Understanding pedestrians' perception of crowdedness at mass events

A simultaneous survey and monitoring study into personal, trip and event characteristics

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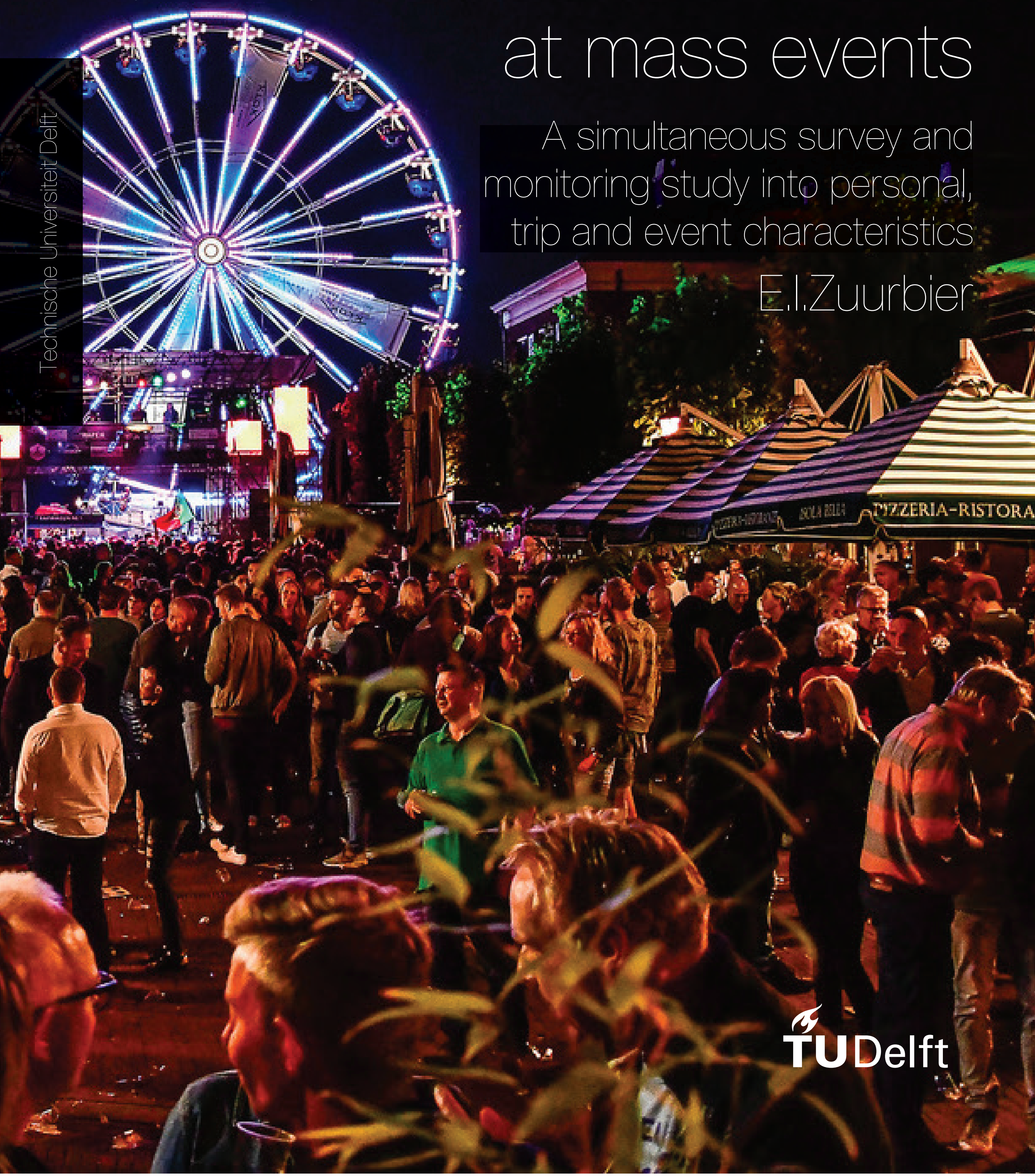

TU Delft

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by

E.I. Zuurbier

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Photograph cover: Property of TT Festival, photographer F. van Bergeijk, 2018.

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TU Delft

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Summary

Mass events have become increasingly popular in recent years. They can take place in a city centre or at a festival terrain. They offer music, sports or other attractions and can be meant for all age groups and all types of people. Likewise, tourism has grown exponentially. Especially in city centres, due to events and tourist attractions, larger crowds accumulate. Although these mass gatherings are for a recreational purpose, there are also negative aspects related to crowdedness. Panic in bottlenecks can cause death and injuries, such as the accident at the Love Parade 2010 in Germany, where panic in a tunnel caused 21 deaths. Luckily, these types of incidents are not common, but inefficient use of space, by arising jams and blockades is common. Pedestrians can experience crowdedness as *unsafe, unpleasant, frustrating* or *stressful*.

This research is aimed to gain a better understanding on how pedestrians experience crowdedness, in order to provide insights to enhance the experience of pedestrians. For this reason, it is necessary to investigate pedestrians' perception in relation to all factors that could possibly influence pedestrians' perception of crowdedness at an event. The following research question is answered:

"To what extent is a pedestrian's perception and experience of crowdedness influenced by personal, event and trip characteristics?"

From literature, the factors that could influence perception of crowdedness were derived. These can be split up in the categories Socio-demographics, Personal state & Trip factors, Event & Environment factors and Actual crowdedness. Perception & Experience of Crowdedness contain the perception of Crowdedness, Safety, Comfort, Attractiveness of the environment, Atmosphere and Experience of Crowdedness. In a theoretical framework, based on the theory Planned Behaviour, all the categories are linked to each other.

Data collection for this research was done with a simultaneous survey and monitoring study at two events. This made it possible to capture the effects of a variety of factors on perception of Crowdedness. The events chosen for this research were the TT Festival 2018 in Assen and the Red light district in Amsterdam. At both events, three locations were researched on three different evenings. Monitoring data was collected from Wi-Fi sensors and counting cameras. This data is processed to represent crowdedness, by first filtering the data, then applying a simple moving average to capture a specific time window and finally calculating the variables flow, density, volume/capacity and flow proportion. Light and sound intensity measurements were performed every at intervals. Socio-demographic factors, Personal state & Trip factors and perceptions were included in a survey.

At the TT Festival, the main source of entertainment was music, performed on multiple stages throughout the inner city. Each stage had a unique atmosphere and function. Most of the visitors were locals who visited every year. The Red light district is not an actual event, since it can be visited every day of the year. However, it is treated as an event in terms of crowd management and the visitors of the area tend to have an 'Anything goes' attitude. The red-light windows and bars mainly attract tourists, who are unfamiliar with the area and come to walk around in the area.

The analysis method consists of three parts. First, correlations between the explanatory factors and perception variables are tested, to determine which factors are most relevant. Second, an exploratory factor analysis is performed to identify which researched perceptions and experiences form latent variables. Third, Structural Equation Modelling is used to test the hypothesised relations in the theoretical framework. Structural Equation Models have a high explanatory power and can differentiate direct, indirect and pure effects of each of the factors included in the model. Furthermore, Structural Equation models can include measurement models for latent variables.

The results show that for both events perception of Safety & Comfort form one latent variable and perception of Attractiveness & Atmosphere form another. Perception of crowdedness influences perception of Atmosphere & Attractiveness in both case studies. For the TT Festival this influence is positive, while at the Red light district, this influence is negative.

For both events, the crowdedness indicators that correspond to the perception variables best are the processed Wi-Fi and camera counts, opposed to the calculated variables for density and flow. The Wi-Fi counts affect the perceived crowdedness strongly. In the TT case, local 15-minute Wi-Fi counts (Density) capture this relation best, while at the Red light district, the strongest influence is found for global 60-minute Wi-Fi counts. In the TT model, a strong negative influence of camera counts (Flow) on perceived Safety & Comfort is found, which indicates that movement around a person makes one feel less comfortable and safe. Attempts to create a combined model were not successful, indicating that there are many event specific factors at play that were not quantified. Other factors that influenced perception at both events are trip purpose familiarity and emotional state. Noticeably, foreigners at both events have a more positive overall perception.

The relation between perceived crowdedness and perceived safety & comfort was expected to be more prominent, but the results do not show a strong influence. For future research, it is recommended to include multiple questions regarding safety & comfort in a survey, in order to capture specific aspects of these perceptions, such as physical, physiological, facilities, security officers and social aspects. To be able to compare the events better, it is recommended to apply exactly the same processing steps to the monitoring data. In this research, it was not possible to compare measured levels of crowdedness, because the measurement and filtering of the monitoring data was performed differently. For gathering light & sound data, it is recommended to use accurate sensors on fixed locations performing continuous measurements.

For event planners, it is recommended to use monitoring data as an indication of the pedestrians' experience of crowdedness, but to use different boundary conditions to determine a pleasant amount of crowdedness, depending on the function of the location and the characteristics of the crowd that is expected to be present at this location.

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Glossary

Crowd *"A large number of people gathered together in a disorganised or unruly way." 1.1 "An audience, especially one at a sporting event.", 1.2 "A group of people who are linked by a common interest or activity."* - Oxford University Press, 2018.

Crowded *"Filled near or to capacity", "Filled with a crowd"* - American Heritage Dictionary of the English Language, 5th Edition, 2011.

Crowdedness Crowdedness, or "*drukte*" in Dutch, is the degree to which a place or event is crowded with people.

Quantified Crowdedness Crowdedness is quantified by deriving variables from measurement or observation. There are multiple variables possible to describe crowdedness quantitatively. Measures of crowdedness are dependent on the area per person or the distance between persons over space and time Duives et al. (2015).

Perceived Crowdedness The perceived level of crowding by pedestrians. This perception can be influenced by other factors, such as background and environment factors as well.

Level of Service *" a qualitative measure to describe operational conditions of vehicular and pedestrian traffic, based on service measures such as speed and travel time, freedom to manoeuvre, traffic interruptions, comfort and convenience."* - Bloomberg and Burden, 2006.

For different types of pedestrian infrastructure, such as stairways and corridors, the level of service can be categorised based walking speed, pedestrian spacing and the probability of conflict at various traffic concentrations (Fruin, 1971).

Mass event *"A mass event or large scale event is a gathering of a specified number of people at a specific location for a specific purpose for a defined period of time."* - World Health Organisation, 2008.

According to Jago and Shaw (2000), what makes an event special is: *"the number of attendees, the international attention due to the event, the improvement to the image and pride of the host region as a result of hosting the event, and the exciting experience associated with the event."*

In this thesis, a mass event is a gathering of people in a restricted area where a certain type of entertainment is provided.

Monitoring data Any type of data collected through electronic sensors to monitor/observe/count pedestrians. Examples include: Wi-Fi/Blue-tooth/infrared sensors, counting cameras, mobile phone data and GPS trackers. The sensors observe the progress of the pedestrians movements over a period of time. More information on data collection types can be found in 4.2.

Perception *"The neurophysiological processes, including memory, by which an organism becomes aware of and interprets external stimuli."* - Oxford University Press, 2018. In this thesis, perception is seen as a the way an individual observes external stimuli, which is coloured by his/her background and personal state.

1 Introduction

Mass events are becoming increasingly popular. They can take place in a city centre or at a festival terrain, they offer music, sports or other attractions and can be meant for all age groups and all types of people. Likewise, tourism has grown exponentially. Especially in city centres, due to events and tourist attractions, larger crowds accumulate. Although these mass gatherings are for a recreational purpose, there are also negative aspects related to crowdedness.

For example in the city centre of Amsterdam, where nearly 7 million foreign tourists visited in 2017 (Groenendijk, 2018). The whole inner city is very crowded and has reached its maximum capacity. There are more tourists than residents on the streets (van Dun, 2016). Residents have learned to avoid certain areas, because of unpleasant levels of crowdedness. The Red light district, Negen straatjes and the Kalverstraat are monitored by the municipality, because there is a threat of overcrowding. These are situations where the number of people at one location becomes that large, that people start to feel anxious (van Dun, 2016). The Kalverstraat has already been shut down multiple times by the police, to prevent overcrowding (van Dun, 2016). This could be dangerous, because that anxiousness can lead to panic. Moreover, pedestrians in a crowded system cannot be evacuated quickly.

Similarly, the Red Light district is another area where there are problems related to crowdedness. The Red light district is sometimes closed down as well, for example to clean trash from the street or to facilitate emergency services (van Lieshout, 2018). The municipality of Amsterdam has to manage the crowd in such a way that panics are prevented and nuisance and discomfort are minimised.

