Pedestrian movement in shared space versus conventional road design

A comparison between Haren and Helpman

Final version

Lodewijk Vos

Supervisor : Koen Bandsma

Colophon

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Author	Lodewijk Hendrik Vos
Study programme	Technische planologie Faculteit ruimtelijke wetenschappen Rijksuniversiteit Groningen
Supervisor	Koen Bandsma
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Abstract

Shared space road design is often used to control traffic flows, increase safety and create a more welcoming urban environment opposed to conventional road design. Pedestrians play a key role in shared space design, as they are encouraged to share the road with vehicles. However the subjective safety of pedestrians is lower in shared than in conventional road design. This study will examine whether the implementation of shared space leads to an increase in pedestrian movement as opposed to conventional road design. A non-participatory observation study was used to research the movement of 168 pedestrians on the basis of pedestrian activities. The results showed that the implementation of shared space does indeed lead to pedestrians using the shared space. However, an increase in pedestrian activities was not proven. Concluding, pedestrian movement can be changed by implementing shared space, but it will not change their activities.

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1. Background

In this chapter the background for this study is discussed, first the social and scientific relevance of the subject is discussed in the introduction. In the second part of the chapter the research problem is formulated along with the research questions. The final part of this chapter contains a reading guide, explaining how this study came about, and providing a proverbial handle for reading this thesis.

1.1 Introduction

"Shared space is a street or place designed to improve pedestrian movement and comfort by reducing the dominance of motor vehicles and enabling all users to share the space rather than follow the clearly defined rules imposed by more conventional designs"(Luca, 2012, p53). In this definition, and in many others, such as Hamilton-Baillie (2008) and Hammond (2013), one of the specific goals of shared space is to increase pedestrian movement. Many studies focus on pedestrian perception, concerns and safety within shared space, including Kaparias (2012), Hammond (2013), Kang (2016) and Hamilton-Baillie (2008). Research has shown that there is an improved vehicle flow with lower traffic speeds and a reduction of accidents when shared space is implemented (Hamilton-Baillie, 2008).

However, Kaparias (2015) notes that pedestrians give way to vehicles more often in shared space than they did before, in a conventional road design with separate areas for different types of road users, and suggests this area to be further investigated.

While in many cases one of the implementation goals of shared space, set by policy makers, urban designers and researchers (Gemeente Haren, 2008, Luca, 2012), is to increase pedestrian movement there is a lack of knowledge to what extent this implementation goal is met. Knowledge of the ways in which pedestrian movement can be changed by implementing shared space can be used by policy makers and urban designers to create more pedestrian friendly environments, and optimise the design features of shared space.

1.2 Research problem

The aim of this research is to examine in what ways the implementation of shared space influences pedestrian movement within the municipality of Groningen. Groningen has been selected because it has the presence of both types of road design within one municipality, with equal functions and traffic types.

To examine this, a comparison will be made between the Verlengde Hereweg in the neighbourhood Helpman, which has a conventional road design with separate lanes for pedestrians, cyclists and motor vehicles, and the Rijksstraatweg in the neighbourhood Haren, which has a shared space design. These locations have been selected because they are both retail areas and they are both connected on the same through route, being used by the same types of traffic. A first observation of traffic intensities shows that they have comparable road-traffic intensities, however pedestrian intensities are not measured (NDW, 2019). These two different road designs with equivalent functions will be compared in this research on the basis of pedestrian movement with the central research question:

To what extent does shared space change pedestrian movement in comparison to traditional street design in the municipality of Groningen?

The first sub question aims to identify the goals of implementing shared space in regard to pedestrian movement and is formulated as follows;

How does shared space influence pedestrian movement?

The second sub question means to examine the differences in pedestrian movement between shared space and conventional road design;

What is the difference in pedestrian movement between shared space and conventional road design?

The third and last sub question combines the first question with the second to examine whether or not the desired changes in pedestrian movement are met by implementing shared space. To examine whether there are any discrepancies between the implementation goals and the observed reality the following research question has been formulated;

Does the intended influence of shared space on pedestrian movement correspond with the actual pedestrian movement?

1.3 Reading guide

The structure of the research is based upon the research problem and the formulated research question. On the basis of the research problem a theoretical framework will be constructed. The theoretical framework will provide an in depth way of understanding pedestrian movement. Pedestrian movement will be broken down into separate activities, which will be used as a basis for describing pedestrian movement throughout this thesis. Using this framework, the first sub question will be answered, and a hypothesis will be formulated for the second sub question. In the methodology section we will discuss the chosen method, in respect to the research problem, and describe how the data collection and analysis will be conducted. In the results chapter, the results from the data collection and analysis will be discussed. First per separate activity, then in the conclusion we combine these results with the research problem to answer the research questions. In the discussion recommendations for further research will be given.

2. Theoretical framework

In the theoretical framework chapter a benchmark will be set which defines the different aspects of this study. First the two types of road design are defined, explaining the motives to use a certain type of road design, and the negative effects it might have on pedestrian movement. Then we break down pedestrian movement in activities, to better understand how a certain road design might influence pedestrian movement. After this, the first sub question will be answered, and from this a hypothesis will be derived. In the final paragraph of this chapter the conceptual model is shown and explained.

2.1 Conventional road design

In this study, we separate shared space road design and conventional road design. To fully understand this difference we must first determine what a conventional design is. Conventional road design is a design conform the segregation principle in which different modes of transport are separated from one another and every type of transport has its own lane (King, 2009). Although forms of traffic segregation date back to before the invention of cars, it was the car, and the steep increase in traffic volumes that followed, that led to the need of strict separation between the different modes of transport (Hammilton-Baillie, 2008). This has led to the urban roads as we now know them, with traffic barriers, traffic lights, signalized crossings, 'zebra's', bike lanes and overpasses.

The benefits of conventional road design are higher traffic speeds, a better traffic flow (King,2009) and higher subjective due to separation of traffic (Luca, 2012). Objective safety used to be one of the reasons to implement a conventional road design as well, however, sharing space has shown to have higher objective safety (Hammilton-Baillie, 2008). Another con of conventional road design is the inability to move around the area freely, crossing has to be done at formal crossings.

2.2 Shared space

Shared spaces create a surrounding in which pedestrians have more priority, compared to conventional road design, and can safely move around or interact with their surroundings (Karndacharuk 2013). By creating an unclear traffic situation, in which the rules are less obvious, and the users have the responsibility interact and negotiate about the right of way, motorized traffic should slow down and share the space with pedestrians. And because of this new situation, often paired with esthetic improvements (Luca, 2012), pedestrians should feel more comfortable in an area. All in all, this should lead to more pedestrian movement and activities.

However, Kaparais (2015) notes that although pedestrians have more confidence in shared space, they give way to vehicles more often in shared space than in conventional road design. This would mean quite an opposite outcome to the intended improvement in pedestrian mobility. Nonetheless, I believe it is a matter of getting acquainted to the new situation, because shared space is a less straight forward concept, without strict rules and with room for negotiation. And it will have its teething problems, as any relatively new concept has, in which the users will have to adapt over time. Hamilton-Baillie (2008) states that shared space is a radically different view on street design, in which it takes quite a bit of learning to understand the new rules and visual aspects of the design. This case study is about the shared space in Haren, which was realised in 2002 and thus most of the pedestrians and other users will have become used to the situation.

