable data on the direction, preferences and discrepancies amongst the attributes and the groups of population.

Observing the stated behaviour of the parents of the children who attend the case school which is situated next to a specifically hazardous GOW50 road and other parents of children who attend elementary schools it can be concluded that GOW50 roads which are dangerous increases the use of cars in the area. This is in line with the findings of VVN (2018) that when parents perceive a road to be dangerous the use of cars increases in bringing the children to school. This is also to be observed in the findings of this research, where the parents of the case school had stated in greater amounts that the reason why they bring children to school with car is due safety reasons. The most important reason for bringing children cycling is for both groups is due to reasons of fun/comfort. Therefore, a conclusion is made that cycling is experienced positively by the parents and the when roads are perceived as dangerous especially around hazardous GOW50 roads, the use of car to bring children to school increases considerably. Moreover, parents who bring their children to schools in the surroundings of dangerous GOW50 roads have stated to willing to cycle more in the future if the speed limit on the road is lowered to 30 km/hour. A conclusion is made from this that the most positive attitude towards cycling more is from people who bring their children to schools that are in a currently hazardous GOW50 roads surroundings. There is also an increase found towards this attitude with the frequency of the use of bicycles in the daily travel behaviour.

Considering the results of the direct approach for the best measure according to the population that increases the safety around school areas and the safety of cycling children. The reduction of the speed limit ranks second the existence of separation of cycling lanes. The separation of the cycling lane is according to the respondents more essential measure to have so that an effective increase in the safety of cycling children has happened. This is in contrast with the weights of the attributes included in the choice situations. In the latter case, the weights of both attributes are shown to be similar and this can be seen in the choice behaviour at the choice situations. In these situations, it was observable that the choice situations that were divisive in the choice behaviour were the choices where the main trade-off was the cycling lane against the speed limit of the road. In contrast, measures that target bicycle users are chosen the least meaning the respondents prefer measures that target vehicles and vehicle users more than bicycle users. Additionally, respondents are given the freedom to state the elements on their own and the most frequent used terms are “Target the use of mopeds” and “Provide more education for road users”.

This research provides a number of recommendations for policymakers through which roads can be made that are encouraging for cycling children on. The first essential step is to do is to define the term “School zone”. As it is the reason why the reduction of the speed limit for cars policy is done, there is no definition of the area or the zone that this policy is aiming to protect and to improve. There is a need to look wider into a school zone area as the roads directly adjacent next to the schools are predominantly residential roads and the guidelines for the speed limit on these roads is already set to 30 km/hour (CROW, 2019). Therefore,

a clear definition of a “school zone” is needed for policy makers and road operators to include in the evaluation process of deciding which roads can maintain their 50 km/hour speed limit and which ones need to be lowered. A recommendation is to have the average distance that children need to cycle to their schools in any city or place as the new definition of “school zone” as these data are already available.

The second recommendation is based on the findings of the weights of the different elements in this study. To increase the feeling of safety of the roads most essential steps are lowering of the speed limit, segregating the cyclists from cars and providing priority for crossing for cyclists at the intersections. The removal of parking spaces and placing speed displays do not generate any significant feeling of safety for the whole population. Only two groups in the sample population seem to perceive the removal of the parking spaces as a step that generates roads that perceived safer for cycling children and these groups are the parents and more greatly the people who do road designing. Parents of elementary school children however do not perceive roads to become safer when the parking spaces are removed. A recommendation is to provide a better understanding to the people to the effects of removing parked vehicles on the road for the safety of cyclists. This way, the intended goals and expectations of people who do road designing can be matched by the population. Furthermore, the placement of speeddisplays does not generate the feeling of roads have become safer. Therefore, more awareness needs to be brought on the effects of using this element on the road.

It is shown in the interviews that some roads cannot have their speed limit reduced to 30 km/hour due to their importance for public transport and emergency services besides being important distribution roads for the network. In this case, separated cycling lanes and providing priority for crossing for cycling children is essential to do on these roads to have the intended effect of creating a subjectively safe and encouraging cycling environment.

The future stages in this research area could go in many different directions due to the large potential for development and improvement. A recommendation for future research is to study with revealed choices, which types of GOW30 roads in its different elements attracts more cyclists. Furthermore, a recommendation to study the exact effects of different elements on the roads on causing or preventing crashes on distribution road so that a comparison can happen between the level of subjective preference with respect to safety and the level of crashes caused or prevented by the various elements.

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Introduction

1 INTRODUCTION

In the Netherlands, bikes are used as a day-to-day mode of transport, and they are even considered an essential property of every Dutch citizen. To put that into perspective, there are 1.3 bicycles for every citizen in the Netherlands. This is partly possible because the country is mostly flat, making biking almost effortless and desirable. In addition to that, the Netherlands has an extensive cycling network making travelling by this mode easier and safer for its users (BBC, 2013).

Travelling by bike is considered beneficial because of the benefits it provides for the people and the societies. Cycling has been proven to benefit cyclists' physical health and mental well-being (Martin et al., 2014). Multiple studies have already pointed out the benefits of walking and cycling on the citizens' physical and mental health. For example, it increases fitness and reduces obesity and anxiety rates (Gao et al., 2017; Martin et al., 2014; Marquart & Schicketanz, 2022; Tainio et al., 2016). In addition to the benefits for the physical and mental well-being of the users, the aforementioned reports state that cycling is affordable and improves accessibility, especially for the economically disadvantaged population. Moreover, cycling poses little threat to vulnerable users (other bikers, pedestrians) compared to the threats posed by other motorized vehicles (Deloughry, 2018). For these benefits, the Dutch government has been trying to promote active modes of transport in the last decade (Ministerie van Algemene Zaken, 2022). Significant amounts of funding have been dedicated to adjusting the infrastructure and introducing new policies that make the use of bikes more desirable and safer (Reid, 2018).

Even though significant amounts of fundings have been made on increasing the safety of cyclists, reports show that there has been an increase in a disproportionate number of crashes and fatalities involving this type of road user (Boele, 2021). There are many reasons why these incidents are occurring, such as the introduction of E-bikes and the use of mobile phones (SWOV, n.d.). However, looking at the numbers that Schepers et al., (2017) have compiled that consider the factors of cyclist fatalities from 1996 to 2014, it could be noticed that 75% of the deaths where cyclists were involved occurred after crashes with motorised vehicles. This is apparent through the numbers, which state that most cycling-related crashes happened inside the Dutch cities, where there is a high number of conflict points between cars and cyclists (VeiligheidNL, 2017). From this, it can be concluded that the current situation of the roads in the cities where cyclists and cars coexist is not considered safe for cyclists.

Inspecting the numbers even further, it can be noticed that the children from the age of 4 to 14 years old are the biggest demographic group that had to be brought to the hospital or given first aid treatment after a cycling crash (VeiligheidNL, 2014). This is the range of age that children attend elementary school in the Netherlands and start to learn cycling on their own (Janssen Lok, 2020). The government has introduced several measures to improve the safety of cyclists, especially the cycling children. Measures such as restrictions on the number of cars in some areas and more speed bumps for cars in school zones were introduced (Ministerie van Algemene Zaken, 2022a). These measures had varying results, but most

importantly, the number of fatalities in the cyclists and cycling children categories did not seem to decrease significantly (fietsersbond.nl, 2021). Therefore, authorities have decided to implement policies on a city-sized scale. One of these new policies is the plan to reduce the speed limit for cars on the Dutch roads from 50 km/hour to 30 km/hour. The Dutch parliament adopted this strategy in 2020, and the main reasoning behind the resolution was that 50 km/hour speed is considered hazardous for the safety of the children travelling in areas around their schools (Tweede Kamer Der Staten-Generaal, 2020). This is also backed up by the parents' concerns, who stated that they fear that accidents would happen to the children around the school areas in their absence (VVN, 2020). Parents experience the school environment as unsafe and threatening, partly due to the chaos of cars around the school and the lack of safe routes and facilities for pedestrians and cyclists (CROW, 2012b). Due to these concerns, parents take their children to school by car, exacerbating the problem even more (CROW, 2022; VVN, 2018).

Although vehicle speed reduction is expected to reduce the severity of the accidents on the roads (Alnawmasi & Mannering, 2022), this policy has a significant impact on the road network in numerous ways. In the Dutch cities, most 50 km/hour roads are distribution roads. This means that these roads link the flow roads (highways) and the residential roads. The distribution roads have a higher intensity and vehicle volumes than the residential roads and therefore need a higher speed to keep the vehicles flowing in the network (SWOV, 2017b). The reduction in the speed has thus implications on the flow of vehicles through the city and has a particular impact on the public transport and emergency services (Schrader, 2021). Therefore, new designs of these roads, dubbed GOW30 roads, are introduced. These designs consider, on the one hand, keeping the flow of vehicles minimally affected and, on the other hand, ensuring and increasing the safety of the cyclists and, more importantly, the cycling children while simultaneously creating an encouraging cycling environment for (CROW, 2022).

Even though there is a new concept that is introduced which is the GOW30 roads, the exact definition of the GOW30 roads and which elements should be included in them are not defined yet, and the effectiveness and influence of introducing this road type are still unclear (Goudappel Groep BV, 2022). Reducing the car speed limit in the cities is expected to lower the number of fatalities and injuries on the road by 22% to 31% (SWOV, 2019b), making cycling in cities safer for road users. That said, it is unclear what are the effects of the increase in this safety on creating a safer feeling for the road users so that more use of the bicycle can be made and less use of motorized vehicles in their daily travel. This is specifically important around school because, as mentioned, when parents do not consider the school routes safe, they tend to use the car to bring the children to school. This means that there is a correlation between the mode of transport and the feeling of safety. Therefore, a latent effect of the GOW30 roads will be making the roads safer to cycle on so that safety will be less of a criterion for the road users to choose the bicycle. Especially, the roads need to seem safer and the safety that the roads provide need to be perceived believable, so are parents are less inclined to use the car to bring their children to school for safety concerns, and road users are more comfortable using the bicycle instead of the car.

1.1 PROBLEM STATEMENT

The intended objective of lowering the speed limit for cars policy in the Dutch cities is to make cycling safer and particularly safer for the children around their schools. This will reduce the severe accidents on the road and make the roads safer. The subsequent goal of this policy is to create an encouraging cycling environment where the need to use of cars can be reduced and cycling can be encouraged. The unclear point in this process is that there are yet no guidelines on how the roads should be redesigned and reshaped to reach the set goal.

Infrastructural and traffic policy adjustments are primarily based on objective safety data (Félix et al., 2020; Rich et al., 2021): data such as the number of registered accidents, the locations where these accidents occur, and statistical analyses of the number of accidents before and after implementation of a particular policy. Though this information is eminently valuable, it is limited to the factual numbers of events that occurred in those specific places where they have been registered. The subjective preferences and perceptions are seldom taken into account in the evaluations. Reports show the significance of the perception of safety and its role in mode and route choices (Blitz, 2021; Chataway et al., 2014; Lawson et al., 2013). This is also apparent in the case of the parents when they perceive the route to school to be unsafe, they would bring their children to the school by car (CROW, 2022; VVN, 2018). These subjective preferences which affect the mode choice and route choice are not registered.

The problem statement is that there is little to no inclusion of the subjective perception and preferences of the people in the design process of the roads. More specifically to the context of this thesis, there is no inclusion of the matter of the perceived safety of roads and speed limit for cars, and the influence of a change in the speed limit in making roads appeal safer to cycle on. Yet these preferences may hold some answers to the questions such as which elements need to be used on the roads either with the 30 km/hour speed limit or with 50 km/hour speed limit that an environment could be created where cyclists feel safe to cycle on and possibly choose to cycle instead of using the cars. The main objective of lowering the speed limit for cars in Dutch cities is to create a safe and encouraging cycling environment for cyclists and cycling children. However, the inclusion of people's preferences on how they perceive a safer cycling environment has not been done. The intention is to make roads safer, but the public's reaction that will use these roads is not studied, and thus the effect of this large-scale policy will only be studied after the policy has been implemented. A group or groups of citizens will view the lack of public involvement in the formulation of significant policies as extremely unjust because they were prevented from considering alternatives, solutions, and other factors. As a result, people start to feel helpless and resistant to the various policies and adjustments, which lowers public trust in the government (Mouter et al., 2022).

1.2 SCOPE AND FOCUS

The policy of lowering the speed limit for cars will significantly impact all types of road users in the Netherlands. Road users, from pedestrians to drivers, will adapt their travel preferences and behaviour in some way due to this change. Therefore, the impact of this rather large-scale policy, which affects numerous places and cities, is worth investigating. Whether it is a change in method of transportation, an increase in journey time, or a change in greenhouse gas emissions, as several publications have suggested (Gressai et al., 2021; Müller & Reutter, 2021). Having said that, the primary reason this policy will be implemented is to enhance the safety of the streets and specifically roads around schools in the Netherlands (Tweede Kamer Der Staten-Generaal, 2020). Therefore, it is prudent to study the area this policy is trying to target and influence. In addition to that, a general aim in the country is to increase the use of bicycles and active modes of transport (Ministerie van Algemene Zaken, 2022c). Accordingly, this research will focus on combining these two themes together namely the increase the use of bicycles around the primary schools following the implementation of the lowering of the speed limit for cars policy in the Dutch cities. To specify even more on what is meant by the increase in the safety, this research will solely focus on the increase in the subjective safety, in this case the perception of the safety, of the roads due to this policy. The perception of safety is found to have an immense effect on the route and the mode choice (De Hollander et al., 2015). Therefore, in this research, the objective elements will be set aside and from the subjective evaluation of the road users, the effects of the GOW30 policy will be studied. To scope down the research even further, the preferences of a number of groups will be made distinct to investigate whether different groups that are relevant to the topic of GOW30 topic and school zones have different preferences or attitudes towards elements on the roads. Due to time constraints of this research, the subgroups of the population that will be studied, is limited to a number of certain groups that are the have the most impact and are the targeted group in the lowering of the speed limit for cars around schools policy. Personal factors that will be considered from the respondents are whether the respondent does road designing as profession, gender, whether the respondent is cyclist and whether the respondent is a parent. Through literature it will be studied whether there is a scientific basis that there might be differences in the attitude and in the preferences on the road elements within these groups.

The emphasis will be on the factors that the general public sees as crucial to fostering a safe cycling environment in the context of GOW30 policy. The findings will be utilized to inform policymakers when a choice needs to be made regarding the design and purpose of the roadways, what the public believes is required to encourage the usage of bicycles near schools, and what is necessary to have in order to allow children to cycle to school.

1.3 RESEARCH QUESTIONS

In this research, the lowering of the speed limit policy is put under the spotlight to examine whether implementing it will create a cycling encouraging environment in the Dutch cities. This environment would enable children to cycle on the roads freely, and following that, there would be less needed to use cars and other motorised vehicles in the future. This study also aims to include the road safety perception of the road users in the decision-making and design processes of the Dutch roads within the topic of lowering the speed limit for cars policy and the GOW30 road design discussion. For that reason, two objectives are set to be achieved in this thesis. The first objective is to find out the differences in the perception of safety towards the different elements and the second objective is to investigate the influence of the lowering of the speed limit policy on creating a positive cycling environment. Considering the objective, a general research question is formulated as follows:

"Which policies and measures are perceived to increase the safety of roads for children cycling to school?"

A variety of sub-questions are formed to address and supplement this question, as these serve to obtain additional knowledge for answering the primary question, uncover essential notions, and provide coherence to the study. Accordingly, the following sub-questions are developed:

- What are the differences in the perception of safety towards the various elements from different groups in the population?
- Which methods are adequate to gain insights about the weights of the different elements from a subjective perspective in relation to safety perception?
- To what extent does safety play a role in the choice of the mode of travel for parents around schools?
- To what extent does the lowering of the speed limit policy play a role in encouraging people to cycle more in school zones?

These sub-questions will be addressed throughout the report and summarized at the end.

1.4 APPROACH

This study is based on the opinions and preferences of road users, who comprise a significant proportion of the Dutch population. Surveying is a typical method for aggregating the preferences of a large group of people. This method will consequently be used in this study as well. An essential aspect of this research is determining how much different road components contribute more or less to making roads safer for cycling adolescents. This is done through the preferences of road users in the Netherlands. There are in general two main methods through which the required information can be gathered, a revealed preference and stated preferences. In this study, the stated choice experiment will be utilized. An explanation of this choice is done in section 3.1.2. Through this method a model is constructed with the different components of the road and their corresponding weights, which do and/or do not affect establishing a safe cycling environment

according to the respondents. Creating such a survey is done carefully, with each piece serving a specific purpose. To obtain the required results a strategy is developed to construct the survey and then how to analyse the responses.

The strategy starts with a literature review in which pertinent sources that discuss and consider the subject of matter of this thesis are sought. First, the GOW30 discussion's features and measures that are still up for debate are looked at. The purpose of this literature review is to compile the significant factors that influence whether children can cycle to school, which are also controversial issues in the GOW30 topic. The third step is to research the aspects of the roads that have an impact on cyclists' safety, particularly that of cycling children. Fourthly, it looks at the traffic conditions that parents of young children pay additional attention to. This is a result of the fact that parents have a significant influence over how children can travel to or be transported to school. Finally, research is conducted to determine how to perform appropriate surveys and how and how many elements that are set to be studied can be included in the surveys in an adequate manner. Moreover, it is looked at the techniques that can be utilized to obtain the answers to the questions based on previous work and recommendations from the literature.

The theories that have been developed and presumptive from the literature concerning the behaviour and the subjective evaluation of the road from various groups in society are discussed in the part that follows. The survey's construction is then demonstrated using the components that were added to them. Finally, the methods of analysis are displayed. It is necessary to examine the survey replies in a way that clarifies the respondents' decision-making process. As a result, a suitable analysis technique is created that provides the best justification for this selection behaviour.

Finally, through the found results conclusions are made on the patterns and the preferences of the road users. Following that, recommendations are made on what needs to be done on the roads around school areas so that safe cycling environments could be created that encourages people to cycle more and encourages parents to let their children cycle instead of bringing them to school by car.

1.5 SCIENTIFIC CONTRIBUTION AND PRACTICAL RELEVANCE

It makes sense to think about the study's aims and goals before digging further into its application to determine whether it has any scientific or societal worth and benefits. To ascertain the value added and necessity of undertaking this research, the following part investigates this.

1.5.1 Scientific contribution

Many studies have considered the infrastructural aspects of the road and its effect on the safety of cyclists; other studies have considered the regulatory factors and their impacts on regulating the traffic and safety both from objective point of view (Høye et al., 2020; Lawson et al., 2013; Márquez & Soto, 2021). However, an astonishingly small number of papers compare them or considered the effects of such elements from a subjective perspective. The question of which has a greater impact from these two methods has yet

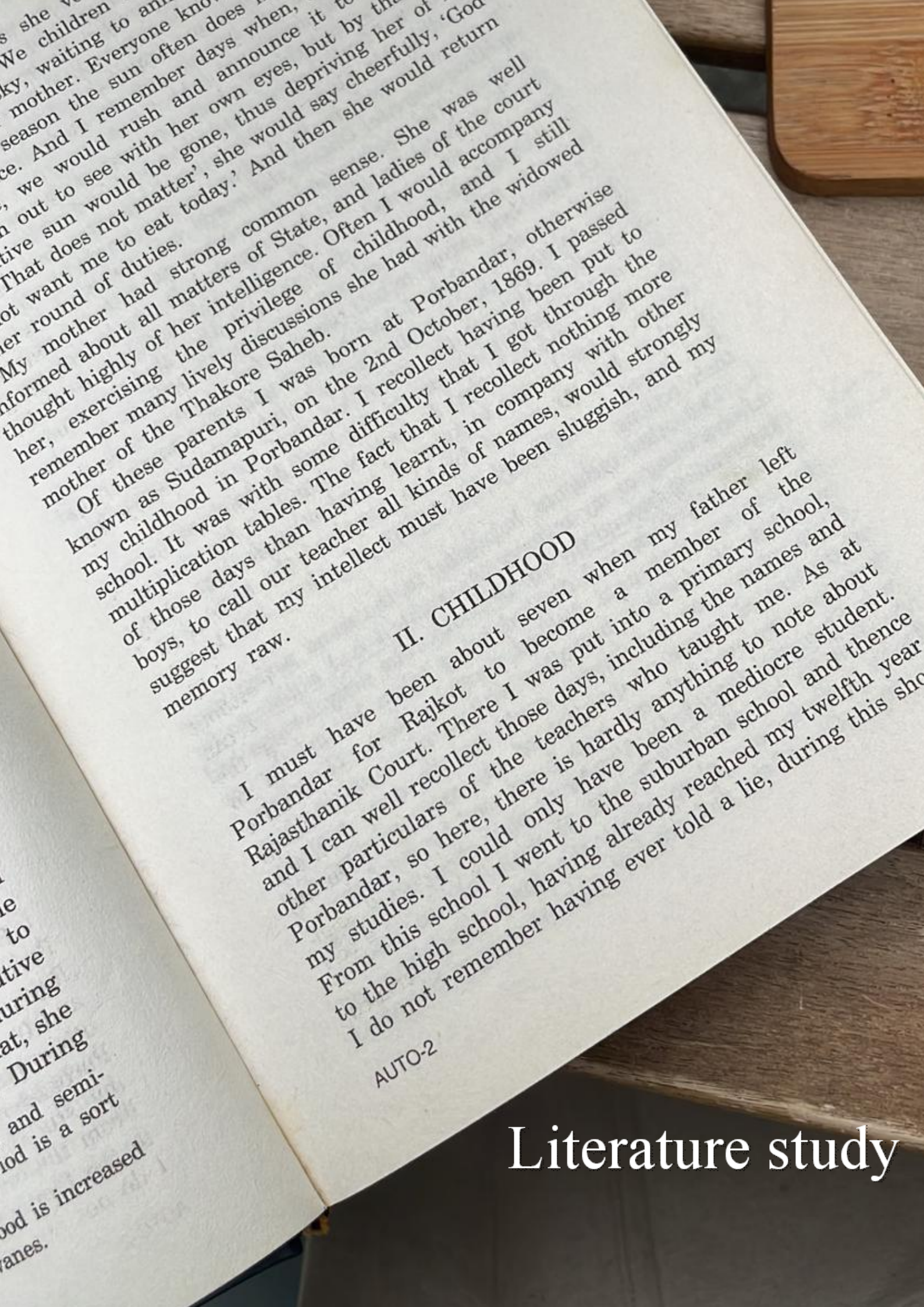
to be addressed, particularly in the area of perceived safety. Furthermore, there is a paucity of research on active road users' perceptions of safety and which demographic groups are more receptive to use non-motorized modes of transportation following an increase in the safety image of roads and routes. This study will shed light on which factors influence road users' perceptions of safety and to what extent they do so. It will also provide insight into the situations under which a safer cycling environment is established, according to the public. Moreover, this research is unique in its method of information gathering. This is because unlike previous research, this study will gather information and preferences from a certain group from the public on adjustments that influence the way of travelling of other group in the population. Namely, the questions will be aimed to adults while the subjects will be the children, which may create different weights to the parameters of the factors than in the situation where the subject questioned would be the subject of the matter in the survey. This tactic is used because communities want to safeguard society's most vulnerable group, which is children. Therefore, the emphasis will be more on the safety aspects of the road rather than aesthetics or travel mode preference gains. From this, the differences in how safe road elements are perceived can be studied and this may reveal discrepancies in the preferences on the road when different subjects are considered as the focal point of the study.

1.5.2 Societal relevance

The knowledge about the relationship between the perceived safety of roads and the modal choice can be used by decision-makers and governments to better understand the population’s choices and the relevance of the policies in place. The feeling of safety is even more emphasised when a parent has to decide if their children can travel on their own to school. Providing a “safe” feeling is essential in letting the children move more and in creating a liveable environment where parents cycle more instead of using the cars which exacerbates the safety issues, or even letting their children cycle on their own to their schools. Consequently, the knowledge gained by this study can be used in the decision-making process to decide in which areas the GOW30 policy should be targeted, and which design elements be used in these new roads so that the use of bicycle is more encouraged.

1.6 STRUCTURE OF THE THESIS

There are seven key chapters in this report. The first chapter is the introduction where the problem and the scop of this thesis is introduced. Following the introduction, Chapter 2 is about literature review of relevant material that is necessary to have a thorough understanding of the subject and determine what measures to take next. After that, Chapter 3 discusses the procedures for creating the survey and the analysis strategy of the responses. In the following chapter, Chapter 4, which mostly discusses the survey's designs and its questions, is then introduced. Chapter 5 illustrates the survey's raw results and direct observations. In this chapter the models along with their parameter weights are also announced. The interpretations, the implications and the limitations of the results are discussed in Chapter 6. Finally, Chapter 7 provides conclusions to the research questions and recommendations for both policy makers and future research.



Literature study

2 LITERATURE REVIEW

This literature review is performed to gather the available information about the factors influencing the safety of cyclists and, more specifically, the safety of cycling children and what is an (un)safe road according to the parents. The information sought is mainly related to infrastructural and contextual elements influencing their perception of safety. Scientific papers and relevant studies in English and Dutch are included. More emphasis was put on the literature from the Netherlands since the country has unique roads and distinct topography, unlike many other countries in the developed world. A condition is set that the papers and studies that considered the differences in the perspectives of people should not be older than 15 years as behaviour and preferences of people changes over time (Protzko & Schooler, 2019). International papers that have done research on the safety perception of road users are nevertheless used next to the Dutch studies. This is because Dutch studies, in contrast to the international ones, did not mention subjective perspective of road users in a significant amount. Google Scholar and ScienceDirect were the main online search engines that were used. Next to that, physical documents such as CROW Standaard RAW Bepalingen (2020) and CROW ASVV (2021) were also used. The search started with typing generic words in the online search engines such as "Perception of safety", "Subjective safety and mode choice" and "Speed limit for cars and subjective safety on the roads". When more information was required, more specific terms relating to the topic of the thesis were used such as "Lowering of the speed limit for cars and enhancing the subjective safety of the roads", "The role of the subjective assessment of the roads by parents in the decision-making process of bringing children to primary schools" and "School zones and the GOW30 policy". The snowball technique is also utilized from the papers and sources found online. Supplementing the physical documents, interviews were held with road designers working at Royal HaskoningDHV and the municipality of Rotterdam to gain insight about the views on the topic from experts who are directly involved with the GOW30 project. This is done because this topic is relatively new, and published documents and research about it is quite scarce.

The goal of this research is to determine the components required on roads adjacent to school zones so that cycling can be encouraged under the assumption that roads have become safer as a result of the GOW30 policy setting. Three crucial components in this project can be emphasized. These components are, lowering of the speed limit for vehicles, cyclists, and schools. These three components will therefore be the main focus of this literature research. The GOW30 policy and the ongoing conundrums around this subject are first illustrated. Second, factors that have an impact on cyclists' safety are investigated. Thirdly, this literature study identifies the components that need to be given greater attention to when implemented in school zones. The goal is to integrate these three components in such a way that the grey areas of the GOW30 discourse that relate to cyclists and, more crucially, to the group that this policy is seeking to protect, namely the kids near the schools, can be identified.

The following objective of the literature review is to identify and comprehend the processes by which the relative importance of the various factors based on the public's subjective preferences about road safety can be established. The use of surveys in this study was alluded to in the introduction. This chapter examines the particular surveying method that supports the study's goal and makes it possible to respond to the questions posed. Additionally, a more extensive study is conducted on the methods for creating surveys and the impact of the survey questions on the results.

2.1 GOW30, CYCLISTS AND CYCLING CHILDREN

Gebiedsontsluitingsweg 30 is also known as GOW30, which is Dutch for "distribution road with a 30 km/h speed limit for cars." The Netherlands has not yet adopted this new form of road, although it is the result of the government's policy to reduce speed limits, which was established in 2020 (Tweede Kamer Der Staten-Generaal, 2020). The goal of this new form of road is to replace the current Dutch distribution roads, which have a motor vehicle speed limit of 50 km/h. Although the idea of these new types of roadways has been developed, there is still no clear picture of what these roads should look like (CROW, 2021b). There are several issues of contention that need to be resolved first, which is why the new design for this type of road is not yet obvious.

2.1.1 GOW30 uncertainties

Firstly, the consensus of the reports that analyse the shift from the former distribution roads (GOW50) to the new lowered speed distribution roads (GOW30) is that the starting point is to realise that the lowering of the speed of every GOW50 is not possible or even desired on every distribution road in the cities (CROW, 2021b; Goudappel Groep BV, 2022). There remains a need for a hierarchy in the network and roads on which buses and emergency services can travel smoothly. Some roads must keep a 50 km/hour or even a higher speed limit. This is due to the importance of the distribution roads for public transport and emergency services and their role as major distribution roads for the private vehicles on the city scale. Making these roads safer for cyclists and cycling children is challenging due to the trade-offs between the need for safer roads and the need to keep a high traffic flow. Therefore, there is still a major point that needs to be clarified which is where and when a GOW50 road needs to be transformed into a GOW30 road.

Second, there is still no consensus over the infrastructure and legal requirements that must be incorporated in the GOW30 roads. The above-mentioned fact that some roads have purposes other than just a distribution route for vehicles, such as being crucial for emergency services or public transportation, is the primary source of this indecision. Some factors should not be used for these services, such as numerous speed bumps or narrow roadways (Rottier, 2019). The GOW30 imperils some sustainable safety tenets, such as uniformity, which is the second cause of the hesitation. According to homogeneity of traffic in sustainable safety, people traveling at various speeds should be kept apart from one another (CROW, 2019). The boundary between the speeds of motorized and non-motorized vehicles also becomes hazy and indistinct

with the reduction of the speed limit for cars. This is due to the fact that a formal categorization of the GOW30 roads does not exist yet.

The third reason there is a debate about GOW30 is that the combinations of items that need to be used to improve road users' safety are not specified. The primary design features that are the most confusing in the GOW30 discussion are disclosed through interviews with road designers at Royal HaskoningDHV and area operators at the municipality of Rotterdam. Table 1 contains these components to organize them clearly.

Table 1 The elements that are still a discussion point in the GOW30 policy

	ETW 30	**GOW 30**	**GOW 50 (70)**
Surroundings	Urban	Urban	Non-urban
Function	Residential	Distribution or semi residential	Distribution
Speed limit for vehicles	30 (15) km/hour	30 km/hour	50 (70) km/hour
Priority rules at intersections	Equivalent for all road users	Priority rule when needed	Priority
Position cyclists to cars	No separation	Separated cycling lanes or cycling paths on the road	Separated cycling lanes when there is space
Pavement	Clinker	Asphalt (possibly clinker)	Asphalt
Public Transport	Preferably not used on these roads	PT stops on the driving lanes/possible on own stop	PT stops on own stop
Parking for vehicles	Allowed (perpendicular)	Allowed with restriction (lengthwise parking when permitted)	Not allowed
Demarcation	No	Where needed	Yes
Speed regulating measures	Yes	Limited/where needed	No

It may be noted that parts of the list's recommendations for using certain items are occasionally vague. These include the purpose of the road, intersections, how cyclists are positioned in relation to cars, parking of vehicles, the type of pavement, public transportation halts, demarcations, and methods to regulate speed for vehicles. The speed limit is also a factor that needs to be decided as not all distribution roads can or wished to have the speed limit for vehicles lowered to 50 km/hour (CROW, 2021b). This assessment framework is applicable to all urban areas and disregards the presence of nearby schools.

Last but not least, there is the fact that the subjective safety and perception of the road has not yet been investigated in this case, which is indicated in the assessment framework of the CROW (2021b) for the GOW30. It is unknown how lowering the speed restriction will affect the environment for bicyclists, and it is also unclear exactly which factors should be combined to improve this subjective safety. Multiple papers show the importance of the subjective safety as a factor for the use of bicycles and the route choice

(Gössling & McRae, 2022; Götschi et al., 2018). The combinations of the elements used in the GOW30 that increase the feeling of safety for cyclists is unidentified and needs to be checked off from the discussion.

