The experience of safety of cyclists and pedestrians in a shared space

A research at the Jacob Gerritstraat in Delft



The experience of safety of cyclists and pedestrians in a shared space

Bachelor Thesis

By

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Preface

In front of you is the Bachelor thesis 'The experience of safety of cyclists and pedestrians in shared space'. It is conducted as part of the Civil Engineering Bachelor program at the Technical University of Delft. This topic gave me a new insight in the possibilities in the field of civil engineering. It was also a good introduction to how to face a major project on my own.

Hereby I want to thank my supervisors Maria Salomons and Yufei Yuan for their support and weekly evaluation to bring this report to a higher level. The same for my fellow students who reviewed parts of the report on weekly basis. They provided good suggestions to my research and thereby my report.

Furthermore I want to thank Dorine Duives who was always helpful with all the questions I had restricted to my research. She also made sure I was focused and aiming the final goal from the beginning. When I started doubting about the feasibility, my parents and friends where there for support which I am grateful for. It was very helpful to talk about the subject to clear my mind. A special thanks goes to Edwin Scharp and Peter van Oossanen. They helped a lot in inventing a plan how to film the Jacob Gerritstraat and executing it. They even were willing to help fixing the camera on their day off. As latest I want to thank the employees of the Randstad. Without any further explanation was needed, they provided the location to film from. Without them this research would have had a total different set up. This also applies to the respondents of the survey.

Simone Hoskam Delft, 25 October 2017

Summary

This report is drafted to show the results collected from the research about the experience of safety of cyclists and pedestrians in shared spaces. When research is done to safety, it mostly aims at objective safety: how many accidents happen on yearly basis. Less attention is paid to subjective safety: how safe people are experiencing a certain place. Shopping areas are placed where more attention should be paid to the feeling of people. It is mostly used for leisure and it can influence the way people are shopping in both a positive and a negative way. A safe street can make the shopping area more appealing.

In this research is looked into which factors influence the feeling of safety. This, in combination with how it is experienced in the current situation, form the basis to answer the research question: "How can the feeling of safety in the Jacob Gerritstraat be improved?". The Jacob Gerritstraat is a shopping street in the city centre of Delft. Over here pedestrians and cyclists are mixed as in a shared space. The municipality of Delft made their decision for the current situation to create an accessible city centre which is safe to all users.

To answer the research question, there is started to look into the literature what safety is and what determines the feeling of safety. With these results a survey is conducted, to test the subjective aspect of safety. To be able to compare this with objective results, a camera is installed which gives an overview of the intensity in the street. When the results of the research are analysed, any possible correlations with the feeling of safety are determined. In first place is looked into how people experience safety in combination with the experienced level of crowdedness and if this is depending on any demographics as gender, age, motive, place of residence and frequency. As second, there is also looked if there is any correlation between how people experience crowdedness and safety toward how many people are passing the street. Based on these findings the improvements are stated and recommendations are done.

Literature shows safety can be categorized by objective versus subjective; physical versus social; situational versus general; and anticipated and actual safety. A certain situation can be sub grouped in different categories. Every kind of safety gets influenced by own factors as age, gender, overview of the street but also by crowdedness and atmosphere. By crowdedness there is again a difference between how crowded it really is and how crowded people experience it. A shared street is seen as crowded when the combination of pedestrians and cyclists becomes hard, so cyclists have to go walking. In literature the reference value of 141.1 pedestrians per hour per meter road width is maintained. Deviations occur by optimized street layout. By using this guide line there should be good thought about which regulation will be implemented and if separation of traffic is needed.

The municipality of Delft made the decision to create one rule for the entire city centre: it is a pedestrian zone where bicycles are allowed as guest. An increasing number of cities is implementing this act. Nevertheless there are also cities, for example Utrecht, that expand the prohibition for cyclists.

After the analyzation of the survey and the video results, correlations are found between the earlier expected factors and the feeling of safety, crowdedness and atmosphere. Nevertheless every function for experience gets influenced with different weights of factors.

To improve the feeling of safety, especially the experience of crowdedness should be adjusted. This can be done by optimizing the design of the street by introducing a rider. Furthermore the speed difference between cyclists and pedestrians should be lower. It has to be made clear to cyclist the speed which is desired is walking speed. This has to be communicated by road signs. The municipality of Delft is currently doing research about the influence of signage.

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1. Introduction

Many cities struggle with the question how to create an accessible and liveable city centre. People want to drive up to their destinations by car but at the same time the municipality wants to create a car free centre where people can go for leisure activities as shopping. The common goal of them is to create a place where the traffic is safe for everyone, but people also experience it as safe. At least in such a way it is not discouraging to go there. Nevertheless, after a street is designed, it is only labelled as unsafe when lot of accidents happen. In shopping areas, more attention should be paid to the experiences of people. It is mostly used for leisure and it can influence the way people experience shopping in both a positive and a negative way. A safe street will make the shopping area more appealing.

An upcoming method to create a safe space is the use of shared spaces. Shared spaces focus on the multifunctionality of public space, on the relationship between road safety and the surrounding environment. As it is used as a residential space, it must invite to behave social. So the characteristics of the road and the environment must tell which behavior is desired. It assumes that the speed of different forms of transportation will be lower when people have to interact with each other to create their right of way. (CROW, 2009)

Also the municipality of Delft struggles to create a safe city center. Since 2004 the plan of a (almost) car free city center was introduced. This plan is still functioning nowadays, shown in figure 1-1. The entire green area in this figure was turned into a pedestrian zone. Since 2008, bicycles are allowed everywhere but only as guests. One of the streets in this zone is the Jacob Gerritstraat (red). This is situated between the "Markt" and the "Brabantse Turfmarkt" and will be the case study of this report. It is part of the shopping area of Delft. This particular street was chosen because this is one of the streets which is negatively known among inhabitants of Delft.

The Jacob Gerritstraat is mainly accessible for pedestrians and cyclists. An extra category is trucks who have to supply the local stores. They have dispensation for this street from the municipality. As there is a mix in way of moving, people may experience this street as chaotic. The pedestrians are most of the time wandering around and looking for stores while the cyclists are on their way to a certain destination. There is also a difference in speed which makes the discrepancy even bigger.



Figure 1-1, Map center of Delft with Pedestrian free zone (StadIndex)

Although there is a lot of activity in the Jacob Gerritstraat, only few collisions are reported on yearly basis (municipality Delft, 2017). If they occur this is mainly with no to light injury. Reasoning for this is the fact that most of the street users, especially the cyclists, seem to be aware of their environment when they are participants of the traffic. On the opposite it also makes wandering and biking through the streets less relaxing because of the constant attention that has to be paid. Even when this is done, some fearful moments may occur as cyclists are also passing pedestrians from behind. This may cause an unsafe feeling. It tells that the perception of safety of the street can differ from how safe it really is. The feeling of unsafety by the users of the street is resulting in the research question:

"How can the feeling of safety in the Jacob Gerritstraat be improved?"

The answer to this question is provided by dividing the main question in to the following sub questions:

- How to identify and analyse the feeling of safety in traffic?
- What factors influences the feeling of safety?
- How did other cities deal with problems related to the feeling of safety?
- Why did the municipality of Delft make the decision in 2006 for a mixed area?
- What feeling of safety are cyclists and pedestrians experiencing at the moment they pass through the Jacob Gerritstraat?

This study looked at the difference in feeling of safety between quiet and crowded moments. This is done by comparing results of a survey that is executed on several moments during the day. The outcome was correlated with the crowdedness which is based on counting people using the video material of that same moments. It gives an overview when people are feeling safe and which factors are on influence. This is checked with information that is collected from literature as CROW and BRO. For external factors a solution will be formulated of how to reduce the feeling of unsafety. This is applied to the current situation of the Jacob Gerritstraat. Therefore is looked into the situation, why the municipality of Delft made the decision for a pedestrian area with cyclists allowed.

It does not take in account the moments when trucks are standing still for supplying the stores, as it will influence the experience of a street. Furthermore young children and disabled people are not taken into account as this is only a small amount of users, too small to be used as a reference. Also the influence of the weather will not be taken into account as there will be to little survey moments.

Overall this report is most useful for the municipality of Delft. The theoretical framework can also be applicable for other municipalities as it is a general description of how people are experiencing safety and what will influence it. It may help them to redesign the situations in their own cities. Eventually, when changes are made, cyclists and pedestrians are also influenced by this report. Even shop owners and market leaders as the shopping experience may change.