Shared spaces uses the principle of self-organisation (Helbing, 1998), in which social forces drive pedestrians to behave in a certain way. Within shared space these social forces should effect the pedestrians in such a way that they feel more free, compared to conventional road design, to move around and share the space with vehicles. These social forces are also applied to drivers of vehicles, which are forced to interact with other drivers and pedestrians to negotiate over the right of way (Luca, 2012).

However, shared space also lowers the subjective safety of its users (Kang, 2016), which might lead to pedestrians feeling unsafe to share the space. This could lead to a decrease in pedestrian movement where an increase was intended, however this area has not yet been researched (Luca, 2012). Other cons of shared space are a lesser fit for public transport (Currie, 2006), and no parking within the area, which most conventional roads do have. These aspects could lead to people avoiding an area because it is harder to reach.

2.3 Pedestrian movement

To study pedestrian movement, we must first define pedestrian movement. Timmermans (2009) states that pedestrians make simultaneous decisions in path-choice and area-activity-choice, and that certain activities are not planned but triggered by impulses from the physical environment. Due to a more pedestrian friendly surrounding in which pedestrians can travel around safely shared space should lead to an increase in these activities (Karndacharuk 2013).

In this study pedestrian movement will be broken down into activities which define the pedestrian's behaviour. Breaking movement down into activities will give a better insight into the ways in which pedestrian movement differs in both street designs. The distinguished activities are Road-crossing, shopping or retail, conversing, change of transportation and recreation. In the next section, each of these factors of pedestrian movement will be discussed.

Road crossing

Research has been done into road crossing, such as King (2009) whom assesses safety in road-crossing. In pedestrian mobility road crossing is seen as one of the most important factors, however much of this research is about formal road crossings such as traffic lights or 'zebras'. Hamilton-Baillie (2008) notes that these formal crossings have become an established part of the urban environment, yet in the concept of shared space there are no formal crossings. While the subjective safety of pedestrians has been lowered (Luca,2012), pedestrians should be safe to cross the road at any given point within shared space. The lower traffic speeds and lowered subjective safety of drivers, which causes more alertness to their surroundings, should ensure safe crossing for pedestrians (Kang,2016). However this might not be the case for vulnerable road users, such as the elderly, since they are used to conventional road design, and might not understand how to share the space (Kaparias, 2012).

Shopping or retail activity

One may argue that retail activity is not a part of pedestrian behaviour, because a pedestrian leaves the public street to go inside a private store or establishment. However, these shops play an important role in the physical environment of pedestrians. Since they are often destinations for pedestrians in city centres or urban areas, and they play an important role in the route choice of pedestrians (Borgers, 2014). Furthermore, Timmermans (2009) states that activities, such as shops or retailers can influence the route and behaviour of pedestrians, as they may decide on the go whether or not to enter an establishment. Hammond (2013) notes that in his research participants are more likely to browse shops in shared space. The shops make up an important part of the physical environment of a pedestrian and therefore shopping or retail activity is an important factor to take into account in studying pedestrian behaviour.

Conversing

The concept of shared space is based upon all street users moving on the basis of informal social interaction and negotiation (Hamilton-Baillie, 2008). While many of these interactions are of non-verbal nature, such as a nod to give someone the right of way between a cyclist and a car driver. Between pedestrians however, more of these interactions are verbally. Another aspect defined of shared space is that of being a more welcoming surrounding to stay or dwell in, and thus being more appropriate to stop and have a conversation (Hammond, 2013). Hammond (2013) states that people are inclined to have more social interaction and conversation in shared space. Conversation can therefore be used as a degree of measurement for social interaction and dwell time activities in pedestrian behaviour.

Change of transportation

There is a major focus on creating a more pedestrian-friendly urban design, considering increasing urban density, congestion and mixed land use, and creating a transit orientated transport system rather than a car orientated transport system (Wey, 2013). Such a transit orientated transport system is required in order to get people to walk in places that are beyond walking distance of their homes. Shared space is an example of such a pedestrian-friendly urban design, and therefore transit is an important part of this design, whether this happens within the shared space or near it. However, this is also the case for conventional road design, and conventional road design is better suited for public transport due to the separation of traffic (Currie, 2006).

Recreation

People who live in cities seek for a comforting environment to satisfy both physical and psychological needs, and the growth of cities has put these city residents under considerable pressure, since there is less room for recreation (Polat, 2015). Shared space could offer such a comforting environment with pleasant aesthetic features and safer surroundings. While their subjective safety should be lowered when moving through an area, the aesthetic features of the urban design should provide a more pleasant surrounding to dwell in(Hammond, 2013). Polat (2015) states in his research that the visual quality of urban design has a positive influence on recreation from pedestrians. Since this is also included in our definition of shared space, creating a more pleasant environment to dwell in, recreation can be a significant factor in observing change in pedestrian behaviour.

Concluding this literature study of different activities in pedestrian movement, the first sub question has been answered. *How does shared space influence pedestrian movement?* In short, shared space will increase road crossing, shopping activity, conversing and recreation, and will decrease change of transportation. From this the hypothesis is derived, which is more detailed for each activity as well as the general differences, as shown in figure 2.1.

	Conventional road design	Shared Space
General	- Lower objective safety - Higher subjective safety - Better traffic flows due to separation - Less pedestrian movement	- Higher objective safety - Lower subjective safety - Lesser traffic flow due to shared use of space - More pedestrian movement
Change of transportation	Better fit for multiple types of transportation and parking places for cars, lead to more changes of transportation	No parking space for cars and a lesser fit for public transport, due to slower traffic flow, leads to less changes of transportation
Conversing	Separation of traffic leads to less interaction	Users moving on the basis of interaction and negotiation, leads to more interaction
Road crossing	Mostly at formal road-crossing, less crossing in general	Shared use of space, pedestrians should feel free to cross anywhere and thus cross the road more, except for vulnerable users
Recreation	Aesthetically less welcoming	A more pleasant environment to recreate in
Shopping or retail activity	Less attractive to dwell in, leads to lower amounts of 'shop-browsing'	More aesthetically pleasing environment and more pedestrian movement, leads to more shopping

Figure 2.1; Hypothesis, expected changes for pedestrian activities

2.4 Conceptual model

The concepts in the conceptual model, as shown in figure 2.2, are al embedded in the theoretical framework. The two types of road design, with their main characteristics, influence the way in which pedestrian move. This happens through different sets of rules and different social forces. Road design is formulated on a planning level while pedestrian movement takes place on a user level. There is some feedback from pedestrian movement to road designs, however there is a lack of knowledge and understanding of pedestrian movement. This leads to marginal amounts of feedback to the planning level, hence the feedback is shown as a dotted line. Pedestrian movement is explained and defined by the different pedestrian activities.