2.1.2 Factors influencing safety of cyclists

Through readings of the literature, a relatively large number of factors that influence the safety of cyclists in some way or another are found. Understanding the factors is considered essential so that good interpretation of the results can happen and the question why choices are made in the survey from certain people can be understood. These factors are further divided into groups to prevent the repetition of different factors and reduce the exhaustion caused by compiling many factors in one set. These groups are compiled in a Table 2 to have an oversight on what these groups are:

Table 2 General description of the factors found in the literature

Description of the group
Physical characteristics of the cycling lane
Existence of other subjects on the cycling path
Speed regulating factors for other vehicles
Existence of other objects in the surroundings
Contextual elements
Personal elements

Each group will furthermore have its own table in which the sources that mention the different factors within the set are included with a brief description of the impact of each factor on the safety of cyclists. Furthermore, it is looked through these lists and sources if the subgroups defined in the sources are mentioned to have difference in the preferences towards certain elements or if they behave differently while interacting with certain elements.

Physical characteristics of the cycling lane

The studies describing the GOW30 designs (CROW, 2021; Goudappel Groep BV, 2022) contend that the physical qualities of the bicycle lane are one of the most crucial elements influencing cyclists' safety. "Cycling lanes" will now on be referred to as those lanes that are physically segregated from the roads where motorized vehicles are permitted to drive. Additionally, "Cycling paths" will be used to designate locations where there is no physical separation between cyclists and automobiles but there may be demarcations.

Table 3 Factors influenced by the physical characteristics of the cycling lane

Attributes	Source	Description
Separated cycling lanes	(Balogh, 2017; CROW, 2012; SWOV, 2016; Useche et al., 2018)	Physical separation between vehicles and cyclists. Separates different masses and speeds to come in contact on the road. Females are found to prefer the segregation of the cycling lanes from motorized vehicles compared to males. Cyclists are also found to have certain preference for this element on the road. The reasoning given in the literature that cyclists feel safer when there is a separation existence from motor vehicles that reduces the mental exhaustion from the cyclists to continuously pay attention to the hazardous road users which are the cars and vehicles.
Cycling paths separated by demarcation	(CROW, 2012; Useche et al., 2018)	Indicative lanes that are dedicated for cyclists. Cars may make use of the cycling lane if necessary. Provides a distinct separation for what is designated for cyclists and which parts of the road are designated for cars.
Colour of the cycling lane	(Vera-Villarroel et al., 2016)	Providing a distinction between the cycling paths or lanes and the road designated for vehicles.
The distance to the car road	(Amanda, 2018; CROW, 2021a)	Proximity cars to cyclists influences the feeling of hazard for being close to a high velocity vehicle that requires extra attention and care from both the cyclists and the drivers of the motorized vehicles.
Width of the cycling lane/path	(Amanda, 2018; SWOV, 2016)	Has impact on the proximity of cyclists to the vehicles and the space available for manoeuvrability among cyclists.
The number of directions on the cycling lane/path (one or two)	(CROW, 2021a)	This is generally influenced by the space available to lay a cycling lane/path. The cyclists need to pay more attention when there are two directions on the lane/path. The cyclist needs to be careful about overtaking bikes/mopeds and for bikes and moped coming from the opposite direction.
State of degradation of the pavement	(CROW, 2021a)	Influences the ease of cycling. This has an effect on how cyclists cycle as well because people frequently avoid dangerous spots on bike lanes, which in some cases forces them into main roads where vehicles travel.
Type of pavement	(CROW, 2021a)	Both bikers and cars can ride more smoothly on asphalt, but it also provides drivers the ability to drive faster. On the other hand, because of the vibrating effect brought on by the rise in speed, clinkers make it challenging to comfortably raise the speed of cycling or driving.
Cross points with vehicles	(SWOV, 2019c; CROW, 2012)	With the increase in the conflict points between the motorized vehicles and bicycles, the probability of a crash increases as well. This is the place where different masses and speeds cross the roads, and it has the effect of creating hazardous situations.

Existence of other subjects on the cycling path

The existence of other subjects in the same space as the cyclists causes significant confusion. In addition, as biking lanes are self-regulated and many objects can pass through simultaneously, confusion is created, especially when the speed of the different elements on the biking lane is not homogenous.

Table 4 Factors that influence the safety of cyclists from other subjects using the same road infrastructure

Attributes	Source	Description
Mopeds/ speed pedelecs on the bike lane	(SWOV, 2016; Pejhan et al., 2021)	The average cycling speed is around 12 km/hour in the cities in the Netherlands (Verderfietsen.nl, n.d.). Electrical bikes, mopeds and speed pedelics are allowed to drive/cycle on cycling lanes with a maximum speed of 25 km/hour. In some cases, this speed is exceeded which creates dangerous situations for cyclists while overtaking, crossing and estimating the breaking moments for cyclists with traditional bicycles.
Cars using the bike lane	(CROW, 2021a; Pucher & Buehler, 2008a)	The relatively big difference in the mass and velocity of bicycles and motorized vehicles is the main reason why of crashes in the cities between these two types of road users.

Speed regulating factors for other vehicles

The importance of speed regulating factors is repeatedly expressed in the literature (Forbes, 2012; Rasch et al., 2022). The differences in the speeds of the different road users should be minimised as much as possible to minimize the impacts of collisions according to the principles of sustainable safety (CROW, 2019). Speed plays an important role in the degree of the crash severity and for this reason the lowering of the speed limit policy is introduced. Speed should be calmed, monitored and also enforced to decrease the chances of severe accidents and to increase the safety of all road users.

Table 5 Factors that help in calming and enforcing the speed of vehicles

Attributes	Source	Description
Speed bumps	(CROW, 2021a; ETSC, 2016)	Speed calming/enforcing factor that is placed near conflict points. This measure is not only a speed reducing factor in its place but can be also seen from a further distance and gives an indication for a crash sensitive place.
Speed displays	(CROW, 2021a; ETSC, 2016; Malin & Luoma, 2020)	Speed calming/enforcing measure for vehicles. Vehicles do lower their speed when passing by a speed display. These displays are placed at intersections but more importantly in areas where schools are existent and residential roads.
Traffic lights	(CROW, 2021a; ETSC, 2016)	Traffic regulating factor for the flow on the network. Traffic lights are placed in high traffic volume places to ensure the safety of crossing road users and to regulate the flow of the system.

Existence of other objects in the surroundings

The view of the road should accommodate the psychological understanding and the abilities of the road users (CROW, 2019). Distracting objects should therefore be minimised, and objects that affect the sight of the road should be eliminated as much as possible.

Table 6 Factors that influence the safety of cyclists by other objects in the surroundings

Attributes	Source	Description
Trees	(SWOV, 2019c)	The distance between the bicycle and road lanes and the trees must be sufficient. If trees are planted next to bike lanes, their branches may obstruct the cyclist's view of the road and push him to veer off course.
Buildings	(SWOV, 2019c; Misokefalou et al., 2016)	Buildings and signs can be distracting factors for cyclists and drivers to pay less attention to their driving behaviour. This can lead to a variety of hazardous situations when the concentration is laid on these external objects rather than the driving path and behaviour.
Parked vehicles	(SWOV, 2019c; CROW, 2012)	When vehicles are improperly parked and some of the parked vehicle's parts are in the cycling lane or path, it can be dangerous for cyclists. Because of this, bikers frequently utilize the road intended for cars. When parked at or near conflict zones, parked cars can endanger oncoming traffic by obstructing their view of the road and posing a danger to other drivers.
Walking path adjacent to the bike lane	(SWOV, 2019c)	If a cyclist's path is impeded for some reason, paved pedestrian walkways offer a safe sanctuary where they can stop or use. Additionally, it permits cyclists to use the paths when they believe the traffic conditions are hazardous.

Contextual elements

Contextual elements are outside of the influence of the policymakers. However, they have a direct influence on the decision to use bicycles. In addition to that, contextual elements affect the cycling and driving behaviour and can create dangerous situations (Meng et al., 2016).

Table 7 Factors that are influenced by contextual elements

Attributes	Source	Description
Rain	(Pazdan, 2020; Meng et al., 2016)	Influences the sight of the cyclists and motorized vehicles.
Wind	(Pazdan, 2020; Meng et al., 2016)	Influences the speed and the trajectory of the cyclist.
Mist/fog	(Pazdan, 2020; Meng et al., 2016)	Influences the sight of the cyclist and motorized vehicles and can create hazardous situations in conflict points.
Lights	(Madsen et al., 2013)	It has an impact on drivers of motorized vehicles and cyclists' vision. Additionally, it aids in locating other drivers and determining their closeness to one another.

Personal elements

Personal circumstances being mental or physical can influence driving and cycling behaviour (Blitz, 2021). For example, being angry or stressed while driving a car has been proved to increase the risk of crashes on the road (Zhang et al., 2019). For that, this list has also been included in the factors.

Table 8 Personal factors that influence the safe cycling behaviour on the road

Attributes	Source	Description
Gender of the cyclist	(Aldred et al., 2016; Heesch et al., 2012; Useche et al., 2018)	The gender of cyclists and drivers of vehicles have an impact on their risk-taking behaviour. It is also found that there are differences in the preferences of road elements and the perception of safety according to the gender of the road user. The literature for example points out that females have more preference towards the existence of separated cycling lanes than males.
Experience of biking	(De Waard et al., 2020; SWOV, 2016)	This aspect affects the riders' ability to handle dangerous situations and their capacity to recognize potentially dangerous ones.
Influence of substances	(Alonso et al., 2021)	This factor affects both drivers' and cyclists' abilities to perceive hazardous conditions and their capacity to drive and cycle safely.
Distractions by hardware or software	(SWOV, 2016)	This factor influences the ability to focus on the road and driving/cycling.
Mental stress/disorder	(Magaña et al., 2020; Alonso et al., 2021)	The ability of a road user to drive and identify road risks depends on their mental and psychological health.

2.1.3 Factors influencing cycling children

In this section, factors that influence the safety of the cycling children in specific are investigated. This is done to highlight the most critical elements that influence the safety of children around schools.

DHV B.V. (2011) wrote, at a request from the CROW, a guideline on how to design roads safely around elementary schools in the Netherlands. In this document, several elements were defined as hazardous

elements that affect the safety of the children. Next to those elements, various solutions and approaches were suggested to make the roads around schools safer for children. These elements are compiled in the table below, and their importance is also highlighted.

Table 9 Factors that relate to the safety of children around school areas in the Netherlands

Elements	Motivation
Demarcation on the road	Demarcation on the road that this is a school zone makes the drivers alert, and it is an invitation for them to slow down
Barriers against parking on the sidewalks	Parking next to the school or the playground is dangerous, and parking should be minimized and even not permitted on the sidewalks
Speed limit of 30	This speed is normal to have next to the schools in the residential areas. A 30 km/hour speed limit is strongly advised if the schools are next to distribution roads.
Separate biking lanes	The report states that biking lanes are essential to have but also recognizes that the biking lanes are mostly unavailable next to the schools in residential areas, even when the speed on the road is 30 km/hour.
Cycling paths	It is suggested to let cyclists cycle on the sidewalks instead of the road when shared with cars.
Parked vehicles next to schools	The residents in the areas next to the school park their cars adjacent to the schools when spaces are available. Parents also bring their children to school by car. The report states that even when parking garages are available 100 metres away, parents park their vehicles next to the school or on the sidewalk for convenience. Therefore, it is advised not to have many parking spaces near schools since children are smaller than the average Dutch person and can be unnoticed behind a parked vehicle when crossing the road.
Priority for crossing for cycling children	Most schools are placed in residential roads (ETW30). These roads do not have any special priority rule more than the driver/cyclist coming from the right side on an intersection has the priority of crossing first. Children do not always follow this rule and that can lead to confusions on intersections. Therefore, it is advised to consider making rules for priority of crossing in areas around schools.
Static and dynamic speed display	In the Netherlands, when an equivalent intersection exists, drivers coming from the right side have the priority of crossing. In the residential areas, most intersections are equivalent intersections, and hence this policy is still in effect. However, children often do not know of this rule, and confusion can be created between vehicles and cycling children. Therefore, it is advised to provide priority for cyclists while crossing.

2.1.4 Parents' perception of roads

In the Netherlands it is common that parents would accompany their children to school in the mornings and back home in the afternoons, especially children that attend kindergartens and elementary schools (age 3 to 12). Research done by VVN in (2014) states that almost 40% of the parents said that they perceived the trip from home to school to be not safe. And another study shows that when parents consider a route from home

to school as “safe” then the percentage of children going to school on the bike was 80%, and when the parents deemed the route as “unsafe” then that percentage was lowered to 67% (VVN, 2021). This thus shows that road safety has an impact on the manner through which children get brought to their schools. The VNN (2021) study does not specify what were the factors that the parents did not perceive safe and whether the existence of 50 km/hour distribution road was one of these factors. This study does not specify who are the people who were interviewed and to what are the factors led to the choice of a road to be safe or not.

Another study done by CROW (2019) shows that 21% of the parents of children who live in a radius of one kilometre of the elementary school bring their children by car, and the percentage increases to 52% when they live in areas outside of the radius of one kilometre. Many parents do not only feel unsafe about the traffic situation but also about general safety: they do not dare to let their children go out on the street without supervision (CROW, 2022). It is not that every child is capable of cycling on his own on the streets. Children below the age of 8 are considered too young to be allowed on the roads on the bikes on their own (Van de Ven, 2016). After the age of 8 children in the Netherlands start to cycle on their own even though in the first period for limited ranges (Lamberts, 2019). The cycling of the children on their own is dependent on the perception of the parents of the road and the intensity of vehicles on the routes to the schools. Parents fear accidents and consider the school environment unsafe and threatening, partly due to the chaos of cars around the school and the lack of safe routes and facilities for pedestrians and cyclists (SOAB, 2016). That being said, the main element that is mentioned in the literature is that parents perceive the existence of cars around school as dangerous and for that reason they decide to bring the children by car exacerbating the problem (CROW, 2012b)

To zoom in more on one of the groups that are defined in the scope that might have a difference in the perception of the safety, gender is found in the literature to have an impact on driving/cycling behaviour perception of safety of roads (Cordellieri et al., 2016). In the research of Cordellieri et al (2016), a conclusion is driven that the level of worry about this danger varies between the genders, with men being less worried about the possibility of a serious crash. This shows that the primary distinction between the two groups has more to do with the degree of anxiety felt around the potential repercussions of the risk than it does with the assessment of perceived risk likelihood. Additionally, another study (Aldred et al., 2016) has found that females have more preference towards segregation of cycling lanes than males. Therefore, there seems to be a difference in the preferences and perception of risk depending on the gender of the road user. Therefore, it is considered worth studying what the perception and preferences of the two genders would be towards the different elements on the road with respect to the safety of the children. The hypothesis is that because women prefer segregation of the cycling lane from the motorized vehicles, there would be a higher preference for this element by females than men.

2.1.5 Where children cycle

School zone is a vague term that is frequently used in the literature. In the readings of the different documents, there was no specific definition of a "school zone". According to DHV B.V. (2011), a school zone is the immediate area around a school, where streams of children come together. Within this zone, parents pick up and drop off their children. Ideally, in this area agreements between school, parents and local residents about traffic-safe behaviour apply. This definition is ambiguous to say the least that does not standardize to which extent and to which distances the rules of "School zones" should be applied. From research done by Traffic Test B.V. (2003), it showed that the average child lives in a distance of 1.26 km from the elementary school. This research was done based on a survey that was filled in by 1456 parents from every province and place in the Netherlands. The distance that children need to cycle to school differs from a place to other. For example, children in Haarlem, Amsterdam, Schiedam and The Hague need to lay the least amount of distance to reach their schools with around 600 meters, while children in less densely populated areas such as in the province of Drenthe, often need to cycle around 1.5 kilometers (Haddou & Van Uffelen, 2020). The distance to school decides with which mode of transport the children get to be brought to their schools next to how safe these roads are perceived by the parents (CROW, 2022; Traffic Test B.V., 2003).

2.2 SURVEYING

To gather information about travel behaviour patterns and preferences, surveying is commonly utilized in research (Baltas & Doyle, 2001; Cherchi & Hensher, 2015). Through this method of data collection preferences can be collected from target groups to answer various questions. The making of a survey is a complex procedure that needs to be done carefully and therefore needs to be studied in depth first to guarantee a surveying procedure that delivers the results required (Sudman et al., 1996).

2.2.1 Quantitative and qualitative

Surveying has two main forms, quantitative and qualitative. Data collection procedures for qualitative and quantitative studies are very varied since they use different types of data. Statistical or quantifiable data are used in quantitative studies. Comparative studies, on the other hand, rely on first-person narratives or written records that provide in-depth descriptions of how people behave in social contexts (GCU, 2021).

The type of the planned outcome is one of the characteristics that set qualitative research apart from quantitative ones. Qualitative researchers, often known as their informants, aim to acquire specifics from the accounts of persons investigating. Conclusions are reached through gathering, contrasting, and assessing the feedback and input from the informants throughout the course of a study. In qualitative research, the reason behind a phenomenon is investigated. Quantitative data, in contrary, are quantitatively evaluated to create a statistical representation of a trend or connection. These statistical findings might clarify the causal connections. They might support or contradict the initial hypothesis of the study. The

result, whether favourable or unfavourable, can prompt awareness and action. The "what" of a phenomena, correlation, or behaviour are frequently the subjects of quantitative research (GCU, 2021; Surbhi, 2018).

2.2.2 Stated choice and revealed choice

To gain knowledge of the preferences of the public or a group of people, observations are made on their behaviour. This is done both through the behaviour they showed previously in practice or through the behaviour they show while making choices about scenarios in the future (Takemura, 2021). The method to analyse the first case is through revealed choice (RV) experiments. As the name suggests, the data gathered through this method is when the behaviour of persons or a segment of a group are observed based on their behaviour in the past, hence the word revealed. Based on this, models can be made that are based on the conclusions from what already has happened, and which choices respondents have already made.

A scientifically developed technique called the stated choice experiment (SC) looks at how respondents respond to difficult circumstances that either never happened or don't exist yet (Cherchi & Hensher, 2015). This approach allows the researcher the flexibility to present scenarios and settings to a group of participants and ask them to select what they prefer in a particular context or scenario. This flexibility can be both the strength and the weakness of this data gathering method (Kløjgaard et al., 2012). The strength is that the respondent's behaviour may be seen and scenarios that do not exist. The disadvantage is that if the situation given does not accurately reflect reality, responders begin to feel fatigued from the focus required to comprehend the material or from providing arbitrary replies that do not accurately reflect their true feelings about the subject (Sanko, 2001). Numerous strategies can be used to overcome these challenges. These strategies include but not limited to pilot surveys that demonstrate the respondents' level of exhaustion, short and concise questionnaires, avoiding repetitive and uninteresting questions and creating as realistic as possible scenarios and situations (Davies, 2021).

2.2.3 Questioning style in surveys

The way and order in which the respondents were questioned has a direct bearing on the responses they provided (Garland, n.d.). This method is predicated on the idea that when respondents are presented with numerous options and asked to select one, they will pick the one that maximizes their interest and benefits. This idea was created by Mcfaddon in 1974 and is known as the Random Utility Maximization theory (Gul & Pesendorfer, 2013). On the other hand, Chorus (2008) created a fresh theory of utility strategy known as the Random Regret Minimization (RRM). In contrast to the RUM, the core idea of this new theory is that respondents choose decisions that they will regret the least (Belgiawan et al., 2019). This is most prevalent when the questions asked to relate to taboo subjects such as loss of lives or physical and mental damage to subjects and living beings. Taboo trade-offs are when people are asked to choose between options that could potentially have an impact on their life or the lives of other people with a personal gain or loss on the other side of the scale (Fiske & Tetlock, 1997). Children who ride bicycles are the primary focus of this study since they are seen as vulnerable road users whose safety is also forbidden (Paul, 2019). RRMs can

be used to gain knowledge about people's willingness to avoid loss or their readiness to spend money to save a life. In contrast, RUMs can be used to determine the relative importance of several components that try to promote children's safety.

2.2.4 Response rate

According to Zacharias (2021), most surveys have a bad response rate between 5% and 10%. This is one of the biggest challenges of the surveying. In the found literature (Beretta et al., 2014; Diwan, 2022; Geisen, 2021; Wigmore, 2022; Zacharias, 2021) there are a number of reasons why this happens, and these reasons are:

- *Survey is long and extensive:* The most effective surveys should ideally take 5 minutes or less to complete. Given the increased demands on the survey taker's time, it is not unexpected that longer surveys have lower completion rates. The ideal survey length in scientific research is under 12 minutes, however 8 to 10 minutes is more preferable (Wigmore, 2022; Zacharias, 2021). Frequently, the lengthier the survey, the higher the dropout percentage is. According to Wigmore (2022), surveys that are longer than 25 minutes lose more than three times as many respondents as those that are completed in less than five. The number of questions answered directly affects how long it takes to finish the survey, thus it is important to give serious thought to this factor.
- *No real reason to fill in the survey*: respondents are more interested in surveys that they are invested or care about (Wigmore, 2022). For that reason, the survey should be clear and socially relevant to let respondents care of filling it in.
- *Standardized questions:* Too many surveys begin with a list of demographic questions that are frequently superfluous when surveying (name, title, address, phone number, email, etc). (Beretta et al., 2014). Because of previous surveys they've answered or out of concern for their privacy, respondents may find these questions to be repetitive, similar to others in their format, and end the survey early (Geisen, 2021).
- *Not reaching enough people:* the way the survey is spread is also very important. People who do not get notified of the survey, naturally will not make the survey. This aspect is often overlooked and with a proper strategy the number of the responses and even the response rates would go higher (Zacharias, 2021). A sample size of roughly 385 people is thought to be sufficient to make assumptions for practically any population size with a 95% confidence level and a 5% margin of error (Kibuacha, 2021). Because of this margin of error, 400 and 500-person samples are frequently utilised in research. Therefore, a proper strategy of spreading the survey should be developed to reach this amount of people who not only will see the request for the survey but also complete filling the survey.
- *Fatigue from filling the survey:* There is a phenomenon in surveys known as "speeding," which refers to responding so quickly that it is doubtful the question has been properly understood (Conrad et al., 2017). In web surveys, the phenomena of speeding is regularly seen. Respondents

who hurry up are more likely to give quick replies because they feel pressured to submit anything, even if it isn't exactly the correct answer. Thus, it is doubtful that accuracy will be higher than what can be predicted by chance when respondents react quickly. This phenomenon persists when respondents must complete surveys repeatedly or when they are overly lengthy (Greszki et al., 2014). According to a study done by Conrad et al (2017), in the control condition, which refers to situations where there was no intervention for speeding, between 37% and 85% of respondents accelerated at least once while responding to seven important questions. Regardless of how speeding is classified, these statistics on speeding show that the phenomenon is widespread. For high stakes applications like social scientific and government surveys, a way to reduce speeding could therefore help potentially improve the quality of web survey data and increase confidence in the mode (Conrad et al., 2017). This fatigue and speeding effects influence directly the response rate and the number of completed surveys, and also the validity and the reliability of the responses.

2.3 LITERATURE REVIEW CONCLUSION

It is clear that the GOW30 policy debate has not yet come to a conclusion and that further research and clarification are needed in some areas. A new list of the elements that need to be identified for this policy is then made, followed by an illustration of the function that each of these criteria has in ensuring the safety of cyclists and cycling children. In order to create a subjectively safe and motivating cycling environment for kids, this step aims to further identify the factors that need to be examined before bringing them to the public and letting them provide the weights of the different attributes.

Table 10 Relating the factors that are still discussed in the GOW30 discussion to the safety of children

	Possible alternatives	**Impact on cyclists (cycling children)**
Function	Residential/Distribution	Decides the priority rules for crossing. Distribution roads have a higher traffic volume which increases the chance of a traffic crash. Most crashes occur in the Dutch cities on the distribution roads.
Speed limit for vehicles	GOW30/GOW50	The speed of the vehicle is directly correlated with the severity of crashes. Cyclists are road users who do not have physical protection as vehicle drivers have.
Intersections priority rules	Priority for vehicles or for cyclists	Has influence on the understanding of the priority rules and can be difficult to estimate children's crossing behaviour.
Position cyclists to cars	Separation with cycling lanes or with cycling paths	Cycling paths create a situation where cars can make use of the path when needed, making a contact with a cyclist possible. Separated cycling lanes physically separate both types of road users.
Pavement	Asphalt or clinkers	Asphalt gives an ease to cycling and driving but also give an opportunity for speeding. Clinkers negate the speeding factor but makes cycling/driving less comfortable.

Public Transport	The stopping point of public transport	When the stopping point of the public transport modes are on cycling paths, this creates hazardous situations for children that might want to overtake the public transport by deviating from the cycling path.
Parking for vehicles	Allowed with restriction (lengthwise parking if permitted)	Creates confusion when cars are parking and crossing children become less visible for the road users when cars are higher than the children on their bicycles. Opening of the doors of parked/parking vehicles creates also hazardous situations for cycling cyclists and cycling children.
Demarcation	School zone signs	Gives the drivers a signal of existence of schools in the area.
Speed regulating/calming measures	Speed bumps/speed displays/speed plateaus	This factor lets motorized vehicle drivers slow down their speed nearby possible hazardous intersections such as nearby schools.

With the goal of increasing the feeling of road safety so that kids and their parents can cycle to school instead of using other means of transportation, the weights of these factors, or part of these factors, need to be decided. It is obvious that parents worry about the roads and routes leading to primary schools, which is why they often opt against letting their kids cycle to school on their own. These worries are also the main reason parents drive their kids to school, aggravating the issue even further. The weights of the various aspects in relation to the road users' subjective evaluation need to be estimated, as is recommended in the GOW30 assessment framework (CROW, 2021b).

Second, different demographic groups were selected as the study's focus areas under the assumption that these groups would perceive and prioritize roadways differently in terms of their subjective safety. This was done in order to define the target populations and have a clear direction for the study. These categories include the gender of the road user, whether or not they are cyclists, whether or not they have experience with road design, and whether or not they are a parent. In the literature most of these groups have different preferences to the various elements and factors mentioned. The group that does stand out with little to no research about their particular perception and preferences are the people who design and make the roads who decide how people are moving on the roads based on objective data gathered from the past. Therefore, there is a knowledge gap about the preferences of this type of road users and needs to be studied. Furthermore, the studies that are illustrated above are all of what is perceived safe or unsafe for the studied subgroups themselves and not when a child or a vulnerable person is the subject of matter. A recent study done by Daniel et al. (2022) shows that the weights and preferences of attributes differ when respondents are asked to evaluate elements that affect vulnerable people. For this reason, it is useful to find out the preferences of the different groups in the population and their perception of the “ideal” road environment where children can cycle safely on the roads.

The literature analysis makes clear that a parent's decision about their child's mode of transportation to school matters. There are roads and routes that parents may see as either dangerous or safe. The main reason

mentioned in the literature that parents perceive the roads to school is dangerous is the existence of cars around the school, which is a main motive of bringing the children to school by car.

According to the literature, the gender of the parent and the other road user does affect how safe they perceive the road to be (Cordellieri et al., 2016). The study demonstrates that gender differences in risk taking and perceptions of what is safe and what is not have an impact on road users' driving/cycling behaviour. For that reason, it is suitable to understand the differences and preferences of the two genders for the different safety measures that tend to increase the safety of cycling children.

In addition to that, it is clear that there are measures that enhance the safety of cyclists in specific. There is then a clear distinction of what is designated to target the safety of the cyclists and what is designated to target the safety of motorized vehicles. That being said, no literature is found about the differences in the perception of safety of these two types of road users for the different measures that are meant to enhance the safety of the road, and it is sensible to make a distinction between these two groups to study further.

The materials that describe the GOW30 strategy and the actions that should be performed to promote cycling also make it clear that there are certain ambiguities for policymakers and road planners that need to be explained. The subjective perception of the roads under this new strategy needs to still be investigated in order to have the desired results, according to the CROW (2021b) assessment framework. Consequently, it is sensible to assume that there are some areas where those who study roads as a profession and who are frequently exposed to the objective safety measuring data have a different understanding of what is safe and what is unsafe on the road, and this may influence their subjective assessment of the safety of the roads. Therefore, in order to foster understanding between the two groups, it is important to take into account the differences in the subjective preferences of the roads and components between those who pursue a career in road design and those who do not.

Lastly, it is evident that "School zones" have no true definition. Although there is no strict understanding of the zones, this term provides the impression that a particular location is inside a school's limits. Because there are no clear lines delineating the start and end of school zones, the GOW30 regulation surrounding schools is difficult to apply. For the GOW30 policy's assessment system to be used effectively around schools, this needs to be clarified better.

Moving to the use of surveys analysis, there are a number of conclusions that could be made based on the information provided from the literature. Firstly, surveying is a method that is used often in the past in scientific research with reliable results when done properly under a set of conditions.

Data from road users and the general public can be gathered using both quantitative and qualitative survey methods. Both procedures are legitimate and scientifically established, but they should be selected based on the aim that needs to be accomplished. Both stated and disclosed options can be used, although they

serve different functions. While stated choice experiments are for brand-new, speculative circumstances, revealed choice experiments are for situations that have already occurred.

It is also obvious that the way a question is posed affects the way it is answered, which in turn affects the findings produced at a later stage. Depending on what needs to be investigated and which values are planned to be attained, the theories of Random Utility Maximization and Random Regret Minimization can be used.

Finally, there are also pitfalls identified in the surveying process that need to be thought of before spreading the survey.

The methods selected to obtain the answers to the research questions are illustrated in the next chapter, with the rationale for the selections based on justifications found in the literature.

Methodology

3 METHODOLOGY

This chapter provides an explanation of the process involved in conducting the public preference survey for the goals set for this research. Additionally, the strategy set for response analysis is illustrated. The goals defined by the research questions and the information in the literature study are taken into consideration while selecting the methodologies and strategies for the surveying. As the method of analysis largely depends on the method of information gathering, the strategies for data analysis are also selected after an extensive literature review but only after the surveying method is chosen. Therefore, it is deemed more natural to describe the analysis methods and the justifications for why they are appropriate for this research in this chapter after the surveying method has been established.

3.1 SURVEYING

In this study, the preferences of various public groups are gathered in order to determine their tastes for various road elements within the context of the policy to reduce the speed limit for vehicles with the aim of making roads seem safer for cyclists, and more specifically for cycling children around schools because of which cycling becomes more encouraged and more used. Surveying is a technique that has been utilized frequently in research and, when performed properly, is shown to produce the desired findings. As a result, this methodology is used in this study as well. More survey details are displayed in the subsections that follow. Additionally, strategies how the pitfalls stated in the literature are demonstrated.

3.1.1 Qualitative approach

Qualitative research does provide answers to questions that need to understand the reasons why choices are being made. Qualitative research does provide answers to questions that need to understand the reasons why choices are being made. In contrast, quantitative research helps to clarify the decisions that have been taken. The major goal of this study is to identify the elements that need be added to the GOW30 roads in order to create a subjectively safe cycling environment that will encourage increased cycling by kids and adults. What weights, if any, do the traits have in relation to the perception of safety is the core of the question. In short, this research is mostly focused on figuring out what is considered to be safe, rather than why certain roads are thought to be safe or unsafe. As a result, quantitative research is picked as the approach for carrying out the survey. This method also has the benefit of reaching more people because it takes less time and produces findings that are more representative of the general population. However, using quantitative research has the disadvantage of not allowing researchers to fully grasp the motivations behind decisions, but it is outside the focus of this research and is thought to be an acceptable disadvantage.