Also at events, high numbers of visitors can cause problems. Events such as the TT festival in Assen and Mysteryland attract respectively 160.000 (Circuit van Drenthe Holding b.v., 2018) and 110.000 (van de Velde, 2017) visitors over the duration of the events. The TT Festival is a free festival that takes place yearly in the city centre of Assen as evening entertainment during a motor racing event and Mysteryland is a large, paid festival in nature with mainly dance music. Even though these events take place at another type of location, have a different public and another type of general atmosphere, both of these events experience similar difficulties. As van de Velde (2017) states, congestion, queues and blockades arise at Mysteryland, because the festival terrain is not fit for the daily 55.000 visitors. This can be frustrating for event visitors, because they cannot move freely. This might lead to feeling unsafe or uncomfortable. Furthermore, behaviour of visitors can be a problem. The TT festival was actually founded to entertain troublesome youths, who were attracted to the city for the TT Races (van Gool, 2018). This concept proved to work very effectively. Even though the same people and the same amount of people gathered, the atmosphere was different.

To summarise, many problems can occur in crowded places. These problems are not purely physical, but also psychological. In the worst case, *panic* can occur. For example, the horrible accident at the Love Parade 2010 in Germany, where a panic at a bottleneck caused 21 deaths (BELGA, 2017), or the stampede at the 2014 New Year's Eve celebration in Shanghai, where at least 36 people died by being trampled or falling of the stairway leading up to a viewing platform (Kaiman, 2015). Luckily, these types of incidents are not common, because crowd management to prevent this is well thought out. However, *inefficient use of space*, by the arising jams and blockades is common. This is frustrating for the pedestrians, because they cannot walk at free flow speed. Moreover, pedestrians can experience crowdedness as *unsafe* (Hoskam, 2017), *unpleasant, frustrating and stressful* (Lee et al., 2001).

Generally, people state that they dislike crowded places, as Galama (2016) found in a stated preference survey. However, the revealed preference for the same situation showed that pedestrians tend to go to crowded places. This is logical, since the presence of a crowd is usually at an attraction. Therefore, it seems that crowdedness is experienced differently, either positively or negatively, depending on the context. For example, when there is an artist performing and the whole crowd is singing along, crowdedness could be seen as something positive altogether, but when a queue arises for a ticket stand, this is seen as something negative. This suggests that perceived crowdedness is dependent not only on the number of people, but also on the context. However, it is unknown how the context influences the perception of crowdedness and which characteristics of this context are important. Understanding the relation between event characteristics and the perception of crowdedness can be useful, because when the relation is understood, event characteristics could be influenced in such a way that the crowdedness is perceived more positively. In other words, this knowledge can be used to provide better crowd management. This could enhance *safety, efficiency and experience.*

1.1. Problem statement

Crowd monitoring is getting more attention as a research topic for *safety* and *efficiency* purposes. Crowd monitoring focuses on data that is observable with electronic sensors, such as Wi-Fi sensors, counting cameras and GPS trackers (Daamen et al., 2016). These methods give much insight in crowdedness that can be measured, but do not consider pedestrians' perception of crowdedness. At an event, next to providing a safe and efficient environment, it is also important to give people a good experience. In what way the level of crowdedness influences peoples perception on crowdedness is unknown. Therefore, to gain a better understanding on how pedestrians experience crowdedness, it is necessary to investigate pedestrians' perception and the relation to crowdedness. It would be quite logical to provide crowd management that does not only enhance objective values, but the subjective values as well. However, the perception of pedestrians is difficult to determine, since a perception cannot be observed directly. Also, individual characteristics such as gender, age and trip purpose cannot be identified with monitoring data alone.

To find out how a perception is formed, it is necessary to investigate all factors that could possibly influence the perception. For pedestrians, there is not that much research available as to what influences the perception, but there is research as to what factors influence behaviour, specifically route choice.

Hoskam (2017) and Grolle (2017) have researched the different ways in which pedestrians perceive crowdedness, safety and atmosphere at a shared space street and on Kingsday at train station Amsterdam Zuid respectively. Factors such as social demographics, familiarity, recent experiences and stimulant usage were found to influence perception. Furthermore, they compared observed/measured crowdedness to perceived crowdedness and found that these are also related. However, they did not yet identify the interrelation between these factors. In order to interpret the influence of individual factors and crowdedness, a model needs to be created that captures all significant effects.

Knowledge gap Pedestrian movement behaviour at large-scale events is receiving more attention in recent studies (Yuan et al., 2016; Daamen et al., 2016), but the research mainly gathers monitoring data. With monitoring data the physical crowdedness can be analysed, but the perception of pedestrians on crowdedness is not considered. This is required to give people a pleasant experience. The knowledge gap that is addressed in this research is to what extent the pedestrians' perception and experience of crowdedness is influenced by crowdedness and which other factors influence pedestrians' perception.

1.2. Research question and objective

To address the problem stated in the previous section, a research objective is defined.

Objective The objective of this study is to gain a better understanding of pedestrians' perception and experience of crowdedness. More specifically, the objective is to find out how crowdedness and perceived crowdedness are related. Furthermore, to understand how crowdedness is perceived, it is necessary to find the other factors that influence the perceived crowdedness beside the actual crowdedness.

For this objective, the following research question is defined:

"To what extent is a pedestrian's perception & experience of crowdedness influenced by personal, event and trip characteristics?"

With the perception of crowdedness, the direct perception of the amount of people nearby is meant. With experience of crowdedness, factors such as safety and atmosphere are meant. It seems from previous research that the perception of crowdedness is coloured by circumstances/context. However, there are other perceptions, sensations and experiences that are crowdedness related. Some of these are mentioned in the introduction, for example: feeling frustrated, feeling anxious, feeling unsafe, feeling uncomfortable and experiencing the crowdedness as unpleasant. Which of these will be included as crowdedness related perceptions/experiences is not yet determined.

Moreover, several types of characteristics are mentioned. These cover all the factors that are expected to influence a person's perception of crowdedness at an event. Personal characteristics are factors that are related to the individual. For example, socio-demographic factors like age and gender can influence a person's perception. Also, emotions that a person experiences can be meant by this. Trip characteristics are typically found in route choice behaviour research and can include trip purpose and group composition.

With event characteristics, two types of categories can be distinguished, which are the crowd/crowdedness and the infrastructure. The crowd and crowdedness characteristics are created by the pedestrians that are present and their movements. Infrastructure characteristics include all other event characteristics, such as location sizes, event layout and stalls, and light and sound systems.

Furthermore, the following sub-questions are defined:

1. How do personal, event and trip characteristics influence perception & experience of crowdedness according to literature and how does perception of crowdedness relate to other crowd-related perceptions?

2. How can perception & experience of crowdedness be explained by a theoretical framework and which hypotheses relate to this?

3. Which data collection methods can be used to study the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

4. How can we analyse/model the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

The sub-questions are related to the content of this thesis in Section 1.4.

1.3. Scope

In this thesis, the focus is on events, even though the definition of an event can be vague. In this research, events that take place in city centres are considered. One is the TT Festival 2018 in Assen, the other is the Red light district in Amsterdam. The main common aspect is that they are large gatherings of people in a limited space for a mainly recreational purpose. The social norms are different at these type of events compared to daily live. The consumption of alcohol and other drugs is considered normal and people behave differently. Other types of events, such as sports events, large festivals in nature and indoor events might have some aspects in common, but are not researched specifically. An important aspect in research into crowds and crowdedness is the population that is researched. In this research, a limited number of surveys is collected, therefore, the number of respondents is not large enough to be seen as a sample of the population present. However, it will give an indication of the population. The difference in population and the effect this has on the perception of this population will therefore be considered mainly by keeping these characteristics in mind while analysing the data. The survey will not be aimed at specific persons or groups, but rather on anyone present at the event, with the aim to gain insight in differences in perception between types of people.

The way the monitoring data is gathered is determined in advance, because this data is used for other studies and practices as well. Therefore, this research will not focus on how this data is retrieved, but more on how the data can be used. The monitoring systems consists of Wi-Fi sensors and counting cameras. A combination of these two is used to find the macroscopic flow variables that describe crowd dynamics. In this research, the focus will not be on complex and detailed analyses which can be done using this data to determine how many people are where and which routes they take. Rather, the focus will lie on finding a good and simple way to describe crowdedness with this monitoring data. Specifically, a way to describe crowdedness that fits in with the way pedestrians perceive the crowdedness.

Up until this point, the perception that is mentioned is the perception of crowdedness of pedestrians. In this research, other perceptions that are related to crowdedness are included as well, referred to as the experience of crowdedness. The reason for this is because crowdedness can be perceived high or low, but to understand whether the crowdedness is seen as something positive or negative, more information is needed. Various ways to define crowdedness related perceptions will be considered in literature and in the analysis. In the conclusion, the relation between perceived crowdedness and other crowd-related perceptions, such as safety and atmosphere will be discussed.

Finally, this research will not be aimed at developing a new Level of Service methodology based on perception. It will merely try to show which factors are relevant in this perspective. The conclusions of this research could be used for such a purpose, but is not feasible in the limited time.

1.4. Thesis outline

The approach for this research is displayed in Figure 1.1. Each step in the methodology is related to one or more research questions. First, the problem statement is constructed, which shapes the rest of the research steps. Second, a literature review is executed.

2. **Literature study**

   How do personal, event and trip characteristics influence perception & experience of crowdedness according to literature and how does perception of crowdedness relate to other crowd-related perceptions?

In this chapter, research in the field of crowd dynamics will be discussed. First, the basis of traffic engineering for pedestrians is discussed. This addresses the event characteristic crowdedness. It has to be determined how crowdedness can be quantified in order to compare this to perceived crowdedness. Subsequently, previous research into the relation between Level of Service offered and the perception of the transportation users is elaborated upon. This is important, because Level of service is one of the ways by which crowdedness can be quantified. In other words, these studies partly cover the relation between perceived crowdedness and quantified crowdedness. Their methods and the factors that they include can be adopted. After that, psychological theory will be consulted, to find ways to explain the relation between personal, trip and event characteristics and perception. This is done by comparing different psychological frameworks, such as the theory of planned behaviour. A framework for this research has to be chosen or created, in order to make it possibly to analyse the effects of all the characteristics combined.

Finally, this chapter will conclude with a section will be dedicated to an analysis per characteristic, to find the relation between that characteristic and perceived crowdedness. Furthermore, various types of perception that are important at an event are identified, such as safety, comfort and atmosphere and their relation of perceived crowdedness.

3. **Theoretical framework**

   How can perception & experience of crowdedness be explained by a theoretical framework and which hypotheses relate to this?

This chapter will begin with a theoretical framework based on the conclusions of Chapter 2. The potential interrelations between the factors will be identified. Based on the framework, research hypotheses can be developed. The framework will be used to determine the model estimation method. The hypothesis will be discussed again in the results.

4. **Data collection method**

   Which data collection methods can be used to study the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

This chapter aims to identify possible data collection methods for personal, event and trip characteristics. To choose a data collection method, it has to be kept in mind that the data has to be collected in such a way that all characteristics can be analysed together. With the knowledge about the possibly important factors (Chapter 2) and the data collection methods (Chapter 4), it can be determined which factors are relevant as well as feasible to take into account for this research. In this chapter, the case studies are also introduced. Why these are relevant for this research is discussed here as well. More than one case study can be performed. A plan of action specifying research locations and times is determined. Also, a glimpse into the data that was gathered and an evaluation will be presented. The case studies are described together with the data collection methods, because the way a case study is performed is determined together with the data collection method.

5. **Data processing method**

   Which data collection methods can be used to study the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

   How can we analyse/model the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

This chapter explains how crowdedness can be quantified using the chosen data collection method. First, it will explain the filtering steps that are necessary make the raw data usable. Next, it is described which formulas and variables are chosen to quantify crowdedness.

6. **Model estimation method**

   How can we analyse/model the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

The analysis method is presented in this chapter. The analysis will consist of two phases. First, a statistical analysis will be performed, in which a detailed look into uni- and bi-variate statistics will be made. This will give a first impression on which hypotheses can be confirmed and which relations are important to model. Second, multiple regression and specifically structural equation modelling will be explained theoretically. It will be explained how this modelling method will be applied and assessed.

7. **Results**

In this chapter, the models that were created will be presented. The aim of this research is to create two event specific models, that best explain the perceived crowdedness at each event studied. Furthermore, a general model that would also be applicable to other events is presented here. The hypotheses of Chapter 3 will be tested to find the relations between perception, crowdedness and other factors.