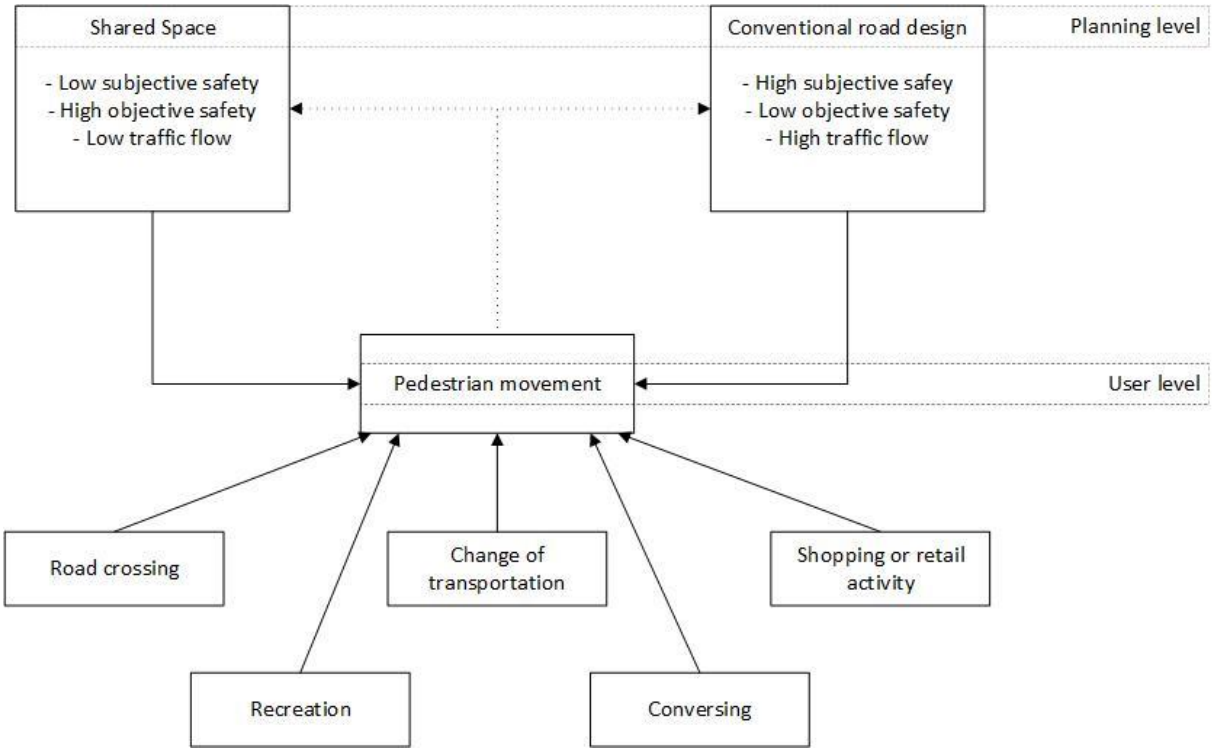

Figure 2.2; Conceptual model

3. Methodology

This chapter contains an in-depth explanation of the research and analysing techniques used in this research. In the first paragraph, the research method will be defined on the basis the research problem and the required data to answer the research questions. The second paragraph will give insight in how this data will be acquired, and in the third paragraph the best statistic test will be determined, to analyse the data and answer the research questions. Next the validity of the data will be discussed followed by the ethical considerations, both containing considerations which are to be taken into account during the research. Concluding this chapter with a guide to analysing the final results.

3.1 Research method

In the theoretical framework, a benchmark was established for the general reasons of implementing shared space in regard to pedestrian movement. Different activities of pedestrian movement have been identified. To answer the research question, the effect of implementing shared space on these activities should be measured. In order to prove causality, a quantitative research method will be applied. The aim of this research is to study the influence of urban design on the behaviour of pedestrians. For studying behaviour in a public space, without influencing that behaviour, a naturalistic observation method is most suited.

Two streets within the municipality of Groningen have been selected as a case study, the Rijksstraatweg in Haren with shared space design and the verlengde Hereweg in Helpman with a conventional street design. Figure 3.1 shows a map with the exact study areas.

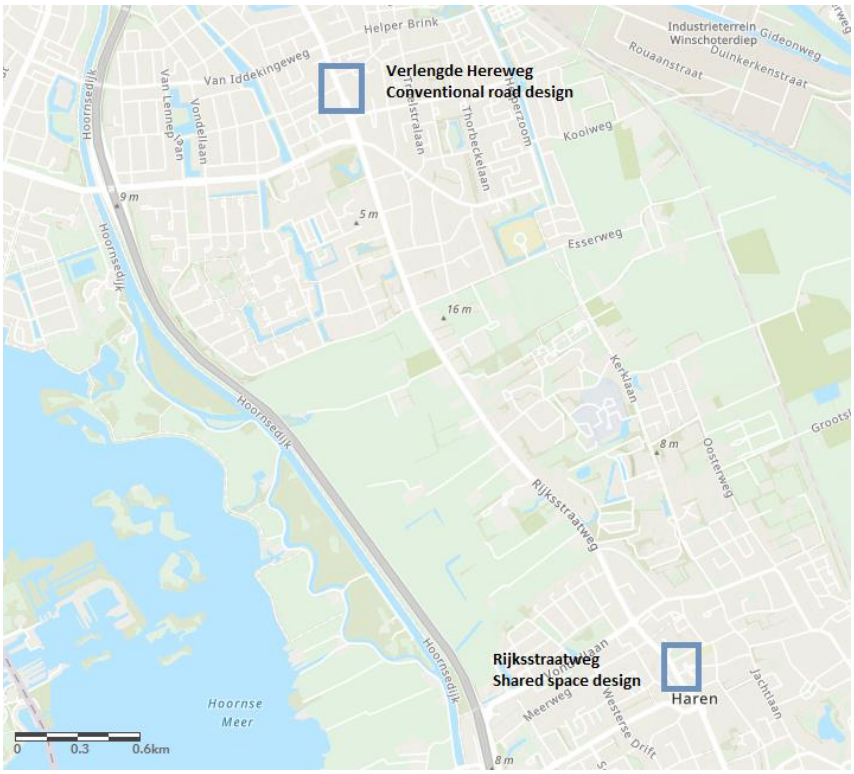

Figure 3.1; Observation locations (source: Arcgis, 2019)

The research will be conducted by a systematic sample, in which every 10th pedestrian will be observed. It is not feasible to observe every pedestrian because the observations are carried out by one person, in real time, at the location, in which it would not be possible to capture all the data. A systematic sample gives the observer time to capture all the data and will ensure valid data (Albert, 1971). On both locations there will be observations made on comparable days, since it is expected different days will have different types of traffic due to retail activity. The exact days will be selected through comparison in weather predictions and type of days (holidays, special events etc.) at least one week in advance of the observations. The observations per day will take place in three blocks: 10.00 – 11:30, 12:00 – 14:30 and 15:00 – 17:00. This time frame has been selected because within this frame all the retailers in both areas are opened, except for Monday which will not be used as an observation day.