3.1.2 Stated preferences

The GOW30 roads are a new type of roads that do not yet exist in the Netherlands. The possible features that are suggested and discussed about this topic do exist in practice, such as separated cycling lanes and intersection priority rules. Nevertheless, neither the countryside nor the Dutch towns have a mix of the various features, speed restriction, and volume of distribution roads. Therefore, it is impossible to determine

why the GOW30 roads were used in the past or how the general population feels about them. In light of this logic, a stated choice experiment will be used to carry out this survey. The fundamental drawback of this approach is that it is unclear whether respondents' reported preferences are actually what they like. The importance of the survey to the respondents and the fact that the survey's primary topics are vulnerable children—a group that society as a whole works to protect and cares about—help to dispel this concern (Enskär et al., 2021).

3.1.3 Questioning style

It is clear from the literature that the questioning style, the order of the questions and the and the content of the question influence the answers given. Instead of focusing on achievements in other areas, the goal is to allow the respondent to maximize the safety of the cycling children. Gains like shorter travel times, retaining the usage of favoured modes of transportation, and improving the aesthetics of the street should all be eliminated since doing otherwise would force unacceptable trade-offs when children are the topic and their safety on the road is at stake. The goal of this study is to better understand how to maximize bicycle safety for children by using subjective population assessment. Therefore, when the respondent is given the choice to select an alternative that could affect the safety of the children, any insinuations that could result in profits of any kind in any way will not be included in the survey. In this way, Random Utility Maximization (RUM) takes place, and this theory will be used to the data analysis.

In order to prevent the surveying fatigue and the “speeding” phenomenon in surveys, a different approach of questioning will be adopted than the traditional surveys. As discussed in the literature, not having imaginable situations in the survey where the importance of the survey is not emphasised, respondents tend to give less importance to this survey and either not complete or rush through it. For these reasons, three main strategies will be adopted. The first is to remind the respondent of the importance of the survey and the objective is to provide a safe and an encouraging cycling environment for children. For this reason, traditional encouragement for making the survey for example rewards or gift cards will not be offered so that people who are interested in the safety of children would fill in the survey and it is not for any other gains. The second strategy is to prevent the fatigue element by keeping the time required to complete a survey in a manageable 8 to 10 minutes. This is done through a pilot survey in which the time needed for the people who participated in the pilot survey to complete the survey and asking these people if there were points in the making of the survey they experienced as “annoying” or “boring”. The third strategy which also partly backs the second strategy, is the use of images in the survey instead of textual questions.

An extensive study done by Jansen et al. (2009) that investigated the use of images in stated choice experiments is used to substantiate the choice of this method in this research. A profile description may offer a variety of advantages if it includes photos. First, some characteristics, like physical designs, could be challenging to sum up in a short term. As a result, the respondent could choose to imagine such traits which may lead to different interpretations by each respondent. Second, respondents may be able to better comprehend and appreciate the numerous possibilities and hence make better decisions by visualizing

specific features. Third, experiments should closely match how customers make decisions in the real life to ensure that the respondent is making an actual choice, and the inclusion of visuals may make this possible. Fourth, because imagery is less subject to human interpretation than written descriptions, it might result in impressions that are more uniform. Finally, the responders may find the work to be more engaging and less burdensome.

Although it is evident that the use of pictures enhances the realistic experience of the survey for the respondents (Holmes et al., 2017; Steine et al., 2005; Van der Waerden, 2006). Using photos in practice can be problematic because pictures can convey a lot of information, which, if not carefully regulated by some very precise constraints, can lead to answers that can't be reliably linked to the traits being assessed. As a result, confounding consequences are very possible, as is the potential of ambiguity in the interpretation of the choice process (Cherchi & Hensher, 2015). It is true that videos and moving images do enhance the realistic experience of a survey even more. However, they do also extend the survey time which will increase the fatigue of the respondent.

Therefore, the use of images is an acceptable and a scientific backed technique that increases the feeling of reality in surveys making the results more valid, and it is an engagement enhancing method that is deployed in this research. A lot of care is put in processing of the images and eliminating the factors that can be distracting is put to keep the respondent focused on the task at hand. Moreover, existent roads will be integrated in a base case image that also exists in reality to give a more realistic appeal for the images. The base image is selected from a real situation where children go to a school that is considered be situated in a hazardous area in Rotterdam. The choice for this city is because Rotterdam is car-oriented city unlike Amsterdam. The choice of an example school is done for multiple reasons. The first reason is to find out how do people who bring their children to a school that is situated next to an objectively unsafe GOW50 road behave compared to parents of elementary schools in general. The second reason is to understand later on whether the lowering of the speed limit would change the behaviour of these parents. The choice of a unique location with unique features that can be identified both from 2D and 3D perspectives is considered to enhance the realism of the experience and let the respondents be able to imagine the situation with the context laid for him. The process of choosing the example school is done in section 4.3.

3.1.4 Selection of attributes

In a stated choice experiment, there is no limit to the number of attributes that should be included in a survey. However, it is strongly advised to include only the most important attributes due to the fact that including other attributes will lead to larger designs and larger choice sets which will exhaust the respondent (Chorus & Moilin, 2020). The inclusion of more attributes leads to more questions asked to the respondents to ensure the validity and reliability of the weights of the parameters (Chorus & Moilin, 2020). This will in turn make the number of attributes correlate positively the fatigue effect of the respondents. An earlier experiment by Kløjgaard et al. (2012) showed that including six attributes was too many where the

respondents looking at different features had difficulty recalling the attributes. Therefore, the number of attributes used in this research is set to be less than six factors.

The attributes are chosen from the list compiled in the literature conclusion that are the factors that are still a grey area in the GOW30 discussion and affect the safety of the cycling children. The choice of the attributes is done through interviews with experts. These interviews were conducted with road designing experts inside Royal HaskoningDHV and road designers inside the municipality of Rotterdam that were asked to choose the most important factors that need to be included in the survey. The questions asked in the interviews could be seen in Appendix C: Factors included in the survey.

3.1.5 Groups of respondents

A sample size of roughly 385 people is thought to be sufficient to make assumptions for practically any large population size with a 95% confidence level and a 5% margin of error (Kibuacha, 2021). Because of this margin of error, 400 and 500-person samples are frequently utilised in research (Kibuacha, 2021). Therefore, the aim is to gather at least 400 responses. That said, it is not specified in the literature how many members of a subgroup must make up a part of the entire sample for that subgroup's opinions to be deemed representative for that category. It is often stated that the sample needs to, to an extent, mirror the population if the target group is the population itself if the quantity of the subgroups in the population are known (Ali, 2022; Beretta et al., 2014). This is done because including people from different backgrounds will create biases of the responses depending on the characteristics of the respondents. In this research, the subgroups within the population will be investigated whether they do reflect the population or not. When disproportions are found that will be mentioned in the limitations of the results. In any situation, the minimum requirement of 30 people will be set as a benchmark to study the differences in the preferences of the various subgroups. This number of people is the conventional number of people is used for pilot surveys and it is often considered the minimum number that a research's results can be based on in quantitative research (Delce, 2010).

3.2 DATA ANALYSIS METHODS

The aim of this research is to find out which combination of elements on the road in the GOW30 context will create a subjectively safe and encouraging cycling environment. This is done through the question "when will a road with different features included or excluded on it be chosen to be subjectively safe around the school zones?". To be able to give an answer to this question, the weights of the different elements in respect to the subjective preference of the respondents to these elements need to be calculated. This will be done through calculating the percentage of people who would find a road that contains the speed limit of 30 km/hour safer than to the base case as it is now with 50 km/hour with the different variations of the attributes on both road alternatives. Because it is decided to use the RUM theory in the making of the questions and the analysis of the data, the linear additive functions will be utilized. On the other hand, a

random utility model provides the likelihood with which each alternative is picked. The standard way of the linear utility functions is given in the following form:

$$Ui = \beta Xi + \varepsilon i$$

Where:

U = *the utility of j*

β = *the weight of the attribute*

X = *the availability of the attribute*

ε = *unobserved random factors*

Then the probability of a person choosing alternative j is calculated using the following formula (Chorus & Molin, 2020):

$$P(j|X) = P(BXj + \varepsilon i > BXi + \varepsilon i \; for \; all \; j \; is \; equal \; to \; 1, \ldots\ldots\ldots, J; i \neq j)$$

In this research, two alternatives will be presented. The utility of roads with 30 km/hour, and the utility of roads with 50 km/hour. Eventually, the preferences of both roads will be estimated with the weights of the included attributes. The idea behind this is to estimate in which circumstances the 30 km/hour road would be considered a safer alternative for cycling children than 50 km/hour roads. The choice of the attributes and design of the survey will be illustrated in section 4.1.

3.2.1 MNL and ML with Panel Data

One of the most common methods to estimate the weights of variables through a dependent variable is the Multinominal Logit model (MNL) (Krisztin et al., 2021). The MNL is a model that is used to estimate a single set of parameters and is widely used due to its ease of computing and the straightforward ability to interpret its outcomes. The MNL assumes that the choices made by the responses are independent and that the choices made are not done based on irrelevant or unincluded variables or alternatives. The MNL is utilized in the analysis procedure in the first phase after the responses have been gathered to use it as a reference point. An advantage of the MNL model is that it has a relatively straightforward method to calculate the probabilities of the utility functions, presented in the following formula:

$$P(i) = \frac{\exp(\beta i * Xi)}{\sum_{j=1..J} \exp(\beta j * Xj)}$$

This method will be used to analyse the differences in the taste parameters of the different groups for its ease in calculations and the relatively short amount of time needed to complete the calculation. Through this method the differences in the perception of safety towards the different features will be assessed.

A disadvantage of the MNL is that it assumes that the choices made by the respondents are rational and that each choice made is independent from other choices previously made, leading to biased estimation outcomes (Chorus & Molin, 2020). This disregards personal preferences and taste heterogeneities that might exist between the groups of the respondents, possibly due to their socio-demographic characteristics.

To counter that, other models are available to assess the weights of the parameters and the respondents' preferences based on the multiple choices they make. One of these methods is the Mixed Logit with panel data estimations (ML). This model does not assume an independent and identical distribution (I.I.D.) of the random components, it rather considers that there could be patterns in the choices respondents make in a sequence of choices (Yáñez et al., 2010).

The ML relaxes the I.I.D. assumption and distinguishes unobserved factors that persist over time. Therefore, levels of variation across individuals can be identified that can be caused by biases, and more pure values of the weights of the considered elements and constants can be estimated. This is useful in this research because as it can be seen in section 4.4.2, respondents are requested to choose their preferred road with different features multiple times over the time span of their participation. When people are expected to perform actions that are a sequence the phenomenon of behavioural consistency prevails (Fessenden, 2018). The tendency for people to act in a way that is consistent with their previous choices or actions is known as behavioural consistency. It is simpler to make one decision and stick to it than it is to make a new option each time a problem arises prevails (Fessenden, 2018). Behavioural consistency is a judgment heuristic that humans default to in order to facilitate decision-making. From an evolutionary perspective, behavioural consistency also makes sense since it makes it more difficult for unpredictable people to fit in and thrive in a social setting prevails (Fessenden, 2018). Considering this, it is sensible to use the ML model with the panel data in this research and it is the reason why it is utilized.

A disadvantage of the Panel Data method is the high computation time. Because of time constraints and the lengthy computational time of the ML model with panel data, this method is applied only once to estimate the permanent taste heterogeneity and biases parameter of the best performing model in the MNL phase, not to the different samples within the group of respondents. Only in case larger differences are found in the results of this model, the ML model will be utilized to improve the performance of the remaining models. The strategy of the data analysis is given in the section 3.2.2.

In the mixed logit model, random effects are estimated. This means that the unobserved factors of individuals that persist over time are identified (Bierlaire, 2020). The panel effect relaxes the assumption of the randomness or "noise" ε over time, creating a fixed parameter that is estimated over time, given by the following formula:

$$\varepsilon = \sigma + \varepsilon'$$

Where:

ε = *randomness in choice behaviour across individuals*

σ = *the effect that is estimated to happen by biasness*

ε' = *unexplainable by the model randomness in choice behaviour*

After the analysis with the two models are done, the values of the Bayesian Information Criterion (BIC) are compared between the MNL and ML models. Among a limited number of models, the BIC is a selection criterion; models with lower BIC are typically favoured (Chakrabarti & Ghosh, 2011). The likelihood function serves as one of its foundations. It is feasible to enhance the likelihood when fitting models by adding parameters but doing so runs the risk of overfitting. The BIC introduces a penalty term for the number of parameters in the model in an effort to address this issue. To account for taste heterogeneity, a further parameter will be added to the ML model. The performance of the two models, including the new parameters, may be assessed using the BIC. Therefore, the model with the lower BIC will prove to be the better estimating model.

3.2.2 The strategy of data analysis

It is crucial to develop a work strategy for what should be analysed and in what order before beginning the data analysis. A number of groups of participants are aggregated at the conclusion of the literature review to examine the variations in their preferences and subjective evaluations of the various experiment components. These clusters include the respondent's gender, his or her cycling habits, the fact that they are road designers, and the fact that they are parents. Because the school zones talked that are targeted by the policy are elementary schools and there is also a specific group that is targeted that brings their children to school around dangerous GOW50 roads, an additional group is added which is the parents of the example school and other parents of children that attend elementary schools. The main strategy of the analysis of the responses with both model types is illustrated in Figure 1.

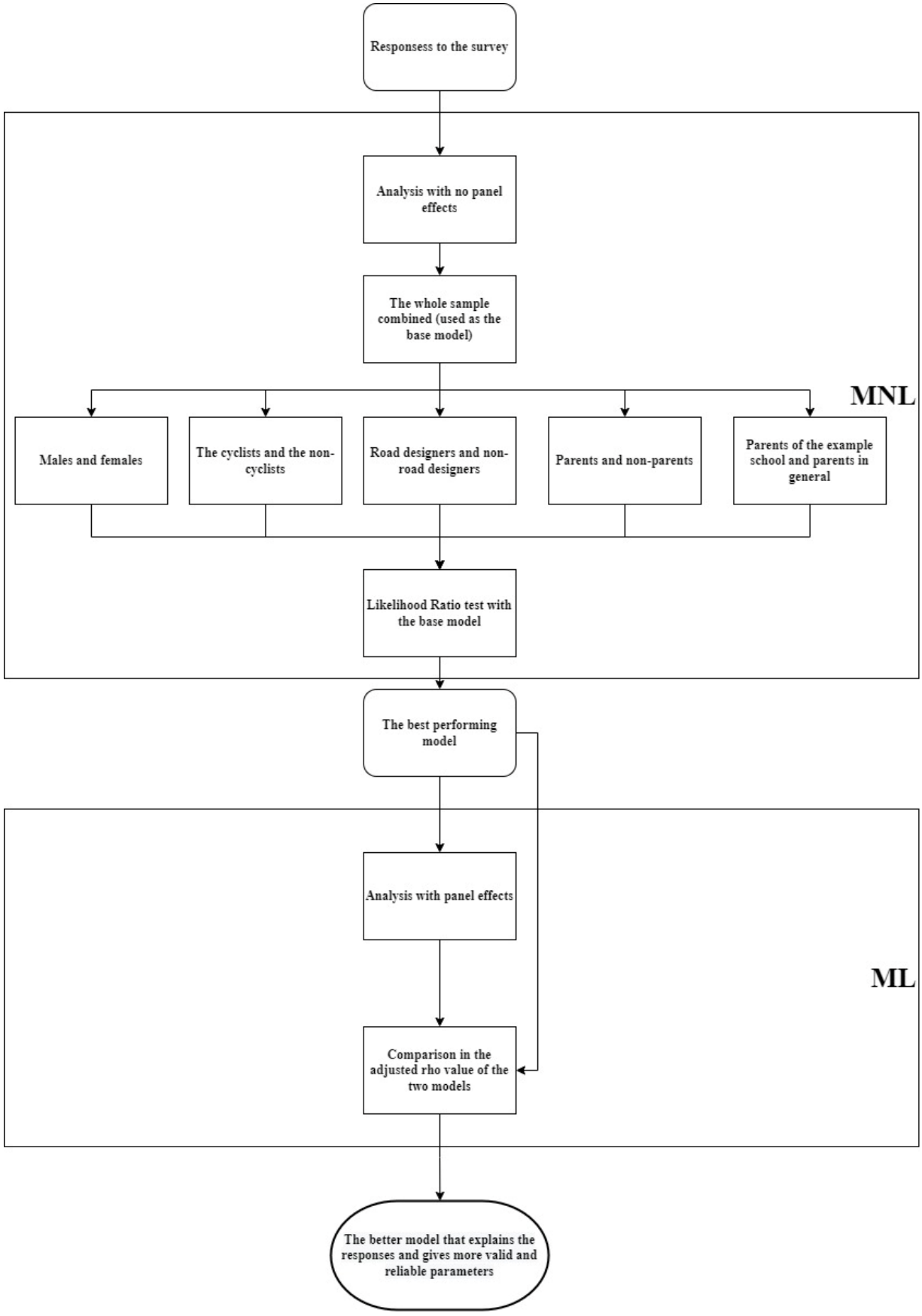


Figure 1 Strategy to analyse the results

As it is illustrated in Figure 1, the base model will be when no distinction nor subgroups are made within the sample population. In the base model with the different weights of the attributes, the loglikelihood is pinpointed. This is done to use the loglikelihood of this base model as the bench to compare to with the subsequent models that are analysed but split into the different subcategories. This comparison is done through the Likelihood Ratio Test (LRT). The LRT is a statistical test of the goodness-of-fit between two models is the. To test if a certain dataset is significantly better matched by a given model, a relatively more complex model is contrasted with a simpler model. If so, subsequent analyses frequently make advantage of the extra parameters of the more sophisticated model. Only when comparing hierarchically nested models is the LRT valid. That is, the inclusion of one or more parameters must be the only way the more complex model differs from the simpler model (evomics.org, 2016). Therefore, this test suitable to investigate whether the different MNL models do perform better than the base MNL model that contains the whole respondents' sample, and not in comparing two different models types which are in this case the MNL and the ML model with panel data structure. All attributes will be analysed in model and no attribute will be eliminated in the process. After analysing the models that contain only two categories of respondents as were the hypotheses, combinations of the subgroups are also made to investigate whether that would make the models perform better. These groups that are combined are the groups that their adjusted rho value is better than the rho value of the base model that includes all groups. The outcomes of these new models are then tested with the LRT with the base model. The combinations at the beginning are limited to two different subgroups (e.g., parents and cyclists, gender and road designers, etc.) due to constraints in time and the complexity of making many more models with more subgroups. These combinations will produce more parameters. A greater likelihood score will always be obtained by including more parameters. However, there comes a point where adding more parameters is no longer necessary to significantly increase the model's fit to a given dataset (evomics.org, 2016). If models containing more than the basic two subgroup that make the initial model perform better, then the results will be shown in section 5.4.1, otherwise it will be left out of the report.

The highest performing model is then subjected to an ML with panel data structure examination to see if it can estimate more accurate and objective parameters. Due to the lengthy time that the ML model requires to do the computations, only the best performing model will be conducted by the ML. Through this stage, it is determined which of the two models can be utilized in the future to estimate the parameters of the elements in relation to the survey-based subjective evaluation of the road users with the deployed method of images in the discrete choice experiment.


Survey construction

4 SURVEY CONSTRUCTION

In this chapter, the elements included in the survey are illustrated. Firstly, the attributes selected are shown based on the elements that are still in the grey area and predominantly influence the safety of cyclists and cycling children in school zones. Secondly, the number of choice situations that is used to be able to calculate the weights of the parameters is shown. Thirdly, the choices made for the case used to increase the immersion for the respondents are illustrated. Fourthly, the structuring of the survey is illustrated with the purposes of putting each element in the designated places in the survey. Finally, the outcomes of the pilot survey are stated with the impact of this survey on the survey design.

4.1 CHOICE OF ATTRIBUTES

In a stated choice experiment, there is no limit to the number of attributes that should be included in a survey (Chorus & Moilin, 2020). Nevertheless, it is strongly encouraged to only include the most crucial characteristics as introducing other characteristics would result in longer designs and wider sets of options, which will exhaust the respondent. The maximum number of features included in the survey is five, as specified in the methodology. In the literature conclusion the following features were identified as the elements that are undecided in the GOW30 context:

1	Function of the road
2	Speed limit for vehicles
3	Priority rules at intersections
4	Position cyclists to cars
5	Type of pavement
6	Public Transport
7	Parking for vehicles
8	Demarcation on the road
9	Speed regulating/calming measures

From these 9 attributes, 5 are chosen. The choice of attributes is done after interviews with road designers at Royal HaskoningDHV and the road operators at the municipality of Rotterdam. The interviewed experts are asked to choose five factors that need to be included in the survey that are according to them the factors that need to be studied most thoroughly from the subjective perspective of the road users. A criterion is for the road designers to choose the attributes that are self-contained. Including traits with similar interpretations is ineffective and could produce incorrect results (Sivarajah et al., 2017). The fact that the values of the parameters of these attributes are unbiased cannot be guaranteed if the attributes are not different on their own. Another criterion is to choose the attributes that are directly related to the safety of the cyclists and cycling children and not focused on other aspects such as travel time or emissions. Lastly, the features should be observable and controllable to include in the survey photographs so that the

respondent may quickly recognize them. The attribute should not stand out as an element that doesn't belong in the image and should not be the only thing the respondent pays attention to.

The factors chosen to be presented to the respondents are:

- Speed limit for vehicles: This is the main topic of the thesis, and papers have related the reduction of the speed limit to the decrease in the severity of accidents (Rasch et al., 2022; SWOV, 2012).
- Parking for vehicles: Children are shorter than adults, making them difficult to notice when bigger objects block them from the view of the drivers. The opening of the doors of the vehicles are create hazardous situations that affect the space available for cyclists and creates confusion for breaking and accelerating for cyclists. Therefore, their existence is considered a significant threat to the cycling children.
- Position cyclists to cars: The physical nature of the biking lanes is a central discussion point in the GOW30 discussion. Because of the lack of space in the city, it can be difficult to designate separate biking lanes on the distribution roads. This is the most frequently mentioned factor that is studied in both subjective and objective aspects.
- Speed calming/enforcement measures: The effect of speed lowering measures next to school areas on increasing the attractiveness of the roads for cyclists is not yet studied even though they are strongly advised to place them near schools (XTNT, 2014). Therefore, it is chosen to include it, to study its effect through the subjective preference on making the school zones safer.
- Priority rules at intersections: Children can sometimes be unaware of the traffic rules, leading to confusion at crossings. For that, it is advised to prioritize cyclists and cycling children crossing the road (XTNT, 2014). However, this affects the traffic flow, especially on the distribution roads. Hence it is a discussion point in the GOW30. Moreover, this aspect is not studied extensively before in the subjective preferences domain.

A distribution road is assumed to remain a distribution road due to the volume of traffic it receives, hence the function of the road is not determined. Thus, the safety effects on bicycles and other road users are not taken into account while choosing the type of function. The choice of the road demarcation as the least significant component was made because to its relative simplicity in execution and adjustment in the future. The road's pavement is thought to play a significant role in how images of slower-moving roadways are formed. In practical application, it was discovered that it was very challenging to include the clinker kind of pavement in the photographs without drastically distorting them and are therefore chosen not to be included. The stops for public transportation were thought to be crucial. The bus stops on the road element are dependent on whether cyclists cycle on the same road as other vehicles or on separate cycling lanes, so it violates the self-containing restriction. This causes a clash between the two characteristics of the stopping of public transportation and the positioning of autos with bicycles. The experiment will only display the latter attribute because it is thought to have the greatest effect on rider safety.

The latent question in the research is whether the 30 km/hour GOW roads in their different variations will create a safer and encouraging cycling environment than the traditional GOW50 roads. The road's speed limit is considered an alternative rather than an attribute. This is done to understand the change in the preferences from the base situation where the speed limit is 50 km/hour and in the new situation that does not exist yet with a 30 km/hour speed limit. Through this step, the general preference for the GOW30 roads in respect to GOW50 roads can be studied. The change does not affect the shape of the images nor the questioning style, i.e., it can be seen as an attribute. However, this does impact the number of choice sets presented to the respondents, which will be elaborated more in section 4.2.

To summarize, there are five attributes of which one is considered an alternative that are chosen to be studied in this research. The alternatives are either 30 km/hour distribution road or a 50 km/hour distribution road. The attributes are more specified in Table 11.

Table 11 The selected attributes with the levels

Attributes	**Options**
Parking spaces for vehicles	Available (lengthwise parking)/ non-available
Position cyclists to cars	Cycling paths/cycling lanes
Vehicles speed calming measures	Speed calming measures/no measures
Priority rules at intersections	Priority for vehicles/priority for cyclists

For each attribute, options are shown that are mentioned in the literature for each of the attribute (CROW, 2021b; SWOV, 2012; XTNT, 2014). Each attribute is limited to two to magnify the effects of the existence of each factor by showing the biggest contrasts between the elements. These options form the levels of the attributes.

Speed calming measures measures are numerous in the literature. Most noted ones are speed bumps, speed displays and narrowing of the streets (Neijts et al., 2022; Visser, 2022). Speed bumps and narrowing of the streets have significant impact on the comfort of driving. These are especially not preferred by the public transport companies as speed bumps are shown to have an impact on the health of their drivers and users (Rottier, 2019). This does impact another attribute which is why the physical speed regulatory elements are exempted from the attributes. This leaves the speed display as an agreeable option and is why its utilized for this attribute.

To check if the calculated weights of the attributes make sense and the respondents perceive the elements as intended, it is sensible to investigate in which way the weights of the attributes should logically be. The expected values of the attributes will be for the difference between the base level and the following level as shown in Table 12.

Table 12 The expected change in the value of the attributes in the experiment

Attribute	Base level	Following level	Expected direction in the value of the parameter
Parking spaces for vehicles	No parked vehicles	Parked vehicles (lengthwise)	Negative
Position cyclists to cars	Cycling paths	Cycling lanes	Positive
Speed display	No speed display	Available speed display	Positive
Priority rules at intersections	Priority given to vehicles	Priority given to cyclists	Positive

The expectations are substantiated with the following arguments:

- The addition of the parking space is expected to make the road crossing less visible due to blocking eyesight (Liu & Wang, 2013), this has also negative effects when a cycling path is integrated into the road as it is opening of the doors of parked vehicles and wrongly parked vehicles effect the available cycling space for cyclists. Therefore, the addition of the parking spaces and cars is expected to generate undesirable feelings from the respondent.
- The separation of cycling lanes follows the guidelines of sustainable safety of separating different masses and speeds from each other on the road (SWOV, 2018). In the literature, it is also found that cyclists consider manoeuvring vehicles as dangerous phenomena (CROW, 2021a; Pucher & Buehler, 2008a). The separation of the cycling lane is expected to provide rest in mind from the manoeuvring vehicles that a contact with the vehicle is about to happen. Hence, separating of the cycling lane measure is expected result in a positive perception of safety.
- The increase in car speed correlates with the increase in the severity of accidents (SWOV, 2012). In addition, bikers pay attention and fear passing next to them that are speeding, especially while overtaking (Rasch et al., 2022). Therefore, the calming of the car speed should generate a positive weight for the parameter.
- The priority of crossing is given to the bikers at roundabouts in Dutch cities. This is done to ensure the safe passage of these vulnerable road users (Rottier, 2021). However, this is not done at every cross point with vehicles. Adding this in a choice situation is expected to produce preferences to the roads that provide priority of crossing for cyclists when the safety of cyclists and cycling children is the focus point of the research.

4.2 NUMBER OF CHOICE SITUATIONS

As with the number of attributes and levels, there is no fixed number of choices to present in a survey. If all possible combinations of selected attributes levels are constructed, a full factorial design is generated through the following formula:

$$L^N$$

Where L is the number of levels and N is the number of attributes.

All the combinations of attributes and alternatives can be presented through the full factorial designs to the respondents. Full factorial designs allow observing and investigating the interaction effects among attributes. This survey consists of two alternatives which are, in the terms of the stated choice experiments, called labelled. This is based on the fact that both alternatives are distinct and not generic. Generic attributes are road 1 and road 2, while labelled alternatives are options that are distinct such as the speed limit of the two alternatives. In the choice sets presented to the respondents, one alternative will always contain the speed limit of 30 and the other the speed limit of 50, is thus considered a labelled alternative. The places where each alternative is shown to the respondents are varied to prevent easy clicking on the preferred alternative, and to prevent the speeding phenomenon which arises partly due to repetitive actions.

Since they are both labelled alternatives with four attributes having 2 levels each, this results in 2 to the power of 4 times 2 which results in 256 different choice sets in a full factorial design. This number of choice sets is extremely high and is unacceptable to show to each respondent. Hence, full factorial designs are not suitable for this research.

Orthogonal designs could be utilized to cut down on the amount of choice sets. Orthogonal designs, also referred to as fractional factorial designs, can lower the number of decision sets to a reasonable level. These designs do not capture the interaction effects between the qualities, which is a drawback. The interaction effects between the qualities are, however, assumed to be zero in transportation (Chorus & Molin, 2020). Therefore, it is seen appropriate to adopt orthogonal designs.

The minimum number of choice situations and the variations that should be presented to the respondents can be determined through Ngene (Reed Johnson et al., 2013). The syntax used in Ngene is presented in Appendix D: Ngene code for survey design. The calculated minimum number of choice sets is given to be 12 choice sets with the two labelled alternatives. The disadvantage of using the fewest possible choice sets is that not all of the alternative variations and their characteristics can be displayed to the respondents. The parameters' accuracy is negatively impacted by this. The validity of the parameters will be impacted by respondents being fatigued as a result of employing additional choice sets. The usage of 12 choice circumstances is deemed justifiable because the validity of the parameters is valued more highly than their dependability (Chorus & Molin, 2020). Moreover, the number of choices a respondent is expected to make without experiencing fatigue is around ten choice sets (Chorus & Molin, 2020). This also substantiates the

choice of the 12 choice sets for this research. The design generated for this research is presented in Error! R eference source not found..

Design								
Choice situation	30.cyclepath	30.parkingspace	30.priority	30.speeddisplay	50.cyclepath	50.parkingspace	50.priority	50.speeddisplay
1	1	1	1	1	1	1	1	1
2	0	0	0	1	1	1	0	1
3	0	0	1	1	1	0	1	0
4	0	1	1	1	0	1	0	0
5	1	1	1	0	1	0	0	1
6	1	1	0	1	0	0	1	0
7	1	0	1	0	0	1	0	0
8	0	1	0	0	1	0	0	0
9	1	0	0	1	0	0	0	1
10	0	0	1	0	0	0	1	1
11	0	1	0	0	0	1	1	1
12	1	0	0	0	1	1	1	0

Figure 2 The choice sets generated by Ngene

These choice situations are assessed through a pilot survey where dominant choice situations, meaning the options that are chosen for more than 90% of each time, are then eliminated. The elimination of these elements is important because they have no added value in the showing the trade-offs the respondents make (Chorus & Moilin, 2020). These choice situations could also contain the elements that the public perceive as the safest in any case. For that reason, these choice situations are removed from the final survey.

With the choice models, the weights of the aforementioned attributes are calculated. Because there are two distinct alternatives and the preference for the GOW30 roads is set to be determined, the outcomes of models are based on the following utility functions:

$$U(30) = \text{ASC30} + \beta_{Cycling\ lane} * Cycling\ lane - \beta_{Parking\ places} * Parking\ places + \beta_{Priority\ for\ cyclists} * Priority + \beta_{Speed\ display} * Speed\ display + \varepsilon$$

$$U(50) = \beta_{Cycling\ lane} * Cycling\ lane - \beta_{Parking\ places} * Parking\ places + \beta_{Priority\ for\ cyclists} * Priority + \beta_{Speed\ display} * Speed\ display + \varepsilon$$

Table 13 What each attribute in the utility function stands for

$\boldsymbol{U(30)}$	The utility function for choice of road that contains the speed limit of 30 km/hour
$\boldsymbol{U(50)}$	The utility function for choice of road that contains the speed limit of 50 km/hour
$\boldsymbol{ASC30}$	The alternative specific constant for the 30 km/hour road for the 50 km/hour road is used as the base alternative
$\boldsymbol{\beta_{Cycling\ lane}}$	Taste parameter for the existence of designated cycling lane
$\boldsymbol{\beta_{Parking\ spaces}}$	Taste parameter for the existence of parking spaces
$\boldsymbol{\beta_{Priority\ of\ crossing\ for\ cyclists}}$	Taste parameter for the availability of crossing priority for cyclists
$\boldsymbol{\beta_{Speed\ display}}$	Taste parameter for the existence of a speed display

The existence of the parameters in the final results depends on the parameters' significance. These utilities can be expanded when the models according to the pre-defined groups that might show to explain the choices better.