In chapter 2 (Theoretical framework) is given what actual feeling of safety is, how it can be identified and what is influencing on it. Furthermore the guidelines of a pedestrian zone witch cyclists as guest are stated. In this chapter is also written how other cities deal with the situation of cyclists and pedestrians in one area. In chapter 3 (Methodology) is the plan described which is executed during this research. The reasoning behind the survey is explained, how the camera is setup and what is done with the results of both. In the up following chapter (4, Research results) the results of the research as described in the methodology are evaluated and a comparison is made between the results of the camera and the survey. With the information possible changes to the current situation are mentioned in chapter 5 (Improvements). After all the conclusion is formed in chapter 6. In chapter 7 (Discussion) these results will be argued. Future research options will also be suggested in this chapter.

2. Preliminary research

In this chapter the theoretical background is defined. It explains what traffic safety is and how people experience it; what the guidelines are for a street shared by pedestrians and cyclists; how different municipality interpreted these guidelines; and what are indicators for possible solutions.

2.1 Experiencing traffic safety

When a spatial area is designed, traffic safety has a big impact in the design. Safety is defined as "the condition of being protected from or unlikely to cause danger, risk or injury" (Oxford, 2017). The word safety includes the cause of the threat, the chance it will happen (risks) and the way there is dealt with. Therefore are different ways of safety to be categorized.

One of the categorization is objective and subjective safety. Objective safety is measuring how often a happening occurs, in this case a maneuver or collision. It are factual numbers of attention or absence of threats (CBS, 2015). Subjective safety is the extent of how threaten people are feeling during a happening (Elffers & de Jong, 2004). This is hard to record as it is strongly depending on specific events that happened. Also, feelings of anxiety disappear when talking about it. An objective way to register it is by physiological standards as sweat, heartbeat and breathing. Only this is hard to implement in the current situation and setting.

There is not necessarily a strong connection between an objective and subjective way of expressing safety (Vlakveld, 2009). More correlation can be found between the demographic groups and the feeling of being threat. Examples of these groups are age, gender and place of residence. By the last one it is important if people are raised in a small town or live in an urban city. This is also connected with how often people visit a certain location. When they come over regularly, people get used to the situation and experience less anxiety (Vlakveld, 2009). There are also different factors that are influencing the risk perception as own influence, voluntary exposure, impact and consequences.

Another way to categorize safety is by making a division in physical and social safety. Physical safety is described as "Threat of health and property due to all kinds of accidents in nature or technology" (Elffers & De Jong, 2004). These kind of issues are restricted with guidelines of design and setting. In contradiction is social safety: "Threats to health and property by third party actions" (Elffers & De Jong, 2004). This threat comes from the inside and is influenced by other users. Accidents that can evolve till conflicts between civilians. So it's about the connection between people. This connection is influenced by a lot of different factors. Not all of them can be adjusted, like migration and aging. These things cause a more and more feeling of anonymity which influence the way people react to each other on the street. People with a different age and cultural background also have others norms and values, which create less cohesion, solidarity and empathy for others (Elffers & de Jong, 2004). This, and subjective safety, gets influenced by media.

Furthermore it is known that people base their feeling of safety from three characteristics of a street: prospect, concealment and escape (Fisher and Nasar, 1992). When a street offers a good overview of the situation (prospect); possible offenders have minimal opportunities to hide (concealment); and maximum opportunities to escape (escape), people feel safer. This is partly matching with the general experience of safety mentioned in "Handboek veilig ontwerp en beheer" (López et al, 2008). Over here is stated that people feel safe when the street is: uncluttered, this consist of see and be seen, depending on sight lines and clarity; unambiguity, the status and function of a certain place should be clear and giving points of orientation to prevent confusion; accessibility, in this way people can use the road where it is designed for with accessibility in case of emergency but limited to unwanted users; and attractiveness to show standards that are desirable.

There is also information known about the way people react on anxiety. When people feel threaten, they will be paying more attention to their surrounding which will prevent from accidents to happen. This is called behavioral adaptation (Vlakveld, 2009)

The third differentiation in safety is situational safety and general safety. One speaks of situational safety when there is asked about the present moment. In this case, people are mostly using social information to come up with what kind of people are in their surrounding and which rules of conduct are desired (Vanderveen, 2011). When asked about the current situation, people also react different from when is asked about a certain situation weeks after. Certain events, like near collisions, have a big impact on the feeling of a moment but only a small impact on the feeling about an entire week. When talked about general safety, people will also make more comparisons with other situations and see things in perspective. So the influence of physical layout is less on impact on general safety feeling (Van Rijswijk e.a., 2012).

As latest, a categorization can be made in anticipated and actual safety. Anticipated safety is about the safety people expect, whether or not due to a change, for example, a new design and layout of public space. Actual safety is about the safety that is actually measured objectively or subjectively experienced. This distinction is particularly relevant in participation processes where residents (possibly) resist a change in physical space. Residents anticipate when assessing the safety on the change. This assumes that safety is deteriorated. This distinction between anticipated and actual safety is less relevant to what is actually designed, but more for the communication process around it, as people will make assumption about situations (van Dijk, z.d.).

Shown is there are a lot of different ways to express the feeling of safety. In this research will be talked about subjective safety. Most of it will be about the situational safety, as people are asked with the survey direct after they leave the Jacob Gerritstraat. Nevertheless there is also asked about their general feeling when they visit the street more often, so comparisons can be made. These feelings are influenced in a physical and a social way, where social safety will be less influencing on the general feeling of safety. When recommendations are done, anticipated safety should be taken into account.

2.2 Guidelines design

To ensure the safety on the streets different guidelines are existing. These are no strict rules which has to be followed but more recommendations for the desired result. Because there were only the guidelines of the CROW first, which were even general guidelines for all shared spaces, BRO was asked to conduct guidelines for streets were only cyclists and pedestrians are mixed, mostly in shopping areas. BRO is an advisory and design company for project in the field of urban planning, spatial development, landscape and economics. Below, the existing guidelines are behold. These guidelines can be used to see if the current design of the Jacob Gerritstraat is fulfilling the requirements.

"Het Fietsberaad" composed guidelines in 2005 for which circumstances the combination of cyclists and pedestrians are seen as possible and when it is deemed impossible. This is based on the objective measurements executed by BRO. They looked into 91 current situations if there were any lessons to learn, an empirical research. Among other things, it is examined whether or not to be cycled and how it is legally regulated; what pedestrian and cycling intensities are on a working day afternoon (15.30-17.00) and a shopping evening (19.00-20.30); what the profile looks like and what conflicts occur between pedestrians and cyclists. Based on this is determined which factors were influencing and eventually guidelines determined (Fietsberaad, 2005).

Cyclists always seek the most attractive route to drive from A to B. Which route for the cyclist is the most attractive is determined by various factors such as length of route, ease or speed of cycling, conflict with other traffic, etc. The width of the road profile in pedestrian areas does not play a role in the attractiveness of the cyclist. Looking at the intensities it is mentioned that combinations of high bicycle and high pedestrian intensities are not found in the dataset. Apparently, there is something about a self-regulatory mechanism. Whether or not stimulated by prohibitions and cycling facilities inside and outside the pedestrian area, cyclists take other, more attractive routes at high pedestrian intensities are expressed in amount of pedestrians per hour per meter profile width. To conclude if a combination of cyclists and pedestrians is possible the observer (in all cases a traffic expert) has formed a total picture of the situation (intensities, conflicts, profile layout, etc.). Three conclusions were possible: yes, difficult or no. The results are shown in figure 2-1. The red line represents the results the research of Hellmut Schubert in 1984. The study concluded that a pedestrian density of more than 0.07 pedestrians per m² is no longer possible to cycle. This equals 141.1 pedestrians per hour per meter profile width. It still matched with the situation of 2005.



Figure 2-1, Combination cyclists / pedestrian possible, against pedestrian intensity (BRO)

From the research the following conclusions can be made about when a mixture should be possible and not:

- At pedestrian densities up to 100 pedestrians per hour per meter profile width, full mixing is possible.
- At pedestrian densities above 100 pedestrians per hour per meter profiles, separating pedestrians and cyclists within the profile is desirable. Up to 160 pedestrians per hour per meter profile width provides the use of a rider in an unread profile. At higher pedestrian densities (up to 200 pedestrians per hour per meter profiling width), there is a profound profile outcome.
- If the pedestrian density rises above 200 pedestrians per hour per meter of profile width, the combination of cyclists and pedestrians is no longer possible.