3.2 Data collection

In appendix 1, the data collection tool is added, which mainly consists of the same factors listed in the theoretical framework. For every activity carried out by a observed pedestrian the corresponding box will be ticked, with the exception of passing by, which will only be selected if none other is selected. So for every observed pedestrian, or case, we will have seven dummy variables, 1 or 0. Also there will be field notes taken during the observations of any special events or occurrences which may influence pedestrian behaviour. These field notes will also have an explanatory value in the analysis of the variables. These field notes will be logged on basis of time and can be used in analysing the data to explain certain changes or anomalies in the data.

The observations will be made while being in the area, watching from a bench. To ensure discrete data collection, without giving people the idea that they are being watched, the data will be collected via a mobile app, and notes made on mobile. A screenshot of the app is added in figure 3.2. Because only three questions have to be answered in the app, all with one click, this will also ensure the focus can be held on observing pedestrians. The app atomically logs time and location for each observation, temperature and weather conditions will be logged in the observation notes and will be added for each case during the data processing.

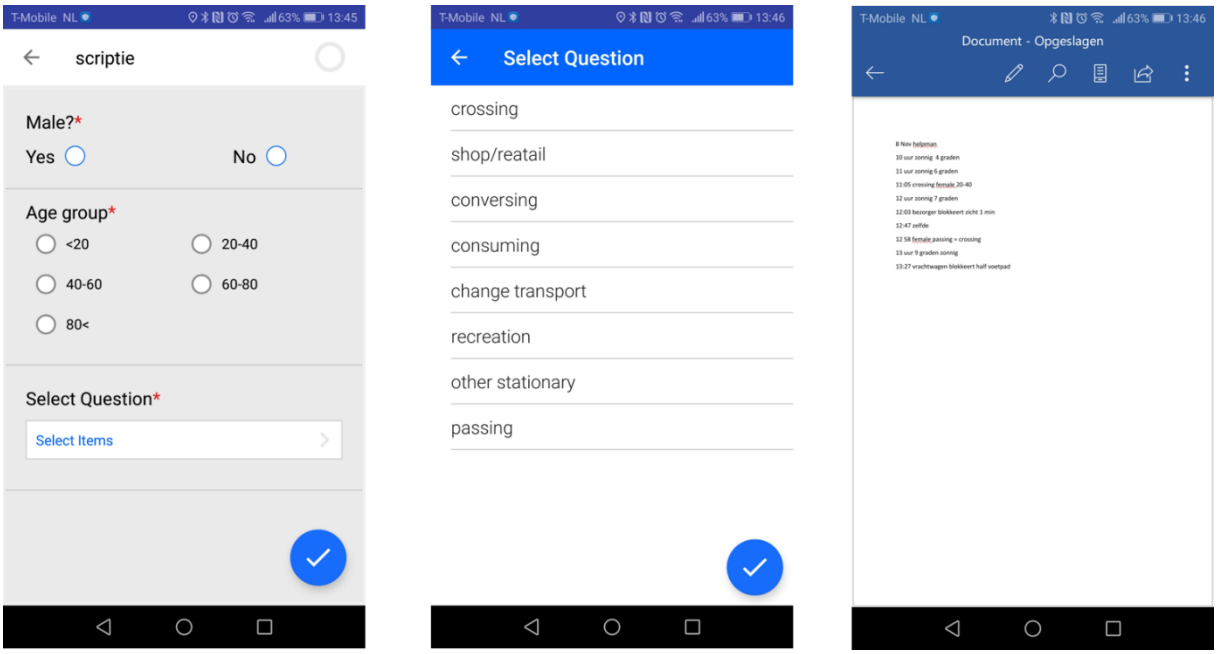

Figure 3.2; Data collection app

3.3 Data analysis

This research will have two datasets, one from each location, both datasets contain the factors for every pedestrian observed shown in figure 3.3.

	Variable	Level of measurement	Data-type
Control variables	Estimated age group	<20, 20-40, 40-60, 60-80, >80	ordinal
	Estimated gender	Male, Female	nominal
	Temperature	Celsius (hourly)	interval
	Weather type	Sun, cloud, rain, fog	nominal
	Time of observation	Time in minutes	Interval
Dependent variables	Location	1, 0	dummy
	Road crossing	1, 0	dummy
	Shopping or retail	1, 0	dummy
	Conversing	1, 0	dummy
	Change of transportation	1, 0	dummy
	Recreation	1, 0	dummy
	Other stationary activities	1, 0	dummy
	Passing by	1, 0	dummy

Figure 3.3; research variables

The dependent variables are all dummy variables, so they are either 1 if the pedestrian does a certain activity or 0 if they do not do a certain activity. This type of data suits the nature of the regression analysis which will be used. In a logistic regression no assumptions have to be made considering the distribution of variables. Furthermore, predictor variables can be continuous or discrete, and independent samples are required. The data collected from the observations fits all these conditions.

The first step will be analysing the influence of the control variables on the dependent variables within both groups and comparing these results to see if there are any anomalies to be taken into account for the rest of the process. The next step will be comparing both groups to see if there are, and if so where there are, differences in the dependent variables in both groups.

Both of these steps will be carried out with logistic regressions. The advantage of this type of analysis is that the effect of each variable can be analysed and it shows for each separate variable whether or not they are significant. It is also possible to take out certain variables if they are not significant or if there is not enough data on a certain variable. The downside to using a regression is that because of the amount of factors and the nature of the regressions, we will get a lot of outputs or results. So the outcome will not be straight-forward and will have to be examined thoroughly.

3.4 Data validity

Internal validity

Because pedestrians are observed in a non-participating manner, there will be no influenced behaviour or self-reported data. One could argue this is not a total non-participating observation because the researcher is present in the area, which might be noted by pedestrians. However, a test of the observation method showed that, because of the use of a mobile app, pedestrians will not notice that they are being observed. The mobile app logs time and location atomically and also requires all fields to be filled before a case can be logged, which will help prevent missing data.

With a naturalistic observation method, repeatability is nearly impossible (Albert, 1971). However, by clearly defining the different observation variables, and conducting testing of these observations, reliable data can be collected. Interference within the observation location could also effect the validity of the data, for this reason field notes will be taken during the observations. These field notes can be used to explain anomality within the data.

External validity

Since no two road designs, whether conventional or shared space, are exactly the same, the results of this study cannot be compared one to one to another area. However, because these road designs in different locations have many similar functions, design features and users, it can be used a good indicator or predictor for different locations. In analysing the results this should be considered before making generalising assumptions.

3.5 Ethical considerations

Because this method is non-participatory, the people who will be observed will not be able to give or decline consent to take part in this research. However, the data collected in this study is of a non-intrusive nature. Apart from the activities, estimation of age and estimation of gender, no personal data is collected, and the data collected, cannot in anyway be linked to a specific person. This will guaranty compete anonymity and privacy for the study subjects. In gathering the data this should always be in the mind of the observer, as to be sure not to invade anyone’s privacy.

Moreover, if a person within the study area approaches the observer, complete honesty and transparency about the nature and method of the study should be given. Additionally, the data will have appropriate measures of confidentiality as the data and the results are only presented within the Faculty of spatial sciences of the Rijksuniversiteit Groningen.