4.3 CHOICE OF A REPRESENTATIVE SITUATION

A real representative place has been searched to be utilized to use to convey the task to the respondent in order to make the experience of conducting the survey as realistic as feasible. The choice of an existing situation has been regarded crucial in order to improve immersion in the experience and help the respondent comprehend the issue's context, both of which will increase the urgency of making the roads around school zones safer for cyclists. In addition to that, this allows to identify the travel pattern around school zones that contain dangerous distribution roads with 50 km/hour speed limit.

The hypothetical case is chosen to be in Rotterdam. Rotterdam is the second-largest city in the Netherlands, a city that also adopted the policy of lowering the speed limit for cars, and most importantly a car-oriented city unlike Amsterdam. First, the most dangerous roads in Rotterdam are identified by looking at the number of accidents (Open Rotterdam, 2021; Vocke, 2019)**.** In addition to these sources, mobility experts in the municipality of Rotterdam were asked to suggest the city's dangerous 50 km/hour roads. Second, elementary schools in a radius of 500 meters were compiled. This is the distance that children need to cycle on average in Rotterdam to reach their elementary schools (Haddou & Van Uffelen, 2020). Putting the two components together in one picture offers a clearer view of the dangerous roads in proximity to elementary schools (Error! Reference source not found.).

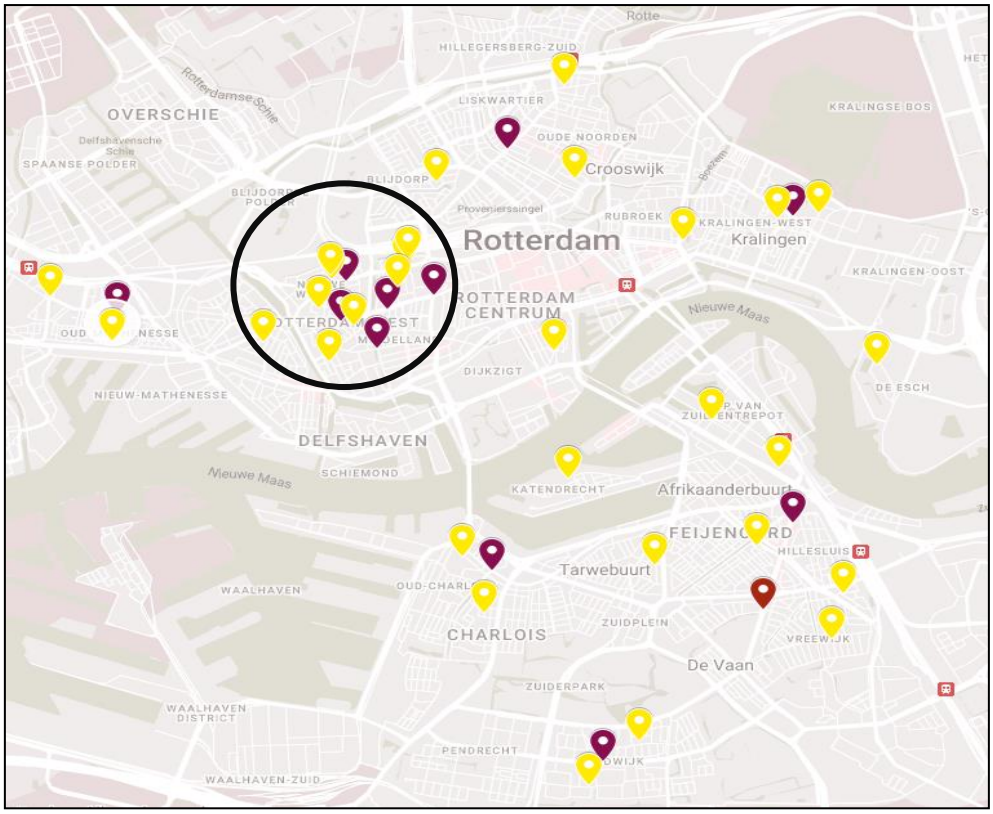


Figure 3 The concentration of hazardous roads and primary schools in Rotterdam

From Figure 3, it can be noticed that a relatively high number of primary schools and dangerous roads are concentrated in the Nieuwe Westen area in the city (marked with a **black** circle in Figure 3). It is also noticeable that four elementary schools are situated on the same dangerous road which is Beukelsdijk. The location of this road can be seen more clearly in Figure 4 where it is indicated with a blue arrow.

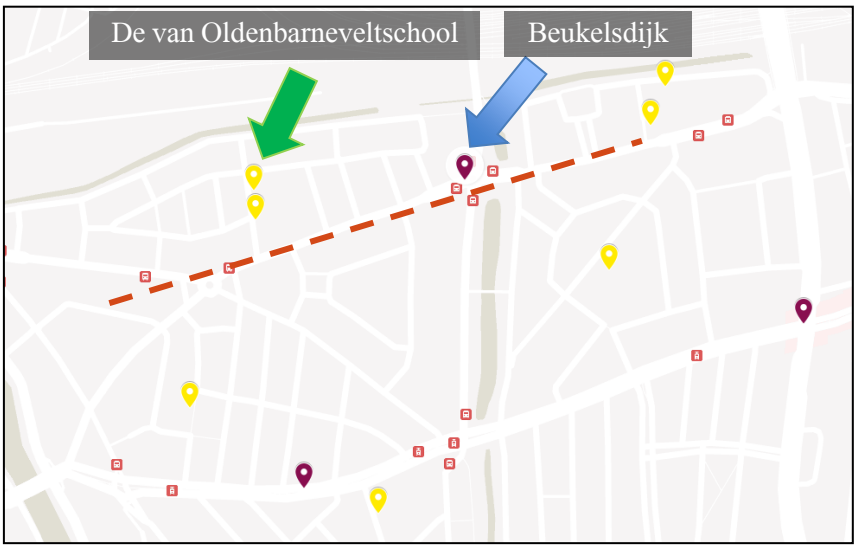


Figure 4 The location of the example school and the dangerous GOW50 Beukelsdijk road

A large elementary school close to this road is de van Oldenbarneveltschool (indicated with a green arrow in Figure 4). This school is situated next to a large church that can be clearly shown in a 3D and in a 2D

form making the road and the situations more identifiable for the respondents. The 3D form can be seen in Figure 5 and 2D form can be seen in Figure 6. This elementary school is directly situated on an ETW30 road with no cycling lanes and many car parking places. About a hundred metres from the De van Oldenbarneveltschool elementary school there is the GOW50 Beukelsdijk road with a high intensity of cars and was listed as a dangerous road. Therefore, this situation is considered representative enough of the dilemmas of the GOW30 conflict points that is used as an example.

4.4 QUESTIONING STRUCTURE

In this section, the structure of the questions is illustrated with the reasoning the placement of the questionnaire. In the first section the general characteristics and the habits of the respondents are asked. The second part is where the choice situations are shown to the respondent and he is then asked to make the choice. Finally, a number of supplementary questions are posed in an effort to elicit information on the GOW30 topic and the development of the cycling environment that was not possible to obtain through the choice scenarios.

4.4.1 General characteristics and habitual patterns

The respondent's sociodemographic characteristics, such as age and gender are asked. The gender question is necessary to find out whether there is a difference in the preferences on the road elements in respect to the subjective safety assessment. As found in the literature, there are differences for the preferences for certain measures by the two genders. In this case, the study will occur when the two groups have to evaluate the safety of the roads for children instead for themselves. The age question is also asked for the reasons of eliminating responses from underage people and these are two. The first reason is to eliminate underage respondents because a consent of the parents is not asked to fill in the survey. This is also done to protect the identity and the privacy of children. For that reason, any information or response from respondents who stated that they belong to the age category of 18 years old or younger is deleted. The second reason why the elimination of children is occurred is because the main premise of the survey is that adults care about the safety of the children and consider them a vulnerable group in the society. That the emphasis on the safety would be bigger. Therefore, the preferences of the people who are also the subjects of the survey is deliberately set outside of the scope of this research and the responses are accordingly deleted.

Secondly, the cycling behaviour of the respondents is asked. This is done because in this case as well, differences are found in the preferences for certain elements on the road and the hypothesis is to test whether these differences remain in the case of having another subject for the experiment. Cyclists also have different experience on the road infrastructure than non-cyclists (Rasch et al., 2022) and this difference may become apparent in the preferences towards the different elements. Thirdly, the respondent is asked whether he has ever been involved in designing roads in the Netherlands. The assumption is that there might be a difference in the preferences between the people who are continuously busy with improvement of roads and have access to the objective impacts of measures and rules and people who do not. Not many studies

found about the differences of the groups who are continuously observe the objective effects and consequences of implementing measures and road elements and the effects of this on their subjective preferences. The discrepancies between the groups of who are know the objective consequences of rules and policies and the common people who presumably are less informed about these matters is not studied before. In the next step, respondents are asked if they have children, if they have children that attend elementary schools, if these children cycle on their own to the schools, and what are the reasons why they accompany the children to the school on the bicycle or car when applicable. This is done firstly to assess the extent to which safety plays a role in bringing the children by car or bicycle. People who stated that they do not have children, are then forwarded to the choice situation part. Furthermore, this step is taken to assess the people who are parents and people who are not because as found in the literature, parents have a specific perception on the road and the safety of the road on the way to the primary schools.

4.4.2 Choice situations

The respondents are asked to imagine a hypothetical situation where their supposed children (aged between 8 and 12) are cycling on their own (unaccompanied by adults) along the yellow route in Figure 5. As mentioned in the introduction this the age when children in the Netherlands usually start biking on their own at this age (Van de Groep, 2019). For this reason, it is assumed that the respondent can imagine a situation where a child is cycling on its own. The blue tower of the church is visible in both 2D and 3D forms as it can be seen in Figure 5 and Figure 6. Through this, respondent can recognize the crossing place. The crossing is important to identify because this is the place where the hypothetical cycling children would possibly be vulnerable to a possible perpendicular crash where the speed of the vehicle is at its permitted maximum.

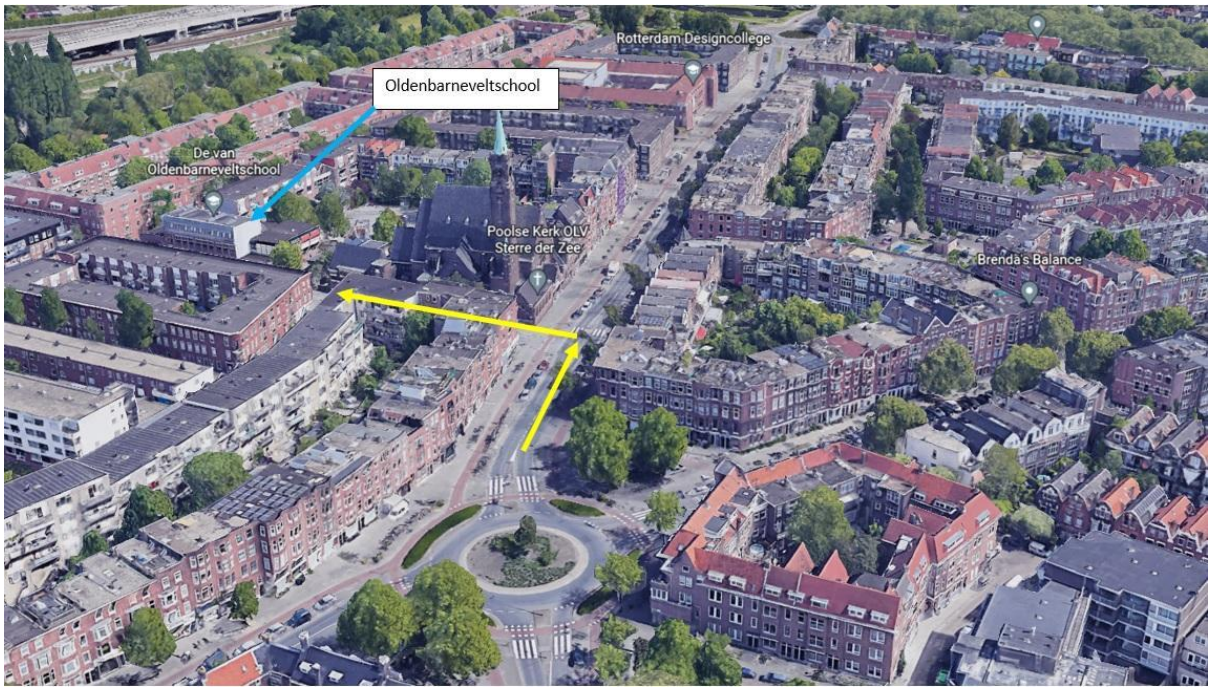


Figure 5 3D visual of the location that is used to provide a context to the respondents of the route that the cycling child is following in the choice situation (illustrated with arrows in yellow)

The base 2D image of the road is shown in Figure 6. Objects that might be considered distracting or considered as an attribute in the choice of which road is safer or less are removed. Objects such as trees, shadows, unrelated traffic boards, graffiti on the walls and public transport related elements.

Figure 6 An illustration how the base situation is cleaned and processed

Similar roads were sought in Rotterdam or the surrounding areas that contain the other levels of the attributes that the base road does not have. The levels that this base image does not have are: no parking spaces option, indication that priority of crossing is for the cyclists, a speed display and cycling paths. A criterion of the roads that were sought is that they should be with similar characteristics as the base road. Characteristics such as the width, curvature, and elevations, were set as targets. With this, the realism of the survey experience is expected to be increased. Examples are presented Figure 7.

Figure 7 Examples of similar roads that are then situated in the base road image

This process is by no means flawless. For example, the grass on the left side from Figure 7 was found to be difficult to remove without damaging the image of the road to unbelievable extents. However, after a round of feedback, the images are considered realistic enough by the interviewed people.

Twelve choices of this type are presented to the respondents, and the question remains the same "Which road between the two is safer to let your child (age between 8 and 12) cycle on his own to the school?". This question is asked because of its straightforwardness. The respondent would not think of any other gains or losses in the choice of the road. This is essential in the Random Utility Maximization theory. Therefore, the only goal that the respondent is asked to reach is maximising the safety of the children through the choice of the road.

4.4.3 Attitude towards various policies

In final stage of the survey, several additional questions are asked to the respondents for various reasons. The first question is whether the population would let the children cycle on their own without being accompanied by the adults. The reasoning behind this question is that in the choice situations in the previous

section, no option stated, “either way, I would not let my child cycle on his own ". The respondent is limited to two options. This question helps understand to what extent people are willing to let their children cycle independently and thus the attitude towards cycling. If the response to this question is that the parents refuse to let their children cycle on their own, then this response is filtered out because that makes the previous choice questions obsolete. This question is placed at the end to let the respondent get the context of the situation and evaluate whether they have a child or not how situations could look like if they let their children cycle on their own.

The next question is whether the respondents themselves are willing to cycle more than other mode alternatives if the speed limit for cars on the road is lowered. This is done to determine if the speed reduction on its own is an encouraging factor in making a desirable cycling environment for adults too and whether parents are more inclined to cycle more with the introduction of this policy. The main purpose of this question is to relate the habits of the parents around the example school which is evidently around dangerous 50 km/hour road to the encouragement the new policy would provide to use the cycle more. The modal shift could have been better estimated with another choice situation task with the different modes of transport. There is however a major drawback of including another choice experiment in this survey as for one it will extend the survey making time significantly and second the impact of safety of children in this experiment might become ambiguous which may lead into a different choice pattern and not follow the decided Random Utility Maximisation choice behaviour logic. With this question, the question will be if the parents themselves are willing to use the bicycle more than other modes of transport with lowered speeds for cars. A simple but straightforward question that might give clear answers to the question.

Finally, the respondents are asked to choose the most important factor that, according to them, is the most effective in creating a safer cycling environment for children. This is a closed form question with one option where the respondent is allowed to fill the answer that he wishes. The reasoning behind this question is two folds. The first one is to determine the choice behaviour of the respondents in a direct questioning form where there is an attribute that limits the use of cars. The second reason is to answer the question of which type of policy is preferred by the respondents to be implemented to enhance the safety of the cycling children. Furthermore, this question helps to identify the public’s attitude towards different safety enhancement measures and to a certain degree the difference in the public’s attitude towards the measures that target the cars and bicycles. The chosen factors were based on the factors found in the literature that recommend these specific measures to be implemented on roads that are directly adjacent to schools and are not specific to distribution roads (CROW-Fietsberaad, 2013; DHV B.V., 2012; Jacobs, 2020; VVN, 2020b). These attributes are selected after interviews with experts at the municipality of Rotterdam and Royal HaskoningDHV. The condition for the selection of these measures is as with the selection of the attributes that they are self explanatory and do not conflict with factors that are may explain other factors.

Table 14 Factors included to give the respondents the possibility to express the favoured measure to implement that enhances the safety of cycling children

Factor	Target	Source
Separated bike lanes	Cyclists and vehicles	(SWOV, 2016)
Lowering the speed limit for cars	Vehicles	(CROW, 2021b)
Severe punishments for speeding cars	Vehicles	(Lama, 2008 ; SWOV, 2020)
Severe punishment for the use of mobile devices while driving/cycling	Cyclists and vehicles	(SWOV, 2020)
Mandatory bicycle lights	Cyclists	(fietsersbond.nl, 2021)
Mandatory helmets for cycling children	Cyclists	(fietsersbond.nl, 2021)
Restricting the number of vehicles	Vehicles	(Szarata et al., 2017)
More speed bumps for cars	Vehicles	(CROW, 2021b)
Other (open to fill in)	--	--

This question allows to validate factors selected for this research. There is a drawback of the usage of this method and the interpretation of the results of this question. The direct questioning approach is found to produce to some extent unreliable and bias results in research (Daniel et al., 2022; Hoffmann et al., 2016). In these studies, it is found when people are asked questions about sensitive topics with the direct questioning style choose the answers that are socially accepted and appealing answers (Daniel et al., 2022; Hoffmann et al., 2016). Moreover, it is found that biasness in this questioning form increases, and favoured measures or options are usually chosen based on the appeal and personal gains rather than real preference in a topic or purpose (Cherchi & Hensher, 2015; Welling et al., 2022). For that reason, this question will be primarily used to investigate the general attitude of the respondents towards the different measures, to investigate the avoidance of the option that suggests limiting the number of vehicles and also to give the opportunity to let the respondents fill in measures that are neglected or left out of the survey.

4.5 PILOT SURVEY AND OUTCOMES

To eliminate any obvious dominant selections from the questionnaire, a preliminary survey is done. The pilot survey's secondary goal is to determine how much time respondents will need to complete the survey. The aim is to have a survey that can be completed between 8 and 10 minutes, ideally about 8 minutes. Additionally, the respondents are requested to provide feedback on the survey regarding any potential grammar errors or whether the order of the photographs and story line makes sense.

It is important to remove the dominant choices (the choices that are made too often by the respondents) because it is difficult to tell if a respondent picked the choice to simplify the choice task because its severity and difficultness or because the disparities in attribute values were too great (Sælensminde, 2006). This preliminary survey is also done to gather feedback from this initial group to determine which aspects of the survey are not clear or ambiguous and whether it contains grammatical and linguistic mistakes. Around 35

people were asked to complete the survey, and their responses are considered sufficient to improve the surveying experience. According to Sheatsley (1983), prior to full-scale administration, the survey should be tested on at least 12 to 50 participants. While another study by Delce (2010) has fixed this number to 30. For this, the 35 respondents were considered sufficient.

34 out of the 35 people who were asked to participate in the survey completed the test successfully. The feedback on the grammar, the survey structure, and the visualisations were used to improve and enhance the survey experience. The average time the respondents needed to complete the survey was around 8 minutes which was the intended time. However, the duration of the response was a bit higher when the respondent stated that he has children and mounted to 9 minutes. Nevertheless, this was expected to happen because respondents with children need to give more answers than those who do not have children. With the elimination of the dominant choice sets, the amount of required time to complete the survey is assumed to be lowered.

Many respondents stated their annoyance about the number of choices they had to make in the second part of the survey. After several questions, the respondent lost track of the task and what he considered important. One of the reasons why the respondents said this was an issue is because they were persistently trying to stay consistent with their answers and trying to remember which choices they made in the previous options. From this, it was concluded that the number of choice sets must be reduced.

To remove the choice sets that do not offer any trade-offs or insights about the respondents' preferences, the dominant choices are assessed in this pilot study. A dominant choice is an alternative that gets chosen 90 percent of the time or higher (Chorus & Molin, 2020). In total, five alternatives were chosen more than 90 percent of the time. This happened in choice sets 1, 4, 5, 7, and 9 (for the choice sets, see Appendix F: Dominant choice sets from the pilot survey). All these choice sets apart from the first one are removed from the survey. This will reduce the number of choice options to a manageable 8 choice sets. This also has the effect of not needing to use blocking techniques to divide the number of choice sets into two or more different blocks. This gives the advantage of not needing more respondents to complete the survey to obtain significant results.

One of the dominant choice sets is kept in the survey to use it as a fatigue check. Choice set 1 was unsurprisingly chosen 100 percent of the time (as seen in Figure 8**).** In this situation, every aspect of both options was the same except the speed of road 1, which is 30 km/hour, and the speed of road 2, which is 50 km/hour. It was thus natural that the respondent would choose road 1 when safety is the point of the study. This also shows that the respondents did understand the task they were appointed to accomplish. This question will be presented at the end of the choice situations to know if the respondent is still focused. In earlier research it is shown that 91% of respondents will give quick responses when surveys are experienced as “too long” or “exhausting” (Ali, 2022). This percentage will also be used to find out whether speeding or fatiguing has happened with range of plus or minus 5 percent tolerance. In this case when over 91% ±5%

of the respondents give the “wrong” answer to the last question, the responses of these respondents will be deleted.

Figure 8 The dominant option left to study the fatigue of the respondents

4.6 SPREADING OF THE SURVEY

The survey is released on the 10th of May 2022, after the end of the traditional May vacation in the Netherlands when primary schools are closed. This was done to make sure that people are back from their vacations and parents can be interviewed on the street. People asked to complete the survey on paper or online (by scanning a QR code).

The survey was also sent to colleagues at the municipality of Rotterdam and Royal HaskoningDHV from different departments. However, more requests were sent to those who work in the departments of mobility and infrastructure. The responses of the latter group are needed to assess whether there are differences in the taste parameters between road designers and the rest of the population. In addition to that, deals were made with teachers of civil engineering at the university of applied sciences of Rotterdam so that the survey can be sent around per email to students and other teachers alike. In return, two educational guest lectures are given on the topic of the research and the experience of studying at TU Delft.

VVN and various other private organisations showed interest in this topic and spread the survey to their organisation members. Furthermore, posters were hung inside the elevators of the civil engineering faculty, urging people to fill in the survey. Websites such as ouders.nl were used to publish the survey as it is free for students who would like to gather parents' preferences about matters. Groups of friends and acquaintances were asked to post provoking questions beneath the post on this website because it was observed that more responses led to more engagement for the post and thus created more traffic for the survey.

Finally, different groups of people also helped in spreading the survey such as inside various church communities in the town of Barendrecht, groups of parents of elementary schools in the specified town and inside group chats of refugee work in the Netherlands (VWN), groups that the parents of the researcher are part of or work for.

Results

5 RESULTS

The row results of the survey are presented in this chapter. Firstly, the process of filtering the responses is presented. Then the demographic of the sample population is further illustrated. Furthermore, the values of the parameters of the choice experiment are given for both MNL and ML models. Finally, the answers to the inclination to cycle more and the measures that the public has large preferences towards are aggregated.

5.1 THE GATHERED RESPONSES

In total, 486 responses were gathered. However, not all answers were considered in the analysis. This is due to the fact that some answers were inconsistent. Underage people were as stated before eliminated from the results of the survey. A number of participants have chosen the option "I'd rather not say" every time that this option was given. This provides a major difficulty in identifying the person. Whether they are cyclists or not, whether they are a parent and most importantly whether they are underage children. Therefore, the people who answered with option "I'd rather not say" to every question were filtered out.

On average, the time needed to complete the survey was eight and half minutes. However, some respondents completed the survey in an astonishing low amount of time. Outliers therefore are taken out of the results. Finally, the respondent is asked whether he would let his child (aged between 8 and 12) cycle on his own. The idea is to find out, while giving the possibility of choosing the safer road, whether the respondent considered imagining the child cycle on his own and saw it as a safe thing. This also helps in the choice situations because no third option was given that allowed the respondent to state that either way, he will not let the child cycle on his own. Through this question, the public's general attitude towards letting children cycle on their own can also be investigated. Figure 9 visualizes the answers stated for this question.

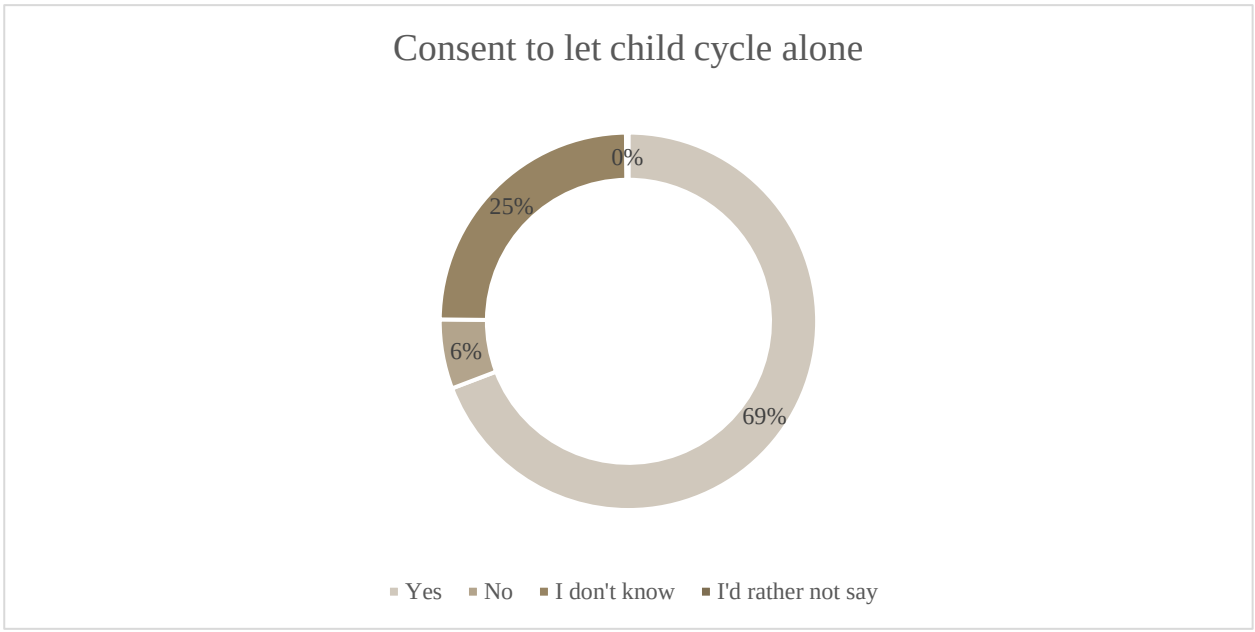


Figure 9 The percentage of people that would consent to let children cycle on their own

It is clear that most respondents would let the child cycle on his own, while 6% stated that they would not. It is unknown why the respondent was not ready to let the children cycle on their own, as there was no open question for the reason about their choices. For that reason, the responses of this group was filtered out of the whole. Another 25% stated that they are unsure about letting their children cycle independently. The responses of the latter group were kept in the data set as there was no firm objection of letting children cycle on their own. All respondents who chose this option were people who stated that they do not have children.

In the end, 441 responses were considered acceptable. This amount is also sufficient to suppose the results represent the population, the target of which was above 400 responses. Consequently, in the following sections, the sociodemographic characteristics of the respondents will be dissected to investigate who were the people who filled in the survey and whether the number of people who are clustered into subgroups defined in the formed hypotheses comply with the set threshold which is minimum number of 30 respondents for each subgroup.

5.2 GENERAL CHARACTERISTICS OF THE RESPONDENTS

408 people completed the survey designated for the general public and 33 people completed the survey designated for the parents of the example school. Even though the threshold that is needed to consider the sample's preferences representative to the population is reached, for transparency reasons, the characteristics of the sample are compiled in Table 15. In addition, the results of the study can be originated or caused by the characteristics of the person. Therefore, the characteristics of the sample population is given. Compiling this information allows further observation about the respondents and their habits in one comprehensible table. In this table, it can be observed whether the subgroups that are analysed reach the set minimum number of people required to have a representative response for each group which is 30 people.

Table 15 The descriptive statistics of the respondents

	PERCENTAGE SAMPLE	NUMBER OF RESPONDENTS	PERCENTAGE IN THE DUTCH POPULATION	SOURCE
AGE				(CBS, 2021)
0 - 18 YEARS OLD	0%	0	0%[I]	
19 - 30 YEARS OLD	41%	180	19%	
31 - 45 YEARS OLD	23%	101	23%	
46 - 60 YEARS OLD	26%	115	28%	
61 - 75 YEARS OLD	9%	40	21%	
OLDER THAN 75	0%	0	9%	
RATHER NOT SAY	0%	0		
GENDER				(CBS, 2021)
MALE	59%	260	49%	
FEMALE	41%	180	51%	
RATHER NOT SAY	0%	1		
CYCLING PATTERNS				(No source)
0 DAYS A WEEK	12%	53	%	
1 DAY OR MORE	88%	388	%	
RATHER NOT SAY	0%	0		
PROFESSION				(No source)
ROAD DESIGNER	32%	141	%	
NOT ROAD DESIGNER	67%	295	%	
RATHER NOT SAY	1%	4		
PARENTING				(CBS, 2017)
PARENT	49%	216	51%	
NOT A PARENT	50%	221	49%	
RATHER NOT SAY	1%	4		

[I] These are the adjusted percentages in the Dutch public because 18 years and less were excluded from the analysis of the sample of the survey.

Even though the benchmark of 385 respondents is reached to have the sample represent the population of large amounts, i.e. the whole population, the respondents to the survey for this research do not exactly reflect the many subgroups and differences in the general population, as can be observed from the characteristics of the respondents.

- **Age of the respondents**

The fact that there was a vigorous spread of the survey at the technical university in Delft and the university of applied sciences in Rotterdam, both of which are populated by young adults, also contributed to the overrepresentation of the relatively young population in the sample. The premise of asking the age question is to find out and eliminate the underage respondents from the survey and that is done in this case. It is however apparent that the population of 75 years old or older are non-existent and no analysis of the preferences of this group can be done as this group does not pass the 30 respondent's benchmark. Additionally, no hypothesis of differences between the different age groups of the populations is formed. Therefore, these differences are deemed acceptable and anticipated.

- **Gender of the respondents**

Secondly, the questionnaire was primarily distributed at engineering schools and offices where men are overrepresented, so the disparity in the number of respondents between the genders was expected. Having said that, each of the two groups contains more responses than the required number of 30 to analyse respondents' preferences. And with that, the preferences of the two genders are to be studied.

- **Cycling patterns of the respondents**

There was no source that specified how many individuals in the Netherlands cycled or did not cycle. There are numerous sources available regarding the distance travelled by bicycle in the Netherlands and the reason for those trips (De Waard et al., 2020; Den Hoed & Jarvis, 2021). Nevertheless, as previously noted, no source was discovered to correspond the sample's cycle patterns to the population. Both groups do pass the benchmark of 30 respondents and the preferences are therefore studied.