8. **Conclusion, Recommendations, Discussion**

   To what extent is a pedestrian's perception of crowdedness influenced by personal, event and trip characteristics?

Finally, a conclusion answering the main research question will be drawn based on the analysis. Furthermore, issues for discussion will be provided and recommendations for future research will be given.

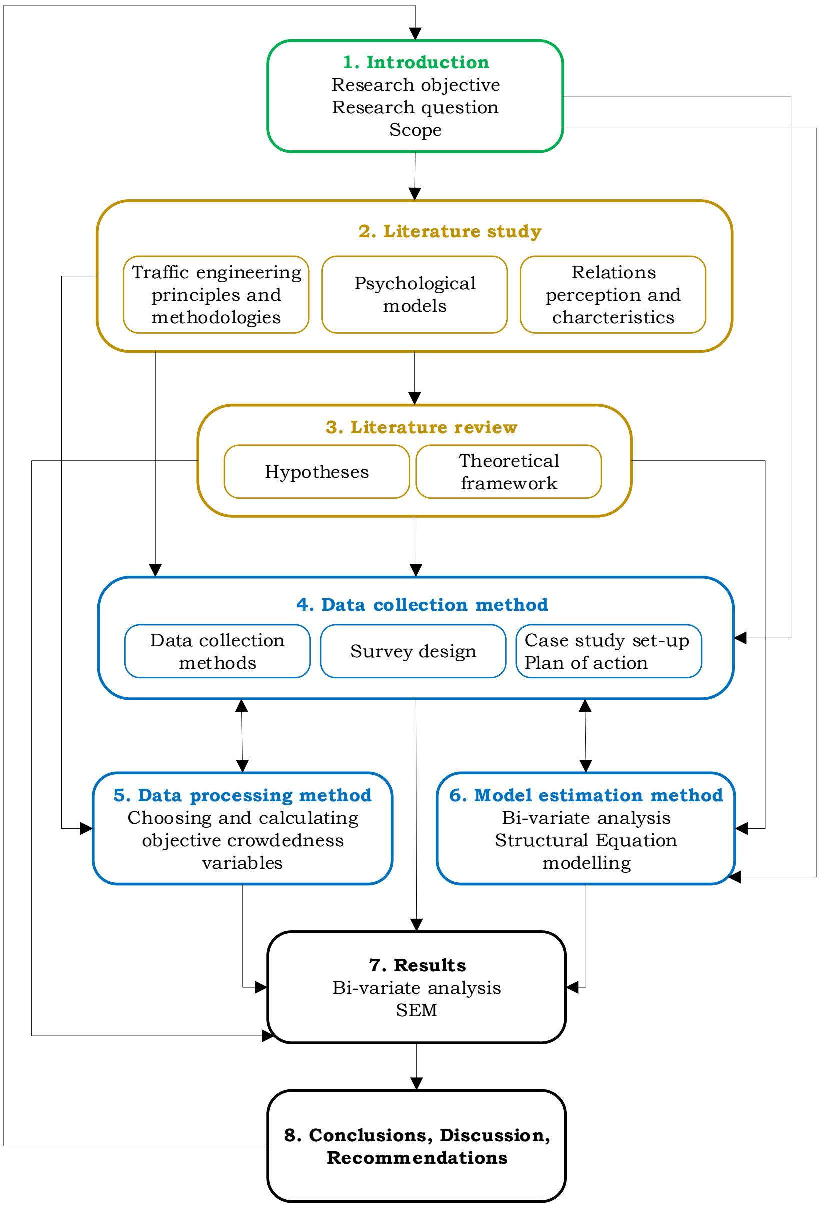

Figure 1.1: Visualisation of the outline of this thesis

I

Literature

2

Literature study

In this literature review, the following research question will be answered:

How do personal, event and trip characteristics influence perception & experience of crowdedness according to literature and how does perception of crowdedness relate to other crowd-related perceptions?

The first section illustrates how pedestrian dynamics in a crowd are often quantified, using macroscopic flow variables (Section 2.1). Second, the Level of Service system is introduced, which is a system that is used to assess the level of crowdedness based on the macroscopic flow variables (Section 2.2). Third, the limitations of this assessment system are discussed (Section 2.3). Fourth, state of the art research that compares crowdedness to the perception of transport users is discussed (Section 2.4). Knowledge of their data collection methods, analysis methods and their results can be used to develop a method for this research. The research method will be further discussed in Chapter 4. The following part of the literature study considers psychological research into the behaviour and perception of people (Section 2.5). This will help to theorise which relations can be found between explanatory factors and perception and help to create a theoretical framework for this specific research. And finally, an extensive literature study is performed to clarify which factors play a role in a pedestrian's perception of crowdedness in Section 2.6.

2.1. Traffic flow theory for pedestrians

This section contains a short overview of traffic flow theory regarding pedestrians. Research into crowds from a traffic flow theory perspective is relatively new, and it is opposed to more challenges than vehicular traffic flow theory.

Generally, traffic states are identified by means of a fundamental diagram, which provides insight in the relations between flow, speed and density. For crowd movements, however, it is difficult to identify these variables, as pedestrians move around in a 2D plane and consequently have more freedom of movement. The macroscopic flow variables are expressed as shown in Table 2.1 for pedestrians.

Table 2.1: Macroscopic flow variables

Variable	Unit
Walking Speed	m/s
Density	pax/m^2
Flow	$pax/m/s$

$$Flow = Density \times Speed \tag{2.1}$$

Examples of fundamental diagrams are shown in Figure 2.1 (Vanumu et al., 2017). In the Flow-Density diagram, the relation between these two variables is shown. The first part of the line is more or less straight in all models and illustrates a free flow situation, where pedestrians can walk in their desired direction at their desired speed. As the line is reaching the maximum, the maximal flow is reached. Here the flow is still stable. After this point, the flow becomes unstable, congestion arises and density increases. At maximal density, the effective flow towards a goal will be 0. There is still movement, but the flow is unstable and multidirectional.

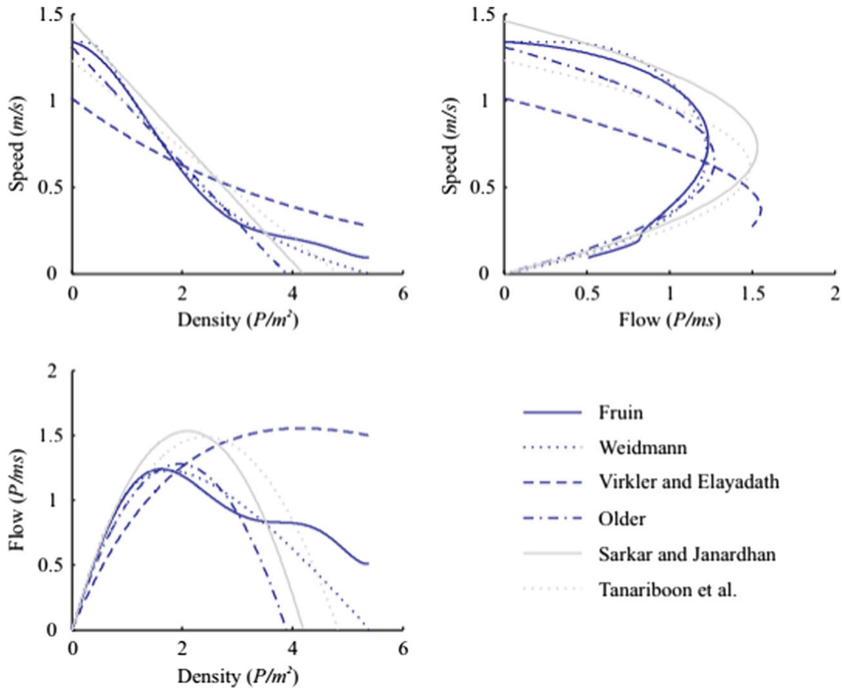

Figure 2.1: Fundamental Diagram Pedestrian (Vanumu et al., 2017)

As can be seen in Figure 2.1, the relations between the variables differ substantially between experiments. There is not yet a consensus on the shape of the fundamental diagram for pedestrians. Moreover, the necessary parameters that need to be taken into account to create consistent fundamental diagrams are not completely clear yet. Most experiments only take a few parameters into account. Geometry, location, time of day, culture and personal factors are found to be significant factors in various researches (Vanumu et al., 2017). For example, in a culture where pedestrians are crowd-minded, the flow remains stable at a higher density (Duives, 2017). On the other side, a pedestrian system where pedestrians are goal-oriented or in a rush, for example in a train station, this can be seen in a fundamental diagram from at higher free flow speed. However, this also means that the flow becomes unstable sooner.

Another form of visualising pedestrian movement is using trajectories. Trajectories offer a different insight in pedestrian behaviour and requires individual tracking. Trajectories can show direction and speed, which can make flow types such as stable/unstable, uni/bi directional, crossing and overtaking visible (Duives, 2017).

2.2. Level of Service for pedestrians

As a way to incorporate the density experience of pedestrian into infrastructure design, Fruin (1971) introduced the Level-of-Service concept for pedestrians. The levels are based on traffic engineering principles, and consider freedom to choose a speed in locomotion functions, overtaking possibilities and crossing the flow. Different occupancy levels are developed for different situations, such as walking a corridor, stairs, queues, people movers, exits/entrances platforms or any kind of pedestrian environment.

In order to calculate the Level of Service, the same macroscopic variables as Table 2.1 are used, with the difference that instead of Density, the reciprocal variable Module ($m^2/ped.$) is used (see Table 2.2). Fruin made this decision to prevent expressing pedestrians in a unit with decimal points. Headway is added in Table 2.2 as well, although it is not used to calculate Level of Service. This results in the flow equation given in Equation (2.2).

Table 2.2: Fundamental variables Fruin

Variable	Unit
Walking Speed	m/min
Module	$m^2/ped.$
Flow Volume	$ped/min/m$
Headway	s or m

$$FlowVolume = \frac{avg.Speed}{avg.Module} \tag{2.2}$$

Fruin (1971) researched pedestrians at various locations to develop the Level of Service system. He found an average free flow walking speed of 80.8 m/min. The Module (Density) required to keep this free flow speed was 3.2 ped/min/m. In Table 2.3, this value can be pointed out as the limit of level A, which is the optimal Level of Service. The following levels indicate decreasing level of service, where level E indicates the beginning of the unstable flow. The available space for a pedestrian is 0.5-0.9 m^2 at that point. When the available space drops even further, the flow stagnates and drops (Level F).

Table 2.3: Levels of Service on walkways (Fruin, 1971)

Level	**Occupancy** (m^2/ped)	**Flow** (ped./min./m width)	**Comments**
A	3.2 or more	23 or less	Free flow No conflicts
B	2.3 - 3.2	23-33	Normal walking speed Minor conflicts
C	1.4 -2.3	33-49	Restricted flow Some conflicts Walking speed controlled
D	0.9 - 1.4	49-66	Conflict Walking speed restricted Difficulty in passing
E	0.5 - 0.9	66-82	Frequent adjustment of gait Walking speed restricted
F	0.5 or less	Variable to 82	Shuffling and bunching Extreme restriction of speed Breakdown of flow

2.3. Criticism on Level of Service

Although the Level of Service methodology has been applied broadly and has been included in the Highway Capacity Manual Rouphail et al., 1998, there is criticism on the system as well. For example, the current LoS methodology is not very sensitive to changes in effective sidewalk width or pedestrian volume. (Bloomberg and Burden, 2006). Furthermore, the methodology does not consider personal pedestrian characteristics, such as age, gender and trip purpose. It is suggested in the Highway Capacity manual to adjust the limits of the levels of service to local conditions (Rouphail et al., 1998). For example, in an area where elderly people live the average walking speed is lower and in a business area the walking speed is higher. This flexibility in the assessment might sound great, but these are general adjustments, meaning that variability is not considered. For example, in a neighbourhood where many elderly live, the average walking speed necessary to calculate the level of service is adjusted. However, this adjusted Level of service is not applicable to all pedestrians, because not all of them are old.

Besides this, critique is expressed about quantifiable factors that are not included such as time spent following, number of collisions and waiting times (Bloomberg and Burden, 2006). Weidmann (1993) states that frequency of forced changes in speed and direction and the number of crossing, meeting and passing conflicts have to be considered in a LoS assessment. Moreover, perception of comfort, safety and convenience are not taken into account. In various studies, it was found that pedestrians' perception of the walking environment affect pedestrian behaviour significantly (Bloomberg and Burden, 2006).