3.6 Analysing the results

The third and final sub-question will be used to compare the theoretical framework set in answering sub-question one, and the results and conclusions from the observation-research in sub-questions two and three. With this comparison it will become clear if there are any discrepancies between the expected changes in pedestrian movement and the actual changes. Which can be used by planners and policy makers to see whether or not implementing shared space is useful in changing these activities of pedestrian movement.

The results from all these sub-questions will give insight in the conceptual aim of shared space with regard to pedestrian movement, the observed differences in pedestrian movement between shared space and conventional road design and how those two comply. Then, the main research question can be answered and give us insight in how the implementation of shared space changes pedestrian movement in the municipality of Groningen. Furthermore, we will know in detail which activities of pedestrian movement change due to the implementation ,and if this change is different for certain age groups or genders. And which activities of pedestrian movement can be improved by implementing shared space, and which activities may need extra attention in further research or in planning and policy making.

4. Results

In this chapter the results of the observation research are presented as well as an answer to the second and third sub question. The first paragraph show the general data characteristics of the research. In the second paragraph the results are used to answer sub question two and three per activity, and to explain, combined with literature studies, the differences in expected and observed results. The third paragraph contains recommendations for further research. In the final paragraph, the conclusion, the main research question will be answered and the results will be placed in a general context.

4.1 Data characteristics

In total, 168 pedestrians have been observed in this research. The observations have been made on three different days, switching between both locations. The field notes taken during the observations, which are added in appendix 3, have been processed in the data. For example, on 8 November log contained '12:58 female passing = crossing', which has been added into the table. By coincidence the amount of pedestrians observed in both areas is exactly the same, both 84. This was not intentional, it means that within the observation time-span, which was the same for both locations, the total amount of observed pedestrians was equal.

Comparing both locations on the basis of the control variables with logistic regression, as shown in figure 4.1, shows that both groups have no significant differences in age distribution and gender. However, there is a significant difference in weather type and temperature. This is due to the fact that there were just three days of observations, and the weather did not change much within the timespan of the observation-intervals. Both locations have similar types of pedestrians in terms of age and gender, however these observations have been made under different weather conditions and temperature. For each analysis of the different factors these control variables will also be taken into account, therefore it will become clear whether these factors influence certain factors of pedestrian movement or not.

Variable	Significance
Age groups	0,686
Gender	0,877
Temperature	0,002
Weather type	0,000

Figure 4.1; Control variables

4.2 Analysis of the factors of pedestrian movement

For each factor of pedestrian movement a logistic regression has been applied, to see whether there are differences in these factors between both locations, and to see if any of the control variables has a significant influence. The results of these regressions will be discussed for each factor.

Changing transportation

Variable	Significance
Location	0,481
Age groups	0,104
Gender	0,432
Temperature	0,731
Weather type	0,436

Figure 4.2; regression results changing transportation

As figure 4.2 shows, there is no significant difference in changing transportation between both locations. While Currie (2006) states in his research that the separation of traffic flows is more fitting for public transport and for transportation changes, there was no difference noted in this study. One of the reasons for the expected difference in change of transportation was the ability to park your car in conventional road design, with designated parking areas. However, during the observations it became clear that people will use the shared space as well for short period parking. There has not yet been any research done into the effects of parking in shared space, however parking is not described as an intended use of shared space in most definitions (Hammilton-Baillie, 2008, Hammond, 2013, Kaparias, 2012). Furthermore Larsen (2017) notes in his study that parked cars lower the objective safety of a street. Which is contradictory to shared space, which aims to increase objective safety(Kaparias, 2012).

Another factor that might explain that there was no difference observed in changing transportation, is the amount of changes being made from and to bicycles. People will usually park their bikes as close to their destination as possible (Larsen, 2017). Within the observed retail areas, people usually parked their bike in front of their first destination, whether there where bike racks or not, and proceeded on foot.

Conversing

Variable	Significance
Location	0,962
Age groups	0,247
Gender	0,142
Temperature	0,870
Weather type	0,995

Figure 4.3 regression results conversing

While the concept of shared space is based upon its users having social interaction and negotiation (Hamilton-Baillie, 2008), and people should be more inclined to have more social interaction and conversation in shared space(Hammond,2013), there is no significant difference observed in conversing between shared space and conventional road design. Hamilton-Baillie (2008) Describes conversing as an important factor of interaction between shared space users, however within this study this does not seem the case. It seems that within our study these interactions are mostly done in a non-verbal way.

Although temperature and weather type have no significant influence within our dataset, it might still be an interesting factor on conversing. Ennis (2004) notes in his study that over ninety percent of people have seasonal variation in mood and behaviour, in which lowered desire to socialize with others is one of the factors in which these changes of behaviour take form. Within this dataset temperatures reached from one to twelve degree Celsius, and all observations have been made in the fall. In a larger study, done over a longer period of time, with more variation in seasons, weather type and temperature, this might be an interesting factor.

Road crossing

In road crossing there is a significant difference observed between shared space and conventional road design. Without the need to use formal road crossings pedestrians indeed feel safe to cross the road at any given point. The odds-ratio shows that there is a positive relation between shared space and road crossing, since conventional road design is coded as zero, and shared space as one. A pedestrian is 4,3 times more likely to cross the road in a shared space design, than in conventional road design. While their subjective safety is lower than in conventional road design (Luca,2012), pedestrians will still share the road space and use this to cross more often.

Variable	Significance	Odds-ratio*
Location	<0,001	4,300
Age groups	0,414	-
Gender	0,528	-
Temperature	0,985	-
Weather type	0,417	-

*Figure 4.4; regression results road crossing (*only added for significant results)*

A remarkable outcome of this regression is that age does not seem to play a role in the difference in road crossing behaviour. While Kaparias (2012) notes the elderly as a vulnerable category of pedestrians, whom might have trouble moving around in shared space, this does not show within our study. Gender, temperature and weather type do not have a significant on road crossing behaviour either.

Recreation

As shown in figure 4.5, there is no significant difference in recreation between conventional road design and shared space. Polat (2015) states that the visual quality of urban design has a positive effect on recreation behaviour of pedestrians, and the aesthetic design features of shared space provide this visual quality (Hammond, 2013). While this study does not show any differences in recreation, this might be due to the timing of the study. Kántor (2012) states that the use of urban recreation is related to thermal and weather conditions. This study was conducted during the fall, while people are more likely to recreate in urban areas during spring and summer (Kántor, 2012). Temperature and weather type do not show a significant effect in the analysis, but the dataset only contains fall observations with three types of weather and a temperature ranging between one and twelve degrees Celsius, so no comparison can be made to different seasons.

Variable	Significance	Odds-ratio*
Location	0,492	-
Age groups	<0,001	0,260
Gender	0,963	-
Temperature	0,328	-
Weather type	0,664	-

*Figure 4.5; regression results recreation (*only added for significant results)*

Figure 4.5 also shows there is a significant difference recreation between age groups. The odds-ratio shows that if you go up one age group the changes of recreation decrease with factor 0,260. While there was no expected effect of age on recreation, it seems that younger people recreate more in both conventional road design and shared space. During the observations it became clear that younger people exercise more than the older age groups.