- **Road designers among the respondents**

The number of people who do road designing or are involved in adjustments on the roads in the Netherlands is unknown. This means that there are no statistics available on how many people work as road designers in the Netherlands. However, it seems that this group is overrepresented, as it does not seem sensible that more than 30 percent of the population is a road designer which was also anticipated because the survey was distributed more widely at organizations where road designers usually are found, such as Royal HaskoningDHV and the municipality of Rotterdam. Both groups have however more respondents than 30 people and further analysis of the groups is considered sensible.

- **Parents among the respondents**

According to the Centraal Bureau voor de Statistiek (2017), the Netherlands has 4,1 million fathers and 4,8 million mothers. This equates to 8,9 million persons who are parents. In percentage terms, this sum represents 51% of the Dutch population. This element appears to be fairly represented in the sample. In conclusion, it is deemed sufficient to conduct an analysis of all groups whose preferences are set in the hypotheses to differ because they all received more than 30 responses from each group which was the bare minimum.

5.3 PERCEPTION OF SAFETY AND TRAVEL BEHAVIOUR AROUND SCHOOLS

An investigation of the travel patterns of the parents whose children attend the case school is conducted based on the fact that it is clearly in a hazardous position with regard to the traffic condition. A hypothesis is that there are differences in preferences between the parents of the example school and other parents because the example school is located next to a particularly dangerous road, their behaviour is also compared with other parents from the general group to see if there are differences in the way they travel. The second reason for the distinction of this group is because the only report found on the change in the travel behaviour of parents in the Netherlands due to the concerns of safety (VVN, 2021), does not specify the reasons why parents find the roads unsafe or safe, and whether these schools are in a close proximity to a dangerous distribution road of 50 km/hour speed limit. For this reason, a comparison is made between parents who take their children to a school that is situated in a hazardous area and parents of children attending elementary school in general. 33 parents of the example school have completed the survey while 72 other parents of children attending elementary schools have completed the survey designated for the whole public. Both groups have more than 30 respondents and the preferences can be further studied.

Table 16 The differences in the travel behaviour to school by the parents of the example school and other parents whose children go to elementary schools

	Parents of elementary schools' children [#]	Parents of the example school [#]	Parents of elementary schools' children [%]	Parents of the example school [%]
NUMBER OF RESPONDENTS	72	33		
Has a car	57	24	79%	73%
Has a bicycle	60	27	83%	82%
Car use patterns to bring children to school				
0 days	42*[II]	7*	74%	29%
1 to 3 days	10*	11*	18%	46%
4 to 5 days	5*	6*	9%	25%
Bicycle use patterns to bring children to school				
0 days	16	9	27%	33%
1 to 3 days	22	12	37%	44%
4 to 5 days	22	6	37%	22%
Reasons for bringing children to school by car				
WORK RELATED REASONS	24*	5*	42%	21%
TIME	10*	2*	18%	8%
SAFETY	17*	16*	30%	67%
FINANCIAL REASONS	0	0	0%	0%
FUN/COMFORT	0	0	0%	0%
OTHER REASONS	6*	1*	11%	4%
Reasons for bringing children to school by bicycle				
WORK RELATED REASONS	4**[III]	5**	7%	19%
TIME	10**	6**	17%	22%
SAFETY	9**	7**	15%	26%
FINANCIAL REASONS	2**	0**	3%	0%
FUN/COMFORT	20**	8**	33%	30%
OTHER REASONS	15**	1**	25%	4%

It is clear that for both groups, safety weighs more heavily in the decision to drive children to school than to bring them by bicycle. Between the two groups, there is however a significant disparity in this area. For the parents at the example school, the safety concern ranks higher than all other considerations as to why they drive their children to school compared to the other parents. The latter group's first justification is that

[II] * is placed when the differences between the two groups are significant on 95% confidence interval
[III] ** is placed when the differences between the two groups are significant on 90% confidence interval

the reason is tied to their jobs. This can be the case because other parents' children do not attend schools that are located close to hazardous streets. This suggests that the location of the school affects the form of transportation that is chosen. For all groups, the choice of fun/comfort over safety is the predefined criteria that receives the highest score when it comes to choosing the bicycle as a form of transportation. This might be the case since riding a bicycle does not provide an added sense of security because cyclists are still susceptible to injury in the event of a collision. The responders still have the opportunity to select "other," where they can explain why they were not given the information. The explanation was largely left blank when this option was selected, but from the responses that did mention the "other reasons," which were mainly mentioned in relation to the cycling habit question, a few important words can be identified. These phrases are "Many factors," "Limited use of the car," and "Fuel prices." Other than the fact that some respondents are willingly driving cars less for some reason, these extra responses did not offer fresh research-related information.

It is also clear to see that the percentage of parents from the example school who own cars that also bring their children to school once or more per week is much greater of the parents in general who have children attending elementary schools. Relating this to the question of why the children are brought to school by car could be concluded that safety plays a significant role in bringing children to school by car and parents of children going to schools situated around hazardous roads are more likely to use the car to bring the children to school as it was stated in the literature (VVN, 2018). The reasons for the use of the bicycle in bringing the children to school is more or less similar among the two groups.

5.4 CHOICE MODELS

The choices that the respondents made in the part where they had to choose the road that for them seemed safer to let their children cycle on their own is analysed through two main methods. These methods are the Multinomial Logit model (also denoted by MNL) and the Mixed Logit with panel data structure (ML). Eight choice sets were in total shown to the respondents. Seven of these choices were the non-dominant choices in the pilot survey while the eight is used to observe whether fatigue had played an effect on the choices of the respondents. 96% of the choices that were made in the eighth-choice set was the choice that was logically supposed to be chosen. That is the dominant choice set that was placed at the end of the survey to find out whether the respondent was still focusing and still understood what was asked from him. Therefore, it can be concluded that the overwhelming majority of the respondents was still focused, and no fatiguing or speeding happened outside of the group of people who were already filtered out for completing the survey in a relatively short amount of time. The other 4 percent are assumed to have made a mistake or have a personal preference of the other alternative and they were deemed fine to keep in the dataset.

Without considering the attributes included in each picture, it can be seen in Figure 10 that there is a majority preference for the 30 km/hour roads. That being said, the choice for 50 km/hour roads is also

apparent where around 36% of the choices was for the 50 km/hour roads. This means that there are some circumstances where the respondent considered a 50 km/hour road as safer to let his child cycle on his own.

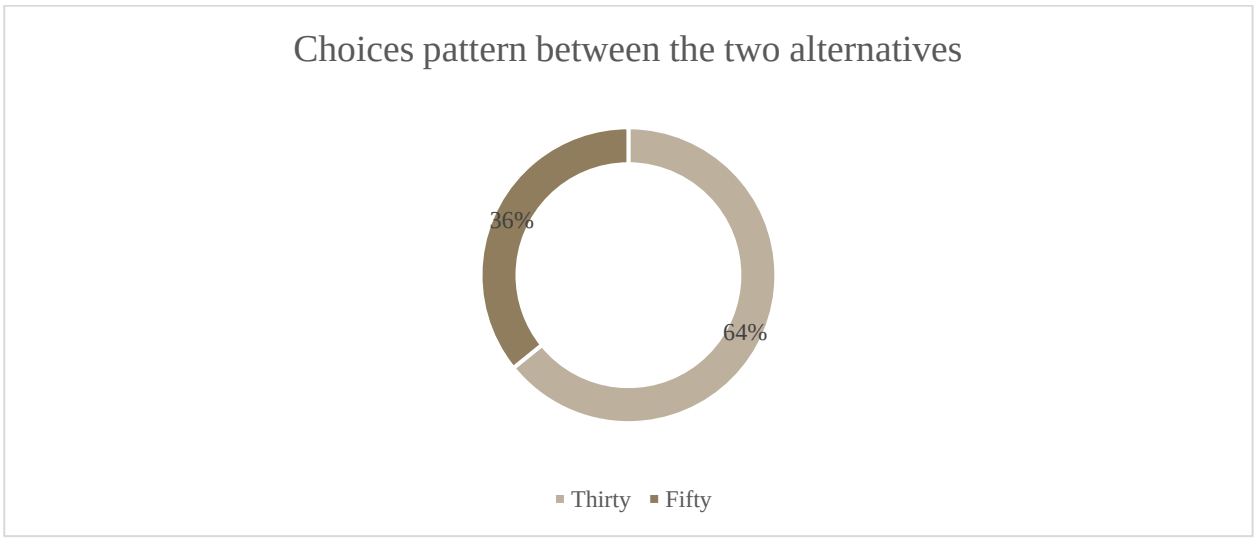


Figure 10 The choice pattern for the two alternatives

Subsequently, the choices of the remaining seven choice sets are illustrated in Figure 11.

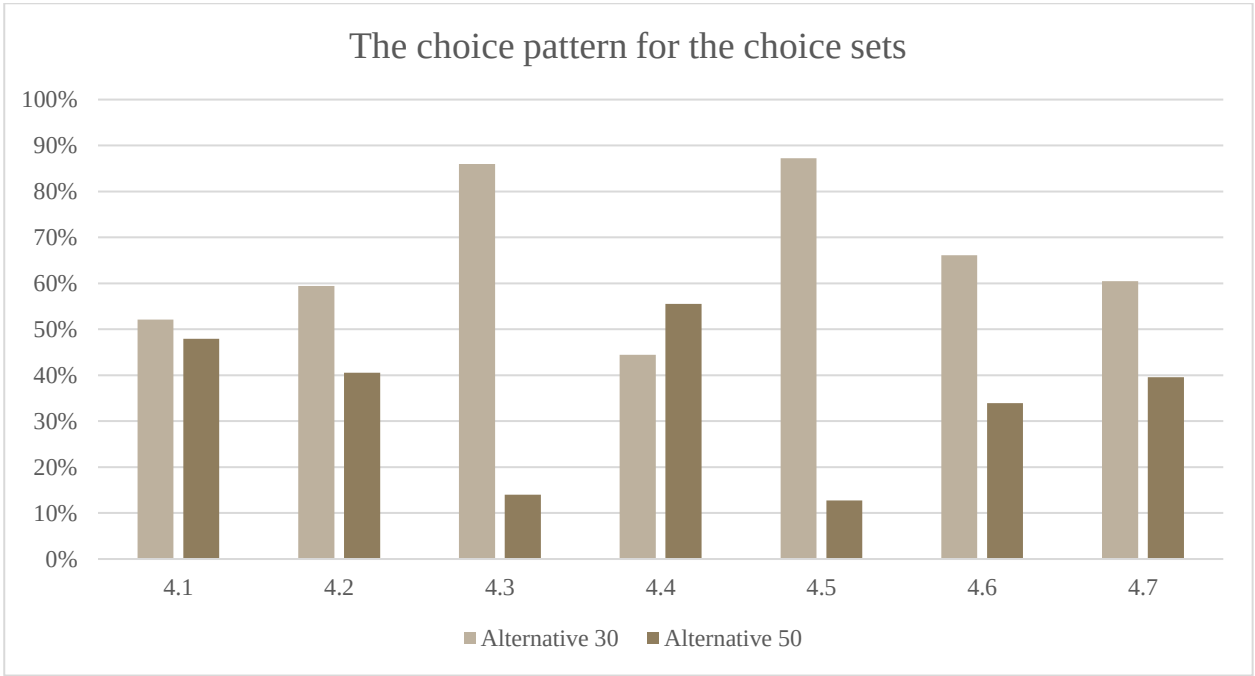


Figure 11 The choice pattern for the two alternatives for the choice sets

As it can be seen in Figure 11, the roads containing the alternative for 30 km/hour road are generally more preferred and chosen than the traditional 50 km/hour distribution roads. The only situation where a 50 km/hour road is preferred more by the majority of the respondents than a 30 km/hour road is choice situation 4.4.

In the following sections, these circumstances are investigated more thoroughly and the weights of the attributes according to the choice behaviour of the respondents is made clear.

5.4.1 Multinominal logit analysis

The data analysis for the weights of the parameters was performed using Biogeme, an integrated module within Python that analyses the choice behaviour of choice experiments through coding commands (Bierlaire, 2020a). The codes used to estimate the results of the MNL method are presented in Appendix I: Biogeme code for the whole sample population. The significance of the parameters is also considered. In an interval of 95% that the estimated parameters are not equal to zero, either the p-value is examined which has to have a value lower than 0.05 or the robust t-test value is examined which needs to have a value greater than 1.96 in absolute terms. The insignificant parameters are taken out of the tables because those are then assumed to be zero and to not confuse the reader with many numbers in each table.

The results of the base model that contains all respondents are as follows:

$$U(30) = 1.72 + 1.71 * Cycling\ lane + 1{,}35 * Priority + \varepsilon$$

$$U(50) = 1.71 * Cycling\ lane + 1{,}35 * Priority + \varepsilon$$

With adjusted rho value of 0.129 and final loglikelihood of -1884.

As it can be noticed from the utility functions, for the whole population only the cycling lane and the priority for crossing for cyclists have significant parameters while that of parking places and speed display are insignificant. There is also a significant alternative specific constant for the speed limit of 30 km/hour. Following this, other models including the groups that are stated to have differences in the preferences are analysed. The different groups are represented with dummy variables and then multiplied with the parameter of the attributes creating an interaction effect. The alternative specific constant is fixed for every group to have a reference point for the models. All parameters are set to be calculated for each model in every combination without excluding the insignificant parameters.

The groups that are set to be studied in the scope and found in the literature that there might be differences in the preferences are placed in Table 17to ease the identification of the models in later stages. An additional group is also added as there is an assumption created in the survey construction that the parents of case used and other parents of children attending elementary schools.

Table 17 The models developed to be analysed

Model name	Description
M1	All together
M2	Professionals and non-professionals
M3	Cyclists and non-cyclists
M4	Parents and non-parents
M5	Males and females
M6	Parents of the case and Parents of elementary school children in general

The values of the parameters for the different groups are then compiled in Table 18.

Table 18 The values of the dummy variables for the attributes set to be analysed

Group	Alternative specific constant for the speed limit of 30 km/hour	Cycling lane	Parking space	Priority for cyclist	Speed display
All	1.72	1.71		1.35	
Parents of the case school and other parents					
Parents of the case school	1.27	1.57		0.955	
Other parents	1.27	1.29		0.463	
Cyclists and non-cyclists					
Cyclists	1.72	1.74*		1.31	
Non-cyclists	1.72	1.33*		1.66	
Parents and non-parents					
Parents	1.72	1.8	-0.129	1.15*	
Non-parents	1.72	1.64		1.53*	
Gender					
Females	1.72	1.68		1.43	
Males	1.72	1.73		1.28	
Profession					
Road designer	1.72	1.76	-0.22	1.14*	
Not a road designer	1.72	1.68		1.59*	

As the alternative specific constant at every model is set fixed to have a reference point, the differences in the preferences for the attributes in respect to the subjective safety are examined.

- **Parents of the case school and other parents**

Interestingly, there are no significant differences found in the between the values of the parameters of both the parents of the example school and the parents of children who attend primary schools. For both groups there are significant preferences towards the speed limit of 30 km/hour, the separation of cycling lanes and giving priority for crossing for cycling children. The existence of parked vehicles does not seem to have a significant distaste towards it. This is also applicable for the existence of speed displays on the road.

- **Cyclists and non-cyclists**

Cyclists also have a similar preference as the parents of the case school to the separation of the cycling lane compared to people who do not cycle. In fact, the taste for this attribute has a higher value than the speed limit of cars of 30 km/hour. The priority for crossing for cyclists is the third highest value among the attributes for the group that does not cycle compared to the other attributes. This attribute scores the lowest among the significant attributes for the cyclists. Cyclists thus give the most importance to the segregation with the motorized vehicles then the speed limit of 30 km/hour and lastly the priority of crossing. While the highest value for the non-cyclists is the speed limit followed by the separated cycling lane and priority

of crossing respectively. Both parking spaces and speed display attributes had insignificant values for both groups.

- **Parents and non-parents**

There is a high value for the separation of the cycling lane for the parents. The difference between the values for this attribute with the non-parents are however insignificant. What is significant is that there is significant distaste for the availability of parking vehicles and parking spaces for parents while this is insignificant for the non-parents. Parents do see the parked vehicles as a threat and makes the roads seem less safe when there are no parked vehicles. This is according to the earlier reports that parents see the congested roads and parked vehicles next to school as dangerous elements which is also apparent in the significant value of this parameter. The value for this attribute is however lower that the other significant values. The non-parents group give more importance to the priority for crossing for cyclists compared to the group of the parents.

- **Males and females**

In the case of the gender, no significant differences in the values of the parameters are found. The value of the priority for cyclists at crossing for both genders rank the lowest among the other attribute while the values for the speed display and parking spaces are insignificant for both groups. The differences in the values for the attribute of separated cycling lane are also insignificant.

- **Road designers and non-road designers**

Lastly, the most interesting difference between the preferences of the road designer and non-road designers is that the road designers consider parked vehicles as hazardous and have a distaste for the existence of parking spaces around schools while that is not the case for people who are not road designers. There is also a large difference in the preferences for the priority of crossing between the groups where the non-designers have a more preference for this attribute than the non-designers. The difference in the taste parameter for the separation of cycling lane from motorized vehicles is found to be statistically insignificant.

The adjusted rho values and the final loglikelihoods of the different models are subsequently compiled in Table 19 to potentially make more advanced models as specified in the methodology.

Table 19 The performance of the various models

Model name	Adjusted Rho squared	Final log likelihood
M1	0.129	-1884
M2	0.136	-1872
M3	0.129	-1881
M4	0.132	-1877
M5	0.128	-1881
M6	0.0619	-2025

A likelihood ratio test is done on the models that contain the parents and non-parents and the model that contains the road users and non-road users. The only model to pass the likelihood ratio test is the model M2 that contains the professionals and non-professionals. The likelihood ratio test is formulated as follows:

$$LRS = -2 * (LLA - LLB)$$

$$LRS = -2 * \big(-1884 - (-1872)\big) = 24$$

The first model has 5 parameters while the second one has 9 therefore there are 4 degrees of freedom. In the $\chi 2$ table with 5% chance of coincidence the value of LRS needs to be higher than 9,488 so that a conclusion can be made that the second model performance was better, and this was not due to coincidence. This is indeed the case in this situation where 24 is a higher number than 9,488 and thus it can be concluded that the second model does indeed explain the choice behaviour better than the general one and it is not due to coincidence. Therefore, it can be concluded that there is a taste variation between the professionals and non-professionals in road designing and the distinction between the two models makes the model perform better.

Following the strategy set in the methodology, the values of the rho squared and the loglikelihoods of the different models are observed. It is interesting to see that only two models have a higher adjusted rho value than the base model. Only when the additional term enhances the model fit more than would be predicted by chance alone does the adjusted rho value rise (Frost, 2022). Therefore, the models that include the parents and road designers are the only ones improving the model. These two models are then further combined to understand whether the model can be further improved. The results of this model are compiled in Table 20.

Table 20 The values of the model that combines the dummy variables of road designers and parents

Group	Alternative specific constant for the speed limit of 30 km/hour	Cycling lane	Parking space	Priority for cyclist	Speed display
Professional and parent	1.73	1.91		0.82	
Professional and non-parent	1.73	1.63		1.40	
Non-professional and parent	1.73	1.74		1.29	
Non-professional and non-parent	1.73	1.64		1.59	

It is remarkable to observe that the parameters for parking spaces become all insignificant when the groups are combined while the groups one their own, the parameters for this attribute were significant. The adjusted rho value of this model is 0.138 and the loglikelihood is -1869. Even though this model scores better than the previous models, this model does not pass the likelihood ratio test meaning adding more variables of road designers and parents did not improve the model significantly. Therefore, the model that performs the best is then the model containing the road designers and non-road-designers. This model can thus be forwarded to the second Mixed Logit with panel data analysis phase.

5.4.2 Mixed Logit with Panel Data (ML)

As previously mentioned, the MNL does not consider taste heterogeneity and panel structure. These factors are important because multiple studies show that people make choices based on preferences and biases (Brus et al., 2016; Krueger et al., 2021; Yáñez et al., 2010). In this research, mixed logit model with panel data structure is utilized based on the knowledge that the respondent had to choose an image out of two that seemed safer to let a child cycle on its eight times in a certain amount of time. The assumption is that the respondent tried to justify the sequence of choices through a certain narrative or logic.

The results of the mixed logit model with panel data are shown in Table 21. The missing values in the table are because the values through the analysis are shown to be statistically insignificant on a 95% confidence level.

Table 21 The outcomes of the Mixed Logit model

Name	Alternative specific constant for the speed limit of 30 km/hour	Cycling lane	Parking space	Priority for cyclist	Speed display	Sigma
Road designer	2.04	2.14	-0.233	1.44		1.02
Not a road designer	2.04	1.95		1.66		

As it can be noticed, the random parameter that investigates biasness is statistically significant. This parameter is normally distributed with N (0,1.02) distribution and is dependent on the person meaning the

value 0 is used in the utility functions when calculating the percentage of people who would choose either one of the alternatives as safer than the other (Alnawmasi & Mannering, 2022).

To understand the changes occurred to the values, the outcomes of both MNL and ML models are placed together in one table to make it clearer to read.

Table 22 Comparison of the values of the two models

Name	Alternative specific constant for the speed limit of 30 km/hour	Cycling lane	Parking space	Priority for cyclist	Speed display	Sigma
MNL						
Road designer	1.72	1.76	-0.22	1.14*		
Not a road designer	1.72	1.68		1.59*		
ML						
Road designer	2.04	2.14	-0.233	1.44*		1.02
Not a road designer	2.04	1.95		1.66*		

When panel data is considered, the values of all parameters have risen except for the speed display which stayed insignificant. That said, the directions and the ranking order of the attributes in respect to their values have stayed the same.

From this it can be concluded that the mixed logit model gives a purer estimation of the values. The performance of both models is also considered and compiled in Table 23.

Table 23 Comparison in the performance of both models

	ML	MNL
Init log likelihood:	-2577	-2175
Final log likelihood:	-1804	-1872
Adjusted Rho-square:	0,296	0,136
BIC value	3669.8	3980.1

As both models are not constrained versions of each other, a likelihood ratio test cannot be performed. It is however obvious that the Mixed Logit model performed better than the MNL model with a value of the adjusted rho being higher with a factor of 2 than the adjusted rho value of the MNL model.

When the Bayesian Information Criterion of the two models are compared, the ML model performs better as well. The BIC value of the MNL model is 3980.1 while that of the ML is 3669.8, making the Mixed Logit model with the panel data the better performing model.

Therefore, it can be concluded that the Mixed Logit with panel data structure is the better method to analyse the responses to surveys that contain a sequence of images where the respondent is asked to make a choice in which one of the situations is considered safer to let a child cycle on its own. That through this model the taste heterogeneity of the respondents can be captured and better estimated values for the parameters can be produced. Having said that, the direction of the values and the ranking of the values of the attributes do not differ from the values presented through the MNL model.

5.5 GOW30 PREFERENCE

To find out to what extent the lowering of the speed limit on its own impacts the perception of safety and encourages the use of the bicycles, the respondents are asked whether there would be a change in their travel mode behaviour to more cycling than other modes when car speed limit is lowered. The responses to that question are seen in the Figure 12**.**

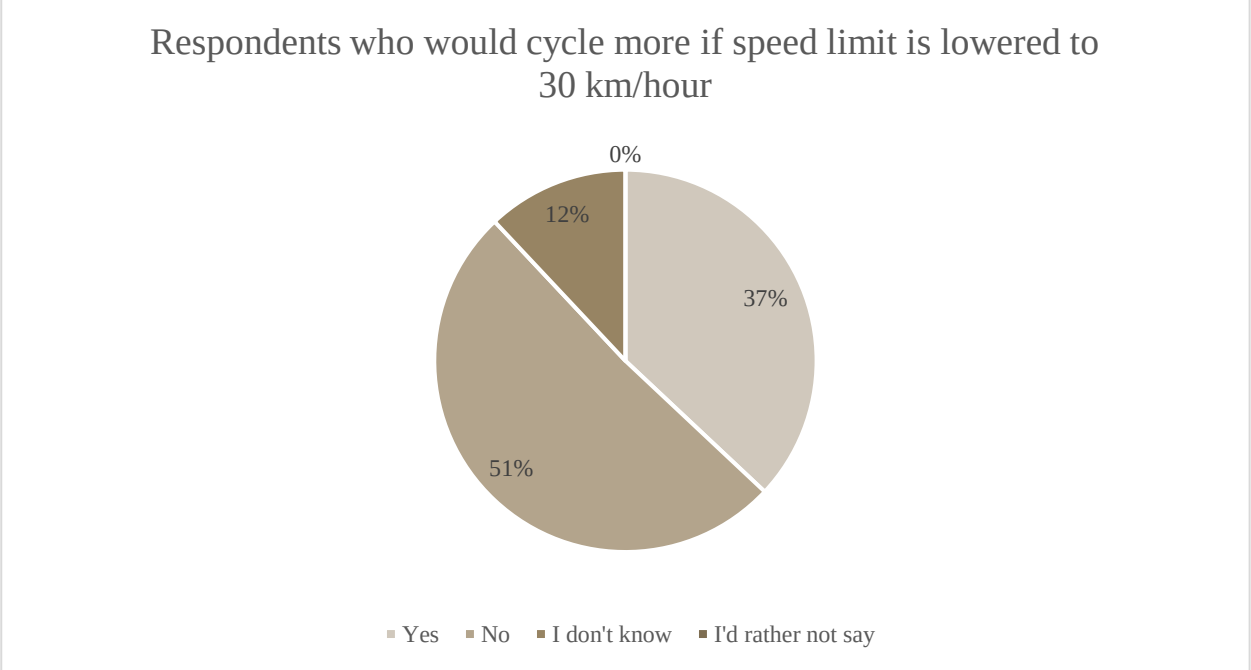


Figure 12 Attitudes towards cycling more with the introduction of the lowering of the speed limit policy

51% of the respondents stated that lowering speed had no effect in making them cycle more. On the other hand, 37% of the respondents have stated that this policy would let them use the bicycle more than other modes of transport when the speed limit of cars is introduced. It is not apparent whether this is due to an increase in the safety perception of the roads or whether other modes of transport would become less attractive to use. Nevertheless, a conclusion can be made that lowering of the speed limit has an effect on encouraging a great amount of people to cycle more but the majority of the people does not see it sufficient enough as a factor to cycle more. The preference for this measure by the different subgroups set in the hypotheses are studied in Table 24.

Table 24 Attitude towards cycling more from the different subgroups

Group	Would use the bicycle more	Would not use the bicycle more	Do not know
All	37%	51%	12%
Cycling patterns			
0 days	22%**[IV]	69%**	9%**
1 to 2 days	32%	58%	10%
3 to 5 days	37%**	51%**	12%**
6 to 7 days	39%**	52%**	9%**
Gender			
Males	38%*[V]	56%*	6%*
Females	29%*	54%*	17%*
Profession			
Road designer	33%	58%	8%
Non road designer	36%	52%	11%
Parents and non-parents			
Parents	36%	54%	10%
Non-parents	38%	53%	9%
Parents of the case school and other parents			
Parents of the case school	49%**	37%**	15%**
Other parents of elementary school children	33%**	58%**	9%**

A number of distinct differences can be found in this table. An interesting observation is that the attitude towards cycling more with the introduction of the lowering of the speed limit policy rises with the more often use of bicycles. This could be due to the preference for cycling or due to an increase in the safety perception. On the contrary, the overwhelming majority of respondents who do not cycle stated that they would not use the bicycle more when the speed limit is lowered. Therefore, the preference for this factor for this group is the lowest among all other groups with only 22% of the respondents who do not cycle who stated that they would use the bicycle more if the speed limit for cars is lowered. 38% of males have showed a positive attitude towards the lowering of the speed and more frequent cycling while that is 29% for females. Differences between the attitude of people who design roads and non-road designers, parents in general and non-parents towards cycling more with the introduction of lowering of the speed limit policy are found to be statistically insignificant. Lastly, there is also a large difference in the responses to this

[IV] ** Differences are significant with confidence level of 0.10
[V] * Differences are significant with confidence level of 0.5

question between the parents of the example school and other parents of children who attend primary schools. The parents of the case school are more prone to cycle more with the lowering of the speed limit for cars than other parents. This substantiates the assumption that dangerous GOW50 roads have an effect on the cycling behaviour and the introduction of the lowering of the speed limit can be perceived as an encouraging factor around school ones.

Finally, the respondents are asked to choose which measure is the most important measure that needs to be taken to create a safe cycling environment for children. Another advantage of this question is to find out whether or not included elements in the design were to play a significant role as well or whether the insignificant parameters were to be found significant in other combinations of attributes. The opinions of the respondents are compiled in Table 25.

Table 25 Most effective measure according to the respondents by using the direct questioning approach

	Separated cycling lanes	**Speed limit lowering for vehicles**	**Severe punishments for speeding cars**	**Mobile use punishments**	**Mandatory bicycle lights**	**Helmets for cycling children**	**Number of vehicle restriction**	**Additional speed bumps**	**Other**
All respondents	51%	19%	5%	3%	1%	1%	10%	6%	5%
Parents of the case school and other parents									
Parents of the case school	41%	25%	8%	3%	6%	0%	3%	8%	6%
Other parents	49%	22%	6%	6%	3%	4%	4%	2%	4%
Cyclists and non-cyclists									
Cyclists	49%*	20%*	3%*	2%*	1%*	1%*	12%*	6%*	7%*
Non-cyclists	40%*	13%*	17%*	10%*	5%*	1%*	0%*	0%*	13%*
Parents and non-parents									
Parents	52%*	17%*	8%*	1%*	1%*	1%*	10%*	4%*	6%*
Non-parents	53%*	17%*	2%*	4%*	2%*	2%*	11%*	6%*	4%*
Gender									
Females	58%*	13%*	8%*	1%*	1%*	1%*	10%*	5%*	2%*
Males	50%*	19%*	2%*	4%*	1%*	1%*	11%*	5%*	7%*
Profession									
Road designer	50%**	19%**	4%**	4%**	1%**	1%**	9%**	2%**	8%**
Not a road designer	57%**	13%**	5%**	2%**	1%**	1%**	11%**	7%**	3%**

It is apparent that for every group and the groups combined the highest scoring factor is the separated cycling lane. For the whole population the lowering of the speed limit is the second highest factor chosen by the respondents. This makes the lowering of the speed limit a popular measure among the populous, but the physical separation of cyclists and non-cyclists seems to be more important for the whole population when directly asked. These results are not reflected in the values of the parameters as the alternative specific constant for the 30 km/hour alternative is not higher than the value of the parameter for the separated cycling lane and this difference will be discussed in Chapter 6.

5% of the respondents also gave "Other" as option which is left open for respondents to add any measures that were not given an option. The most common sentences for this option are aggregated with key words. The most common reasons are four which make around 85% of the stated reasons and those reasons are "Multiple factors, Less mopeds on cycling lanes, Education and Less manoeuvring space for speeding vehicles". A number of these reasons align with the outcomes of the literature study that cyclists do pay attention and perceive other objects and subjects on the cycling lanes and paths as dangerous when they pose a threat to the cyclists such as mopeds and speeding vehicles. The reasons for stating the education were less clear but often an explanation was also given with this answer that cyclists and vehicle drivers need to be educated about the dangers of speeding an unsafe driving.

- **Parents of the case school and other elementary school parents**

The biggest percentual difference between the two groups is for the separation of cycling lanes. For the parents of the example school the separation of the cycling lane was chosen less as a factor than the other parents. The lowering of the speed limit is preferred more by the parents of the case school than other parents even though the difference is not large. Another large difference in the percentage is the preference for the speed bumps by the parents of the example school compared to the other parents. The differences in the preferences for these two compared groups are however not statistically significant and therefore, these values should be taken as indications and not as a basis for design specifically for these two cases.