2.4. Level of Service based on user perception

Given the criticisms of the Level of Service method, recent studies have attempted to find a user-based assessment of Level of Service (Landis et al., 2001), which may contain various perceptions, such as perceived crowdedness, safety, atmosphere, comfort, convenience or attractiveness of the (built) environment.

Apart from crowd dynamics, the subject of user-based methodologies to assess Level of Service has been researched for other subjects in the transportation field as well, such as bus services (Madanat et al., 1994), sidewalks (Landis et al., 2001), bicycle lanes (Landis et al., 1997), vehicular traffic on a highway (Papadimitriou et al., 2010), and at train stations (van Gelder, 2018). In the following section, several researches are discussed that use some type of perception and compare it to observed/measured crowdedness. Both their methods and results can be useful for this research. In Table 2.4, an overview of the analysis method, data collection method, the objective and results of each study is shown.

Papadimitriou et al. (2010) studied the perception of car drivers on a stretch of highway by use of a survey and monitoring data. In their research, Papadimitriou et al. found a large dispersion in drivers' assessment of level of service for each volume-to-capacity (v/c) value, especially at moderate traffic conditions. The effect of driver's age, gender, driving experience, familiarity with the road, vehicle capacity, and v/c was researched as well. However, only traffic conditions affected drivers' assessment of Level of Service in this sample. The results of this research conclude that there are only two to three levels of traffic conditions perceived. By using piecewise linear regression, significant slopes and breakpoints are found in the relation between perceived LoS and the v/c ratio.

Landis et al. (2001) developed a Pedestrian LoS model using stepwise multivariable regression. This model quantifies pedestrians' perception of safety and comfort and the roadway and traffic variables that influence this perception. The method is similar to methods used in the Highway Capacity Manual to assess car drivers' LoS. The aim of this LoS model is to help (re-)design roadways and evaluate and prioritise measures.

Lee et al. (2007) studied the satisfaction of car drivers and pedestrians at signalised intersections by using a fuzzy aggregation and a cultural consensus analysis technique. This technique is an improvement to conventional measures for LoS, because the qualitative nature of service quality is better reflected. Lee et al. found that user perceptions vary greatly per individual. The assessment on Level of Service based on the perception of the car drivers and pedestrians does not correspond to the traditional LoS assessment.

Madanat et al. (1994) studied the effectiveness and threshold values for a LoS model for public transport users by surveying bus riders. Bus riders were asked to rate their comfort on a scale from 1 to 6. The LoS designations are found by using an ordered probit model.The method proposed in this paper can be used for designating service levels objectively.

van Gelder (2018) studied the influence of crowdedness on the experience of travellers at train stations by comparing survey data and monitoring data. Surveys were conducted on the platform, where cameras are installed that count the number of people in a demarcated area on a regular basis. Furthermore, socio-demographic, personal and trip characteristics, such as familiarity and travel purpose were included, as well as information about in and outgoing trains. An indirect relation between the station and platform appreciation and crowdedness was found. Furthermore, travellers that are at the station more often, rate the crowdedness higher, experience the crowdedness as more unpleasant and also give a lower rating to the station.

Table 2.4: Overview user-based LoS researches

Paper	Subject	Perception	Objective	Method data gathering	Method data processing	Results
Papadim-itriou et al. (2010)	Car drivers, highway	-Level of service	Perception w.r.t personal characteristics and traffic conditions	Survey and monitoring data	Piecewise linear model	- No relation personal characteristics and perception - Perception LoS related to volume/capacity - Only three perceived service quality levels
Landis et al. (2001)	Pedestrian roadside	-Safety -Comfort	Model pedestrian LoS (re-)design, evaluation, prioritisation infrastructure	Observations street experiment	Stepwise multivariable regression	
Lee et al. (2007)	Drivers and pedestrians signalised intersections	- Service quality - Satisfaction	create LoS model which captures perception	Survey experiment video footage intersection	Fuzzy aggregation and a cultural consensus analysis	- Perception differs much between participants - Perception LoS and HCM LoS do not correspond - Three levels of service would be more practical
Madanat et al. (1994)	Public transport users	- Comfort	Develop method for designating service levels	Survey and manual passenger count	Ordered probit model	- Perception LoS and HCM LoS do not correspond
van Gelder (2018)	Travellers, train stations	-Crowdedness -Inconvenience -Station and platform	Perception of crowdedness w.r.t personal and trip characteristics and train information	Survey and monitoring data	Regression	- Relation familiarity/ goal and perception - Relation perceived crowdedness and built environment

From these papers, we can conclude that it is indeed important to take a users' perception into account, because a LoS assessment that is only based on service levels is very different from a perception-based assessment. Perception variables that could be taken into account are: Service quality, Safety, Comfort, Convenience, Crowdedness, the built environment and Satisfaction. Combined research into observed/measured crowdedness and perception has not yet been conducted for event environments, therefore it is currently unclear whether other factors and perceptions are important to take into account as well.

2.5. Psychological paradigm

In travel behaviour research, the Econometric paradigm is often used, because it lends itself well to choice modelling (Kroesen, 2017b). In previous researches, this type of model was applied to develop a route/activity choice model for pedestrians (Galama, 2016; Iliadi, 2016; Ton, 2014). However, for this research, the econometric paradigm is not applicable, since it assumes that people base decisions on complete and objective information. A thought process and perception are not considered.

In the psychological paradigm, there is a focus on the motivation behind behaviour. Consequently, psychological models have a high explanatory power. However, the conceptual models in psychological research are usually complex and often do not lead to surprising insights. Compared to a discrete choice model, the causality between factors is less clear (Kroesen, 2017b).

It is possible to create a hybrid model that combines a discrete choice model with a structural equation model. However, Chorus and Kroesen (2014) argue that these type of models cannot be used to determine policies, because the causality between perception and behaviour is less clear. In Appendix A, more information about the three types of models can be found.

For this research, it is chosen to limit the scope of the research to perception and not include behaviour, therefore the psychological paradigm is chosen.

2.5.1. Theory on perception

In this section, some theories on the formation of perception are stated. This provides insight in which type of factors can influence perception in general and it clarifies the definition of perception.

On perception, multiple theories exist. Gibson's theory (1950) proposed that perception is formed directly as a cognitive recognition of optical flows. In his theory, perception is formed through evolution to recognise patterns in the external environment. However, other research has proven that mental representations and memory also play a role in perception. Also, it is proven that perception changes by learning (Démuth, 2013).

Other theories do include memory and knowledge, the top-down indirect perception theories. These theories propose a system where sensory data must be organised and captured by cognitive functions in the brain and is interpreted on the basis of available knowledge (Démuth, 2013). For example, constructivist theory sees perception as the end product of extracting sensory stimuli, in which individual factors play a role. These factors include expectations, knowledge, motivation and emotion (Démuth, 2013).

Contrary, bottom-up theories belief that sensory stimuli are unconsciously inferred and evaluated (Démuth, 2013). Therefore, the perception of a person is influenced by their background, but subconsciously.

In Neisser's theory (2014), perception does not begin at sensory stimuli per se. By intentional focussing and consciously paying attention, the senses can detect stimuli faster and better. On the other hand, the conscious mind can be triggered to pay more attention by initial detection of external stimuli.

In this research, it is desired to include conscious evaluation as well as unconscious inference of the external stimuli. Further on in this research, this distinction is made clear by using the terms perception of Crowdedness and experience of Crowdedness, where perception of Crowdedness is the unconscious perception that is coloured by a person's background and experience of Crowdedness is an evaluated perception using prior knowledge and conscious consideration.

2.5.2. Theory on behaviour

In order to shape a theoretical framework, a few behavioural theories are elaborated in Appendix A. The following renowned theories are discussed: The theory of Reasoned Action (Fishbein & Azjen, 1980), the Theory of Planned Behaviour (Azjen, 1985), Social Learning Theory (Bandura, 1977) and Habit (Verplanken, 2006). The Theory of Planned Behaviour will be applied for this research, because it gives a clear framework that relates background factors to perception and behaviour in consecutive steps. Furthermore, the factors included in the model correspond with the factors summed up in Section 2.7.

The Theory of Planned Behaviour was created by Fishbein and Azjen as an elaboration on the Theory of

Reasoned Action. It includes background factors, Beliefs, Attitude, Perceptions and Intention as consecutive factors in a thought process leading to behaviour. In Figure 2.2, the framework of the theory is shown.

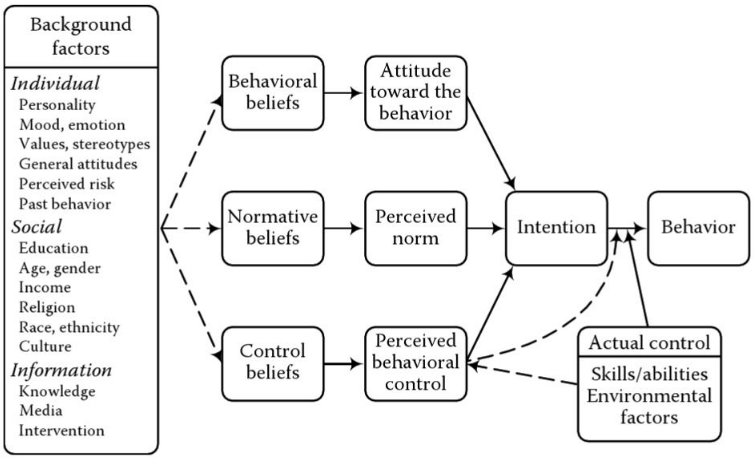

Figure 2.2: Theory of planned behaviour

Figure 2.2 shows that various background factors influence behavioural, normative and control beliefs. The background factors are split up in individual, social and information factors. Beliefs are divided into behavioural, normative and control beliefs. Behavioural beliefs encompass the cost and benefits a certain type of behaviour could have according to the beliefs of the person. By evaluating the outcome of the behaviour, an attitude towards this behaviour is formed (Ajzen, 1991). Normative beliefs are the social norms that a person's beliefs are applicable in certain situations. Based on a persons perception of the situation, the social norm that is applicable at a certain moment is derived. The meaning of Control beliefs according to Fishbein and Ajzen (2011) is the belief people have that they have control over the things that happen in their lives. Perceived behavioural control describes *"a general sense of personal competence or perceived ability to influence events"* - Fishbein and Ajzen (2011).

The Intention, the behaviour that the person in question intents to perform, is determined by the attitude towards the behaviour, the perceived norm and Perceived Behavioural Control. Intention will not always lead to the actual behaviour. Performing actual behaviour is restricted by Perceived Behavioural Control and by Actual control, where actual control depends on a person's skills and abilities, as well as environmental influences.

In previous researches, the theory of Planned Behaviour proved to not be fully able to explain the difference between intention and actual behaviour. Therefore, other researchers have elaborated on the Theory of Planned Behaviour, adding additional background factors and paths to behaviour. Triandis (1979) added Habit and Emotion to the framework. In the figure, Emotions are included as a background factor, influencing a new facet in the framework, namely Affect, which influences Intention.

The term Affect is used to describe general mood and emotional state. Moods can be distinguished between pleasant and unpleasant and activation and deactivation. Figure 2.3 shows the circumplex model of Affect, as developed by (Russell, 1980).

Triandis (1979) added habit in the framework as follows: The frequency of past behaviour is added as a background factor, which goes through a new facet Habit directly to behaviour. A habit is formed by the creation of associations in memory between actions and context in which they are performed (Aarts et al., 1998). Habits may be triggered by environmental cues, such as time of day or location, by internal states, such as particular moods and by the presence of typical interaction partners (Verplanken and Wood, 2006).

Lastly, Bagozzi and Warshaw (1990) add Motivation and Goal pursuit as background factors influencing beliefs.

Psychological models can be defined and measured using Structural Equation Modelling. This method was used by Hoon Kim et al. (2010) for their study at a festival to test the relations between perceived value, satisfaction and intention to revisit. Novelli et al. (2013) used SEM to clarify the relations between social identification, experience of crowdedness and positive emotion at events.