Shopping and retail activity

Both areas have similar shopping or retail activity, as the regression shows no significant difference between both retail areas. While the presence of shops and retailers influences the route choice of pedestrians (Borgers, 2014), the implementation of shared space, and thus the creation of more route options, does not increase shopping behaviour.

Variable	Significance	Odds-ratio*
Location	0,911	-
Age groups	0,002	1,599
Gender	0,013	0,424
Temperature	0,958	-
Weather type	0,476	-

*Figure 4.6; regression results shopping and retail activity (*only added for significant results)*

Hammond (2013) states in his research that people are more likely to browse shops in shared space than in conventional road design. However, this does not lead to an increase in actually entering the shops.

As shown in figure 4.6, age and gender do have an effect on shopping behaviour. There is a positive relation between age group and shopping behaviour. If a pedestrian is one age group higher than another, he or she is 1,6 times more likely to visit a shop in retail areas. Kunc (2011) explains in his studies that this is due to the fact that people of higher age usually earn or have earned more money, and can therefore spend more money in shops. Males, which are coded as one, females as zero, are less likely to enter shops by a factor 0,424. Kunc (2011) describes in his studies that females, while purchasing the same amount of products, visit shops more often than males.

Other stationary activities and passing by

To test whether important differences in pedestrian activities, between shared space and conventional road design, were missing, the category other stationary activities was added. For only five of the observed pedestrians this category was selected, which did not have any significant effects on location. The category passing by was added to see if there was a difference in the amount of people in who did not participate in any other activity. There was no difference between both locations in people who just passed by.

4.3 Recommendations for further research

This observational study into pedestrian movement has been conducted within the months November and December. To get a better insight in pedestrian movement, this type of research should be conducted in other seasons, preferably all seasons. Research shows behaviour changes over different seasons (Kantor, 2012, Ennis, 2004), and it is expected that this will have an influence on pedestrian movement. Furthermore, different observation techniques could be tested. Within this study there was only one person observing. Multiple persons or the use of video could be effective to capture more of the pedestrians movements.

Another recommendation for future studies is the influence of parked cars and bikes in shared space. As this could influence safety, and change the surrounding and sightlines, which in its turn might influence behaviour. For the interaction between pedestrians, a more in depth approach is needed, which also studies the non-verbal communications between pedestrians.

Multiple studies discussed in this thesis have noted that vulnerable road users have trouble moving around in shared space, for which has not evidence was found within this study. A larger sample size, or a study especially devoted to vulnerable road users, could give us more insight in whether they move differently or in different frequencies within shared space compared to other users.

4.4 Conclusion

In conclusion, most of the expected change in pedestrian movement has not become evident in this case-study. As many of the pedestrian activities showed no significant differences between shared space and conventional road design. Nonetheless, there was a strong positive relation found between implementing shared space and road crossing behaviour in this case-study.

To answer the main research question; *To what extent does shared space change pedestrian movement in comparison to traditional street design in the municipality of Groningen?*

Although shared space creates a lower level of subjective safety amongst pedestrians, they still feel safe enough to share the road with other users. The implementation of shared did lead to a change in pedestrian behaviour within this case-study, as they move around more freely than in a conventional road design. However, implementing shared space does not seem to be an incentive to participate in any extra activities, that they would not participate in within a conventional road design.

While one should always be careful in generalising the effects of a location based case-study, some contribution can be made to the general knowledge of implementing space. This research suggests that the implementation of shared space will have a positive effect on pedestrian movement in terms of sharing the road with other users, on the other hand, implementing shared space will not lead to an increase in pedestrian activities.

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6. Appendices

Appendix 1; data collection tool

pedestrian observation

location: day/hour: temp: Weather:

no.	time	sex	age group	crossing	shop/retail	conversing	consuming	change transp.	recreation	other stat.	passing

Appendix 2. Data

n	te	weath	tim		age group	crossing	shop/retail	conversing	consuming	change tr	recreation	other stat	passing	date	loc
1	4	sunny	10:09	0	3	0	1	0	0	0	0	0	0	8-11	1
2	4	sunny	10:12	0	3	0	1	0	0	1	0	0	0	8-11	1
3	4	sunny	10:14	0	3	0	0	0	0	0	0	0	1	8-11	1
4	4	sunny	10:19	1	2	1	0	0	0	1	0	0	0	8-11	1
5	4	sunny	10:25	1	4	0	0	0	0	0	0	0	1	8-11	1
6	4	sunny	10:28	1	1	0	0	0	0	0	0	0	1	8-11	1
7	4	sunny	10:30	1	1	0	0	0	0	0	0	0	1	8-11	1
8	4	sunny	10:32	0	3	0	1	0	0	0	0	0	0	8-11	1
9	4	sunny	10:38	1	4	0	0	0	0	0	0	0	1	8-11	1
10	4	sunny	10:43	0	3	0	0	0	0	0	0	0	1	8-11	1
11	4	sunny	10:48	0	3	1	1	0	0	0	0	0	0	8-11	1
12	4	sunny	10:51	0	2	0	1	0	0	0	0	0	0	8-11	1
13	4	sunny	10:55	0	1	0	0	0	0	0	0	0	1	8-11	1
14	4	sunny	10:59	0	3	0	0	0	0	0	0	0	1	8-11	1
15	6	sunny	11:01	0	2	1	1	0	0	0	0	0	0	8-11	1
16	6	sunny	11:06	0	1	0	0	0	0	0	1	0	0	8-11	1
17	6	sunny	11:09	1	4	0	0	0	0	0	0	0	1	8-11	1
18	6	sunny	11:12	1	2	0	0	0	0	0	0	0	1	8-11	1
19	6	sunny	11:17	1	4	0	1	0	0	1	0	0	0	8-11	1
20	6	sunny	11:21	0	3	0	1	1	1	0	1	0	0	8-11	1
21	6	sunny	11:26	1	1	0	0	1	0	0	0	0	0	8-11	1
22	6	sunny	11:29	1	4	0	0	0	0	0	0	0	1	8-11	1
23	7	sunny	12:05	1	4	0	1	0	0	1	0	0	0	8-11	1
24	7	sunny	12:10	1	4	0	1	0	0	0	0	0	0	8-11	1
25	7	sunny	12:12	1	5	0	0	0	0	0	0	1	0	8-11	1
26	7	sunny	12:19	0	2	0	0	0	0	0	0	0	1	8-11	1
27	7	sunny	12:21	1	5	0	0	0	0	0	0	0	1	8-11	1
28	7	sunny	12:25	0	4	0	0	0	0	0	0	0	1	8-11	1
29	7	sunny	12:27	1	3	0	0	0	0	0	0	0	1	8-11	1
30	7	sunny	12:32	0	5	0	0	0	0	0	0	0	1	8-11	1
31	7	sunny	12:34	0	4	0	1	0	0	1	0	0	0	8-11	1
32	7	sunny	12:39	1	3	0	0	0	0	0	0	0	1	8-11	1
33	7	sunny	12:42	0	2	1	0	0	0	0	0	0	0	8-11	1
34	7	sunny	12:45	0	4	0	1	0	0	1	0	0	0	8-11	1
35	7	sunny	12:49	1	2	0	0	0	0	0	0	0	1	8-11	1
36	7	sunny	12:51	0	3	0	0	0	0	0	0	0	1	8-11	1
37	7	sunny	12:54	1	2	1	0	0	0	0	0	0	0	8-11	1
38	7	sunny	12:58	0	3	1	0	0	0	0	0	0	0	8-11	1
39	9	sunny	13:04	1	2	0	0	0	0	0	0	0	1	8-11	1
40	9	sunny	13:12	1	2	0	1	1	0	0	0	0	0	8-11	1
41	9	sunny	13:15	0	3	0	1	0	0	1	0	0	0	8-11	1
42	9	sunny	13:19	0	4	1	1	0	0	0	0	0	0	8-11	1
43	9	sunny	13:22	1	2	0	0	0	0	0	0	0	1	8-11	1
44	9	sunny	13:24	0	3	0	1	0	0	1	0	0	0	8-11	1
45	9	sunny	13:28	0	1	0	0	0	0	0	0	0	1	8-11	1
46	9	sunny	13:36	1	4	0	1	0	0	0	0	0	0	8-11	1
47	9	sunny	13:42	1	3	0	0	0	0	0	0	0	1	8-11	1
48	9	sunny	13:46	0	1	0	0	0	0	0	1	0	0	8-11	1
49	9	sunny	13:49	0	3	0	0	0	0	0	0	0	1	8-11	1
50	9	sunny	13:54	0	5	0	0	0	0	0	0	0	1	8-11	1
51	9	sunny	13:58	1	4	0	0	0	0	0	0	0	1	8-11	1
52	9	sunny	14:00	1	5	0	0	0	0	0	0	0	1	8-11	1
53	1	foggy	10:03	0	4	0	1	0	0	1	0	0	0	5-12	2
54	1	foggy	10:09	1	2	1	0	0	0	1	0	0	0	5-12	2
55	1	foggy	10:12	1	2	1	0	0	0	1	0	0	0	5-12	2
56	1	foggy	10:13	0	3	1	0	0	0	0	0	0	1	5-12	2
57	1	foggy	10:17	1	4	1	0	0	0	1	0	0	0	5-12	2
58	1	foggy	10:20	0	3	1	1	0	1	0	0	0	0	5-12	2
59	1	foggy	10:24	0	5	1	0	0	0	0	0	0	0	5-12	2
60	1	foggy	10:27	1	4	1	1	0	0	0	0	0	0	5-12	2