- **Cyclists and non-cyclists**

The lowering of the speed limit ranks the second highest for the cyclists while the second highest measure is sever punishments for speeding cars for the non-cyclists. It is also remarkable that not a single choice was made from the non-cyclists for measures of limitation on the number of cars and more speed bumps for vehicles. This may be because of the preferences for the non-cyclists for the use of vehicles and measures against existence of vehicles or making the use of the vehicles less comfortable are not preferred.

- **Parents and non-parents**

It is interesting to see that the preferences for the measures when parents and non-parents are compared are almost exactly identical. For both groups the separation of cycling lane is the highest scoring factor followed

by the lowering of the speed limit reduction and then the limitation of the number of vehicles. The least chosen measures for these groups are the measures targeting the cyclists behaviour and wearing the helmets.

- **Males and females**

Females prefer the separation of cycling lanes more than males. The speed limit reduction is in contrast preferred more by males than by females. There seems to be a small difference in the choice of the limiting the number of vehicles option by both genders. Where a large percentual difference is between the choices of the two genders is for the severe punishment for speeding cars option. In this case females are more in favour of this measure than males.

- **Road designers and non-road designers**

Non road designers prefer the separation of cycling lanes more than road designers. While speed limit reduction is preferred more by the road designers. This could be because the GOW30 discussion is more circulating and being studied more recently by the road designers which may have possible given more awareness about the benefits and the consequences of this measure to the road designers than non road designers.

Discussion

6 DISCUSSION

The impact of decreasing the speed limit for cars on fostering a subjectively safe cycling environment has not yet been the topic of any studies. Additionally, no research has been done that compares the perception of common road users with professional road designers towards different road elements aimed at improving cycling safety. In this research methods are applied to extract the information about the perception and preferences of the different road users towards the elements on the road that might impact the safety of cyclists and cycling children. In this chapter, a reflection is done on the deployed approach and the components of the method, and on the limitations of the produced results. Subsequently, a reflection is done on the results of the study and an interpretation is done on the results with respect to the expectations.

6.1 LIMITATIONS OF THE METHODS

Setting realistic expectations for the value of the research in practice and its potential repercussions is crucial when conducting any study in order to ensure the transparency of the results. In the limitations of this research, first, the limitations for the choices of the attributes are discussed. Then, the limitations of the deployed method of conducting the survey. Furthermore, a reflection is done on the data collected from the sample of the respondents. Finally, the limitations of the method of data analysis are considered.

The choice of the attributes

The attributes for this experiment were chosen through interviews with two experts from Royal HaskoningDHV and two experts from the municipality of Rotterdam. Because the survey was limited to holding up to 5 attributes, the inclusion of more attributes in the survey was constrained, denying the possibility of investigating the quantifiable weights of other attributes. The attributes chosen to be included in this study are the speed limit, the situation of cyclists on the road, the priority of crossing rule, the existence of parking spaces and parked vehicles, and speed regulating/calming factor. The selection process was then conducted solely by road designers and policymakers, with no input from ordinary road users who may have had preferences for other attributes. That being said, the choice of the attributes from the public would have extended the time of the research significantly and would have required another formulation and design of survey which is outside of the scope and focus of this research. As a result, there might be a bias in the attribute selection. However, this was unavoidable because further explanation was required for some GOW30 debate points that had not yet been clarified by policymakers and road designers. Furthermore, interviews with four employees from two organizations, one of which is limited and scoped to a single city and location, limit the insights, and needs of other organizations in other locations and might have created bias in the selection of the attributes. The inclusion of different organizations from different cities which are also interested in this topic may have resulted in the study of different attributes according to the characteristics and road traffic vision of these cities.

A few features that were deemed important to study, such as the road's pavement and public transportation modes and stops, were deemed challenging to include in the experiment. The reason for excluding the pavements from this study is because the methodology of making the images was dependent on finding similar roads with similar characteristics as the distribution road that is used as a base case. However, no similar roads are found in the city of Rotterdam that were both distribution roads with clinkers and had the same characteristics as the base road. Therefore, the inclusion of such elements did distort the images and make them seem not believable. Additionally, it was challenging to add the modes of public transportation in the images without distorting the point of view that is used for all situations and thus obstructing the consistency of the experiment which may lead to invalid results. As a result, it was unfeasible to quantify the weights of these qualities in this study which are still important and relevant to the discussion. However, considering the limit of five attributes and that the included attributes were considered more important or as important as the attributes that were left out, this limitation seems tolerable.

The implications of the methods deployed

Stated choice experiment is applied in this study through the means of surveying. The survey's main focus point was to increase children's cycling safety by identifying the road types and patterns that appear to be safer for kids to cycle on their own. This is done in order to enable the respondent to concentrate on safety-related aspects and the protection of vulnerable road users rather than decisions that could result in gains or losses in their own way of travelling. Because taboo trade-offs were intended to be avoided in this study, it was crucial to avoid the benefits and losses in the area of safety. In order to increase cyclists' sense of safety in the Netherlands under the policy of decreasing the speed limit and the modifications in road designs that this policy brings, the Random Utility Maximization was specifically used for this purpose. This has an impact on the parameter values when it comes to how they affect safety rather than other factors like cycling comfort. It is important to pay close attention to the evaluations of the attributes since they emphasize how crucial safety is when vulnerable people are involved. Because safety might not be as essential to the various groups, the results can vary when other people are the focus of the study, or the adult respondents are asked to select the roads that make them cycle more safely. For instance, males take greater risks on the road than females do, according to a study by Cordellieri et al. (2016), and safety is less of a concern for this group. As a result, (some) parameter values might be lower than what the study's findings indicate. Additionally, the choice behaviour of the respondents may be done on basis of the children’s behaviour too. Study shows that adolescents are more likely to engage in risky and impulsive behaviour than adults (Van den Bos & Hertwig, 2017). For this reason, the choice of the safer road can also be dependent on the behaviour of the cycling child as well and not only the dangerous driving behaviour of the car user. Having said that, the attributes included in this experiment and their effects on the safety of cycling children are also applicable to the safety of cycling adults. Nevertheless, generalizing the results of this experiment to cyclists should be done cautiously and conservatively.

Finally, the conventionally stated choice experiment drawback discussed in the literature review is still relevant to this study. That respondents' stated preferences might not accurately represent how they actually behave. Due to this limitation, the results of the willingness to cycle more question should be evaluated conservatively. This is because the question is presented directly, without laying out any possible choices or creating any choice-related dilemmas through which the probability of cycling more could be calculated.

Data collection and representation

Despite the fact that the survey has garnered more than 400 acceptable replies, the minimum number needed to form a sample that fairly represents the population, the survey was actively promoted in some locations more than others that have a particular type of people with certain characteristics. The places where the spreading was most effective in the Netherlands were engineering and consulting firms as well as technical universities. There are some factors that are common amongst these people such as higher education level and wealth which are found to have an impact on the risk perception and hazard identification (Pförtner & Hower, 2022; Rattay et al., 2021). The sample population of the survey is then divided into numerous subgroups based on a variety of variables, such as gender, cycling preferences, and parenthood. Despite the likelihood that they may actually be intercorrelated, the assessment of the various subgroups is undertaken under the assumption that each cluster is unique from the other. The descriptive characteristics of the respondents, where the younger age groups are overrepresented in the sample, show particularly how successful the survey's dissemination was at the universities. Younger generations often own fewer cars than older generations do and use bicycles more frequently (Centraal Bureau voor de Statistiek, 2015). Older road users take fewer risks on the road and perceive danger differently than younger drivers (Mizenko et al., 2015). But in this study, the groups are assessed independently rather than assessing multiple ones at once while there are similarities in the behaviour or the preferences of some groups and these were not identified in the survey due to privacy concerns or due to concerns about greatly extending the time needed for the survey. This can have the consequence of causing overestimations and underestimations of parameter values for each group, and the survey's findings should be regarded as indicative findings for the various studied subjects. This is especially true given that there are not any individuals in the 75+ age group in the sample and that their choices are not reflected in the preferences of the various subgroups which may impact the weights and the ranking of the different elements that are shown in the results of this study.

Limitations of the use of MNL and ML models

Most of the results of this research are obtained using the Multinominal logistic regression model. This is due to time constraints and the lengthy time and resources required to perform the Mixed Logit model with the Panel Structure model to determine the values of the parameters for the attributes. For the aforementioned reasons, the approach is configured to enhance only the model with the highest adjusted rho value and if major changes occur in the results of the ML model such as direction or large differences in the values of the parameters, the ML would have been used to estimate the results of the other models. As

can be seen from the findings, the mixed logit model with panel data outperforms the MNL model with better adjusted rho value and a superior Bayesian Information Criterion. Additionally, the model was able to account for the respondents' high taste variability. Only the model with the dummy variables for road designers and non-road designers is used in the Mixed Logit analysis. Nevertheless, the parameters' directions did not change, and there are similar discrepancies in the values of the MNL and ML versions of the model that includes both road designers and non-road designers. For that reason, the model results of the MNL model are used to have the indications set to be obtained such as the differences in the preferences amongst the subgroups and the taste and distaste towards the various attributes. Having said that, the use of the Mixed Logit for all models would have resulted in a more accurate weights of the parameters.

6.2 ANALYSIS OF THE RESULTS ON A WIDER PERSPECTIVE

An examination of the research's findings is done in this part of the discussion. The findings of the travel habits of the parents who live close to the case school and other parents whose children attend elementary schools are first given some thought. A reflection is then done on the various parameter values obtained using both the MNL and ML models. The additional insights by the final questions regarding lowering the speed limit policy and encouraging more bicycle use, as well as the policies that the public favoured and disfavoured when directly asked, are then illustrated.

Travel behaviour around schools

It is clear from examining the reasons stated by parents of the example school and parents of children attending elementary schools in general that there are differences in the way the safety of the roads is perceived by the two groups which also affects the manner through which they travel with their children to school. Safety is the most important reason for the parents of the example school, which is situated next to high traffic 50 km/hour distribution road that is considered a hazardous road, for bringing the children to school by car. In comparison, work-related reasons are more of a factor to the other parents of elementary school children. This is also acutely noticeable in the travel patterns of both groups. Parents of the case school who own a car make use of the cars to bring the children more often to school than the other group of parents. This leads to the conclusion that the location of the school and the existence of dangerous 50 km/hour distribution road on the way to the school are important factors that affect the mode choice of the parents to bring their children to school. Fun and comfort appear to be the highest-ranking reason for bringing children to school for both groups. This means that there is a positive attitude toward children cycling to school.

Because the data are available about the mode choice of these two groups for the manner through which children are brought to school, a comparison is made between these groups about their attitude towards cycling more with the lowering of the speed limit policy. Through this, it can be seen that the parents of the example school are largely more positive about cycling more with the introduction of the speed limit reduction policy than the other parents of elementary school children. From this, it can be concluded that

the speed limit of 30 km/hour will be perceived as a cycling encouraging factor when replacing current hazardous 50 km/hour distribution roads and will encourage cycling more in school areas.

Weights of the attributes

To find out which factors play an important role in forming a safe image of the road for the road users, the weights of five elements with respect to the safety perception that are still discussion points in the GOW30 debate are estimated. First, the weights from the MNL models are reflected upon, next, the weights of the ML model and its implications are elaborated.

When the entire sample is considered, it becomes clear that adding parking places and speed displays have no bearing on whether or not road users perceive a road to be safer for letting children cycle on. Despite the fact that studies demonstrate that parked cars and cars opening their doors do cause bicycles to change their cycling course and cause collisions (Richter & Sachs, 2017). The inclusion of this component in the survey did not arouse enough distaste among the entire sample to cause them to avoid the choice sets that include the presence of parked cars.

Comparatively, a study by Lee et al. (2006) demonstrates that installing speed displays in school zones leads to cars lowering their speed. As a consequence, this approach reduces the speed limit for cars effectively. However, when evaluated subjectively, this attribute did not make the roads be seen as subjectively safer for allowing kids to cycle on their own to school. Therefore, when the preferences of the whole sample are aggregated, the addition or the removal of both of these elements would not generate a feeling that a safer cycling environment has been created.

By comparing the values of the alternative specific constant for the 30 km/h speed limit and the attribute of separated cycling lanes, it is evident that the differences between the two parameters are minimal. These two factors are approximately equally important to the respondents. This suggests that if only these two factors are taken into account, the impression that a safe environment for cycling has been established will not increase if one is removed and the other is added. Having said that, the presence of these factors significantly heightens the sense of safety and does indeed foster a supportive cycling environment. In addition, the sample population gave the priority of crossing for cyclists a high attribute weight, indicating that the implementation of this measure did make the road appear safer to let children cycle on, on their own.

The most striking difference between the segments of the sample is that two groups, parents and road designers, are shown to have a significant dislike for the existence of parked cars. In an internal Royal HaskoningDHV interview, two road designers were questioned about why there would be a difference between road designers and non-road designers regarding the presence of parked vehicles and parking spots. The most prevalent response to this question was that road designers are more acutely aware than non-road designers of the objective risks of having parked cars on the road, particularly near school zones.

Therefore, compared to road planners who often deal with such issues, the latter group may not be as aware of the actual risks associated with parking cars close to school zones.

The parents' dislike of the existence of the parking attribute may also be due to their awareness of the dangers of having parked vehicles along the roads as it is found in the literature (CROW, 2012b). Having said that, the weight of this attribute compared to the others seems to be minor. This means that for the parents the speed limit, the cycling lane existence and giving priority for crossing for cycling children have higher impact on the feeling that the roads have become safer to let children cycle on. Parents (in general) are less sensitive towards providing crossing priority for the cycling children than non-parents and this could be because parents take the impulsivity of children in mind and their ability to follow traffic rules or because there is less trust to auto mobilists to obey the priority rules.

In contrast to the group of people who have children whatever their ages may be, it is notable that neither of the two groups, who are distinguished by the fact that they are parents of children who attend primary schools, expresses any significant dislike for this feature. Parents of elementary school students in general and those of the case school do not have a strong dislike for the parked vehicles feature. This could be caused by the fact that in the group of the parents of the example school no road designers are found and in the group of other parents of elementary school children fourteen people identified themselves as road designers. While on the other hand, in the group of parents in general around eighty five people of this group identified themselves as people who do road designing as profession. This may have had an influence on the perception of safety for this element as it is found significant for the group of road designers.

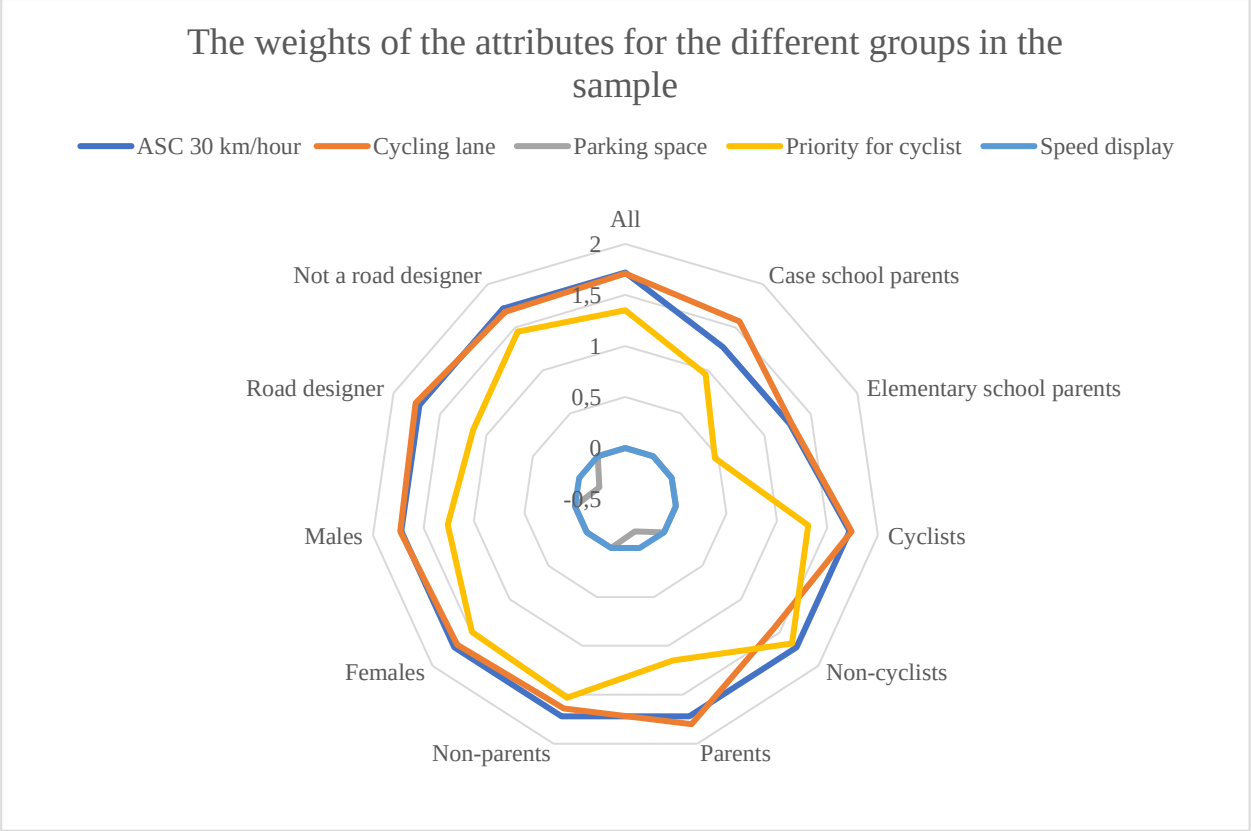


Figure 13 Differences in the perception of safety for the various elements included from the different groups of the sample population

What is apparent is that there is no significant variation between the two genders' preferences for this feature. This contradicts research by Aldred et al. (2016), which found that women were more likely than men to favour keeping bicycles and motorized cars apart. The culture in which the experiments are conducted may be responsible for this discrepancy in the results. In contrast to the Netherlands, where this research was conducted, Aldred et al. (2016)'s research was carried out in Wales and England, which may have different cycling cultures. The cycling habits of the two genders in these two European nations can be related to the disparities in cycling culture and genders between these nations. According to reports, men ride more than three times as often as women do in the UK (Harker, 2019), however, there are no significant disparities between men's and women's cycling habits in the Netherlands (Goel et al., 2021). From this, it can be concluded that males and females in the Netherlands have no difference in the subjective safety perception for the segregation of cyclists from motorized vehicles.

The preferences and values of the parameters for the priority of crossing for bicycles do, however, vary between the groups that compared the cycling habits, the road designing profession and the parents and non-parents. To the best of our knowledge, no prior research has been done on the preferences of the crossing, therefore there aren't any standards or points of comparison that might be used to assess these variations. Nevertheless, some estimates based on knowledge of similar matters could be made regarding some of the differences. In the case of parents and non-parents, it is possible that parents lack confidence in their kids' ability to follow priority rules due to their impulsivity and prefer infrastructure measures that

separate the children from other road users, placing a higher value on the infrastructure than on the road users' ability to communicate and adhere to the rules. This is also the reason given in the interview with the two experts of Royal HaskoningDHV about the differences in the values of the parameters between road designers and non-road designers. The differences in the values for the priority rules between cyclists and not cyclists can possibly be caused by the effort needed to communicate and understand the behaviour of both road users where the cyclist is the more vulnerable partner in this manoeuvre. The communication and understanding between the two types of road users put stress especially to the cyclists who are also the party that is also moving more physically and whose body needs to adapt to the environment and weather. Therefore, this extra concentration and stress are potentially less preferred by the cyclists than the non-cyclists. This can be confirmed by the study done by Pejhan et al. (2021) that states that in complex traffic scenarios the cyclists' mental stress is affected despite having lower speeds on the road.

Lowering of the speed limit and cycling

Lowering of the speed limit for cars has been shown to have an impact on bicycle use. This positive attitude is most noticeable among those who already cycle. As no previous study done that considered the attitude towards a specific policy as the lowering of the speed limit in cities policy which is dominantly existent in the Netherlands, no comparison between the results of this research and previous literature can be done. It is found in this research that people who already cycle have expressed a desire to cycle more if the speed limit for cars is reduced. And the willingness to cycle more with this policy rises with the frequency of the cycling habit of the respondents. With the implementation of this policy, only 22% of people who do not cycle have stated that they will cycle more. This could be due to this group's preference for cars or other modes of transportation, meaning that providing a safer cycling environment would not be an incentive to use the bicycle more in day-to-day travel.

Even though 37% of respondents stated that they would cycle more if vehicle speed limits were reduced, the majority of people stated that they would not cycle more or did not know whether they would cycle more. This means that the policy is insufficient as a motivator for people to cycle more. Nevertheless, the amount of people who stated that they would cycle more is not insignificant. As a result, there is an indication that lowering the speed limit creates an encouraging cycling environment in Dutch cities for the whole population.

Preferences for road safety enhancement measures

A latent question in this research is to find out what, according to the sample, is the most effective measure that are recommended to be implemented specifically around school areas to make the roads safer for the cycling children, and how would the public's preferences be with the direct asking approach. The most frequent answer was a separated cycling lane which was chosen more often than the second in line, which is the lowering of the speed limit followed by restricting the number of vehicles. At the end of the list are the measures that target bicycle users, i.e., enforcement of helmets for cyclists and fines for using mobile

devices while cycling. Although reports show that many accidents happen due to the last two factors (Metting et al., 2016; SWOV, 2020), the respondents have implicitly identified that the measures should be targeted towards the vehicles or protection from the vehicles. Interestingly, restricting the number of vehicles in cities was not the most chosen measure as the vehicles are the source of the hazard on the road. Instead, respondents have preferred prevention methods, for example, separated cycling lanes rather than removing the hazard, in this case, the vehicles.

In the direct questioning approach, the preferences for the separation of cycling lanes do go along with the findings of Aldred et al (2016). In this study too, females chose more often the separation of cycling lanes than males. This study also confirms the research done by Useche et al. (2018) which states that cyclists have a particular preference towards separated cycling lanes. Therefore, with the direct asking approach these differences become apparent between the groups while in the choice situations approach while using a child as a proxy that needs to be protected no differences can be found in the preferences towards separated cycling lanes among the studied groups.

The relatively low amount choice for measures that targets cyclists and their behaviour gives the impression that the respondents recognise the hazard to be from the vehicles and that the measures enhancing the safety of cyclists should be aimed towards this type of modes of transport. Even though the indications all state that respondents want measures aimed to protect cycling children from motorized vehicles, the choice that was given that suggests restricting the number of vehicles in cities was chosen by 10% of the respondents. This gives the impression that participants would prefer having measures that prevents children to come in contact with vehicles rather than lowering the risk of crashes by limiting the number of vehicles in school areas.

Even though punishments for speeding vehicles were chosen less often than other options, 5% of the respondents still chose for this measure to be the most effective measure to increase the safety of cycling children. This is not reflected in the choice situations where speed displays are put as a traffic calming measure. This leads to the conclusion that calming and enforcing the speed limit on the road is important for the respondents but placing speed displays may not be the best measure to achieve this goal to have the intended impact on the public.

Lastly, lowering the speed limit for cars ranks high among the measures presented even in the direct asking approach. The difference in the ranking may be caused by the limitation of the option to select more measures than one as it was noted in the “other” option by many respondents. Moreover, imagining the velocity of moving vehicles in both high or lower velocities is a difficult task to do for humans and is hard to recall (Lidestam et al., 2019). In comparison, physical objects are found to be easier to imagine than moving objects or concepts (Snow & Culham, 2021). Additionally, the choices for the choice situations that were the most divisive (around 50% for both alternatives) are choice sets 4.1 and 4.4. In both of these two situations, the trade-off that was required for the respondents is to choose according to the speed limit

or for the existence of separated cycling lane which caused the division in the choice, making the weights of both of these elements almost equal in practice. Therefore, the trade-off approach can better estimate the real choice behaviour of the population instead of the direct asking approach which goes along with the findings of Daniel et al. (2022). Finally, the fact that the overwhelming majority of the respondents of this study are cyclists, the preference for the measure of the separation of cycling lane in a direct questioning approach confirms the finding of a recent study that is done by Berghoefer & Vollrath (2022) where a qualitative survey is done on the preferences of cyclists for different measures. In this study too, the highest-ranking measure is chosen to be the segregation of cycling lanes from motorized vehicles with the direct questioning approach.

Conclusion

7 CONCLUSIONS AND RECOMMENDATIONS

The primary findings of this study are presented in the report's last chapter, together with answers to the research questions posed in the introduction. Additionally, recommendations for the policymakers are provided in this part based on the study's findings. The conclusion ends with recommendations for future studies that can enhance the findings of this study and offer a wider perspective on the topics that are pertinent to the GOW30 discussion.

7.1 CONCLUSIONS

The weights of the attributes from subjective preferences in relation to road safety from various categories of road users are examined in this study using quantitative research methods. This is done to determine the impacts of the inclusion or removal of particular elements on the perception of road safety, which is known to have a substantial influence on the decision to use the bicycle (Riggs, 2019).

To evaluate the subjective preferences of the road users for the relevant elements, various discrete choice models are created in this study for the different segments of the sample. Children are used as the focal point to elicit preferences from the respondents, who are then asked to select the road that appears safer for children (ages 8 to 12) to cycle on their own. The goal of this inquiry is to underline the importance of safety while also allowing for the examination of findings using the Random Utility Maximization (RUM) theory. The weights of the attributes in relation to only the safety considerations are calculated using this method.

7.1.1 Research questions

The design features that are still in the grey area of the GOW30 discussion are chosen based on interviews with road designers. Out of the many factors that are still disputed in the GOW30 discussion, five attributes are chosen to be studied. In addition to that, the demographic factors of the population are also narrowed down to the most relevant groups. The groups identified are found in the literature to have specific preferences and behaviour on the road. Through this, an answer is given to the main research question which is:

“Which policies and measures are perceived to increase the safety of roads for children cycling to school?”

When the entire population is considered, removing parked vehicles and parking spaces will not promote the perception of a safer cycling environment. This also applies to speed displays. The installation or removal of these two elements had no effect on the perception that the roads have become more or less safe for children to cycle on. On the contrary, it has been discovered that the speed lowering for car speed on the road, bike lanes, and the priority of crossing have a major impact on the impression of safety. Although the speed limit of 30 km/hour is chosen more often than the other alternative of 50 km/hour roads, in some situations latter speed limit was chosen by the respondents as the road containing the elements that make

the roads seem safer. Therefore, the speed limit of 30 km/hour does not make any road seem safer. Rather the combination of elements within it plays a crucial road in perceiving a safe road.

Cycling lane separation and speed limits are found to be equally vital to the entire population. Giving cyclists priority for crossing creates a positive feeling that the road environment has become safer. However, the weight for this attribute are lower than those for the previous two. Nevertheless, providing crossing priority for cyclists does generate positive attitudes from the population that a safer cycling environment is created.

"What are the differences in the perception of safety towards the various elements from different groups in the population?"

The values of the parameters in the different models for the different groups are compiled and presented in Figure 14.

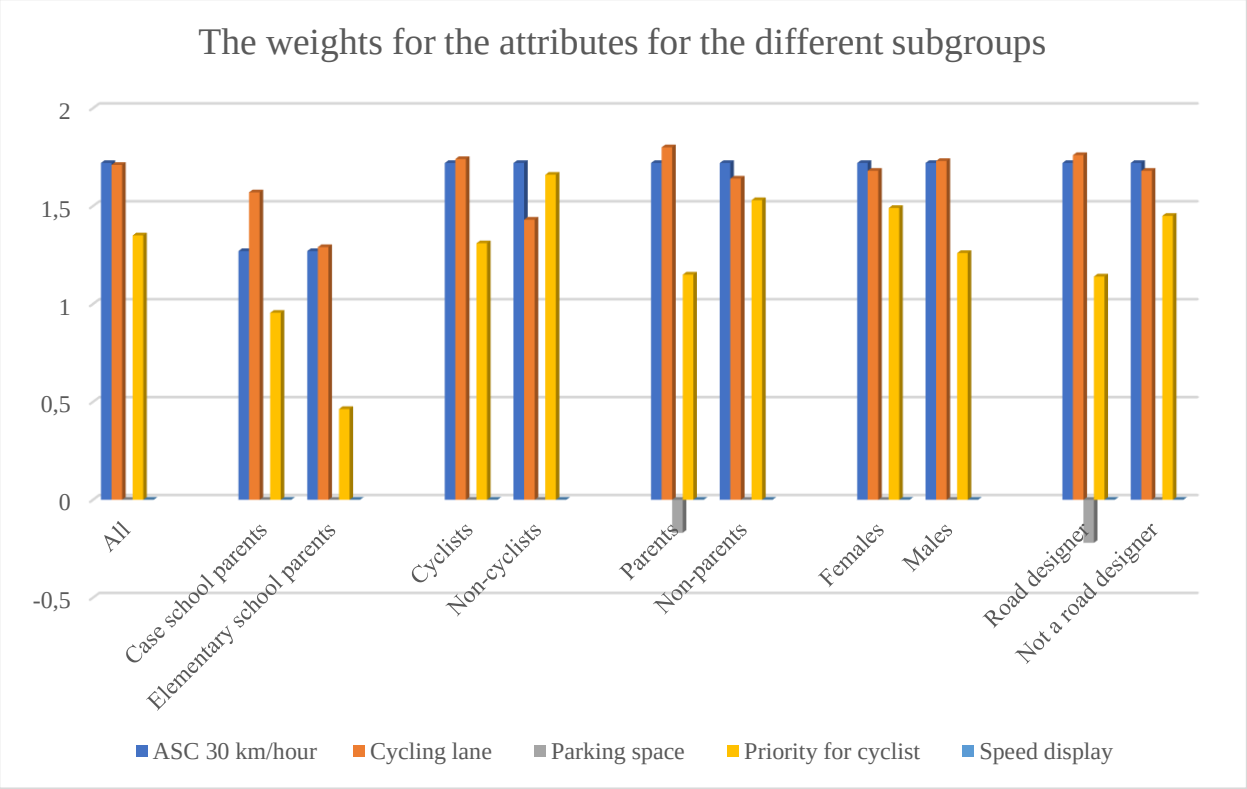


Figure 14 Taste and distaste for the different elements included in the experiment from different groups of the sample population

The discrete choice MNL models that include the dummy variables of the different subcategories that are set to consider the differences, show various results compared to the model that includes all respondents. It is clear that the existence of separated cycling lane is more important for the parents who bring their children to schools that are situated next to hazardous roads than other elementary school children's parents. The segregation of the cyclists with the motorized vehicles is for the first group more important than the speed limit on the road of 30 km/hour. While the two factors are more or less evenly important for other parents

of elementary school children. The priority of crossing for cyclists is the least significant factor for both groups.

Cyclists have a more preference for the separation of the cycling lane than non-cyclists, while the priority for crossing for cyclists is preferred more by non-cyclists than by cyclists. The separation of the cycling lane is evenly important to the speed limit of 30 km/hour for cyclists. Non-cyclists are however less sensitive to the existence of separated cycling lanes than the speed limit for cars.

It is shown that parents (in general) do recognise the parked vehicles as a factor that hazardous and compared to the non-parents, parents have a distaste for this attribute. The value for this parameter is however small compared to the other significant attributes. Nevertheless, the removal of this factor from the roads makes the road seem safer to let children cycle on for the parents. There is also a significant difference between the values of the parameter for the priority of cycling lanes for the two groups. The parents are less sensitive to the existence of this rule around school zones than the non-parents. And interestingly, no significant differences found in the preferences and safety perceptions of the two genders.

For the parents of children that attend primary schools, the removal of parking spaces has no impact on creating a safe cycling environment. Therefore, implementing this measure around currently hazardous GOW50 roads will not be enough to let parents feel that a safer cycling environment has been created for their children.

Lastly, similarly to the group of parents, road designers have also a significant distaste for the existence of parking vehicles and parking spaces compared to the non-road designers. The value for this parameter is the lowest for the road designers compared to the other significant parameters. Non-road designers value more the existence of a priority rule for crossing for cyclists than the road designers.