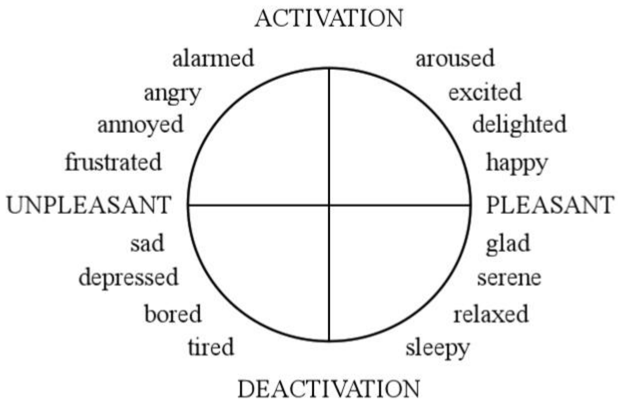

Figure 2.3: Circumplex model of Affect: Emotional states (Russell, 1980)

The psychological paradigm is chosen to research the relation between perception of crowdedness and personal, trip and event characteristics. In this research, the term perception is not only the unconscious interpretation of external stimuli, but it is assumed to be influenced by knowledge, expectations, motivation and emotion. The Theory of Planned Behaviour can be used to explain the relation between personal, trip and event characteristics and perception. A Structural Equation model is used to measure the hypothesised relations.

2.6. Factors influencing behaviour

To identify the factors that could influence the perception of crowdedness, literature about pedestrian behaviour is studied. Gathered from Fruin (1971), Iliadi (2016), Galama (2016) and Daamen (2004), the following factors could influence pedestrian choice behaviour (Figure 2.5). A division is made in four categories: personal, system, event and external.
Personal factors are divided into three subcategories: General factors, trip factors and learning process. General factors include social demographics and personal state and decision style. Trip factors include the situation that specifies the trip, such as group composition and purpose of the trip. Learning process contains typical psychological factors. All these factors are dependent on the pedestrian.

System factors are divided into location and route factors. Location factors are used to determine location choice. The activities available and the dimensions of the location can have an impact. For route choice, distance and travel time are often found to be most significant (Seneviratne and Morrall, 2007). Without realising it, pedestrians tend to choose for the shortest route. The number of attractions, visibility, crowdedness and safety are other route specific factors.

Event factors include the factors that apply specifically to mass events, such as event characteristics, information and crowd management and crowd composition. Event characteristics contain data such as indoor/outdoor, free entrance or paid ticket and the type of activities/music. This might also attract a different type of crowd in terms of social demographics and behaviour. Information contains such things as signs, maps and mobile phone applications.

External factors are the ones that cannot be influenced by humans directly. In this category, weather and environment could play a role.

In the next section, relevant findings about the individual factors in Table 2.5 in relation to perception of crowdedness are discussed.

Table 2.5: Factors influencing pedestrian route/activity/location choice, retrieved from (1) Daamen (2004), (2) Ton (2014) and (3) Iliadi (2016)

Attributes			
Personal factors	**General factors**	Age	(1), (2), (3)
		Gender	(1), (2), (3)
		Familiarity	(2), (3)
		Emotional state	(2), (3)
		Decision style	(1), (3)
	Trip factors	Trip purpose	(1), (2), (3)
		Time spent in an area	(2), (3)
		Group composition	(2), (3)
		Time of day and week	(2), (3)
		Impulse behaviour	(2), (3)
	Learning process	Cognitive learning	(2)
		Habit	(2)
		Choice inertia	(2)
System factors	**Location**	Location dimensions	(2), (3)
		Visibility	(2), (3)
		Amount of shops or other activities available	(2), (3)
	Route	Travel time	(1), (3)
		Distance	(1), (2), (3)
		Crowdedness	(1), (2), (3)
		Comfort	(2)
		Number of attractions	(1), (2), (3)
		Directness	(1), (2), (3)
		Safety	(1)
		Weather protection	(1), (2), (3)
Event factors		Event characteristics	(3)
		Noise	(1)
		Information and crowd management measures	(3)
External		Environment	(2), (3)
		Weather	(2)

2.7. Factors influencing perception

Continuing on Section 2.6, in this analysis, the most relevant insights regarding the relation between personal, trip and event characteristics and the perception & experience of crowdedness are discussed. Furthermore, underlying relations between factors are discussed, as these might introduce interaction effects. When mentioned in literature, behavioural outcomes are discussed as well. Here, it is assumed that a factor that influences behaviour, could also influence perception.

A new classification is used that applies better to perception research. The first category is Social Demographic factors. These were partly covered as general factors in the previous research of Ton (2014) and Iliadi (2016). They are distinguished as one category, because these factors are not influenced by the event characteristics. The next category is Personal & Trip factors, which were previously mentioned in the categories general and trip factors. These factors could be influenced by the event and can differ per trip a person makes. Then, Event & Environment factors are grouped together because from the perspective of an event visitor, the difference between a temporary environment and the built environment is not that important. Furthermore, some of the system factors are included in this category, such as location dimensions. Quantified crowdedness is the final category that is discussed, focussing mainly on the macroscopic flow variables.

2.7.1. Social demographic factors

Social demographic factors are often used as explanatory variables in social research. In Table 2.6, the most relevant Social Demographic factors found in literature are mentioned. These will be elaborated below.

Table 2.6: Social demographic factors

Social Demographic	Age
	Gender
	Height/physical dimensions person
	Residence
	Health
	Education level
	Income
	Culture

Age

According to Bytheway (2011), age is related to individual identity. Furthermore, age is an structural component of organisations and institutions. It influences a person's biology, so it is an indicator of one's physical capabilities. It also shows a person's knowledge and experience. In social research, age is often found to have significant correlation to other factors. According to Démuth (2013), Age influences perception by the development of the cognitive functions (nature) and by psychological and cultural influences (nurture). Hoskam (2017) found that age correlates negatively with perception of Safety.

Gender

Gender, just as the age factor, is often used as an explanatory factor in social sciences. Hill (1982) found that gender influences route choice. From observation, Hill concluded that women tend to choose more complex routes than men. However, in other research, Seneviratne and Morrall (2007) found that there is no difference in route choice between men and women. Hoskam (2017) and Grolle (2017) found that perception of safety and atmosphere differs between men and women, but perception of crowdedness does not. Démuth (2013) states that differences in perception between men and woman exist, but they are not clearly distinguished. According to Démuth (2013), variances between individuals are often greater than the variance that can be explained by gender.

Height/physical dimensions person

In order to determine Levels of service, Fruin (1971) takes space required into account by accounting for a body ellipse that considers the body width and depth of a 95th percentile man. However, as Bloomberg and Burden (2006) state, the average person's size has changed since then. Whether a person's size changes their perception of the situation is not found in literature. In a focus group research of Kendrick and Haslam (2010), physical height was mentioned as a factor by one of the participants, but no further information was available.

Health

A person's health can be of great influence on active mode behaviour. Kroesen et al. (2018) shows that clusters can be created that relate health factors like nutrition, drinking, smoking, physical activity and active mode usage to lifestyles. This means that someone's lifestyle can tell something about their active mode behaviour.

Place of Residence

The place of residence could influence a person's behaviour and perception. Humpel et al. (2004) found that people living near coastal areas walked more in their neighbourhood. This could indicate that environmental attributes influence a person's walking behaviour on a strategic level. Their perception of environmental attributes was not significantly different from the participants living in other areas. Hoskam (2017) found a significant correlation between perception of Safety and Crowdedness and residence population density. Respondents living in more densely populated areas perceived a higher level of Safety and a lower level of Crowdedness in a city street. This shows that people who are *familiar* with crowded city streets have a different perception, because they are used to the crowdedness. Respondents living in densely populated areas have an adjusted reference scale to crowdedness. This acclimatisation to crowdedness seems to lead to an adjusted reference scale to safety as well. Whether the density of place of residence influences the perceived crowdedness at events is unknown. As stated in the introduction, residents of Amsterdam avoid certain areas, because they experience the level of crowdedness as unpleasant (van Dun, 2016).

Education level, Employment, Job type, Income
The factors education level, employment, job type and income could all influence pedestrian behaviour. Education level and income are usually correlated. For example, a person who has a degree from university will have a higher chance of having a high income (Griliches and Mason, 1972). Humpel et al. (2004) gathered data on education level, but it had no significant influence on people's environmental perception. Employment or job type could influence the perception of crowdedness as well. Kendrick and Haslam (2010) included employment type into their research. They found that job type might be related to a different perception on crowds. For example, participants employed as police officers associated crowds with violence.

Cultural background
Culture greatly influences crowd behaviour (Kendrick and Haslam, 2010). For example, crowd-mindedness contributes to a flow that is stable at higher levels of density (Duives, 2017). Culture is learned by a person's surroundings, the country a person's lives in and the people a person is close to. According to Démuth (2013), perception is influenced by cultural background, because it relates to the experience and learning process of a person.

2.7.2. Personal state and trip factors

In this subsection, personal state and trip factors are discussed. These are various factors which have to do with the personal state of an individual at a moment in time while present on the event terrain. In Table 2.7, the personal state and trip factors that will be discussed are stated.

Table 2.7: Personal state & Trip factors

Personal	Emotional state
	Stimulant usage
	Familiarity
	Decision style
	Trip purpose
	Group type

Emotional state
According to Lee et al. (2001), pedestrians experience discomfort, frustration and concern about safety in underground/railway stations. Song et al. (2012) found that emotional aspects were crucial to take into account when perception and behaviour of festival visitors are researched. In the study of Song et al., "Positive anticipated emotion" and "Negative anticipated emotion" are included in a behavioural model that explains the intention of event visitors. Conner and Armitage (1998) shows that anticipated affect is a very strong motivator in the decision making process.

Stimulant usage
While stimulant usage is not a common factor to address, at events it could play a role for perception and behaviour. At events there are more people under influence of some kind of stimulant. The research of Grolle (2017) on the holiday named Kingsday, over 50% of the respondents had used at least one kind of drug. Grolle (2017) found that alcohol use was related to a higher perception of safety. The most common types of stimulants are: Alcohol, Marijuana, XTC and MDMA. The type of substance use is expected to differ at different type of events.

Familiarity
According to Daamen (2004), familiarity with the environment greatly influences route choice behaviour, since it actually influences the decision style. Event visitors who are familiar with the environment can make decisions based on their knowledge, while unfamiliar visitors are more dependent on available information and visual cues. Zomer (2013) found that familiarity with the event influenced the use of information. In her research, Ton (2014) used different frameworks for familiar and unfamiliar people to analyse route and activity choice of pedestrians. van Gelder (2018) found that people who are at the train station more often experience the crowdedness as less pleasant. Hoskam (2017) found that frequency of visit correlated negatively

with the perception of crowdedness.

Decision style
According to Hill (1982), route selection strategies are largely subconscious. Avineri & Prashker (2003) state that decision styles are based on herding behaviour, utility maximisation and habitual behaviour. At events, it can be assumed that route choice is influenced more by impulse, herding, group and habitual behaviour (Iliadi, 2016). When an individual has a specific purpose, for example to see a specific artist, then utility maximisation is the most fitting decision style. In the Theory of planned behaviour (Figure 2.2), these decisions styles are found as well. Utility maximisation is based on the behavioural beliefs, or the expected outcomes of behaviour. Social norms can include group behaviour and herding behaviour. As mentioned in Section 2.5.2, habit can be included in the model is well.

Purpose
Iliadi (2016) distinguishes two types of pedestrians. One group with a predetermined goal and one group that chooses more intuitively. This could be part of the decision style, but it could also be related to trip purpose. When an event visitor has a more particular goal, such as the desire to see a certain artist play this could influence their perception. Iliadi also found that walking has a positive influence on the utility function when it is part of an activity, while it has a negative effect when there is no preference for an activity. Seneviratne and Morrall (2007) found that people heading for work or school pay less attention to the attractiveness of the route. This could also be related to familiarity. This suggests that an urgent purpose changes a person's perception & experience in general. The work of van Gelder (2018) suggests that people with a work or school related purpose experience crowdedness more negatively, since people who visit a train station frequently probably take the train to work or school.

Group type
Hoskam (2017) found that group size correlates positively with Atmosphere. According to Daamen et al. (2017), group characteristics and personal characteristics both influence the route choice behaviour and are intertwined as well. In their research they compared group size to route choice. They found a significant positive correlation between group size and type of performance for men, meaning that the larger the group, the more performance type mattered for the route choice. Furthermore, 64,7% of the respondents to their survey stated that the preference of the group is often important in making a route choice. Group type influences the decision style as well (Hoogendoorn and Bovy, 2004).

2.7.3. Event & Environment factors

Event & Environment factors are grouped together, because they form one whole for a pedestrian. Furthermore, they both require alternative types of data collection. The factors that are studied are summed up in Table 2.8.