Besides the road layout, there are also guidelines for the stage setting. As mentioned in the introduction, the Jacob Gerritstraat is an example of a shared space. It differs from a public space as a shared space focuses more on the multifunctionality and thus on the relationship between road safety and the surrounding environment (CROW, 2009). It is important that the design of the street must invite to social behavior. The users should be able to tell which behavior is appropriate and required based on the road characteristics and its surrounding. In other words the road layout should be in a way it is unambiguously. Hereby the design should facilitate eye contact to encourage interaction. When road users are able to negotiate the right of way, speed will drop automatically and respect will be earned, which results in a better feeling of safety. Other guidelines which are existing with regard to shared spaces are:

- Minimum use of traffic engineering and artificial objects in the street
- Using colored asphalt instead of grey/ black
- Conscious choice of public lighting and lamp posts

Some further guidelines can be created based on the social and psychological influences on safety as described in section 2.1(Experience traffic safety). This can be transformed in the guidelines as:

- Make the layout clear with good sightlines and minimum of obstacles
- The regulation of the street should be known or obviously shown to everyone
- Good accessibility in case of emergency and escape routes as well
- Mess must be cleaned on regular basis and surrounding maintained

The importance of the layout is extra emphasized in the guidelines of Het Fietsberaad. There is an area in the graph of figure 2.1 with the same number pedestrians per hour per meter profile width, different conclusions regarding 'combination cyclists and pedestrians possible' can be seen. They appear to be largely explained by the layout of public space. All situations where the bicycle / pedestrian combination is possible at more than 141.1 pedestrians per hour per meter, have a rider. The three points that are the most right also have a guided profile. By a rider and more by a led profile, pedestrians stay more within their own 'domain', in such a way that cyclists and pedestrians are not affected by each other. The eight most left-hand points in the category of doubtful (middle row) all have major obstacles (such as terraces, bicycle stands, etc.) in the profile. The available profile width is therefore significantly smaller than the total profile width. Therefore, the number of pedestrians per meter available profiles will be significantly higher (more near or even to the right of the red line).

2.3 Approaches of municipalities

Every city municipality is approaching the situation with respect to cycling regulation in the city center in a different way. Most of them created a car free zone. But there is a variation between cyclist free or not. In this section the situation of Delft will be viewed but as well the situation in cities as Mijdrecht, 's-Hertogenbosch, Utrecht and Waalwijk. All the municipalities of these cities approached the situation of an accessible city center in a different way.

Delft

In 2004 the city center of Delft became a car free zone, with some exceptions. Some areas were turned into a pedestrian zone while others became a cyclist zone. In 2006 the motion was accepted to look into the possibilities to make the entire center a pedestrian zone with cyclist allowed as guest (municipality Delft, 2006). The research was done with the argumentation that the proposal would make the city center more attractive and better reachable. Also was taken into consideration that the variety in existing zones were confusing. A research with counting the amount of users was already done in 2004 by BRO, see appendix A. The conclusion was that in general it would be possible to allow bicycles. In the Jacob Gerritstraat it would be hard around afternoon and impossible on shopping

evenings. On the Brabantse Turfmarkt it would also be hard during shopping evenings. Nevertheless the proposal was accepted with the earlier mentioned reasoning. The bottlenecks should solved by self-regulation. This means that on crowded moment cyclist will be walking with their bicycle next to them or they will take a more attractive detour where they can continue with a higher speed. So in 2007 the entire city center became a pedestrian zone were cycling is allowed, see figure 1-1.

In 2008 the municipality evaluated the situation with a positive result. The expected selfregulation is working: when the amount of pedestrians increase, the number of cyclist is not increasing with the same rate. A detour is especially chosen when a detour is provided with high quality and low amount of extra kilometers (municipality Delft, 2008).

In 2017 the municipality did a survey among residents of Delft. This was all about the policy of bicycle parking. Nevertheless it included the statement: "I'm in favor of a ban on cycling in parts of downtown Delft". The results were (totally) agree 19%; in between 11%; (totally) disagreed 70%; don't know 0%. This shows a clear preference to keep the entire city center accessible by bike (municipality Delft, 2017).

Other cities

As stated before, in several city centers the municipality struggles with the question if cyclist should be allowed. For a long time there was no city where it was allowed to cycle everywhere. This was the case in 's-Hertogenbosch as well. Up till December 2008 is was only allowed to cycle between given times. The municipality noticed that even when it was forbidden a lot of people still were cycling as it was seen as possible (Y. Jansen, 2014). Observation showed that self-regulation worked and cyclist adjusted their speed and used different routes when the amount of pedestrians increasing. This made the municipality decide to allow cyclist in the city center except when there was a market taking place. They started to focus on regulating undesirable excessive behavior (municipality 's-Hertogenbosch, 2009). Unfortunately confusion by the cyclists was caused due to bad promotion. So in July 2014 the entire city center became residential area and cycling was allowed everywhere (municipality 's-Hertogenbosch, 2014).

The success in 's-Hertogenbosch even got noticed by a city councilor of Waalwijk. Up till 2011 cyclist were only allowed till 12 am. To get more activity in the center it was proposed to allow cyclists in the afternoon as well. Discussion arose about possible confusion and the lower threshold for mopeds to cross the rules. In February 2014 the municipality decided to start a test for one year with a mixed city center (municipality Waalwijk, 2014). This was evaluated afterwards and concluded that it was a success so the entire center of Waalwijk is now reachable by pedestrians and bicycles.

Likewise the municipality of Mijdrecht turned the shopping area, where cyclists and pedestrians were separated by lanes, into a pedestrian zone with cyclists as guest. This started on 15 of August 2017 as a test for 3 months. The reason for this is that the previous situation was unclear and caused conflicts between both road users.

Nevertheless not all municipalities are in favor of the idea of a mixed city center. The municipality of Utrecht wants to create more space for pedestrians. Some roads are already limited for cyclist with timeslots. These will be extended and also the streets where these apply will be extended (RTV Utrecht, 2017). With the same reasoning as other cities, to prevent confusion, the timeslots will become the same for every single day, from 10.00 till 18.00 it will not be allowed to cycle in given streets. This are the most crowded moments. This will be implemented from 1 of January 2018.

2.4 Indicators measurement

From the previous sections a lot of lessons can be learned. Overall can be said that a municipality is smart to adjust the elements in the road usage that are objective unsafe but also experienced as unsafe. In this way people will be more conscious of the change and adapt to it. One of the items is the regulation which should be provided in a clear way. To do this the signage should be unambiguous. To make it even easier for the users it is recommended to maintain the same regulation for the entire area. Herby self-regulation can be taken into account when looked at the possibilities. Another item to take into account is that prohibition is not always helping. The municipality would do well to promote the regulation amongst residentials as they are used to the current regulation, although not well known.

It is also important to make road users conscious of each other, by stimulating social interaction. One of the ways to do this is to remove obstacles. They prevent eye contact or will form a literal separation between people. Adjusting social demographics is seen as an impossible way to attain interaction. Nevertheless respect should always be shown to other people.

3. Methodology

To perform this research, the methodology as described in this chapter is followed. It is following the chapters of this report and described based on the research (sub)questions.

3.1 Preliminary research

At the beginning of this research, the background information is collected. It tells what the feeling of safety really is, how it can be noticed. With this information it is possible to formulate the questions of the survey and also set the boundaries of this research.

For more information regarding how the identification and analysis of the feeling of safety research is done on the internet. There are several studies about subjective safety. There are also articles and reports about what influences on the feeling of safety in general traffic use. Some of them are applicable on the situation of the Jacob Gerritstraat. In the CROW a section is written about how shared spaces should be implemented. This is quite general and not specified to pedestrian zones in city centres. To get better insight in how to design, "Het Fietsberaad" submitted the mission to BRO in 2005 to look into current situations of pedestrian areas. From analyzing these situations, lessons are learnt about when the combination of pedestrians and cyclists is possible.

The municipality of Delft used the guidelines of Het Fietsberaad to make their decision about the Jacob Gerritstraat. To know more about their current opinion of the situation the municipality is contacted. Furthermore it has been investigated how other cities made a solution for the safety in pedestrian zones and if they involved the feeling of safety of the users. This is done by information provided by the municipalities.