It is remarkable that the value of the attribute for the speed displays is insignificant for all groups making the addition of this element on the roads obsolete when the intended effect is the encouragement of cycling behaviour due to enhancement in the subjective safety of the roads where this measure is implemented.

“Which methods are adequate to gain insights about the weights of the different elements from a subjective perspective in relation to safety perception??”

When comparing the outcomes of the ML model and the MNL model, it can be determined that the Mixed Logit model performs better and reflects the taste heterogeneity of the respondents' responses using the Bayesian Information Criterion. As a result, the mixed logit model is the one that best accounts for the respondents' decision-making process. Despite this, there was little to no large changes in the values of the best performing MNL model, which includes the dummy variables for road designers and non-road designers. The parameters' directions and the order in which the values were ranked remained unchanged. Because of this, the MNL models can be used to provide an indication of the parameter values, and more sophisticated ML models can be used to determine the parameter values more precisely.

“To what extent does safety play a role in the choice of the mode of travel for parents around schools?”

An earlier study has revealed that when parents consider the roads as unsafe the percentage of parents that take their children to school by bike gets lowered (VVN, 2018). To find out to what extent safety plays a role in the travel mode choice in relation to the GOW30 discussion, two groups are compared. The first group is parents of children attending de van Oldenbarneveltschool elementary school which is situated next to a hazardous GOW50, and the other group is other parents of children attending elementary schools. It is evident from the results that when the roads are perceived unsafe, there is a tendency of using the car more. De van Oldenbarneveldschool is situated next to a particularly dangerous road and through the mode use behaviour of the parents it can be concluded that safety does play a big role in this area to bring children to school by car instead of other modes of travel. The difference between bringing children by car by the parents of the example school is significantly larger than the similar group of parents and therefore a conclusion can be made that dangerous GOW50 make it likelier that cars would be used for bringing children to school.

On the contrary, the reason of “fun and comfortable” is the highest chosen reason to bring children to school by bike for all parents of children who attend elementary schools. This means that cycling is experienced positively as a mean that generates rejoice while cars are predominately used for necessities and safety reasons.

“To what extent does the lowering of the speed limit policy play a role in encouraging people to cycle more in school zones?”

It is clear that the lowering of the speed limit does play an important role as an encouraging factor to let people to cycle more. Around 37% of the respondents have stated that this measure would be a factor to cycle more in the future. This factor is shown to be preferred more by people who use the bicycle as their day-to-day mode of travel. Moreover, the positive attitude towards cycling rises with the frequency of the use of the bicycle. Therefore, this policy is considered to be preferred and has the potential to let the people who already cycle to cycle more. Nevertheless, there is also a portion of the population who does not cycle and would consider cycling when this policy is introduced. For that reason, this policy is seen to have a significant impact on creating a cycling encouraging environment.

Relating this to the travel behaviour of parents traveling to the schools, the percentage of the parents of the example school are found to be the most positive group for the suggestion to cycle more with the introduction of this policy. Therefore, this policy is expected to encourage the cycling behaviour in particular in school areas that are currently located in the surroundings of a dangerous GOW50 road.

7.1.2 Recommendations for policy makers

In this subsection, recommendations for the policy makers are given depending on the results of the research.

GOW30 and GOW50

Respondents strongly prefer the 30-kilometer-per-hour speed restriction as a factor that improves the feeling of safety of the roads for cyclists. To appear safer for bicycle using, it is essential to combine this feature with other elements on the road. Equally important for the road user as the speed limit of 30 km/hour is the separation of cycling lanes. Therefore, if the goal is to make cycling safer for everyone, the separated cycling lane component is essential in making the roads appear safer and removing it or replacing it with 30 km/hr roads does not result in an improvement in this perception. However, due to a lack of space in some locations, this measure is challenging to execute. To accomplish the intended result of making the roadways safe and inviting for cycling, further measures must be implemented in this scenario. In addition to lowering the speed limit, other actions that can be taken include establishing priority for cyclists to cross at intersections. This combination will be perceived safer than a 50 km/h road with a dedicated cycle lane and no priority for cyclists to cross at intersections. Relatedly, the availability of separated bike lanes and the provision of priority rules for cyclists can be established, giving the impression that safer roads are constructed, when some roads are regarded to be too important to retain their 50 km/hour speed limit.

From the literature it was found that parking spaces have an impact on the safety of the children. Therefore, the removal of these vehicles from the roads will make the roads safer for people to cycle on. Having said that, the perception from the public is that no safety feeling is generated when this measure is implemented. Only the groups of road designers and parents in general do see this as a positive improvement on the roads, but it has minor effects compared to the other significant attributes. No significant distaste was found among the groups of parents of children attending elementary schools. The importance and the effects of removing parking spaces needs to be emphasized and also compared to other measures so that the real picture can be seen by the parents. Through this, the encouraging effect of the removal of the parking spaces would be better felt and less use of cars can occur. For this reason, a campaign could be initiated before and after the implementation of the policy to spread awareness of the benefits of this measure so that support can be generated, and a feeling can be created that a safer road has been created. This is also applicable for the speed displays. For this element, no group is found to have a preference towards, and this is also substantiated with the open question approach. Therefore, from the insignificance of parameter of the speed display it can be stated that only hanging boards that state the speed of the vehicle and the speed of the board is not sufficient to make roads seem safer for road users more enforcement measures need to be placed or additional elements need to be introduced to have the effect of creating roads that are perceived safer by the population.

School zones

Making school zones and vulnerable road users safer is the primary drive behind the Dutch cities' policy of lowering the speed limit for cars. However, "school zone" is a somewhat ambiguous concept that is not quantified in concrete ways. A school zone is defined by DHV B.V. (2011) as the vicinity of a school where many child streams congregate where parents pick up and drop off their kids in this area. There are already rules on road design in the immediate vicinity of the school in the CROW manual (2019). One of the requirements already set is that the speed limit on roads adjacent to schools should be 30 km/h. As a result, since these roads already have or advised to have 30 km/h speed limit cars, the policy of lowering the speed limit for cars will not have an impact on the immediate surroundings near to schools. As a result, the definition of the school zone must encompass more than just the immediate vicinity of the schools. For instance, one of the boundaries of a "school zone" can be the typical distance that a child must commute to school in each city. Taking the example of Rotterdam, the average distance that a child cycles from its school is found to be 500 meter (Haddou & Van Uffelen, 2020). This distance can be the new definition of a school zone where it is identified as the average distance that a child needs to cycle to his/her school so that the effect of the lowering of the speed limit policy can be felt with the recommended elements.

7.2 RECOMMENDATIONS FOR FURTHER RESEARCH

In this subsection, recommendations are made for future research based on the methods, results and scope limitations of this research.

Improved questioning style

Images are utilized in this study to make the survey seem more realistic, which is believed to increase the reliability of the findings (Holmes et al., 2017; Steine et al., 2005; Van der Waerden, 2006). The time limit established for the survey's completion and the advantages of the use of this method to get the results needed for the research questions led to the decision to utilize this method. However, there are some limitations of the use of this technique. It is here assumed that the respondent will independently feel the speeds of 30 km/h and 50 km/h, which could be challenging depending on the respondent's recollection and experience. This is a drawback of using photographs because the respondent cannot perceive moving items naturally. The realism could be increased by showing respondents video footage of actual events involving moving vehicles. Using this method also enables the consideration of additional elements, the effects of which may be measured in connection to the subjective safety judgment, such as public transit, multiple users of the bicycle lanes, and manoeuvring automobiles close to the cyclists. Videos are more realistic than still images because they allow respondents to observe how road users move and determine how other drivers will act based on their own driving. For these reasons, the use of video images in future survey is recommended.

Inclusion of additional elements

The weights of five attributes related to the GOW30 topic are examined in this study. This restriction on the number of components is necessary in order to study a limit set of less than six qualities, which allows for a manageable number of option scenarios and trustworthy conclusions. Additionally, this affects how long it takes responders to complete the survey. As a result, it is possible to research additional factors that are still up for discussion in the GOW30 discussion, such as the type of pavement and the position of the bus stops.

Survey design

Ngene's creation of orthogonal designs is used to build the choice scenarios for this study. The benefit of this approach is that it preserves the balance of the attributes at the level of choice. The main disadvantage of employing orthogonal designs is that they do not lead to the most effective designs that reduce the standard error of all parameter values (Chorus & Moilin. 2020). Priors should be supplied to Ngene to allow for the creation of efficient designs. Previous studies with similar circumstances and objectives should serve as the source of the prior values. However. no research that used the same kind of questions and context to investigate the values of the parameters for the qualities employed in this study could be located. The use of efficient designs improves choice set designs and establishes a rough estimate of the population size required to obtain significant values for all attributes. However. this study's findings can be applied to future research to produce effective designs.

Focus point of the survey

Children are used in this study as the choice scenarios' focal point to stress the road elements' safety features. However, not everyone values safety equally for themselves as a deciding element when choosing to use the bicycle or a route of travel. Because of this, it is intriguing to compare the values of the parameters used in this experiment, which focused on children, to those used in a subsequent experiment, which would focus on adults or the respondents themselves.

The trade-offs between safety-enhancing interventions and modal shift are also not examined in this study. In order to avoid taboo trade-offs regarding the security of children, who are regarded as vulnerable members of society, this is done. The consequences of implementing certain measures on the shift in the mode of transportation can be the subject of future research.

Extension of the study area

In this study, an example school in Rotterdam is used to draw comparisons between the behaviour of parents and their attitude towards cycling with other parents of children who attend primary schools. The choice of this school is done to its proximity to a dangerous GOW50 road. From the result it is found that the parents of the example school have a different travel behaviour and attitude towards cycling more with the implementation of the lowering of the speed limit policy than the other group of parents. To validate the

results , it is recommended to study the behaviour and preferences of parents going to other schools that are in a close proximity to dangerous GOW50 roads and perhaps in other cities. Showing similar results will confirm the findings of this study that parents around currently dangerous GOW50 roads have different travel behaviour than other parents and the implementation of the GOW30 roads will have more significant impact on the future travel behaviour of these parents in specific.

Latent classes

In this study, it became clear that adding dummy variables for the subcategories of people with interaction with the attributes improved the models' performance. It is clear that some personal traits have enhanced the models' rho values more than others. However, the insights and suggestions that can be made for practical reasons are relatively constrained when personal trait attributes are only included as interaction variables in separate models. To generate more complex policy recommendations about the behaviour of different groups of the population, a latent class model, which sparingly finds segments of respondents with similar likes can be utilized in further research.

Use of revealed preferences

Another suggestion for future research is to combine the outcomes of this stated choice preference with revealed preference choices. The final model's validity is increased by using revealed preference, which takes up greater time but shows the choices that were actually made rather than relying on hypothetical ones. According to this study, some factors have significant effects on people's perceptions of the safety of the roadways, while other factors have little to no impact. Investigating the effects of putting different elements at various locations on the choice of road, route, or mode of transportation could provide interesting outcomes and findings. The fact that this research focused on a particular group of individuals in a particular location was advantageous. This can also be used to examine changes in travel patterns brought on by the implementation of specific measures in school zones, as well as the impact of these components on attracting more cyclists or the use of bicycles on these roads. The restriction of the unintentional assumptions brought on by the inclusion of visual material in the stated choice experiment would also be resolved by employing revealed preference.

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APPENDICES

APPENDIX A: SCIENTIFIC PAPER

Primary Rules On The Way To Primary Schools

M.W. (Marc) Tem Temi

To obtain a degree of Master of Science in Transport, Infrastructure and Logistics
Delft University of Technology, Delft, The Netherlands

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Abstract

With an increase in interest in putting people on bikes instead of driving vehicles for day-to-day transport, new regulations ar being implemented to make roadways safer for cyclists while also encouraging cycling behavior among various segments c the population. The perception of safety has been proven to play a significant role in the decision to adopt active forms c transportation. The significance of this feeling is underlined even more when it comes to vulnerable road users, in this case cycling children. This study seeks to provide a better knowledge of the road conditions that increase the perception of roa safety in order to establish a safe and encouraging cycling environment for adolescents cycling to school. The preferences c different categories of the population toward various measures are explored using the stated preferences experimen Furthermore, with the adoption of the new lowering of the speed limit policy, the attitude toward a growth in the usage c bicycles is done. According to the findings of this study, different sectors of the public have distinct perceptions an preferences toward the numerous aspects shown on the highways. The presence of separated bike lanes, a speed restriction c 30 km/h, and a priority for crossing rule for cyclists are discovered to be components that all groups in the sample strongl prefer. Parking on the country road is limited to the groupings of parents and road designers. Finally, the presence of spee displays is discovered to be negligible for all subgroups in the sample population as a measure that has no influence on makin roads safer for children to cycle on. Furthermore, it has been discovered that parents who bring their children to schools tha are now located near unsafe GOW50 roads have a more positive attitude toward cycling following the implementation of th speed limit policy. More aspects that were discussed in the GOW30 debate could be included in future study to gain a bette understanding of the impact of the various elements on providing a safe cycling environment for children. Furthermore, recommendation is made to examine the behavior of parents in other locations that are also in a close proximity to hazardou GOW50 roads and to incorporate the features of other respondents in order to corroborate the findings of this study.

Keywords: Subjective safety, cycling children, road infrastructure, stated preferences, GOW30

Introduction

Cycling is a sustainable mode of transport that is both accessible for most groups of the society and beneficial for the mental and physical safe of its users (Useche et al., 2019). There are many reasons why people choose to cycle instead of other more conventional modes of transport. The feeling of safety is reported to be one of the important elements that influences the decision to travel by bike (Márquez & Soto, 2021). This sense of security is especially crucial for vulnerable road users, particularly cycling children (Riggs, 2019). According to Riggs (2019), when parents perceive a route to be dangerous, they are less likely to let their children to cycle or walk on it. As the number of cyclists in the Netherlands grows (Netherlands Institute for Transport Policy Analysis (KiM), 2018), so does the number of cyclist-involved crashes (Centraal Bureau voor de Statistiek, 2020). Given that cycling children in the age category when they start cycling on their own are the highest group of the population that receives first aid treatment and are increasingly involved in bicycle crashes (VeiligheidNL, 2014), as well as the fact that the majority of traffic crashes occur on distribution roads with a maximum speed of 50 km/h (Ministerie van Infrastructuur en Waterstaat, 2022). The Dutch government has implemented a new regulation that reduces the speed restriction on city distribution routes from 50 km/h to 30 km/h, with the goal of improving the safety of cycling environments in school zones (Tweede Kamer Der Staten-Generaal, 2020). The implementation of

this policy is predicted to reduce the number of road fatalities and serious injuries by 22% to 31%. (SWOV, 2019). The impact of this legislation on people's attitudes regarding cycling and their desire to cycle more is unknown. Furthermore, the introduction of the reduced speed restriction on distribution roads in Dutch cities introduces a new form of road that does not yet exist in the Netherlands, known as distribution roads 30 or GOW30 (CROW, 2022). The combination of features and measures that must be included on these roadways is yet unknown, and numerous arguments are still taking place about what the strategy is and under which conditions these combinations must be adopted or executed.

A study conducted by Tehrani et al. (2015) demonstrates the relevance of including the public's preferences and perceptions on various elements on the road in policy decision making and execution of design elements to achieve the intended effect of any policy or measure on the road. The Dutch government's general goal is to stimulate and encourage the use of bicycles (Tweede Kamer Der Staten-Generaal, 2018), which, when combined with the fact that the GOW30 roads are intended to increase the safety of cyclists in school zones, creates an opportunity to design new roads that are encouraging to cycle on. Considering the importance of safety in the decision-making process of choosing to cycle instead of driving or using motorized vehicles, and the weight of this element is even more emphasized when it comes to children, who are considered vulnerable members of the population (Bagattini, 2019), and the fact that society tries to protect this group (Paul, 2019). The study's goal is to incorporate road users' preferences and perceptions of safety into the decision-making process for building roadways that are regarded safe for cycling children around school locations. As a result, the research question is presented as follows:

“Which policies and measures are perceived to increase the safety of roads for children cycling to school?”

Methodology

Several approaches were used in this study to answer this question. The first step in the process is to identify the parts that comprise the grey area in the GOW30 discussion. This is accomplished by a review of the reports and documents that explain this issue, as well as conversations with policymakers and consulting specialists. Following that, factors influencing cyclist safety and cycling child safety are sought in order to explore why these characteristics are viewed or identified as elements influencing cycling child safety. The elements that are still being discussed in the GOW30 discussion and play a role in children's safety are then highlighted. The second part of the method involves selecting an example case of a school that is located near a dangerous GOW50 road. This is done to identify the differences in the travel habit in a hazardous school zone and the perception of safety towards the different elements between this group and similar group in the population. Furthermore, this step is done to create a context to use it in the data collection process of the respondents. The third step entails creating a stated preferences experiment with the elements chosen to study their weights from the subjective perspectives of various public groups. The weights of the various elements are first determined using a Multinomial Logit (MNL) model. A Mixed Logit model with a panel data structure is applied to the best performing model to capture taste heterogeneity and investigate whether using a more advanced model changes the differences in weights of the different attributes and the direction of the weights from the MNL model so that the more appropriate model type can be used in future research using the same data collection method as this study. Finally, the attitudes of various groups of the sample population toward the policy of lowering the speed limit are investigated, with the opportunity to state their preferred measure that increases the safety of cycling children.

Selection of factors

Through interviews done with two experts from policymaking organization and two experts from a mobility consultancy, the elements that are still a grey area in the GOW30 discussion are identified. Through this, the factors that can be selected to identify the weights of through a subjective point of view in relation to safety perception. These elements are:

Table 1 Factors that are points of discussion in the GOW30 theme

Factor	Discussion point
Surroundings	The intention is to have only roads that are 30 km/hour inside the cities and make the distribution roads that have a higher speed limit outside of the urban areas. This is however in some cases difficult to implement due to the importance of the certain distribution roads inside the cities.

Priority rules at intersections	Priority rules on distribution roads that have 30 km/hour speed limit is not yet defined as there are no priority rules on the traditional residential roads that are 30 km/hour.
Position cyclists to car	As the speed difference between the different road users is minimized the necessity for separation needs to be reconsidered.
Pavement	The type of pavement determines the image of the road and makes it possible to enforce the speed limit on the road by the use of various types of pavements.
Public transport position	The position of the stops of the public transport modes on the road.
Parking for vehicles	Restricting parking in some places for their impact on the safety of cyclists and the flow of the roads. Parallel parking only allowed on distribution roads.
Demarcation	Introduction of new type of road leads to new division of the road with different priorities and space usage.
Speed regulating measures	The use of speed regulating factors should be preferably incorporated in the road. There are however some concerns about the effects of some of factors on the flow of vehicles and public transport users and drivers.

After relating these factors to the safety of cycling children, five attributes are chosen to be studied based on an interview with the same professionals interviewed to investigate the weights of based on the subjective preference and safety perception from different groups of the population. These elements are:

Table 1 The chosen elements to be studied

Element	Group it belongs
Speed limit of 30 km/hour or 50 km/hour	Surroundings
Cycling lanes/paths	Position cyclists to cars
Giving priority at intersections to cyclists or cars	Priority rules at intersections
Availability of parallel parking or not	Parking for vehicles
Speeddisplays	Speed regulating factors

Selection of example case

The study is designed to collect quantitative weights of the various elements from various groups of the population. And, because the GOW30 roads are still non-existent, the stated preferences method is used to collect public preferences and perceptions of the various elements included to be investigated. Because the elements to be investigated are physical elements on the road that are perceived differently by different people, it was decided in this study to use images to improve the validity of the results (Jansen et al., 2009). To increase the experiment's credibility and to study the differences in travel behaviour and attitude toward the lowering of the speed limit policy of parents who bring their children to schools in the vicinity of particularly hazardous GOW50 roads from a similar group of parents in the population, a specific location is chosen to serve as the base case in the stated choice experiment.

The choice of the location of the example school is done by sieving dangerous GOW50 roads in the city of Rotterdam which is notably a car-oriented city in the Netherlands. Furthermore, the locations of various schools that are situated in the average cycling distance for children in the city from the identified roads are located. Then one of the schools that is in a location which is in a close proximity to a hazardous GOW50 road is picked to use as case in the survey.

2D images are taken of this road to use as a basis for alternative roads which are integrated in the image of the base case. Similar roads are sought that have similar characteristics as base road to enable the integration of the other road images in the base road image. Distracting elements are removed from the various images to keep the focus of the respondents on the elements that are included in the images.

Figure 1 Processing of the image of the base situation

Figure 2 The incorporation of similar roads in the base image

In this experiment, respondents are asked to choose roads that for them seem safer to let children to cycle on on their own. The motivation for this question is that the road containing the the elements that seem safer by the respondent is chosen based on the safety factor and safety feeling rather than gains or losses in other aspects. Through this method, it can be possible to analyse the results according to the Random Utility Maximization theory.

A pilot survey is made with 12 choice sets that were generated with the choice set designing tool Ngene. With 34 people completing the pilot survey, five dominant alternatives were found and taken out of the survey while the remaining choice sets were kept to be shown to the larger group of the population.

The gathered responses

486 responses made completed the survey. As not all responses were useful or permitted to be included, cleaning of the responses happened after which 441 responses were deemed as useful and are according to the purpose of the study. The respondents were from divers backgrounds and subcategories of the population. The different groups of the respondents do no directly reflect the various categories in the Dutch society but every group is considered to have enough people to gather information and preferences from. The distribution of weights by respondents is first modelled using an MNL model, with the utility functions presented as follows:

$$U(30) = \text{ASC30} + \beta_{Cycling\ lane} * Cycling\ lane - \beta_{Parking\ places} * Parking\ places + \beta_{Priority\ for\ cyclists} * Priority + \beta_{Speed\ display} * Speed\ display + \varepsilon$$

$$U(50) = \beta_{Cycling\ lane} * Cycling\ lane - \beta_{Parking\ places} * Parking\ places + \beta_{Priority\ for\ cyclists} * Priority + \beta_{Speed\ display} * Speed\ display + \varepsilon$$

The attributes are dummy coded and the change in the value and the direction of the parameters is interpreted as the addition of the said factor. The expected changes in the parameter is according to the dummy coding of the scheme. The cycling lane value is when a separated cycling lane is existent on the road where the base is the existence of cycling paths integrated on the road. Parking spaces when parked vehicles and parking spaces are existent on the roads and the base case is where no parking spaces and parked vehicles are seen on the road. Priority for cycling is when a priority is given for the cyclists to cross at the intersection. The base case is when cars have the priority. The speed display is when speed displays are placed next to the road for to monitor the speed of the vehicles on the road. The base case is when no speed displays are existent.

Results

The results of this model for the whole sample population are as follows:

Table 1 The weights of the attributes for the whole sample population with the MNL model

Name	Value	t-test	p-value
30 km/hour road	1.72	15.9	0
Cycling lanes	1.71	15.1	0
Parking	-0.0954	-1.71	0.0879
Priority for cyclists	1.35	9.32	0
Speed display	0.0266	0.46	0.646

Subsequently, the weights of the attributes for different groups in the population are calculated with the MNL model. The value is zero when the weight is found to be statistically insigifnicant on the 95% condifence interval.

Table 2 The weights of the attributes for the various subgroups of the sample population with the MNL model

Group	30 km/hour road	Cycling lanes	Parking	Priority for cyclists	Speed display
Parents of the case school	1.27	1.57	0	0.955	0
Other parents	1.27	1.29	0	0.463	0
Cyclists	1.72	1.74	0	1.31	0
Non-cyclists	1.72	1.33	0	1.66	0

Parents	1.72	1.8	-0.129	1.15	0
Non-parents	1.72	1.64	0	1.53	0
Females	1.72	1.68	0	1.43	0
Males	1.72	1.73	0	1.28	0
Road designer	1.72	1.76	-0.22	1.14	0
Not a road designer	1.72	1.68	0	1.65	0

To investigate whether the directions of the weights change and the weights of the attributes change signficantly, the more sophisticated Mixed Logit model with panel data structure is applied on the best performing model. The best perfomring model is found to be the model that contains the dummy variables of the road designers and non-road designers with interaction terms with the attributes set.

Table 1 Differences in values of the best performing MNL model and the ML model

Name	30 km/hour road	Cycling lanes	Parking	Priority for cyclists	Speed display	Sigma
MNL						
Road designer	1.72	1.76	-0.22	1.14		
Not a road designer	1.72	1.68		1.59		
ML						
Road designer	2.04	2.14	-0.233	1.44		1.02
Not a road designer	2.04	1.95		1.66		

Furthermore, the attitude towards an increase in cycling patterns with the introduction of the lowering of the speed limit is investigated. It is clear to see from the results that different groups of the population have different opinion about this matter.

Table 2 The attitude towards cycling more with the implementation of the lowering of the speed limit policy from different groups

Group	Would use the bicycle more	Would not use the bicycle more	Do not know
All	163	225	53
Cycling patterns			
0 days	12	37	4
1 to 2 days	22	41	7
3 to 5 days	59	82	19
6 to 7 days	44	59	10
Gender			
Males	99	146	15
Females	52	97	31
Profession			
Road designer	47	82	12
Non road designer	106	153	36
Parents and non-parents			
Parents	76	117	24
Non-parents	84	118	20
Parents of the case school and other parents			
Parents of the case school	16	12	5
Other parents of elementary school children	21	42	9

Conclusion

The primary goal of this study is to investigate the role and influence of specific factors that remain to be raised in the GOW30 discussion about establishing a safe environment for children to cycle on and a welcoming setting where cycling is promoted and stimulated. The study question, “Which policies and measures are perceived to increase the safety of roads for children cycling to school?” was developed as a result. The findings of this study make it abundantly evident that some factors influence people's perceptions of safety more than others. When the perception of the general population is aggregated, it is evident that the 30 km/h speed limit, dedicated bike lanes, and giving priority for crossing for cycling children do have an impact on how safe people consider the roads to be. Out of all the factors under investigation, the first two appear to have the most of an effect on this perception. The addition of parked vehicles on the roads to school does not generate a great disliking of these roads so that this element can be perceived as unsafe for cycling children. It has been discovered that the location of speed displays does not cause any preference and improvement of the perception of the road as safe, to allow children to cycle more. It is also clear that the respondent's sociodemographic traits to some extent influence their decision to select the safer option from the alternatives presented. For instance, it has been discovered that those responsible for designing roads view the removal of parked

cars as a good step toward enhancing road safety. However, this is not the case for the parent groups that were singled out because they have children attending primary schools.

The attitude of the parents towards cycling more while implementing the reduction of the speed limit policy is investigated since parents have a significant influence in the decision of whether to allow children to cycle or be accompanied by a car to their schools. The parents of children attending elementary schools along the currently hazardous GOW50 roads in this study shown to have different attitudes. Compared to similar group of parents, the parents of the case school are more supportive of bicycle use given that the GOW30 roads are provided. Thus, this policy offers the idea that a more cycling-friendly environment has been established, particularly around schools that are along GOW50 roads, which are already hazardous.

Discussion and recommendation

There are variances in how people perceive and favor certain elements on the road that according to them insure cycling safety of children, according to the study's findings. One significant distinction is that, as evidenced by the literature, road designers do believe that removing parked cars will make roads safer (Liu & Wang, 2013). The parents of children who attend primary schools, on the other hand, do not believe that the removal of this object from the road will increase the safety of their kids or lead them to allow them to cycle unaccompanied. Therefore, campaigns could be used to inform parents of children about the effects of removing the parking spaces for their children's safety in order to have the intended effect of having a cycling-friendly environment.

A major discussion point that makes the implementation of 30 km/hour roads difficult on the current distribution roads is that some distribution roads are too essential for the flow function of cars on the road. Moreover, there are concerns about the effect of lowering of the speed limit on emergancy and public transport services. In the case that roads cannot be converted to GOW30 roads, the addition of separated cycling lanes and providing priority of crossing for cycling lanes are elements that need to be introduced from the elements that are studied to encourage the cycling safety. This does not mean that the addition of speed displays and the removal of parking spaces for vehicles will not make the roads safer but in a subjective point of view, the first two elements will ensure the creation of feeling of a safer cycling environment for children.

Only limited number of studies considered the effects of speed displays on making roads safer for cyclists and other road users (Malin & Luoma, 2020; Lee et al., 2006). These studies did show that drivers do adjust their driving behaviour on the road while approaching these displays. The placemenet of speed displays around schools is also recommended by Dutch guidelines for designing safe school environments (DHV B.V., 2012; SPV, n.d.). Having said that, no group in the studied subgroups found a significant preference towards placement of these elemenets on the road. A better understanding of this element on the road needs to happen to have the intended effect of providing the trust that through this element roads have become safer for cycling children.

This research provides new insights into the role of policies and measures on the road in relation to the perception of safety. It is clear that different elements have different weights according to the respondents and that there are more acute differences to be noticed in different subgroups of the population. The choice of the attributes is however done by questioning a limited number of people who are from certain backgrounds and the weights of these elements are evaluated in this study. It is interesting to consider other elements from other groups of people and to include more attributes in such experiments to evaluate their effect on creating safe cycling environment.

Finally, children are used in this study as the choice scenarios' focal point to stress the road elements' safety features. However, not everyone values safety equally for themselves as a deciding element when choosing to use the bicycle or a route of travel. Because of this, it is intriguing to compare the values of the parameters used in this experiment, which focused on children, to those used in a subsequent experiment, which would focus on adults or the respondents themselves.

The trade-offs between safety-enhancing interventions and modal shift are also not examined in this study. In order to avoid taboo trade-offs regarding the security of children, who are regarded as vulnerable members of society, this is done. The consequences of implementing certain measures on the shift in the mode of transportation can be the subject of future research.

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APPENDIX B: ELEMENTS IN THE GOW30 DISCUSSION

The first interview is held with two employees at Royal HaskoningDHV to ask about the elements they see important and form a grey area in the GOW30 discussion. These interviewees work in the mobility team inside the company and are busy doing infrastructural projects in the Netherlands of places that want to decrease the speed limit on the road from 50 km/hour to 30 km/hour. The interviews are held in Dutch, but the content is summarized in English in this report.

1. What do you think of the lowering of the speed limit policy?

The lowering of the speed limit policy is in the right direction to make the roads safer for cyclists. Many reports and models show that the roads will become safer with the implementation of this policy. The severity of the accidents is bound to be affected by the policy as it is natural that the being hit by a high velocity car is different than getting hit by a lower velocity car. There are many places in the Netherlands that already approached to implement this policy. Even places outside of the biggest four cities in the Netherlands that have already decided to adopt this policy too. The attitude of policy makers is positive towards this policy and the idea is that the roads will become safer for all road users but especially for cyclists.

2. What are the main points about this policy that need to be researched?

The first thing to realize is that this policy cannot be implemented everywhere. Some stakeholders do not see this policy as a positive addition or change on the roads. For example, public transport companies are a bit hesitant about the lowering of the speed limit as buses would be affected by it and more vehicles are needed to be deployed to supply the demand. Moreover, there are still some points that need to be clarified that are related to emergencies and ambulances. In the Netherlands, emergency services are allowed to drive 20 km/hour above the speed limit. Therefore, the ambulance that was driving 70 km/hour on the 50 km/hour road needs to ride 50 km/hour on the new 30 km/hour roads. This will have an impact on the time needed to help people who are in need and it is a point that needs to be clarified. However, there is also a counterargument for this that because the speed limit is lowered on the road then less need will be for the emergency services. Nevertheless, theses points need to be clarified somehow and some roads that connect the network together may need to keep their speed limit as it is now.

Another point that need to be clarified is that travel time for the car users and flow of vehicles inside the cities. Some of the Dutch cities are congested with cars and vehicles and the implementation of the lowering of the speed limit policy may make the roads even more congested and extend the travel time. This can impact the liveability and desirability of cities and needs to be studied. An important question point is that what is going to happen to the roads that connect the highways to the city centres. Highways here are on a high velocity and distribution roads are the link between the highways and the residential roads. On the cross points then from the highway to the urban areas a major congestion point can be created which is undesirable.