Table 2.8: Event & Environment factors

Environment	Information
	Crowd composition & Social identity
	Location
	Light
	Sound
	Time of day/week
	Weather and weather protection

Information
Information, which includes knowledge, mobile phone applications, flyers and route information signs can influence a person's choice behaviour. Zomer (2013) states that whether or not information will be noticed depends on the interactions in a group, familiarity and purpose. For example, when one member of the group is familiar with a city or event, the rest of the group can follow and there is no need to consult (route) information. Furthermore, Zomer concluded that information provided beforehand was more often consulted than information that was available at the event. In the research of Daamen et al. (2017), information was not

found significant with relation to route/activity choice.

Crowd composition and social identity
As Hoskam (2017) and Grolle (2017) found, perception of crowdedness is not purely dependent on the measured density. As Fruin (1971) stated, the size of personal space that is desired between two persons is different for gender, culture and personal characteristics of both persons. Novelli et al. (2013) researched the effect of social identity on perception of crowdedness and the positive or negative emotion towards the crowd. People who identified themselves with the other people present perceived lower crowdedness and more positive emotions.

Location type
There are many location characteristics that could be taken into account. In this case, location size is assumed to be highly relevant. A narrow corridor might be perceived differently, even though the density is the same as in a broad corridor (Kendrick and Haslam, 2010). Furthermore, a location is more than only a sum of physical attributes. A certain location will be a certain ambience, which is created by a combination of all Event & Environment factors, such as lighting and music, but also crowd composition. Moreover, crowds with a common social identity also attach meaning to certain spaciotemporal places (Reicher, 2018). For example, history of a location could play a role in the atmosphere that is perceived at a certain location. According to Health and Safety Executive (2000), retrieved from Li (2019), locations such as entrances and exits, attractions, queues and enclosed spaces should be given extra attention when it comes to monitoring the crowd.

Light
Lighting has a large influence on the perception of safety and can also be used prevent crime (Boyce et al., 2000). Boyce et al. (2000) found that a light intensity of 30 lux at nighttime at a parking lot provided a perception of safety close to the one in daylight. The colour of the light was a minor factor compared to the light intensity. Ariffin and Zahari (2013) found that a small percentage of pedestrians gives "not enough lighting" as a reason not to walk somewhere. Furthermore, different lighting types, such as stage lights and stroboscopes can influence people's emotional state (van Hagen, 2011). Preferred light intensity depends on the situation, the task a person needs to perform and the surroundings (van Hagen, 2011).

Sound
A phenomenon that occurs at events is panic caused by an unexpected sound. In 2010, the "Damschreeuwer" caused panic by screaming at the end of the two minute silence for the commemoration. In the chaos, 63 people were injured (Buis,2014). Furthermore, sounds can also influence the emotional state of a person. Specifically music has been shown to influence mood (Bruner, 1990) and has been used to alter mood in both positive and negative directions. Elements such as tempo, pitch, mode (major or minor) and genre have influence on the mood that people experience (Bruner, 1990). A rising pitch can convey a growing intensity in emotion, songs in higher keys are perceived as happier, music in major expresses more positive feelings and complex harmonies are more sad and agitated (Bruner, 1990). Music that is liked by individuals results in a even more positive effect. In the research of Cameron et al., music likeability reduced the perceived waiting time. Music has also been found to have anxiety-reducing qualities (Cameron et al., 2003). According to Li (2019), noise is a factor that is considered by crowd managers as well.

Time of day/week
In a daily live, time of day is relevant in relation to peak hours, when pedestrians go to work or school. Ton (2014) and Seneviratne and Morrall (2007) researched the difference between peak and off-peak, but did not find a significant relation with route choice. In this research, mainly recreational pedestrians are considered. Different outcomes are expected at different times of day, related to stimulant usage and time spent at the event. Furthermore, time of week could have an influence on the type of visitors. During the weekend, people who work during the week have time to go to events.

Weather and weather protection
From the research of Andrade et al. (2011) it is known that weather influences a person's perception of Comfort. Temperature, wind speed and precipitation all have influence on this perception (Andrade et al., 2011). The presence of weather protection did not influence route choice in the research of Seneviratne and Morrall (2007). According to Li (2019), bad weather can influence the mood of the crowd negatively.

2.7.4. Quantified Crowdedness

Crowdedness can be quantified with a number of variables. Most are mentioned in Section 2.1. Density, flow and speed are most commonly used to describe crowd behaviour on a macroscopic scale (Vanumu et al., 2017). Bloomberg and Burden (2006), Weidmann (1993) and Eijkelkamp (2017) suggest that a local view can be used to give an indication of the crowdedness that a pedestrian experiences, such as the number of (near) collisions, the time spent following and waiting times. Table 2.9 shows the variables that will be discussed.

Table 2.9: Quantified Crowdedness

Quantified Crowdedness	Density
	Speed
	Flow
	Flow type
	Collision/Impedance

Density

The relation between number of pedestrians and available space is the most important determinant for Level of Service (Fruin, 1971). The work of Grolle (2017), Hoskam (2017) and van Gelder (2018) showed that there is a relation between the number of people in an area and the perceived crowdedness of pedestrians. Pécheux et al. (2004), Papadimitriou et al. (2010) and Madanat et al. (1994) all use a number of pedestrians/vehicles in a demarcated time and space to compare this to perception on level of service, comfort, safety and crowdedness.

Speed

A pedestrian has a desired speed, depending on age, gender, time of day, trip purpose and environmental factors (Bloomberg and Burden, 2006). Weidmann (1993) describes 'Free choice of speed' and 'frequency of forced changes in speed' as criteria for assessment of pedestrian infrastructure. At an event, due to the number of people that are standing and walking, it is not always possible to retain a person's desired speed. Subsequently, perception of crowdedness can be related to the walking speed of a pedestrian.

Flow & flow type

The variable Flow is the third macroscopic variable. Flow has a relation to Density and Speed, consequently, it is also expected to relate to perceived crowdedness. Flow considers the movement of all the pedestrians in a system. Density cannot indicate movement, while flow and speed can. Kendrick and Haslam (2010) found that the ability to move (in the desired direction) influenced people's perception of safety and security and their sense of control. Guo et al. (2016) found that pedestrians tend to form lanes for directions. Lee et al. (2005) specified a new Level of Service assessment which included the proportion of flow in two directions for intersections. There are various types of flow that could be distinguished, such as no flow (static crowds), unidirectional flow, bidirectional flow, crossing flow or turbulent flows (Duives, 2017). If a pedestrian wants to cross a steady flow, this will take more time and effort.

Collision/Impedance

Weidmann (1993), Eijkelkamp (2017) Bloomberg and Burden (2006) and Hoskam (2017) use values such as number of (near collisions), control delay and percentage of time platooning as indications for the comfort experienced by pedestrians.

2.7.5. Perception & experience of Crowdedness

The situational perception of a pedestrian is a comprehensive interpretation of the external stimuli. Which of the aspects of situational perception are related to crowdedness has to be determined based on literature. In earlier research Crowdedness, Safety and Atmosphere were considered (Hoskam, 2017; Grolle, 2017). Bloomberg and Burden (2006) mentions Comfort, Safety and Convenience. Landis et al. (2001) also includes Attractiveness of the built environment. Table 2.10 states the perceptions that are discussed in this paragraph.

Table 2.10: Perception & Experience of Crowdedness

Perception	Crowdedness
	Comfort
	Safety
	Atmosphere
	Attractiveness environment

Crowdedness
Since crowdedness is the main topic of this research, this perception has to be included. Based on the findings of Galama (2016), it seems that crowdedness can be seen as a positive as well as a negative factor. Worchel and Teddie (1976) showed that experienced level of crowding is influenced more by the interaction distance than by overall density. Furthermore, the study showed that environmental factors (pictures on the wall) could lower the experienced level of crowding. According to Lee et al. (2001), experiencing discomfort, frustration and concern about safety is possible in underground/railway stations because of congestion and crowded situations. Van Hagen (2011) found that crowding correlates negatively with pleasure and satisfaction and leads to an increase of arousal and stress, because people feel restricted in their available space. However, in a hedonistic environment, such as an event or a club, crowdedness is perceived positively.

Comfort
The Level of Service is often described as the comfort level that is experienced by the pedestrian (Bloomberg and Burden, 2006). Therefore, comfort could be taken into account as an indication of perceived LoS. However, comfort can be interpreted in multiple ways. It can be physical comfort, such as described by Fruin. Comfort could also include social comfort, meaning that a person's comfort is influenced by the behaviour and composition of the crowd. Comfort can also be influenced by time spent. Certain bodily needs can make a person feel uncomfortable. For example, when a person is thirsty, tired of standing or has to use the toilet. This type of comfort can be improved by event facilities, such as benches, water taps and sufficient and strategically placed toilets

Safety
The perception of Safety is related to the perception of Crowdedness, as can be concluded from Hoskam (2017) and Grolle (2017). Grolle found a negative relation between number of people present and perceived safety. Safety is also addressed by Landis et al. (2001), Pécheux et al. (2004) and Kita (2000) as an indicator for perceived crowdedness. Subjective safety is found to differ much from objective safety (Vlakveld, 2009). Often, social demographics can be used to explain perceived safety, such as level of urbanisation. Moreover, familiarity increases perceived safety (Vlakveld, 2009). For safety, there is a difference between social and physical safety. Here, physical safety can be endangered by accidents and oppression in a crowd. Social safety however, concerns the behaviour of other people towards the individual. For example, a person might be mistreated or robbed by another (Hoskam, 2017). Perceived safety is also influenced by past experience and information from (social) media. Event & environment factors, such as clear design of a street, influence perceived safety as well (van den Munckhof et al., 2017). And finally, social control is important. The presence of other people could either increase of decrease perceived safety, depending on the extent to which an individual feels part of that group.

Atmosphere
The perception of Atmosphere is related positively to the perception of Crowdedness and Safety, as can be concluded from Hoskam (2017) and Grolle (2017). Specifically for recreational purposes, considering atmosphere could be important in a person's perception. Atmosphere is a very subjective and intangible attribute, but this might make it even more valuable to identify how crowdedness is perceived.

Attractiveness Environment
Finally, attractiveness of the environment is expected to have a relation to perceived crowdedness and experience. It is expected to be related to perceived safety. Ariffin and Zahari (2013) found that facilities consciously designed for pedestrians contribute to a more positive perception of the walking environment. Humpel et al. (2004) found that men with the most positive perception of the attractiveness of the neighbourhood were significantly more likely to walk more in the neighbourhood.

2.7.6. Conclusion

Many of the factors that were analysed have a relation to perception to some extent, but it is not always clear in what way. Many of the socio-demographic factors influence perception indirectly, because they explain or relate to personal state and trip factors. For example, place of residence relates to familiarity. Age is expected to relate to perceived and experienced crowdedness. However, only a relation to perception of Safety was found. Factors such as culture have influence on perception, but the relation is not clear, because culture in itself is such a broad concept. Emotional state, Substance usage, Familiarity, decision style, trip purpose and group type all seem very important with relation to perception & experience of Crowdedness. All of these are useful to research further, since some have not been researched with relation to perception specifically, or only one research was found. For Event & Environment factors, relations to situational perception and to emotion are found, but not often a relation with perception of crowdedness is found in literature. Therefore, these factors need to be researched further. It is clear that observed/measured crowdedness can be related to perception & experience of crowdedness using various indicators, such as Density, walking speed, flow and impedance. All of these factors are also related to each other. Finally, five perceptions were evaluated. Comfort, Safety, Atmosphere and Attractiveness of the environment have been considered in previous research with relation to perception of crowdedness. These perceptions are influenced by the perceived crowdedness in various ways, but are also influenced by the background factors as well. The effect of perceived crowdedness on the other perceptions (experienced crowdedness) is not always the same. Crowdedness can be perceived as positively or negatively, depending on the context. In the next chapter, the categories will be placed in a framework based on the theory of planned behaviour. Furthermore, hypotheses will be specified based on this literature study. In Chapter 4, data collection methods for these factors are discussed.

3

Theoretical framework

In this chapter, the factors influencing perception found in Chapter 2 will be placed in a theoretical framework based on the Theory of Planned Behaviour, answering the following sub-question:

How can perception & experience of crowdedness be explained by a theoretical framework and which hypotheses relate to this?

In Section 3.1, the theoretical framework that is developed will be explained. In Section 3.2, hypothesis will be presented corresponding to the paths presented in the theoretical framework.

3.1. Theoretical framework

In the previous chapter, factors that could influence behaviour and perception were identified. Already, different categories were used to distinguish these factors. The reason to use these categories is further clarified by the developed framework. The proposed structure of the theoretical framework is based on the Theory of Planned Behaviour (Figure 3.1).