3.2 Description survey setup

With the information which is collected in the preliminary research, the survey is composed. The survey is used to gather information how people experience subjective safety. Demographics are also asked to find possible correlations. In total, the survey will be 17 short to answer questions. When people are held up for too long they may become irritated which can influence the results. The survey is shown in appendix B, survey Jacob Gerritstraat . On the street both a Dutch and an English version is used. When the survey is finished the time and date will be notated to be able to compare it with the video material. This will be discussed in the following sections.

As is shown in chapter 2 (Preliminary research) everyone is reacting different to situations. This is depending on demographics as age, gender and place of residence, but also on why they are using the street and the way of moving. The last two of those determine how observant people will be in the traffic flows and if there is a chance that they will be surprised by other road users. This is why guestions 1 till 6, 12 and 14 are introduced.

Question 7, 8 and 9 are to register how people do experience the street. As this is a subjective question it will be expressed on a scale from 1 till 10. It will help to evaluate the results later on as it is comparable. The 1 to 10 scale is chosen because people will link it to the grading system that is used in schools.

Question 11 is included to compare the subjective safety with the objective part. If people have recently had a scare moments or (near) collisions, where breaks or manoeuvres are needed, it probably will influence their feeling of safety. Besides this counting there are no further numbers know about how many of these moments happens on daily basis. It also will be hard to count these as the camera view is limited so asking people will give the best result. Nevertheless it won't include all (near) collisions.

Questions 16 and 17 are in the survey to find out if people know what the regulation is in the Jacob Gerritstraat. Road users will in general follow the regulation, which is in a certain way for a reason. Therefore it is important that the users also know this regulation so they are able to apply.

The survey is executed by 2 people, dressed in T-shirts of the TU Delft. People tend to feel useful to answer the questions and will have the feeling something can be reached by helping. 15 people are asked to fill in the survey per interval of 30 minutes, which results in a total of 115 respondents. This includes both cyclists and pedestrians. The respondents are chosen randomly but diversity, for example in age, is kept in mind as this is desired for the analysis.

The interview excludes children up till the age of 16, as they have a total different view on how to answer the survey question. They also have a different perception of safety. They may be running

around not noticing other road users. As their parents will be asked they will include the safety of their children into their answer. Tourists are asked about their opinion. They are also users of the street who have to feel safe and even in October there is a represented amount of them. A representative amount for a separate group of road users is not achievable for wheelchair users and that is why they are not asked.

Furthermore the position of questioning is important. It should not influence the video material, by people who are trying to walk around the interviewers. The location is a few meters from the end of the street, the yellow dot in figure 3-1.

Besides the above mentioned there are also external factors influencing the survey results. People will experience the situation different on a rainy night than on a sunny Sunday morning. Therefore the survey is done during daylight on the following moments:

- Tuesday 14.30 15.00
- Wednesday 15.30 16.00
- Thursday 12.00 12.30 & 15.30 16.00
- Friday 15.30 16.00 & 18.30 19.00
- Saturday 13.30 14.00
- Sunday 13.30 14.00

Crowded moments are on Thursday afternoon, Friday evening and Saturday. These are the shopping moments and when the marketplaces are opened. The Market on Thursday and the Brabantse Trufmarkt on Saturday. But when you are there on weekdays in the morning there are only few people walking around and few trucks supplying stores, which is allowed on workingdays between 7.00 and 12.00; Saturday between 7.00 and 11.00; and Sunday between 10.00 and 12.00.

The chosen moments are also matching with the timeslots of the executed counting of BRO in 2004 and 2008 (municipality Delft, 2008). Executing the survey during daylight also excludes the influence of cyclists without light. Nevertheless the weather can't be influenced. For best result the weather is constant during the different level of bustle. To minimalize the influence of weather the survey will be done several times with a same expected level of bustle.

3.3 Description camera setup

Another way to observe the Jacob Gerritstraat is by filming. In the building of Randstad, see figure 3.1 blue dot, a camera is installed on the balustrade on the 3rd floor. It is aiming to the ground, see figure 3-2. On the left side of the picture is the Markt and on the right side the Brabantse Turfmarkt. The camera is filming from 8.00 till 20.00. The material which is not counted is used to get further insights in how people are using the street.





Figure 3-1, Location plan observation (Google Maps)

Figure 3-2, View of camera (own draft)

After the video material is collected, it is used to count the number of cyclists and pedestrians who are using the street. The quantitively information will be collected by counting the number of people during the 30 minutes the survey is done. This is divided in timeslots of 5 minutes. In this way a representative number of road users is shown for the moment the respondent crossed the street. The correlation which will be explained in the following section is more accurate.

The counting is done by drawing a virtual line in the screen. Every person that crosses this line is registered by transportation mode. By dividing the number of people by the width of the street (6.7

meters) it can be linked to the guidelines as founded in the preliminary research, expressed in people per hour per meter.

Besides the counting, the film material is used to see how people manoeuvres to prevent collisions. Manoeuvres that can be made are:

- cyclist has to slalom
- cyclist has to break
- cyclist has to dodge
- cyclist has to step off
- pedestrian has to dodge because of cyclist
- pedestrian has to stop because of cyclist
- collision between cyclist and pedestrian

3.4 Data processing

After that all information is collected, it is time to evaluate the results. The answers from the survey will be filled in into IBM SPSS Statistics Data Editor. In every row a new respondent is added. In the columns the answers to the questions are shown. This is done by numerical data as follows:

- transportation mode: 0 (= cyclists), 1 (= pedestrian) Column 3 Column 4 - gender: 0 (= woman), 1 (= man) Column 5 - age: real number Column 6 - group size: real number Column 7 - group relation: 1 (= family), 2 (= friends), 3(= acquaintance), 4 (= colleges), 5(= otherwise)Column 8 - place of residence: 1 (=Sparsely populated), 2 (= moderately sparsely populated), 3 (= medium population), 4 (=moderately densely populated), 5 (=densely populated) Column 12 - collisions: 0 (= no), 1 (= yes) Column 14 - goal of visit: 1 (= residence), 2 (= work), 3 (= shopping), 4 (= market), 5 (= restaurant), 6 (= on transit), 7 (= otherwise) Column17 - frequency: 1 (= daily), 2 (= 3-5 times a week), 3 (= once a week), 4 (= once a month), 5 (= less than once a month) Column 19 - regulation pedestrians: 1 (= the whole width), 2 (= the sides of the road), 3 (=no) Column 20 - regulation cyclists: 1 (= yes), 2 (= yes, but they are a guest), 3 (= yes, but not on sales nights and market days), 4 (= no)

Furthermore, extra columns are added for intensity of pedestrians, cyclists and the sum of both. Respectively in column number 21, 22 and 23.

With IBM SPSS the correlation coefficients between variables can be found with the function 'Bivariate Correlations'. The above mentioned factor are taken in account toward feeling of safety, crowdedness and atmosphere. Also the internal correlations are considered. It all follows from the result of the survey. From the video material the intensities of cyclists, pedestrians and the sum of these are used to see if there are any correlations. This is done with the method of Pearson Correlation Coefficient (r). Furthermore the number of significance is shown for a two-tailed test and the number of respondents that is evaluated, N.

After the correlations, and thus the important factors, are determined, a regression line is conducted. Only linear regression lines are taken into account. First, all available factors are considered to determine the feeling of safety. Some of them show a low t-value and a high significance number. The t-statistic is the unstandardized coefficient divided by the standard deviation. In general, t-values of (-)1,900 are considered as an important factor. Although some factors with a lower factor are also taken into account to draft the regression line. These factors are mostly shown to have a correlation, only the significance is low due to the number of respondents. So the t-value can increase when the significance drops. This will also result in a higher coefficient. For the function, the unstandardized coefficients B are used, as all factors have a different scale.

In a similar way, the regression line for feeling of crowdedness and atmosphere are drafted.

4. Research results

After the research was performed, which includes the survey and the video material, this chapter will study the results. The first section is about the survey. The correlations between several factors is studied. In the section 'Counting analysis' is looked at the video material that is made during the same week. In the last section the comparison between the survey analysis and the counting is done and investigated for correlations.