n	te	weath	tim	:	age group	crossing	shop/retail	conversing	consuming	change tr	recreation	other stat	passing	date	loc
61	1	foggy	10:30	0	3	0	0	0	0	0	0	0	1	5-12	2
62	1	foggy	10:33	0	3	1	0	0	0	0	0	0	0	5-12	2
63	1	foggy	10:35	1	4	1	1	0	0	0	0	0	0	5-12	2
64	1	foggy	10:39	1	2	1	1	0	0	0	0	0	0	5-12	2
65	1	foggy	10:42	1	2	0	0	0	0	0	0	0	1	5-12	2
66	1	foggy	10:48	0	2	0	1	0	0	0	0	0	0	5-12	2
67	1	foggy	10:49	0	1	0	0	0	0	0	0	0	1	5-12	2
68	1	foggy	10:53	1	3	1	1	0	1	0	0	0	0	5-12	2
69	1	foggy	10:57	0	3	1	0	0	0	0	0	0	0	5-12	2
70	1	foggy	11:00	0	4	0	0	0	0	0	0	0	1	5-12	2
71	1	foggy	11:04	0	3	1	0	0	0	0	0	0	0	5-12	2
72	1	foggy	11:09	0	5	0	0	0	0	0	0	0	1	5-12	2
73	1	foggy	11:10	1	2	1	0	0	0	0	0	0	0	5-12	2
74	1	foggy	11:14	0	5	0	1	0	0	0	0	0	0	5-12	2
75	1	foggy	11:16	0	2	0	0	0	0	0	0	0	1	5-12	2
76	1	foggy	11:20	0	3	0	0	0	0	0	0	1	0	5-12	2
77	1	foggy	11:20	1	1	0	0	0	0	0	1	0	0	5-12	2
78	1	foggy	11:23	0	3	0	1	0	0	1	0	0	0	5-12	2
79	1	foggy	11:25	1	2	0	0	0	0	0	0	0	1	5-12	2
80	1	foggy	11:28	1	4	0	1	0	0	1	0	0	0	5-12	2
81	1	foggy	11:30	0	2	0	0	0	0	0	0	0	1	5-12	2
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83	4	cloudy	15:08	0	1	0	0	0	0	0	1	0	0	5-12	1
84	4	cloudy	15:09	1	4	1	1	0	0	0	0	0	0	5-12	1
85	4	cloudy	15:12	1	3	0	0	0	0	0	0	0	1	5-12	1
86	4	cloudy	15:17	0	2	0	1	0	0	1	0	0	0	5-12	1
87	4	cloudy	15:18	1	3	0	0	0	0	0	0	0	1	5-12	1
88	4	cloudy	15:21	0	5	0	1	0	0	0	0	0	0	5-12	1
89	4	cloudy	15:29	0	2	0	1	0	0	1	0	0	0	5-12	1
90	4	cloudy	15:33	1	1	1	0	0	0	0	0	1	0	5-12	1
91	4	cloudy	15:35	1	4	0	0	0	0	0	0	0	1	5-12	1
92	4	cloudy	15:39	1	2	0	0	0	0	0	0	0	1	5-12	1
93	4	cloudy	15:45	0	3	1	1	0	0	0	0	0	0	5-12	1
94	4	cloudy	15:50	0	2	0	0	0	0	0	0	0	1	5-12	1
95	4	cloudy	15:52	0	3	0	1	0	1	0	0	0	0	5-12	1
96	4	cloudy	15:57	1	4	0	0	0	0	0	1	0	0	5-12	1
97	4	cloudy	15:59	1	2	0	0	0	0	0	0	0	1	5-12	1
98	3	cloudy	16:04	0	3	0	1	1	0	0	0	0	0	5-12	1
99	3	cloudy	16:06	1	1	0	0	0	0	0	1	0	0	5-12	1
100	3	cloudy	16:09	0	4	1	1	0	0	0	0	0	0	5-12	1
101	3	cloudy	16:14	0	1	0	0	0	0	0	0	0	1	5-12	1
102	3	cloudy	16:18	1	3	0	0	0	0	0	0	0	1	5-12	1
103	3	cloudy	16:26	1	2	0	0	0	0	0	0	0	1	5-12	1
104	3	cloudy	16:29	0	3	0	0	1	0	0	0	1	0	5-12	1
105	3	cloudy	16:31	1	5	0	1	0	0	1	0	0	0	5-12	1
106	3	cloudy	16:36	1	3	0	0	0	0	0	0	0	1	5-12	1
107	3	cloudy	16:37	0	2	0	1	0	1	1	0	0	0	5-12	1
108	3	cloudy	16:42	0	1	1	0	0	0	0	0	0	0	5-12	1
109	3	cloudy	16:44	0	3	0	0	0	0	0	0	0	1	5-12	1
110	3	cloudy	16:50	0	4	0	1	0	0	0	0	0	0	5-12	1
111	3	cloudy	16:51	1	3	0	0	0	0	0	0	0	1	5-12	1
112	3	cloudy	16:54	0	2	0	0	0	0	0	0	0	1	5-12	1
113	3	cloudy	16:57	1	4	0	1	0	0	1	0	0	0	5-12	1
114	11	cloudy	12:02	1	2	1	1	0	0	0	0	0	0	19-12	2
115	11	cloudy	12:10	0	3	0	1	0	0	1	0	0	0	19-12	2
116	11	cloudy	12:13	0	3	0	0	0	0	0	0	0	1	19-12	2
117	11	cloudy	12:18	1	4	1	0	0	0	1	0	0	0	19-12	2
118	11	cloudy	12:22	1	5	1	1	0	0	0	0	0	0	19-12	2
119	11	cloudy	12:24	0	1	0	0	0	0	0	1	0	0	19-12	2
120	11	cloudy	12:27	0	3	0	1	1	1	0	0	0	0	19-12	2