Furthermore, it is unknown how the roads should be designed if cities are to adopt this policy. The speed limit lowering should be enforced, and roads should seem believable that the speed limit of 30 km/hour is the speed limit of the road. Some roads as said need to keep their current speed and it is known in the Netherlands that the distribution roads inside cities have the speed limit of 50 km//hour speed. To avoid confusion and to let people drive slower than usual, the roads need to convey the message of their new speed. At the same time, these roads need to also convey the message that a safer cycling environment is created to attract more bike users and to encourage people to cycle more as this has become a major objective of the Dutch government especially with the current fuel crisis and housing crisis.

3. What are the elements that policy maker is still unsure about?

The effects on the safety and the number of crashes is pretty well known for the different measures. What is less known, and it is stated in the comparison sheet of the CROW what are the combinations of the road elements that need to be used on the new GOW30 roads. Moreover, there are also uncertainties where and when the traditional distribution roads need to be changed and converted to the new GOW30 road. A major concern as stated that there are many factors playing in this game with many goals to achieve. On the one hand roads need to become safer to cycle on and on the other hand it needs to keep the flow of vehicles and the emergency services. Moreover, space is scarce in the Netherlands and roads are already surrounded with many buildings that are difficult to remove and displace. Therefore, some measures are difficult to implement in this confined space. Having said that, there are a number of elements that we can state that are a major point of discussion that need to be studied further in any perspective it is. The elements that come to mind are:

- Pavement of the road: as it is known distribution roads in the Netherlands are predominately laid with asphalt. The advantage of this material that it lets the smooth driving of vehicles on the road. This advantage gives it all its own disadvantage as car drivers can drive freely and when no obstacles and monitoring is put on the roads, the car has no infrastructural barrier to raise its speed. For that reason, clinkers are often used in the residential roads in the Netherlands that make driving the vehicle on higher speeds difficult. However, the use of this element riding the car or even the bike uncomfortable to use especially for larger vehicles.
- The function of the road: it is commonly known that when the speed limit of the road is 50 km/hour or more then these roads are distribution roads and not residential roads. The lowering of the speed limit to 30 km/hour with many parking spaces makes on the look of it hazy and vague to have it distinct from residential roads. For that reason, a new design should come that makes the GOW30 roads distinct from the ETW30 roads through which the distribution function of the roads can be distinguished.
- The location of the bus: As mentioned before, lowering of the speed limit can be difficult to implement due to the objections of public transport companies. The location of the bus on the residential roads that

are 30 km/hour has always been on the driving lane. A question comes up for the GOW30 roads, where the location of the bus stop should be so that the flow of the vehicles can be maintained.

- The location of the cyclists on the road: this is arguably the most controversial point that needs to be discussed in this situation. It is from the principles of sustainable safety that different masses with different speeds need to be separated from each other. However due to the lack of space and the fact that when the speed limit is lowered to 30 km/hour for cars, the distinction of speed differences disappear. Moreover, new concepts such as shared spaces show that by then all road users become more careful while driving and cycling that a safer road using environment may be created. In the Dutch cities, it is common to have cyclists and car users use the same road space due to the lack of space. The separation of cycling lane is desired but the location of this element in respect to the new roads is yet unknown. the
- The speed limit: this is the main discussion point of the whole situation. Some roads need to keep their 50 km/hour speed for various reasons and some roads need to lower their speed limit to 30 km/hour.
- Speed calming/regulating/enforcing measures: some suggestions and discussions while discussing this topic is through which measure do we need to inform the road user about the speed limit of the road and through which method we need to enforce this speed. There are some doubt going on for the use of boards as the only measure of information. Some suggest that speed bumps should be used often. For this measure there are many objections as the speed bumps are shown to affect the health of large vehicle drivers such as buses. Another possible alternative is the speed displays that are often placed next to school areas to have the speed of the vehicles monitored which is found to have an impact on.

4. What is according to you the measures that need to be taken to enhance the cycling encouraging environment in the cities?

In the Netherlands we have the tendency to reform the system in such a way that the system needs to be the separating and defining point of the road users. In contrast, many countries rely on the communication of the people amongst each other to have the flow roads going. The separation of cycling lane is important to us to lower of the speed limit but that by no means is the only measure that is essential. Because there is separation, there is less need of communication between the road users and when people reach (unregulated) intersection points, here the communication becomes the essence between the road users. Therefore, a more integral approach should be taken, and more understanding should be gained of the driving behaviour, preferences and distaste of the road users while also we need to emphasize on the measures that provide a safe cycling environment to have people cycle more.

5. Is there something you want to add?

There is this consensus among the policymakers with whom we have contact with that because there is the idea of keeping the infrastructural changes as minimum for financial concerns, that hanging a board or stating that the speed limit on a specific road has become 30 km/hour is sufficient. When we look in reality, people usually don't comply to the rules that often and the speed limit set by a board is often not obeyed. For that reason, we want to know if just stating that the speed limit on the road is sufficient or not in any perspective.

Furthermore, an interview is held with two road designers/road operators inside the municipality of Rotterdam to gain insights from the side of policy making and if there are differences in the opinions and thoughts from this side of profession. The interviewees were informed of the previous talks with the other experts to consider more on other aspects that were not discussed previously. The matters that were mentioned in the previous interview are not repeated. Only the additional information is provided in this section.

1. What do you think of the lowering of the speed limit policy?

We believe that the adoption of this strategy will make the roads safer, according to numerous reports and simulations. Rotterdam has also adopted this policy to be implemented in the city as we are trying to move from the car-oriented style that we had since redesigning of the city after the war. Rotterdam needs to become more cyclist friendly, and this measure is in the direction of making the city more welcoming to this vulnerable group of road users. There are however, some points that need to be discussed about this topic as it is a large (city-scale) policy that is going to be implemented.

2. What are the main points about this policy that need to be researched?

The main points for us are to identify which places this policy should be implemented. Because doing so the approach of redesigning the roads can also be narrowed down. As you may know Rotterdam is unlike many other Dutch cities a heavily car-oriented city. There is already a strategy to change this image about the city by removing some driving lanes for cars and introducing environmentally friendly zones to limit the number of cars accessible to certain areas inside the city. Having said that, there is still no strategy developed for the choice of the streets that need to have the speed limit lowered on them and which roads can keep their current speed. The mentality the choice did however change as previously roads where 50 km/hour unless 30 km/hour is needed while now the mentality has become it is 30 km/hour unless 50 km/hour is needed. We want to create a cycling friendly city and we want to motivate our citizens to make use of this mode of transport. As it is commonly known, cars stand unused for over 90% of its lifespan and the space that vehicles are occupying can be more efficiently used for other purposes for example more sustainable way of transport or to fight climate change.

3. What are the elements that policy maker is still unsure about?

Next to the mentioned elements in the previous interview, there are a number of elements that we would like to shed light to.

- Parking spaces: there is a need to limit parking spaces as this has the function of letting the people to think twice before buying a new vehicle. In addition to that, parking spaces on the distribution road lead to slowing down the traffic. Insertion parking is found to be safer for the road users when parked vehicle is facing the road. However, a lot of space is needed in the city for this type of parking. Therefore, it is difficult to implement it. The parallel parking is seen more hazardous for the traffic and more specifically for cyclists. It is more space efficient than insertion parking but can be more hazardous. For these reasons, there is some discussion point which type of parking needs to be placed if any in these new distribution roads. Moreover, because the speed limit is already lowered, the addition of more parking spaces will lead to less flow in the city on these roads.
- Demarcation on the road: this matter is still undecided as the shape of the road and what it contains are still undecided matter too. The demarcation for cyclists paths and lanes, on the road, the width and where people are allowed to park are still a great subject of debate and should be resolved following the decision of the other elements.
- Priority of crossing: on the ETW30 roads it is common to give the priority of crossing to the road user approaching from the right side of any other road users. On the distribution roads, the crossing is often regulated with signs and traffic regulating systems. The creation of the new type of road makes the crossing point a fairly vague and unstudied one as it was not available up to this point.

4. What is according to you the measures that need to be taken to enhance the cycling encouraging environment in the cities?

A combination of measures needs to be taken. There are multiple measures that could be taken as restriction of vehicles in cities and making the use of the car less and less desirable. There are also measures that encourage the cyclists to use the bicycle instead of the car out of fun/comfort, creating a safe cycling environment and creating roads that make it possible for people to reach their destination more quickly than using the vehicles. All these measures can be taken but when we talk generally. In the case of cities and the GOW30 discussion, the major obstacle for these improvements is the scarcity of space where laying new cycling infrastructure can be challenging and it would be with the cost of travel of other modes of transport. The highest bet is to create a safe cycling environment that cyclists and non cyclists can be encouraged use the bicycle more often and leave the idea of using the cars and motorized vehicles behind.

5. Is there something you want to add?

The lowering of the speed limit discussion and the changes on the road and our driving style is a dynamic procedure that constantly changes. What we think that is sufficient or effective now may in the future appear otherwise or the change in the thinking or the need of implementing new rules can be different in the future.

That’s why we think studies like this are in the correct direction of knowing how the road users will react to the different policies and what are the effects of certain policies as road users know the road they use better than any road designer and policymaker.

APPENDIX C: FACTORS INCLUDED IN THE SURVEY

The interviewees of both Royal HaskoningDHV and the municipality of Rotterdam were discussed to choose the elements that are the most urgent and need to be included in the survey. The interviewees were informed that merely five elements can be included and out of the nine defined elements from the interview choices should be made which ones to include.

Choices made by the experts inside Royal HaskoningDHV are the speed limit on the road, cycling lane and path situations, parking space situation, speed regulating/calming factors and priority for crossing situations.

The choices made by the municipality of Rotterdam are cycling lane and path situations, the speed limit on the road, priority for crossing situations, pavement type and parking space situation.

After considering the difficulties for the inclusion of the pavement in the choice experiment, the speed regulating/calming measures was chosen from the other options to replace this factor. The remaining factors are similar and were therefore chosen to be in this experiment.

APPENDIX D: NGENE CODE FOR SURVEY DESIGN

Design

;alts = 30,50

;rows = 8

;orth = sim

;block = 2

;model:

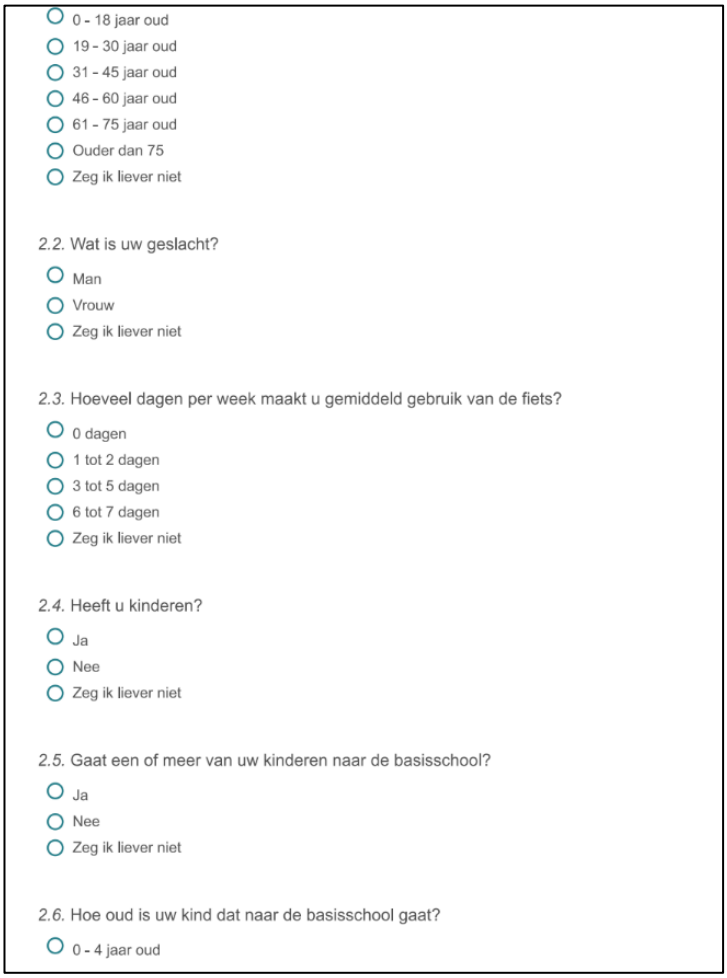
U(30) = b1 * CyclePath [0,1] + b2 * ParkingSpace [0,1] + b3 * Priority [0,1] + b4 * SpeedDisplay [0,1]/

U(50) = b1 * CyclePath + b2 * ParkingSpace + b3 * Priority + b4 * SpeedDisplay

$

APPENDIX E: THE PILOT SURVEY

The surveys were designed in both Dutch and English languages. On the left side the Dutch version will be shown and on the right side the English version. The only difference between the two surveys aside from the language is that in the English version, an additional question is asked of whether the respondent lived for longer than 6 months inside the Netherlands. This is done to filter out the people who may see the post on social media and who do not live in the Netherlands, not knowing the road system and environment in this country.



- 0 - 18 jaar oud
- 19 - 30 jaar oud
- 31 - 45 jaar oud
- 46 - 60 jaar oud
- 61 - 75 jaar oud
- Ouder dan 75
- Zeg ik liever niet

2.2. Wat is uw geslacht?

- Man
- Vrouw
- Zeg ik liever niet

2.3. Hoeveel dagen per week maakt u gemiddeld gebruik van de fiets?

- 0 dagen
- 1 tot 2 dagen
- 3 tot 5 dagen
- 6 tot 7 dagen
- Zeg ik liever niet

2.4. Heeft u kinderen?

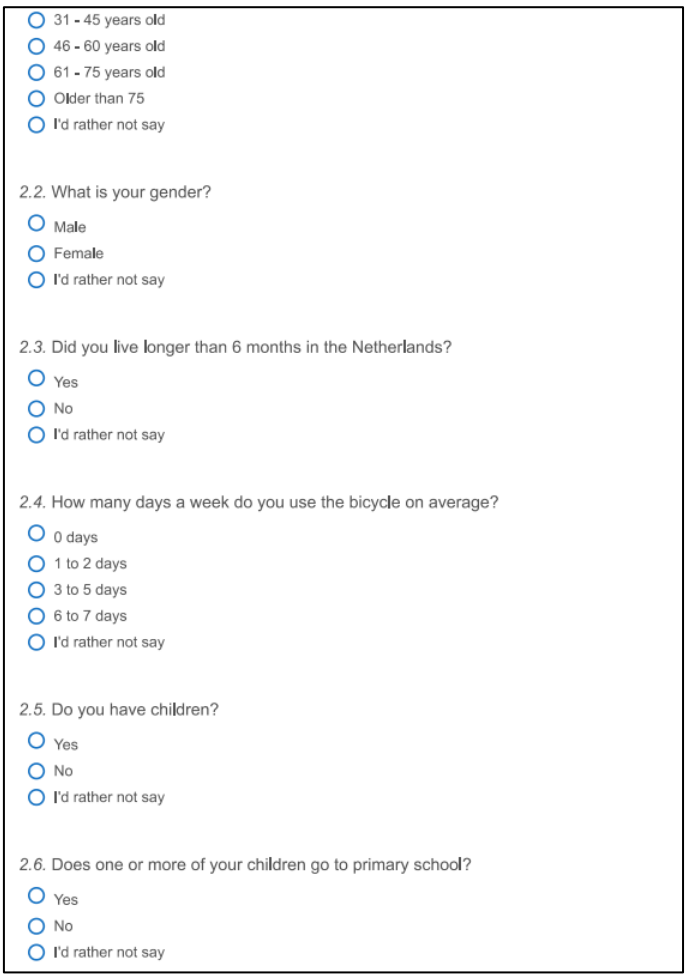
- Ja
- Nee
- Zeg ik liever niet

2.5. Gaat een of meer van uw kinderen naar de basisschool?

- Ja
- Nee
- Zeg ik liever niet

2.6. Hoe oud is uw kind dat naar de basisschool gaat?

- 0 - 4 jaar oud



- 31 - 45 years old
- 46 - 60 years old
- 61 - 75 years old
- Older than 75
- I'd rather not say

2.2. What is your gender?

- Male
- Female
- I'd rather not say

2.3. Did you live longer than 6 months in the Netherlands?

- Yes
- No
- I'd rather not say

2.4. How many days a week do you use the bicycle on average?

- 0 days
- 1 to 2 days
- 3 to 5 days
- 6 to 7 days
- I'd rather not say

2.5. Do you have children?

- Yes
- No
- I'd rather not say

2.6. Does one or more of your children go to primary school?

- Yes
- No
- I'd rather not say

- 5 - 7 jaar oud
- 8 - 12 jaar oud
- Zeg ik liever niet

2.7. Is uw kind dat naar de basisschool gaat in staat om zelfstandig te kunnen fietsen?

- Ja
- Nee
- Zeg ik liever niet

2.8. Heeft u of uw partner de beschikking over een auto?

- Ja
- Nee
- Zeg ik liever niet

2.9. Hoeveel dagen maakt u per week gebruik van de auto om uw kind naar school te brengen

- 0 dagen
- 1 tot 3 dagen
- 4 tot 5 dagen
- Zeg ik liever niet

2.10. Wat is de reden(en) dat u uw kind naar school met de auto brengt?

- [ ] Tijd
- [ ] Veiligheid
- [ ] Werkgerelateerde redenen
- [ ] Gezelligheid/comfort
- [ ] Financiële redenen
- [ ] Anders

2.11. Heeft u of uw partner de beschikking over een fiets?

- Ja
- Nee

2.7. How old is your child who goes to the primary school?

- 0 - 4 years old
- 5 - 7 years old
- 8 - 12 years old
- I'd rather not say

2.8. Is your child that goes to the primary school able to cycle independently?

- Yes
- No
- I'd rather not say

2.9. Do you or your partner have access to a car?

- Yes
- No
- I'd rather not say

2.10. How many days a week do you use the car to take your child to school?

- 0 days
- 1 to 3 days
- 4 to 5 days
- I'd rather not say

2.11. What is the reason(s) that you take your child to school by car?

- [ ] Time
- [ ] Safety
- [ ] Work-related reasons
- [ ] Fun/comfort
- [ ] Financial reasons
- [ ] Other reasons

2.12. Do you or your partner have access to a bicycle?

- Zeg ik liever niet

2.12. Hoeveel dagen maakt u per week gebruik van de fiets om uw kind naar school te brengen

- 0 dagen
- 1 tot 3 dagen
- 4 tot 5 dagen
- Zeg ik liever niet

2.13. Wat is de reden(en) dat u uw kind naar school met de fiets brengt?

- [ ] Tijd
- [ ] Veiligheid
- [ ] Werkgerelateerde redenen
- [ ] Gezelligheid/comfort
- [ ] Financiële redenen
- [ ] Anders

Hypothetische situatie

3.1. Stelt u zichtzelf de volgende hypothetische situatie voor: U heeft een kind (tussen 8 - 12 jaar oud) en uw kind moet met de fiets naar de De van Oldenbarneveltschool (staat links op de foto bij de blauwe pijl). Hiervoor volgt het kind op zijn fiets de gele lijn (getekend op de foto). Het kind moet dus op de fiets de weg oversteken.

In het volgende deel van de enquête worden twee soorten wegen aan u getoond. Het is belangrijk hierbij dat u de weg kiest die u **veiliger** lijkt zodat uw kind zelfstandig naar school kan fietsen zonder uw gezelschap.

- Yes
- No
- I'd rather not say

2.13. How many days a week do you use the bicycle to take your child to school?

- 0 days
- 1 to 3 days
- 4 to 5 days
- I'd rather not say

2.14. What is the reason(s) that you take your child to school by bicycle?

- [ ] Time
- [ ] Safety
- [ ] Work-related reasons
- [ ] Fun/comfort
- [ ] Financial reasons
- [ ] Other reasons

Hypothetical situation

3.1. Imagine the following hypothetical situation. You have a child (between 8 - 12 years old) and your child has to go to De van Oldenbarneveltschool by bike (on the left in the photo next to the blue arrow). In this situation, the child follows the yellow line on his bicycle (drawn in the photo). The child must therefore cross the road on the bicycle.

In the following part of the survey you will be shown two types of roads. It is important that you must choose the one that seems **safer** to you so that your child can cycle to school on its own, without your company.

3.2. Let op!

Als u dit bord op een foto ziet, betekent dit dat de fietsers voorrang krijgen bij het oversteken. Als u het niet ziet, betekent dit dat de fietsers moeten wachten op een veilig moment om over te steken.

3.2.
Please note!

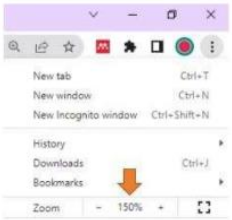
If you see this sign in a photo, it means that cyclists have priority when crossing the road. If you don't see it, this means the cyclists need to wait for a safe moment to cross.

3.3. This is a speed display board. If cars drive above the maximum, this sign will record the speed and send a fine to the car owner.

3.3. Dit is een snelheidsdisplaybord. Als auto's boven het maximum rijden, zal dit bord de snelheid vastleggen en een boete naar de autobezitter sturen.

Advies. (Voor de mensen die de computer gebruiken om de enquête in te vullen)

Het wordt ten zeerste aangeraden om in het volgende gedeelte de schermgrootte op 150% te zetten.

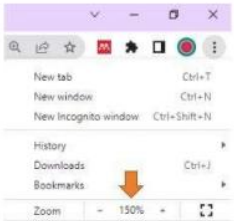


Q34. (Voor de mensen die de smartphone gebruiken om de enquête in te vullen)

Draai uw telefoon naar de liggende modus voor een duidelijker zicht op de foto's en een betere. ervaring.

3.4. (For the people who use the computer to complete the survey)

It is strongly recommended that you set the screen size to 150% in the next section.



Q33. (For the people who use the smartphone to complete the survey)

Please rotate your phone to landscape mode for clearer vision of the pictures and a better experience.

Keuze vragen

4.1. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.2. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

Choice questions

4.1. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.2. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.3. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.4. Weke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.5. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1 Weg 2

4.3. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.4. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.5. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1 Road 2

4.6. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.7. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.6. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.7. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.8. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.9. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.10. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1 Weg 2

4.8. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.9. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.10. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1 Road 2

4.11. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.12. Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

Block 4

4.11. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

4.12. Which road do you think is safer to let your child (between 8 - 12 years old) cycle to school **alone**?

Road 1

Road 2

Block 4

5.1. (Optioneel) Voer hier uw opmerkingen of vragen in

Powered by Qualtrics

5.1. (Optional) Enter your comments or questions here

Powered by Qualtrics

APPENDIX F: DOMINANT CHOICE SETS FROM THE PILOT SURVEY


30
50


30
50

APPENDIX G: THE REMAINING CHOICE SETS

4.1 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.2 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.3 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.4 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.5 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.6 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

4.7 ★

Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

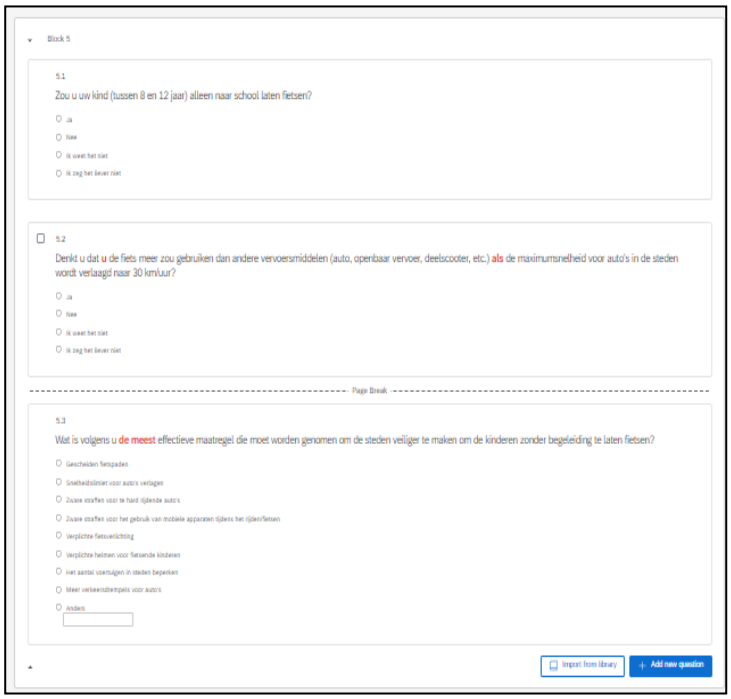
4.8 ★

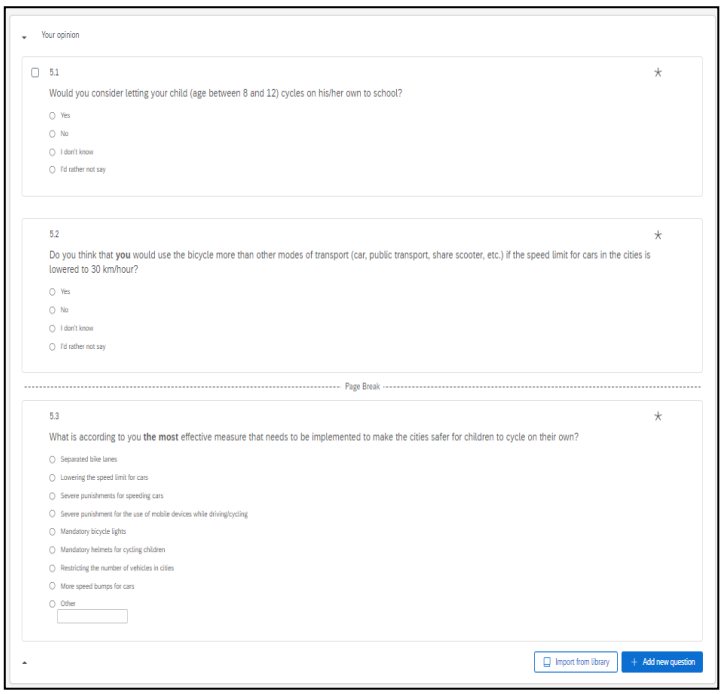
Welke weg is volgens u veiliger om uw kind (tussen 8 - 12 jaar oud) **alleen** naar school te laten fietsen?

Weg 1

Weg 2

APPENDIX H: ADDITIONAL QUESTIONS ADDED IN THE FINAL SURVEY





APPENDIX I: BIOGEME CODE FOR THE WHOLE SAMPLE POPULATION

```
# -*- coding: utf-8 -*-
"""
Created on June 09  09:15:13 2022
@author: Marc Tem Temi
"""
import pandas as pd
import biogeme.database as db
import biogeme.biogeme as bio
import biogeme.models as models
import biogeme.version as ver
from biogeme.expressions import Beta

df= pd.read_csv('C:/Users/Rotterdam/Desktop/ MNL_NO_Panel/MNL_ALL_No_Panel.csv',';')
df
#Statistics
df.describe()
#Create Biogeme database
database = db.Database('MNL_ALL_No_Panel',df)
#Define the name of the variables as Python variables
globals().update(database.variables)
## how many observations
print(database.getSampleSize())
#Model Specification
##Specify list of parameters

### put the first 0 to have the starting point, none is that there is no limit
### last 0 to let Biogeme estimate and put 1 to keep the value

ASC_30 =Beta('ASC_THIRTY', 0, None,None,0)
ASC_50 =Beta('ASC_FIFTY', 0, None,None,1)
```

```
B_BIKINGLANES =Beta('B_BIKINGLANES', 0, None,None,0)
B_PARKING =Beta('B_PARKING', 0, None,None,0)
B_PRIORITY =Beta('B_PRIORITY', 0, None,None,0)
B_SPEEDDISPLAY =Beta('B_SPEEDDISPLAY', 0, None,None,0)

#Specification of the utility functions
## In this case we have three alternatives
### Dont put numbers as names
V30 = ASC_30 +\
      B_BIKINGLANES * BIKINGLANEAVAILIBILITY30 +\
       B_PARKING * PARKINGAVAILIBILITY30 +\
         B_PRIORITY * PRIORITYAILIBILITY30 +\
           B_SPEEDDISPLAY * SPEEDDISPLAYAILIBILITY30

V50 = ASC_50 +\
      B_BIKINGLANES * BIKINGLANEAVAILIBILITY50 +\
       B_PARKING * PARKINGAVAILIBILITY50 +\
          B_PRIORITY * PRIORITYAILIBILITY50 +\
            B_SPEEDDISPLAY * SPEEDDISPLAYAILIBILITY50

# Associate the utility functions with the numbering of the alternatives
## so 1 will be associated with utility function of V30

V = {30 : V30,
    50 : V50}

#Associate the availability conditions with the alternatives
## for each alternative we associate the availability
#Availibility

av = {30 : THIRTY_AV,
    50 : FIFTY_AV}
```

```
# The contribution to the log likelihood function is the logarithm of a logit model
## Three arguments this model: dictionary of arguments V, dictionary of alternatives av and the Choice
# ! means different than so if you say exclude = (PROF ! = 1) it means exclude
# Everything except for 1
# exclude = (CYCLIST > 0)
# database.remove(exclude)

print(database.getSampleSize())
logprob = models.loglogit(V, av, CHOICE)

#Now we start Biogeme
biogeme = bio.BIOGEME(database, logprob)
biogeme.modelName = 'MNL_NO_Panel'

#Running the estimation
results = biogeme.estimate()

#Read the results
pandasResults = results.getEstimatedParameters()
print(pandasResults)
```

APPENDIX J: THE RESULTS COMBINING PARENTS AND PROFESSIONALS

Name	Value	Std err	t-test	p-value	Rob, Std err	Rob, t-test	Rob, p-value
ASC_30	1,73	0,11	15,90	0,00	0,11	16,10	0,00
B_BIKINGLANES_NOT_PROF_NOT_PARENT	1,64	0,13	12,30	0,00	0,13	12,40	0,00
B_BIKINGLANES_NOT_PROF_PARENT	1,74	0,14	12,50	0,00	0,14	12,50	0,00
B_BIKINGLANES_PROF_NOT_PARENT	1,63	0,16	10,10	0,00	0,16	10,20	0,00
B_BIKINGLANES_PROF_PARENT	1,91	0,17	11,00	0,00	0,17	11,00	0,00
B_PARKING_NOT_PROF_NOT_PARENT	0	0,09	0,48	0,63	0,09	0,48	0,63
B_PARKING_NOT_PROF_PARENT	0	0,10	-1,70	0,09	0,10	-1,69	0,09
B_PARKING_PROF_NOT_PARENT	0	0,13	-1,40	0,16	0,13	-1,40	0,16
B_PARKING_PROF_PARENT	0	0,14	-1,21	0,23	0,14	-1,21	0,23
B_PRIORITY_NOT_PROF_NOT_PARENT	1,59	0,17	9,41	0,00	0,17	9,46	0,00
B_PRIORITY_NOT_PROF_PARENT	1,29	0,17	7,44	0,00	0,17	7,46	0,00
B_PRIORITY_PROF_NOT_PARENT	1,40	0,20	6,92	0,00	0,20	7,00	0,00
B_PRIORITY_PROF_PARENT	0,82	0,23	3,60	0,00	0,23	3,63	0,00
B_SPEEDDISPLAY_NOT_PROF_NOT_PARENT	0	0,10	0,19	0,85	0,10	0,19	0,85
B_SPEEDDISPLAY_NOT_PROF_PARENT	0	0,10	1,60	0,11	0,11	1,55	0,12
B_SPEEDDISPLAY_PROF_NOT_PARENT	0	0,14	0,00	1,00	0,13	0,00	1,00
B_SPEEDDISPLAY_PROF_PARENT	0	0,16	-1,28	0,20	0,16	-1,32	0,19

Values in red are the statistically insignificant ones in the 95% confidence interval.

Init log likelihood**:**	-2175
Final log likelihood**:**	-1869
Rho-square for the init. model**:**	0,141
Adjusted Rho-square	0,138