4.1 Analysis survey results

The survey was executed between October the 3 and 8. It was a cloudy week with sometimes heavy rain. While the surveys were done, it was mostly dry, only sometimes drizzle. This was noticeable on influence on the intensity of the crowd. There was during the entire week no extremely busy moment. On the other hand it does not seems to on influence the mood of the people. The composition of the people variated with the days. During the working days the majority of the crowd was 40+. The young people who passed were mostly on the bike and overall not willing to stop. Only Friday evening was an exception with lot of people walking around looking for shops or a place to eat. This also was noticeable in ambiance of the people. This continued on Saturday and Sunday. On this last day there were significantly less retired people in the street.

General statics

In total 115 people filled in the survey, an average of 15 per timeslot. 15 of the participants were cyclists. This existed for 33,3% (N=5) of men and 66,7% (N=10) of women. This differs from the total, which was 47,8% (N=55) men and 52,2% (N=60) woman.

The age of the participants ranged from 16 to 80. In the category below 25 is 25,2% (N=29) of the respondents; between 25 and 44 is 16,5% (N=19); between 45 and 65 is 33,9% (N=39); and in the category 65+ are 24,3% (N=28) respondents.

Notable is the amount of road users that during the trip got scared by other road users, namely 33,9% (N=39). This includes all small and big events. Furthermore it is remarkable that only 21 out of 115 people are able to tell what is the correct regulation for cyclists and pedestrians, despite of 79,1% (N=91) visit the street more often. This does not mean that people who answered the question wrong are violating the rules, as it is allowed to cycle and walk in the street.

Last factors that were taken in to account were: the group size, where 43,5% (N=50) travelled alone, 45,2%(N=52) travelled in pairs and the remaining 11,3% (N=13) travelled with 3 or more; the place they live, with the biggest group of 47,0% (N=54) of the responses from people who live in densely populated places and 13,1% (N=15) in sparsely populated and moderately sparsely populated places; and the intention of people in the street, with as biggest motives shopping, 51,3% (N=59), and on passing, 20,0% (N=23). This is a global indication of how the street is used and by whom.

Perception of surrounding

As stated in section 3.2 (methodology; survey) the experience of safety, crowdedness and atmosphere in combination of different factors is investigated. The average grade of all road users for safety is 7,83, for crowdedness 5,77 and for atmosphere 5,87. But as the street is in first place intended for pedestrians, it is also interesting to look into the grades given by different modes of transportation, as there is a different experience, see table 4-1. Here is shown that all experiences are lower for cyclists. It has to be taken into account cyclists is only a small group used as reference. Therefore the grades for experience of cyclists should more be taken as an indication for experience of all cyclists.

		safety_feeling	crowdedness_feeling	atmosphere_feeling
Cyclist	Mean	7,40	5,53	5,69
	Std. Deviation N	1,765 15	2,669 15	2,840 13
Pedestrian	Mean	7,89	5,81	5,90
	Std. Deviation	1,657	1,862	2,300
	Ν	100	100	88
Total	Mean	7,83	5,77	5,87
	Std. Deviation	1,672	1,974	2,361
	Ν	115	115	101

Table 4-1, Experience safety, crowdedness and atmosphere by pedestrians and cyclists

The focus of this research is on the perception of pedestrians. These experiences can be split into the several time slots when the survey is executed. It is noticed the number given for atmosphere is much higher on Tuesday. This can be explained by the difference in grading scale (1 is good, 10 is bad) in comparison with questions about feeling of safety and crowdedness (1 is bad, 10 is good). On the first day we did not mention this to the respondents so the grading was probably different from their intention, as some people may have noticed and others not. On the remaining days, it is explicitly stated to respondents to watch the scale. Because the results of crowdedness on Tuesday are contaminated, these are left out when correlations are examined.

Demographics influence

The first set of correlations where is looked for is the demographic factors of people. In the preliminary investigation demographic factors came up as important for the experience of people. Results for correlation are shown in table 4-2. The relationships with a high correlations, above 0.100 or below -0.100, are shown in green. This indicates there can be a correlation and the factor is of possible impact on the feeling of safety, crowdedness and atmosphere. Nevertheless not all correlations make sense, as sometime other factors are responsible for the correlation. Furthermore, the sometimes high significant number should be considered. This is when the significance is higher than 0.05. A high number means the correlation can also be based on coincidence. To exclude this, more results are needed. A difference in number of significance is determined by the way the answers of respondents is distributed among the possible answers.

		<i>safety_feeling</i> Pearson Correlation	crowdedness_feeling Pearson Correlation	atmosphere_feeling Pearson Correlation
age	Correlation	-0,181	-0,002	-0,049
	Sig. (2-tailed)	0,071	0,984	0,651
	Ν	100	100	88
gender	Correlation	0,164	-0,092	-0,216
	Sig. (2-tailed)	0,103	0,364	0,043
	Ν	100	100	88
residence	Correlation	0,366	-0,281	-0,199
	Sig. (2-tailed)	0,000	0,005	0,063
	Ν	100	100	88

Table 4-2, Correlation experience safety, crowdedness and atmosphere by demographics

In the table is shown all demographics, gender, age and place of resident, are under influence of the feeling of safety. Hereby the correlation factor of age is negative. So older people experience the street less safe than younger people. By the other experiences there is an extremely high number of significance so there is no good conclusion. The influence of gender is noticeable by feeling of safety and the feeling for atmosphere. Men experience the street safer than women and also with a higher atmosphere (because the scale is turned).

Apparently the most important demographic factor is whether people live in a small town or in the city, which is explainable by the fact if they are used a similar the situation. This is also substantiated by the low significance number, as well for the feeling of safety as of crowdedness. By atmosphere the number of significance is higher but still a plausible factor.

Momentary factors

Besides demographic factors there are other external factors which influence the feeling of safety, crowdedness and atmosphere among the road users. These are: the goal of their visit as shopping or part of the route on transit; the size if the group the street is visited with; the interactions with other road users, for example an near collision with other cyclists; and how often the street is visited in general. The impact of these factors are shown by correlation in table 4-3.

goal of visitCorrelationPearson CorrelationPearson CorrelationSig. (2-tailed)0,7700,8050,298Number of the second
goal of visit Correlation -0,030 -0,025 0,112 Sig. (2-tailed) 0,770 0,805 0,298
Sig. (2-tailed) 0,770 0,805 0,298
N 100 100
N 100 100 88
groupsize Correlation 0,014 0,035 0,249
Sig. (2-tailed)0,8890,7310,019
N 100 100 88
Interactions other Correlation -0,214 0,128 0,158
roadusers Sig. (2-tailed) 0,032 0,204 0,142
N 100 100 88
frequency of visit Correlation 0,028 0,239 0,048
Sig. (2-tailed)0,8070,0350,692
N 78 78 70

Table 4-3, Correlation experience safety, crowdedness and atmosphere by momentary factors

An important factor on the experience of pedestrians in the street is the interaction with other road users. This has a correlation with all three aspects. It is logical when people have had an near collision, their feeling of safety decrease. This is the same for the atmosphere. The feeling how crowded the street is increases when interactions with other road users take place. The significance of this factor is higher than the standard. 30 people have had interactions and they did not all gave a lower grading than people who didn't had any interactions, as an experience is personal for everyone. So more results are needed. This is also the case for a lot of other factors, especially with a low correlation number, shown in grey.

A good correlation is shown between the frequency of visiting the Jacob Gerritstraat and the feeling of crowdedness. People who visit the street more often give a lower grade to this feeling. Another correlation is between the group size and the atmosphere. This becomes better when the group is bigger.

Internal correlations

As people were asked about their perception on safety, crowdedness and atmosphere, it is also possible to find out whether these ratings are dependent of each other. This is shown in table 4-4.

		Pearson Correlation
safety feeling ~ crowdedness feeling	Correlation	-0,275
	Sig. (2-tailed)	0,006
	Ν	100
safety feeling ~ atmosphere feeling	Correlation	-0,087
	Sig. (2-tailed)	0,421
	Ν	88
atmosphere feeling ~ crowdedness	Correlation	0,283
	Sig. (2-tailed)	0,008
	Ν	88

Table 4-4, Internal correlation safety, crowdedness and atmosphere

Good correlations are found both for feeling of safety and atmosphere in combination with crowdedness. In both cases, when the feeling for crowdedness becomes higher, the experience of safety and atmosphere became worse. So for future improvements not only suggestions can be made to directly improve the feeling of safety, but also improvements to make the feeling of crowdedness less. This correlation can be described with the linear function:

Safety_feeling ~ 9,31 - 0,245 * Crowdedness_feeling.