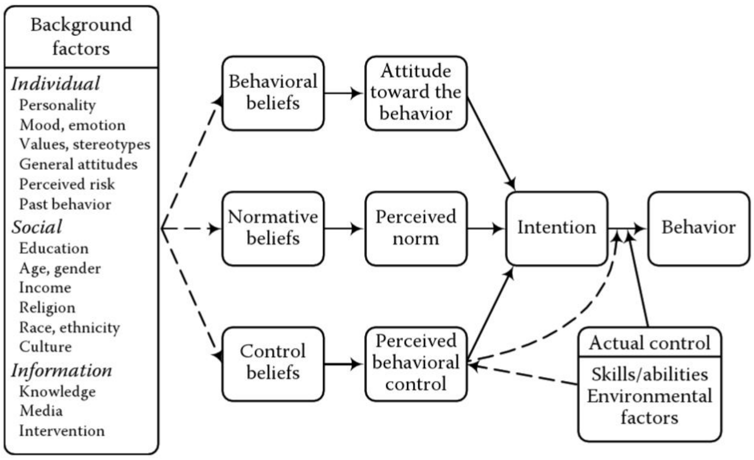

Figure 3.1: Theory of planned behaviour

However, while the Theory of Planned Behaviour focuses on the various beliefs which can lead to a certain type of behaviour, the model specified for this research focuses on the way surroundings and crowds are perceived. Consequently, this newly developed perception model is more dependent on a time and space dependent situation, while TPB is often used to find behaviour patterns that are not dependent on a specific situation (Conner et al., 1999).

Figure 3.2 visualises the new model, which contains the same steps as the Theory of planned behaviour. It visualises the way an individual perceives and experiences crowdedness at an event. The background fac-

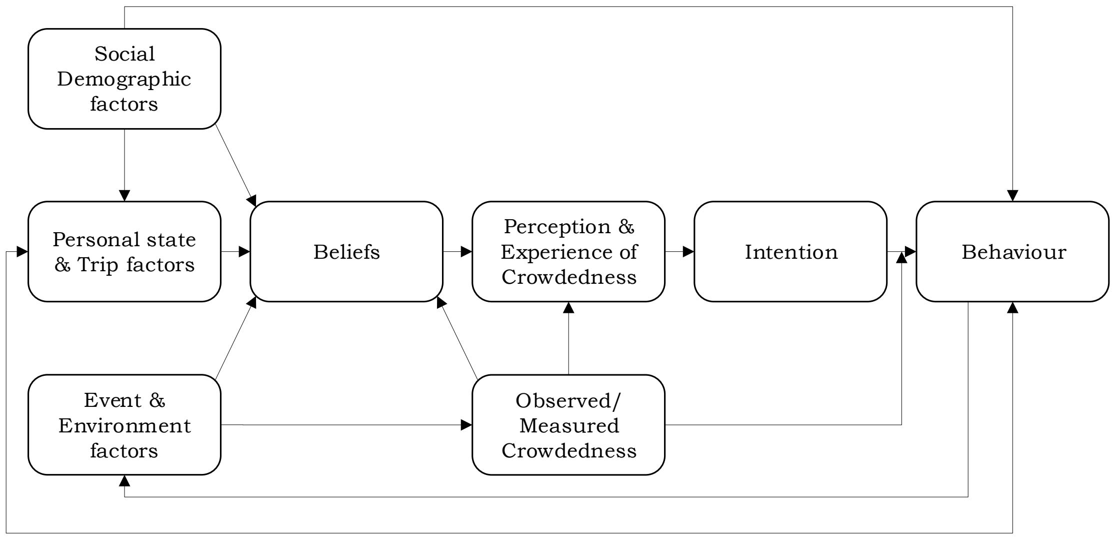

Figure 3.2: Adjusted theoretical framework: Perception & Experience of Crowdedness

tors are split up in three categories, namely Social Demographic factors, Personal state & Trip factors and Event & Environment factors. This division is made, because these categories are related to each other and to perception & experience of crowdedness in a different way. Event & Environment factors are reflected more prominent in the revised framework, as they evidently influence perception of Crowdedness.

Social Demographic and Personal state & Trip factors are both dependent on the individual, and following that reasoning, could be placed in one category. However, they are split, because Social Demographics are typically factors that are constant for a long-term period and are not influenced by other factors in the model. For example, the age of an individual is not changed by their behaviour.

Contrary, the category Personal & trip is dependent on the individual, but can also vary during the event due to the behaviour of the individual. For example, a person can choose to consume alcohol, which changes their personal state. Socio-demographics can also explain personal state & trip factors, which is why an arrow is added between them. For example, age can be used to explain how familiar a person is with a location or event. Both Socio-demographic factors and Personal state & Trip factors can influence behaviour directly in this adjusted model. This relation mainly describes behaviour on the operational level. Age, gender and substance usage can all be used to explain the walking behaviour of an individual.

The event characteristics are split up in Event & Environment factors and observed/measured crowdedness. Event & Environment factors can differ in time and location. In this category, external factors such as weather, which the event organiser cannot influence, are included. On the other hand, Event factors such as number of attractions and music type are included in this category as well. The category Crowdedness includes all types of indicators discussed in 2.1, such as flow, speed, density, flow type and impedance (Bloomberg and Burden, 2006). It is influenced by Event & Environment factors, for example, the width of the passageway is influenced by obstacles that are placed there.

These four categories influence a persons beliefs. In the Theory of Planned Behaviour, beliefs are split up in behavioural, normative and control beliefs. However, since the beliefs will not be researched further, the relation is simplified in this model.

Intention and behaviour include all behaviour that could be influenced by Perception & Experience of Crowdedness. Furthermore, the actual crowdedness influences the difference between intention and behaviour, just as in the original framework. The arrow from behaviour to Event & Environment factors explains the choice of an individual to move from one place to the other. Consequently, the crowdedness will also vary. Intention and Behaviour are not researched further, because it does not fit in the scope of this project.

A simplified model is provided as well (Figure 3.3), which shows only the categories and relations that will be tested. For the interpretation of the results, the full theoretical framework can be used.

Within the category Perceived & Experienced crowdedness, a difference is made between perception of crowd-

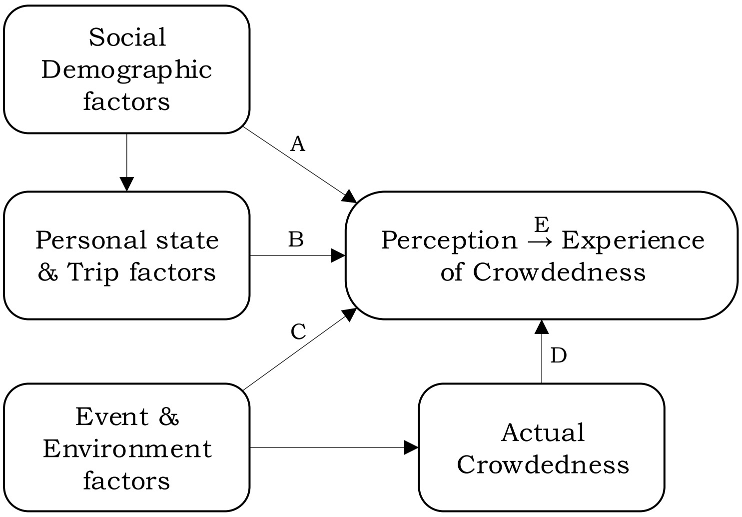

Figure 3.3: Simplified framework for research

edness and experienced crowdedness. Perception of crowdedness contains a person's impression of the people that are present. The experience of crowdedness is a value judgement based on this crowdedness, containing perceptions on safety, comfort, attractiveness of the environment and atmosphere.

3.2. Hypotheses

In this section, the hypotheses based on the literature study (Section 2.7) will be presented. Per category, the relations between the factors in that category and perception & experience of crowdedness are discussed. These relations follow the arrows that are displayed in Figure 3.3. The hypotheses mentioned here are applicable to events in general. In Chapter 4, event specific hypotheses will be discussed.

A. **Socio-demographics → Perception & Experience of Crowdedness**

- Women perceive Safety lower.
- Men perceive Attractiveness of the environment and Atmosphere higher.
- Younger people have a more positive perception towards Safety, Comfort, Attractiveness and Atmosphere.
- Foreign/unfamiliar people perceive crowdedness higher and have another overall perception.
- People who live in a region with a low urbanisation level will perceive crowdedness higher, and comfort and safety lower.

Five hypotheses are formulated regarding the influence of socio-demographics on perception & experience of crowdedness. These relations are all causal, as the theoretical framework shows (Figure 3.2). The hypotheses are mainly derived from the results from Hoskam (2017) and Grolle (2017). For age, Hoskam only found a relation to perceived Safety.

B. **Personal & Trip factors → Perception & Experience of Crowdedness**

- Familiarity leads to a lower perceived level of crowdedness and more unpleasant experience of crowdedness.
- People with a specific purpose will perceive the crowdedness as higher and experience crowdedness more negatively.
- People who are part of a larger group will perceive crowdedness lower and experience crowdedness more positively.

- Positive emotions lead to a more a lower perceived level of crowdedness and a more positive experience of crowdedness.
- Drug and alcohol usage have varying effects on perception. Alcohol makes people perceive level of crowdedness lower and level of safety higher.

The personal state and trip factors each influence the perception of crowdedness in different ways. They are derived mainly from the work of van Gelder (2018), Hoskam (2017), Grolle (2017) and Lee et al. (2001). Drugs and alcohol can have various effects on perception. In the work of Grolle (2017), people who had consumed alcohol perceived safety higher.

C. **Event & Environment → Perception & Experience of Crowdedness**

- At locations with music and activities, perceived atmosphere will be rated higher.
- Loud music and loud noises will lead to higher perceived crowdedness.
- At locations with flashing lights, Crowdedness will be rated higher.
- Atmosphere and attractiveness are rated higher when the weather is warm and sunny.
- At night, Safety is perceived lower and Atmosphere is perceived higher.

Five hypotheses concerning Event & Environment factors are formulated. Since previous research into perception of crowdedness did not focus on events, the effects of lights, sounds and event locations is not yet clear. Therefore, these hypotheses are largely based on the expectations of the researcher and on the literature found (Andrade et al., 2011; Bruner, 1990; Reicher, 2018; van Hagen, 2011). Many of the factors in this category can be used to predict perception & experience of crowdedness, but most of them are not the reason for the change in perception. In this case, the relation is explained indirectly, through actual crowdedness (Figure 3.3). For example, the hypothesis: *"At night, Atmosphere is perceived higher"* is expected to be true, because later at night events are usually more crowded. Still, the effect of nighttime is also expected to have a pure effect, based on people's beliefs about nighttime. For example, nighttime can be found more exiting.

D. **Actual crowdedness → Perception & Experience of Crowdedness**

- Higher density (pax/m^2) causes a higher perceived Crowdedness.
- Higher flow ($pax/m/s$) causes higher perceived Crowdedness.
- The type of flow (uni-, bi-directional, crossing and random) will affect the perceived Crowdedness. When the flow is more structured and even (unidirectional flow or 50/50 bi-directional flow), the perceived Crowdedness will be lower.
- A tipping point can be found for perceived Crowdedness at the tipping point in density between free flow and congestion.

The four hypotheses concerning quantified crowdedness are all based on macroscopic flow variables. They are inspired by the information given in Section 2.1 and Section 2.4. It is expected that both local and global density and flow will affect the perceived crowdedness at one location, because pedestrians are walking around. Therefore, their perception of crowdedness might be based on other locations that they have visited recently as well. It is expected that the relation between perceived crowdedness and flow is not linear, because the relation between flow and density is not linear either. It is expected that the perceived crowdedness for free flow conditions is different than the perceived crowdedness in the unstable phase of flow.

E. **Perceived crowdedness → Experience of Crowdedness**

- In places where crowdedness is perceived very high, people will experience the crowdedness as less pleasant and level of Safety and Comfort will be perceived lower (non linear).
- People who perceive a higher level of crowdedness, perceive atmosphere higher as well.
- It is expected that all perceptions, Safety, Comfort, Attractiveness of the environment and Atmosphere are positively correlated.

The three hypotheses that concern the relations between perceptions and experience of crowdedness are mostly assumed to be positive relations that can be found as a linear correlation. However, the relation between Crowdedness and Safety and Comfort is expected to be more complicated. This depends on whether crowdedness is seen as a positive or a negative aspect. Therefore, the hypotheses state 'very crowded'. Furthermore, it is expected that the perception and experience of crowdedness influences the other perceptions. In other words, a causal order is hypothesised, were the perception of crowdedness determines the other perceptions.