n	te	weath	tim	:	age group	crossing	shop/retail	conversing	consuming	change tr	recreation	other stat	passing	date	loc
121	11	cloudy	12:30	1	4	0	0	0	0	0	0	0	1	19-12	2
122	11	cloudy	12:36	0	2	1	0	0	0	0	0	0	0	19-12	2
123	11	cloudy	12:39	1	3	1	0	0	0	0	0	0	0	19-12	2
124	11	cloudy	12:43	1	3	0	0	0	0	0	0	0	1	19-12	2
125	11	cloudy	12:45	0	4	0	1	0	0	1	0	0	0	19-12	2
126	11	cloudy	12:49	1	1	1	0	0	0	0	1	0	0	19-12	2
127	11	cloudy	12:57	0	3	0	0	0	0	0	0	0	1	19-12	2
128	12	cloudy	13:00	0	2	1	0	0	1	0	0	0	0	19-12	2
129	12	cloudy	13:06	1	2	1	1	0	0	0	0	0	0	19-12	2
130	12	cloudy	13:11	1	5	0	0	0	0	0	0	0	1	19-12	2
131	12	cloudy	13:14	0	3	1	1	0	0	0	0	0	0	19-12	2
132	12	cloudy	13:17	0	2	1	1	0	0	1	0	0	0	19-12	2
133	12	cloudy	13:23	0	3	0	0	0	0	0	0	0	1	19-12	2
134	12	cloudy	13:28	1	4	0	1	0	0	1	0	0	0	19-12	2
135	12	cloudy	13:33	1	3	0	0	0	0	0	0	0	1	19-12	2
136	12	cloudy	13:39	1	2	1	0	0	0	0	0	0	0	19-12	2
137	12	cloudy	13:41	1	5	1	1	0	0	0	0	0	0	19-12	2
138	12	cloudy	13:47	0	1	0	0	0	0	0	1	0	0	19-12	2
139	12	cloudy	13:47	0	3	1	1	1	0	0	0	0	0	19-12	2
140	12	cloudy	13:53	1	2	0	0	0	0	0	0	0	1	19-12	2
141	12	cloudy	13:57	0	3	0	0	0	0	0	0	0	1	19-12	2
142	10	cloudy	15:08	0	4	0	1	0	0	1	0	0	0	19-12	2
143	10	cloudy	15:11	1	5	0	0	0	0	0	0	0	1	19-12	2
144	10	cloudy	15:18	0	2	1	1	0	0	0	0	0	0	19-12	2
145	10	cloudy	15:26	1	3	1	1	0	0	1	0	0	0	19-12	2
146	10	cloudy	15:29	1	2	0	0	0	0	0	1	0	0	19-12	2
147	10	cloudy	15:32	1	3	0	1	0	0	0	0	0	0	19-12	2
148	10	cloudy	15:36	0	2	0	0	0	0	0	1	0	0	19-12	2
149	10	cloudy	15:42	1	3	1	1	0	1	0	1	0	0	19-12	2
150	10	cloudy	15:45	0	4	0	0	0	0	0	0	0	1	19-12	2
151	10	cloudy	15:49	0	5	0	1	0	0	0	0	0	0	19-12	2
152	10	cloudy	15:53	0	2	1	1	0	0	1	0	0	0	19-12	2
153	10	cloudy	15:59	0	3	0	1	1	0	0	0	1	0	19-12	2
154	9	cloudy	16:04	1	2	1	0	0	0	0	0	0	0	19-12	2
155	9	cloudy	16:07	0	1	0	0	1	0	0	0	0	0	19-12	2
156	9	cloudy	16:11	1	3	0	0	0	0	0	0	0	1	19-12	2
157	9	cloudy	16:14	1	2	1	1	0	0	0	0	0	0	19-12	2
158	9	cloudy	16:19	0	3	0	1	0	0	1	0	0	0	19-12	2
159	9	cloudy	16:23	0	4	0	0	0	0	0	0	0	1	19-12	2
160	9	cloudy	16:26	1	1	0	0	0	0	0	0	0	1	19-12	2
161	9	cloudy	16:29	1	4	0	0	0	0	0	0	0	1	19-12	2
162	9	cloudy	16:35	0	3	1	1	0	0	0	0	0	0	19-12	2
163	9	cloudy	16:40	1	3	1	0	0	0	0	0	0	0	19-12	2
164	9	cloudy	16:41	1	5	0	0	0	0	0	0	0	1	19-12	2
165	9	cloudy	16:44	0	3	0	0	0	0	0	0	0	1	19-12	2
166	9	cloudy	16:50	1	1	0	0	0	0	0	0	0	1	19-12	2
167	9	cloudy	16:54	0	5	1	0	0	0	0	0	0	0	19-12	2
168	9	cloudy	16:57	0	3	1	1	0	1	0	0	0	0	19-12	2

Appendix 3; field notes

8 Nov helpman
10 uur zonnig 4 graden
11 uur zonnig 6 graden
11:05 crossing female 20-40
12 uur zonnig 7 graden
12:03 bezorger blokkeert zicht 1 min
12:47 zelfde
12 58 female passing = crossing
13 uur 9 graden zonnig
13:27 vrachtwagen blokkeert half voetpad
5 Dec Haren
10 uur 1c mistig
10:08 zicht deels geblokt geparkeerde auto's
10:29 bezorger blokkeer zicht
11:00 1c mistig
11:14 female pass = shop
5 Dec helpman
3 uur bewolkt 4 graden
15:25 man met hesje blokkeert weg kort
4 uur bewolkt 3 graden
16:15 geparkeerde auto blokkeert zicht, bank wissel
19 dec haren
12:00 11 graden bewolkt
12:23 bezorger blokkeert voetgangers
12:42 geparkeerde auto blokt zich kort
1 uur 12 graden bewolkt
13:27 female 3=4
3 uur 10 graden bewolkt
15:17 auto blokkert zicht
15:30 male passing is shop
4 uur 9 graden bewolkt
16:54 female 4=5