Hereby t = -2,834 and sig = 0,006 for the factor of crowdedness and the overall correlation $R^2 = 0.086$. The constant is 9,31 which makes it impossible for the feeling of safety to become higher than this number as the grade for crowdedness will be between 1 and 10. This indicates the description of the regression line is not perfect for outliers of the crowd.

Overall feeling

Another important factor about the feeling of safety in the street is not only how people experience it at the current moment but also what the overall association is with the street. As stated in section 2.1 (Experience traffic safety) these two can differ from each other. This also evident in the survey. Where 19 % (N=16) of the pedestrians who visit the street more often have a neutral and fine feeling by the street and another 19% experience it as safe, the remaining 62% (N = 53) have a negative association. They highlighted the words as chaotic, unsafe and pressed. Several of them mention that the current moment was quiet and pretty okay but that they also have had more bad experiences.

Preliminary conclusion

When people visited the street during the week of the survey, their overall experience of safety was good, with an average of 7,89. Nevertheless, in general, people want to see a change in the current situation when they look at the overall use of it. Most of the investigated factors can't be adjusted as they are characteristic for the road user. But one of the shown factors is influenceable, namely the amount of interactions between road users. When this will occur less, the feeling of safety raises, the experience of crowdedness drops and also the grade for atmosphere will be better. All correlated factors are shown in figure 4-1.

The experiences are also correlated to each other. So when the experience of how crowded the street is can be changed positively, the feeling of safety increases.



Figure 4-1, Relations to experience of safety, crowdedness and atmosphere

4.2 Analysis counting results

To carry out the counting as described in the methodology, the video material is analyzed. Both intensities of pedestrians and cyclists are registered in blocks of 5 minutes while the survey is done. Due to a technical mistake there are no results of Tuesday 3 October. The intensity of pedestrians is variating the most (pedestrians per hour per meter in width), with a mean of 233.53; standard deviation 90.14; minimum 131 on Wednesday; maximum 724 on Saturday. By cyclists is this: mean 68.55; standard deviation 26.31; minimum 20 on Saturday; maximum 113 on Friday evening. This shows that even the average moments, a workday afternoon, are already approaching the design guideline of 141 pedestrians/h/m. The most crowded moment exceeds this more than 5x. On the other hand, a good correlation between pedestrians and cyclists, of R = -0.545 and sig. = 0.000, is shown. This means that the expected self-regulation is working. Although it has to be taken into account that the moments of high pedestrian intensity are on market days. This makes every route through the Jacob Gerritstraat less attractive for cyclists as stalls are located on "de Markt" and "de Brabantse Turfmarkt", see figure 1-1.

Influence of intensities

When the results of the intensities are linked to the grades for experiences, a lot of variating numbers for correlations and significances are found, see table 4-5. Against expectation, the feeling of safety decreases when the intensity of pedestrians increases and the safety increases when the intensity of cyclists increases. This is not logical when looking into the survey results about correlation of safety experience and interactions with cyclists. The results are also doubtable looking into the significance. Therefore there is also taken in account the total intensity of the street. Here again the feeling of safety decrease when the street is more crowded. The number of significance is also decreased.

For the correlation with crowdedness and atmosphere it is also applicable that the significance number is too high to state the correlations as true. More data is needed and further research about the ratio of cyclists and pedestrians.

		safety_feeling Pearson Correlation	<i>crowdedness_feeling</i> Pearson Correlation	<i>atmosphere_feeling</i> Pearson Correlation
Intensity	Correlation	-0,177	0,038	0,025
pedestrians	Sig. (2-tailed)	0,098	0,726	0,818
	N	88	88	88
Intensity	Correlation	0,114	-0,066	0,015
cyclists	Sig. (2-tailed)	0,292	0,539	0,886
	Ν	88	88	88
Total	Correlation	-0,165	0,021	0,034
intensity	Sig. (2-tailed)	0,125	0,845	0,756
-	N	88	88	88

 Table 4-5, Correlation experience safety, crowdedness and atmosphere by intensity

4.3 Evaluation of research results

As stated in the previous sections, there are a lot of factors on influence on the experience of a street. These influences can be described with a linear regression line. All factors that can be taken into account are age, gender, residence, group size, frequency, goal of visit, intensity cyclists, intensity pedestrians and total intensity. When these are all considered a correlation of R = 0.423 is found. Some factors are showing a low t-value, just above 1.0, and a high significance. Nevertheless these are still taken into account. Expected is the influence of these will be proven when the significance number drops, as correlation is already proven in previous sections. Therefore more respondents are needed. Factor with a t-value lower than 1.0 are excluded.

When only age, place of residence, gender, frequency of visit and total intensity are taken into account, the correlation decreases to R = 0.418. On the other hand, the reliability of separate factors increase. This is shown in table 4-6.

	Unstandardiz			
	В	Std. Error	t	Sig.
(Constant)	8,383	1,494	4,942	0,000
age	-0,022	0,009	-2,375	0,021
residence	0,420	0,201	2,090	0,041
gender	0,324	0,362	1,070	0,373
frequency	-0,123	0,200	1,116	0,269
Total_intensity	-0,005	0,004	-1,242	0,219

Table 4-6, Influence factors regression line safety

This can be used to define a function for the feeling of safety. The unstandardized coefficients are used to exclude the influence of the significance on the formula. Age and total intensity are filled in as a real number. Gender is filled in as a 0 (= woman) and 1 (= man). Residence and frequency are both on a scale from 1 till 5, in the same way as the survey. The function is established as:

Safety feeling ~ 8.383 - 0.022 * age + 0.420* residence + 0.324 * gender - 0.123 * frequency - 0.005 * total intensity

From the table, and thereby regression line, is seen that the feeling of safety decreases slightly for every year the respondent is a year older. Also can be seen that it increases by 0,42 when the respondent is a man. The score is not lowered when the feeling of safety for a woman is determined. When people visit the street less it result in a lower experience of safety, as the inserted value in the function is higher. As latest it is influenced by total intensity. When this increases, the feeling of safety will become less.

A regression line can also be constructed for the feeling of crowdedness and atmosphere. These are influenced by other factors as the correlation between factors and feeling differs, respectively table 4-7 and table 4-8.

Crowdedness is most similar to the feeling of safety, which makes sense as safety and crowdedness are correlated to each other. The correlation R = 0.392 and formed by the function as

shown below. It shows that the feeling of crowdedness gets better, as it becomes lower, when people are living in a higher dense population. This is also the case when people visit the street more often or when it is a man. The number for feeling of crowdedness will in increase when the goal of visit is shifted to a destination further away from the street. Against expectations de feeling of crowdedness decreases when the total intensity increases.

Crowdedness feeling ~ 8.543 – 0.538 * residence – 0.481 * gender + 0.159 * goal of visit + 0.278 * frequency – 0.003 * total intensity

	Unstandardized (
	В	Std. Error	t	Sig.
(Constant)	8,543	1,751	4,879	0,000
residence	-0,538	0,233	-2,307	0,024
gender	-0,481	0,424	-1,133	0,261
goal_of_visit	-0,159	0,153	-1,040	0,302
frequency	0,278	0,231	1,205	0,233
Total_intensity	-0,003	0,003	-1,001	0,463

 Table 4-7, Influence factors regression line crowdedness

By atmosphere even no influence of intensity of road users is noticed. Only residence, gender and group size have influence. Here people will rate the atmosphere better, as it will be lower, when they live in higher dense populated areas, but worse when they are with a big group. Also man are grading atmosphere better than woman. For this function the correlation R = 0.338. The function is defined as:

Atmosphere feeling ~ 6.166 - 0.207 * residence - 0.891 * gender + 0.534 * group size

	Unstandardized (
	В	Std. Error	t	Sig.
(Constant)	6,166	1,190	5,181	0,000
residence	-0,207	0,205	-1,008	0,351
gender	-0,891	0,475	-1,876	0,064
groupsize	0,534	0,278	1,919	0,058

Table 4-8, Influence factors regression line atmosphere

Other factors that should be taken into account, which are not considered in the functions above but examined with the survey, are the knowledge about the regulation in the street and the overall impression of people. Also the chance of possible collisions is on influence of the experiences of people, but left out of the function.

5. Improvements

In the theoretical framework (chapter 2) is shown that a lot of factors are influencing the feeling of safety. In the research results (chapter 4), the influence of these factors is deeper investigated and even more correlations are shown. But not all factors on the experience of safety can be adjusted. Furthermore it is in the case of Delft not desired by the municipality as well by the inhabitants to create a prohibition to cyclists due to accessibility. When the mixture is maintained it is important to make it not fully comfortable to everyone as it will result in the fact that people will pay less attention to their surroundings.

Factors as age, gender, place of residence, frequency of visit, goal of visit and group size are determined by the user. Another factor that is hard to influence is the social interaction between road users. The fact that the population is aging and the level of migration is higher than ever before creates a feeling of anonymity. People have different norms in social interaction and react different to each other. To improve social interaction, pedestrians and cyclists have to be able to look each other in the eyes and negotiate about the right of way in an nonverbal way. For this no objects, which will possible block eye contact, are desired. A lower speed differentiation between road users is also desirable. It will limit the change of collisions, which is linked to a better road experience. Nevertheless it is hard to assert a speed limit, as cyclist in general do not have a speedometer. Only terms as walking speed can be applied. The municipality of Delft is testing to ask awareness for the speed difference, as a test, by a big sign, shown in figure 5-1. The signs tells "Winkels open, liever lopen", which means: if the stores are opened, preferably go for a walk. Further awareness can be gathered by the use of social media.

Removing the signs on the side of the road, place by stores (see figure 5-2 on the left and right side of the rode), has as advantage that the effective width of the road is enlarged. For the current calculation of the amount of pedestrians per hour per meter width the entire width of the street, 6.7 meter, is taken into account. But when the stores are open this is not applicable for the entire length of the street. The signs take up to 0.7 meter off the cross section which lowers the maximum capacity for easy flow, which is stated at 141.1 pedestrians/h/m. It also block the pedestrians from walking straight lines. Nevertheless store owners won't be happy with this decision as they are used to it. But looked at other cities, it is not common to use bill boards on the street.

To enlarge the desired capacity of a mixed street even more, a change in street design is recommended. The use of a rider in the middle of the street creates the illusion pedestrians are expected to the side of the road. In figure 5-3 an example is shown that is located in 's-Hertogenbosch. Over here it is implemented in streets of the entire city centre where stores are located and cars are not allowed. When the rider is conducted in another colour than the sideways, the effect of separation is enlarged. Nevertheless the use of grey or black asphalt is discouraged as it will give the indication it is only for use of cyclists, which is not the case. It is still a pedestrian zone where cyclists are only as guest. Further research has to be done for the most desired colour and material for a rider.



Figure 5-1, Lower speed (municipality Delft)

Figure 5-2, Remove billboards (Google Maps)

Figure 5-3, Insert a rider (Google Maps)

Figure 5-4, Clear regulation (municipality Delft)

Whether changes to the road are done or not, it is important that the applied regulation is clear to everyone. As the municipality of Delft already did, it is good to have one clear rule to an entire area to prevent confusion. Nevertheless this norm should be better shown. Currently signs of the pedestrian zone with sub descriptions for cyclist are only shown at the edges of the area. Just as proven with the results of the survey, people are not conscious of the rules in the street. This is also caused by an unclear definition of the rules. "Cyclist are allowed as guest" is only further defined as cyclists have to adjust themselves to the pedestrians in the street. No limitations are given as a rule that can be exceeded. The influence of good, new designed, signing is currently tested by the municipality of Delft in the Choorstraat, see figure 5-4. To vindicate this rule, it is desired to tackle the excessive undesired behaviour.

The last option to make the use of the Jacob Gerritstraat more appealing to pedestrians is to reduce the amount of cyclists. This can be done, without prohibition, by showing possible detours which even can be faster to certain destinations. When people are common with a certain route, they stick to it as a habit. When detours are shown they might get a new insight in faster routes. A possible way to show these is by the use of social media.

6. Conclusion

In this report is looked into the question *"How can the feeling of safety in the Jacob Gerritstraat be improved?"*. To get to a result, background information is collected about what traffic safety is and how people experience it; what the guidelines are for a street shared by pedestrians and cyclists; how different municipality interpreted these guidelines; and what are indicators for possible solutions. Thereafter a setup is made for filming the street while a self-conducted survey is held. Based on different analyses, a conclusion is drawn about how people experience safety and what can be done to improve the feeling of it while walking through a street.

It turned out there are several groups to categorize safety in. There is objective and subjective safety; physical and social safety; situational and general safety; and anticipated and actual safety. Each of them describe the word safety in a different way and also gets influenced by different factors. The feeling of safety is the best described as subjective safety and gets threated by physical as well social safety. Stated factors which are on influence are age, gender, place of residence, frequency of visit, goal of visit, group size and amount of interactions with other road users. The subjective experiences of safety, crowdedness and atmosphere can be analysed by a survey where the stated factors are processed in as well. The perception can be expressed in a scale from one till ten. The scale helps to make them comparable in a later stage. The objective factors, as actual intensities and collisions, are counted with respect to transportation mode.

Other factors which are on influence of the feeling on safety, but where is not looked into, are layout of the surrounding; layout of the street as obstacles and street design; and the influence of general social factors which can't be adjusted as aging and migration.

The municipality of Delft made the decision to have one regulation in the entire city centre: it is an pedestrian zone with cyclist allowed as guest. The reason for this is to create unity for the area which is clear to its users, even the guidelines of 141.1 pedestrians per hour per width are exceeded. This will be self-regulated with amount of cyclists in the street.

The same regulation is also applied in 's-Hertogenbosch. In the past there where timeslots on which it was not allowed to cycle in the centre. This caused confusion so step by step it became allowed to cycle everywhere, if attention was paid to pedestrians. The municipality of Waalwijk followed the example of 's-Hertogenbosch and after a trial period it is now allowed to cycle in the pedestrian area as well. Nevertheless not all municipalities are in to this plan. In Utrecht the timeslots in which cycling is forbidden are enlarged to create more space for pedestrians. The municipality made the rules the same for every single day of the week which keeps it simple and clear.

Analysing the results of the survey by correlation shows influence of the considered factors on the feeling of safety, but also on the feeling of how crowded the street is and the experience of the atmosphere. Yet, not all feelings are influenced by the same factors. For example, age has an influence on the feeling of safety but, looking at significance, probably not on crowdedness and atmosphere, while gender has an influence on both safety and atmosphere but not on crowdedness, and place of resident is on influence on all three. In the same way correlations are found for goal of visit, group size, interactions with other road users and the frequency of visiting a certain street. A differentiation can be made in the feeling of safety by cyclists and pedestrians. On average cyclists grade it with a 7,40 while pedestrians give it a 7,89. It has to be taken into account cyclists is only a small group used as reference.

Further correlation can be found between the feeling of safety and how the crowdedness is experienced. The correlation between those two is $R^2 = 0.086$ with a significance of 0.006. This is expressed in the function: Safety feeling ~ 9,31 - 0,245 * Crowdedness feeling. The feeling of safety seems not to be correlated to the grading for atmosphere. But the high number of significance has to be considered. As latest there is shown there is a correlation between the atmosphere and crowdedness experience.

When the experiences of safety, crowdedness and atmosphere is plotted against the intensities recorded on the same moments, biggest correlations are found by the feeling of safety. For both as intensity of pedestrians and intensity of cyclist as for the total intensity. These correlations are lower and also less significant for crowdedness and atmosphere.

All collected information about factors influencing the experiences of safety, crowdedness and atmosphere are expressed in the following functions. Correlations are respectively R = 0.423, R = 0.392 and R = 0.338.

Safety feeling ~ 8.383 - 0.022 * age + 0.420* residence + 0.324 * gender - 0.123 * frequency - 0.005 * total intensity

Crowdedness feeling ~ 8.543 – 0.538 * residence – 0.481 * gender + 0.159 * goal of visit + 0.278 * frequency – 0.003 * total intensity

Atmosphere feeling ~ 6.166 - 0.207 * residence - 0.891 * gender + 0.534 * group size

Other factors that should be taken into account, which are not considered in the functions above but examined with the survey, are the knowledge about the regulation in the street, the general impression of people and the number of near collisions.

With all collected information possible improvements are suggested. As is shown, a lot of factors are on influence on the feeling of safety, crowdedness and atmosphere. Most of them can't be adjusted to improve these perceptions. What can be enlarged is the maximum capacity of the road where pedestrians and cyclists can mix together in a good way. This can be done by creating a rider in the middle of the street. Pedestrians will automatically move to the sideways. This shift is even larger when a different colour of road is used. Another thing that should be adjusted is the amount of signs placed by the stores. These obstacles narrow the street which will lower the capacity. Less collisions will occur when the speed difference between pedestrians and cyclists is reduced. As most of the cyclist do not have an indication of speed, it can only be stated as walking speed. In this case only undesired excessive behaviour will be appointed. When people desire a higher speed, detours should be provided. One way to do this is by advertising them on social media. This also a good way to state the regulation in a better way, besides road signs, to the residents.

7. Discussion

To perform this research, literature is used to gather information about safety. This is used to compose the survey, to get information about the experience of safety, crowdedness and atmosphere. A better way to measure the feeling of safety is by measuring physiological factors as sweat, heartbeat and breathing. This is only hard to implement in big crowds, for sure for the small size of this research. So a survey is a good alternative. It is also easy to reuse on other locations for a similar research. Nevertheless the questions should be adjusted a bit. For example people were questioning what to fill in by the group relation when they are a couple. Family was advised to create a uniform answer. Against expectations respondents didn't have any questions about question number 6 "In what kind of neighbourhood do you live?". In general, people where well able to make this decision. While people were making their choice about the grade they would give to safety, there is a chance they did not only involve traffic safety but also general experience of safety as chance of robbery. It is mentioned to the respondents the survey was about traffic, nevertheless the consideration of people cannot be checked. In guestion 9, about the atmosphere, the scale should be turned around to match it with the other experience questions to prevent confusion. At latest question 12 sometimes raised doubts. Often people where in the street with a combination of reasons, like a bit of shopping but the main goal was to visit the market.

The survey was only performed during daylight on stated moments. There was less variation in crowdedness, shown by video material, than expected. This can be caused by the bad weather of the entire week. It was clouded and windy with sometimes rain. There is a change this was also of influence on the mood of people and how they answered the questions about perceptions. This can be checked by perform the research more often with different types of weather. It can also be done during the evenings when it is dark, as it will also be on influence of the perception of safety. Even excluded categories as disabled can be involved by then. In general, more research should be done to collect more data. This will increase the validity and lower the number of significance which are shown by some of the correlations. To even improve the survey, also the people who don't want to fill in the survey should be noted. In this way a good overview of the road users can be conducted.

Also, the setup for the camera was not perfect. In first place, the position of the camera shifted a bit due to strong wind, but the video material was still useable. As second, there were some technical problems. On Tuesday the camera didn't start filming. After starting it manually on Wednesday, it stopped at 6 o'clock. After not knowing the mistake a new computer was linked to the camera and it was programmed to film continuously.

Afterwards, the film material got counted out by hand to find out the intensities. When the results were correlated to the results of the survey, no margin of error is included, assuming the counting is done right. Also a mistake of a few bicycles will not have a big influence on the correlation as it is on an average of 170 people passing in 5 minutes.

When the total research is performed a next time on the same location, similar answers are expected. Variation can occur by difference in intensities and weather. Eventually this will make the functions for safety, crowdedness and atmosphere better as there is more data available and there also can be looked into the exact influence of the weather. When the research in done on a different location, a variation in experience may be shown. The layout of a street is a big factor on these grades. A wider street will give a less crowded feeling than a narrow street with high buildings around. Nevertheless still a correlation should be shown between the different factors on the experiences and between different perceptions.

Overall, the findings at the end of the research were a bit different than expected. People rated the safety higher than foreseen. It seems this was bit due to quiet moments as when asked about the general feeling still lot of people had a negative opinion. Also during the survey people talked negative about the street. Furthermore, where there was still a good correlation between the external factors, analysed by the survey, and the different experiences, the correlation became less when the experiences got compared to the intensities. Especially a stronger correlation with the feeling of crowdedness was expected. But this stays unproven due to high significance.

To improve the correlations and number of significance more surveys should be taken. Furthermore, research should be done to find out of what influence the ratio between pedestrians and cyclists has on the experience of people. Also how cyclists experience the Jacob Gerritstraat is left out because of less respondents. So this can also be analysed in the future.

To see if any improvement to the street is effective, the influence of different measurements should be analysed. The municipality of Delft is already looking at the impact of good signing on the way pedestrians and cyclists use the road and interact to each other. There can also be looked at what the influence is when people understand the current regulation better, as the definition "allowed as guest" is not restricted. However, as the Jacob Gerritstraat is obviously a shopping street, cyclists adjust their speed automatically. Only excessive behaviour should be handled.

A bigger change will be done by adjusting the layout of the street with implementing a coloured rider. There can be looked into different colours and width, and how this will influence the use of the street. It is important to take in to account that it is still a pedestrian area. So introducing a rider should not make this route more attractive to cyclists. It also may cause confusion by the road users about the regulation in the street. So again, good signing and communication is needed.

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Appendix

Appendix A, Research "Fietsberaad" Appendix B, Survey Jacob Gerritstraat 25 26

Delft

Telpunt 2: Jacob Gerritstraat

- Fietsen niet toegestaan
- Fietsparkeren toegestaan
- · Gemotoriseerd verkeer verboden (fysiek afgesloten), uitgezonderd vergunninghouders





Passanten (aantallen per uur)

's middags	
Voetgangers	705
Fietsers	30
'Fiets aan de hand'	60
Bromfletsers	0
's avonds	
Voetgangers	1.200
Fletsers	165
'Fiets aan de hand'	105
Bromfietsers	15

Conflicten (voorkomende 'acties' bij passerende fietsers)

's middags	Aantal	%	's avonds	Aantal	%	
Waamemingen	12		Waamemingen	13		
Fietser rechtdoor	1	8%	Fietser rechtdoor			
Fletser laveren	12	100%	Fietser laveren	12	92%	
Fietser remmen	6	50%	Fletser remmen	6	46%	
Fletser ultwijken	9	75%	Fletser ultwijken	9	69%	
Fletser afstappen	3	25%	Fletser afstappen	1	8%	
Voetganger uitwijken			Voetganger uitwijken	3	23%	
Voetganger stoppen			Voetganger stoppen			
Botsing flets-voetgang	ger		Botsing flets-voetgan	ger		

Conclusie van de waarnemer

74

's middags: combinatie fietsers / voetgangers moeilijk, maar niet onmogelijk

's avonds: combinatie fietsers / voetgangers onmogelijk

Appendix B, Survey Jacob Gerritstraat

Date :_____ Time:

1. Moving mode pedestrian / cyclist

2. What is your gender?

man / woman

3. What is your age?

_____(number)

4. How many people are you here?

_____(number)

5. If question 4 is answered with more than 1, what's the connection between you all

- Family
- Friends
- Acquaintances
- Colleagues
- Otherwise, _____

6. In what kind of neighbourhood do you live at the moment?

- Densely populated (countryside)
- □ Moderately sparsely populated (small town)
- □ Medium population (big village)
- □ Moderately densely populated (suburb)
- Densely populated (city)

7. How safe do you feel in this street at the moment?

(1 to 10, with 1 very unsafe and 10 very safe)

8. How crowded did the street feel when you passed it?

(1 to 10, 1 being very quiet and 10 very busy)

9. Can you give a grade on the atmosphere in this street at the moment?

(1 to 10, with 1 very cosy and 10 very cheerless)

10. Have you had collisions or scared moments when you walked through the street? yes / no

11. If question 10 is answered with "yes" What happened exactly?

See backside

12. What purpose are you in this street?

- On transit, destination (far) outside this street
- Shop
- Residence
- □ Restaurant / dining
- Market
- Work
- Otherwise, _____

13. If question 12 is answered with "Destination far outside this street": Why did you choose this route?

14. Do you visit this street more often?

yes / no

15. If Question 14 is answered with "yes":

How often do you get in this street?

- Daily
- □ 3-5 times a week
- Once a week
- Once a month
- Less than once a month

What is your overall impression on this street? (cross which one most applicable)

- □ Clearly
- Unsafe
- □ Spacious
- Chaotic
- Safe
- 🛛 Нарру
- Pressed
- Otherwise,_____

16. Where can pedestrians walk in this street according to the regulations?

- □ the whole width
- the sides of the road
- 🛛 not

17. Can cyclists use this street according to the regulations?

- Yes
- □ Yes, but they are a guest
- □ Yes, but not on sales nights and market days
- 🛛 No