All the hypotheses in this list will be tested. How factors such as familiarity and purpose will be measured will be discussed in Chapter 4. The exact variables that will be used to determine crowdedness will be explained in Chapter 5. The hypotheses will be tested and reviewed in Chapter 7.

II

Research method

4 Data collection method

In this chapter, the research method is discussed. This chapter will answer the following sub-question:

Which data collection methods can be used to study the relationship between perception and personal, event and trip characteristics?

Determining the best data collection method coheres with the choice of research events and locations and with the specific factors that are gathered, as is illustrated in Figure 4.1.

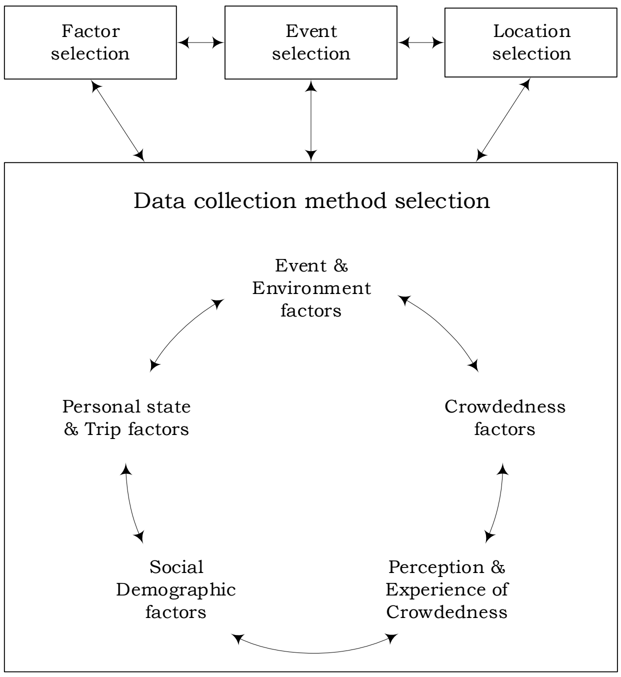

Figure 4.1: The relation between factor, event and location selection and data collection method selection

The choice of factors that are included in the research and the choice of events that are researched are not mutually exclusive. An event is chosen because it can offer insight in all factors and some factors will be included or further specified because of the event chosen. What is meant with the arrow from event selection to data collection method selection is the preexisting presence of sensors at certain events. By choosing an event, the choice for those sensors is inherently made. Those sensors are installed at certain locations. The overarching data collection method must be able to combine all categories for which data must be collected.

For every category, a different data collection method can be applied, as long as it can be connected to the other data. The data collection method should be equal amongst researched events, otherwise it not possible to compare the data. Lastly, the research locations and times have to be determined.

In the first section (4.1), the selection of the events is explained. Furthermore, it is stated which event specific factors need to be kept in mind and what the implications are for the research method. Second, in Section 4.2, data collection methods are discussed for each type of data. A distinction is made between measuring crowdedness, collecting personal & perception data and collecting Event & Environment data. This section will explain why the use of Wi-Fi sensors and counting cameras in combination with a survey was made. Third, Section 4.3 will delve deeper into the set-up of a survey. A selection of factors will be made for this research based on the relevance of these factors that was discussed in Chapter 3 and the feasibility to measure these factors with the chosen data collection methods. Fourth, an overview of the factors selected and the data collection method is given in Section 4.4. Fifth, Section 4.5 will elaborate on the specific research set-up for both events. Finally, the chapter will be concluded with some general descriptives on the data that was collected and a short evaluation of the research performed at both events (Section 4.6).

4.1. Event selection

In this section, the selection of the events will be explained. Two case studies are conducted, one at the TT Festival 2018 in Assen and one in the Red Light District of Amsterdam. It is chosen to research two events, in order to see if perception of crowdedness influenced in the same magnitude by the same factors. Also, two events are researched to find event unique influences to the perception of crowdedness. Why these two events were chosen will be clarified in this section.

4.1.1. TT Festival

The first event that will be researched is the TT Festival in Assen. This event was founded in 1973, as entertainment in the TT night before the races the next day (van Gool, 2018). In the years before the festival, this TT night turned into a riot, where the police had to deal with fighting and trashing youths. After a few bad years, a solution was found: entertainment in the form a fair, a skelter race and a striptease show. The concept worked; the fighting became less. Nowadays, the TT festival is a four day festival that is visited by motorcycle fans, inhabitants of Assen and other people from the region who are looking for a party. Over these four days, there are an estimate of 160.000 visitors. There are eight stages throughout the city centre of Assen, there is a fair, there are activities for children during the day, a nightride and a motorcycle parade (TT Festival Assen, 2018).

Figure 4.2: Crowd at a stage during the TT Festival

This event provides an interesting research area, because of the history of the event. Here, by attracting a larger crowd to various activities, problems with police enforcement diminished. Now, it is a huge event, where extensive crowd management is required. The event has many different areas with a unique atmosphere that can be compared. The event attracts locals as well as foreigners and people of all ages. Furthermore, the effects of light and sound on pedestrians' perception can be researched here, since there are many stages with music and stage lights.

4.1.2. Red Light District

The second case study will be performed at the Red light district in Amsterdam. Although this is not an event as defined in this report, it is a location that attracts large crowds where people have a 'Anything goes' attitude (Livework studio, 2018). The area has been a news topic in the Dutch media this past summer. The municipalities' ombudsman, Arre Zuurmond, called the Red Light District an 'Urban jungle', where it is very crowded and not enough action is taken by the police (van Lieshout, 2018). Therefore, this area is a highly relevant research area. Its special character can lead to new insights compared to the first case study.

The Red Light District or "de Wallen" is an area in the city centre of Amsterdam, which is known for its red-light windows with sex workers, coffeeshops and raucous bars (Nevez, 2018). Ever since the 1300s, the area near the port flooded with sailors who sought entertainment in the various inns and pubs that the area had to offer. Prostitution was not yet legal, so women carried red lanterns to make their profession clear. In the 19th century, prostitution was legalised and only in the the year 2000, brothels were legalised. Since 2007, the municipality has taken action to clean up the area, reducing the number of red-light windows, and eliminating all forms of illegal prostitution, such as human trafficking. Furthermore, they encourage creative enterprises and cafes to set up in the area.

Figure 4.3: Crowdedness in the Red Light District. Foto Marcel Wogram, 2018

Nowadays, the Red Light District is a very crowded area, where many tourists and party-people come to look around. The amount of people and their behaviour is causing various problems in the district. The municipality is taking various measures to improve the situation. There are 'Dweilpauzes' or Sweeping breaks, were the streets are closed down for visitors to clean up trash (van Lieshout, 2018). The district is also sometimes closed down for emergency services. There are hosts designated to guide the crowds during the most crowded evenings. The hosts are a recent invention to try to improve the behaviour of the crowd. They do not hand out tickets, but just give people advice on directions, where to walk, where to throw away trash and where to go to the toilet (Livework studio, 2018).

Livework studio (2018) carried out a qualitative research to see how the crowdedness is experienced by residents, entrepreneurs, police officers and passersby. One resident pointed out that the small alleyways are dangerously crowded. It can get so crowded, that it is not possible to move anymore. This leads to a feeling of unsafety. From all the interviews, five main elements were found to influence the perceived crowdedness: the large number of people, antisocial behaviour, the dirtiness of the surroundings, being impeded in travelling and a (physically) unsafe feeling.

The Red light district provides an interesting research area, because it is dangerously crowded and is treated as an event, even though it is actually just a part of the inner city. The area attracts many tourists, but there are also residents of Amsterdam there. Comparing the difference in perception between tourists and residents will enhance the understanding of the effect of personal factors on perception of crowdedness. Also, the activities offered are different from the TT Festival, which is expected to lead to new insights.

4.1.3. Conclusion

The chosen events have some similarities and differences, which makes the comparison interesting. Both events deal with a large amount of (possibly drunk) people, are located in a city centre and both events are public. Differences are that the TT Festival is a yearly recurring event, while the Red light district can be visited any day of the year. Although the Red light district is not an actual event, it is treated as such, because the same challenges in crowd management are faced here as at an actual event. Besides this, another difference is the crowd that is attracted. Whereas the TT Festival attracts mainly local residents who visit the event yearly, the Red light district mainly attracts tourists who are not that familiar with the area. The last difference is that the TT Festival is an outside event, where there are stages with music where people are gathered and reside. At the Red light district, people mainly walk around while looking around. Other than that, the activities are mainly inside and include visiting bars, coffee shops, brothels, museums and shows. To conclude, at both events, it is expected that people's perception on crowdedness is influenced by different personal, trip and event factors, making them suitable events to research and compare.

4.2. Data collection method selection

In this section, possible data collection methods to measure actual crowdedness, personal, trip and event characteristics are discussed. In this research, monitoring and survey data will be combined, to find the relation between perception of crowdedness and personal, trip and events characteristics. The event characteristics can be split up in crowd dynamics and the event environment. To combine crowd dynamics data with personal data, it is necessary to capture both these data sources at the same time and place. Only then can an accurate comparison between perception of crowdedness and measured/observed crowdedness be made.

4.2.1. Crowd dynamics

In this section, the best method to collect data on crowdedness is discussed. In Section 2.7, five indicators of crowdedness were introduced, namely Density, Speed, Flow, Flow type and Collision/Impedance. These are good indicators for crowdedness, therefore, a measurement method is required that can be used to determine these variables. Here, possible data collection methods and the feasibility of using these methods are discussed. In Table 4.1, the methods that can be used to research crowd movements are shown. Collection methods can be divided into a microscopic and macroscopic perspective and between global and local objectives (Daamen et al., 2016).

Table 4.1: Crowd dynamics data collection techniques (Daamen et al., 2016)

		Measurement objective	
		Local	Global
Measurement perspective	**Microscopic**	Video Time-lapse Infrared Laser	Questionnaires GPS Bluetooth, Wi-Fi Mobile phone data
	Macroscopic	Manual counts Video Time-lapse Infrared Laser	Aerial observations GPS Bluetooth, Wi-Fi Mobile phone data

From the literature study in Section 6.1.2, it is clear that Density, flow and collision/impedance is highly relevant in relation to perception of crowdedness. Density can vary every instant and can be determined for different areas. Density such as used in a fundamental diagram is a macroscopic variable, but it is also possible to quantify local densities. For the macroscopic view, Aerial observation, GPS, Bluetooth, Wi-Fi and Mobile phone data can be used.

Although Speed is normally related to Flow and Density, at an event it is possible that the formula that connects these values does not apply. For example, because the desired speed and actual speed of a pedestrian is zero, near a stage. On the other hand, the actual speed can also be near zero, while a person actually wants to walk somewhere, but is impeded by other pedestrians. Therefore, it is a variable that is useful to determine. Speed can be determined on a microscopic or macroscopic level. For this research, speed can either be determined for a certain area or passageway where perception of pedestrians is also determined or the speed of a specific person is determined, of whom perception is also registered. Therefore, a GPS tracker attached to a pedestrian can be used. It is also possible to determine speed from Wi-Fi sensors or counting cameras, as has been done by Yuan et al. (2016).

Flow partially captures density and speed characteristics. The movement of the crowd is best expressed with this value. It can be determined using video, infrared, Bluetooth and counting cameras. Speed distribution and flow patterns can be observed by using video footage of cameras or by human observation.

To quantify variables such as number of (near) collisions, control delay and percentage of time platooning, would require a microscopic perspective. Camera footage can be analysed to find such variables, either manually or with computer software. Stalking and observation are another way to determine such variables, as has been done by Bloomberg and Burden (2006). Survey questions can also be directed to this, which was done by Hoskam (2017).

For this research, it is chosen to collect data about crowdedness using a combination of Wi-Fi sensors and counting cameras, because all macroscopic variables (Density, speed, flow) can be determined using the combination of these sensors. Local density can be derived using a Wi-Fi sensor. Flow is determined with counting cameras. Flow type can be determined as the proportion of in- and outgoing flows. How these sensors operate exactly and how the macroscopic flow variables are derived will be explained in Chapter 5. The only variables that cannot be determined are collisions and impedance, but this could be included in a survey. Moreover, these types of sensors were already planned to be applied to the TT Festival and are installed permanently in the Red light district. These types of sensors are common at large events, because they provide oversight of the amount of people and the movement of the pedestrians over a whole event area. A real-time dashboard is developed to use this data for crowd management (Daamen et al., 2018). Therefore, it is also interesting to see how crowdedness measured with these sensors relates to the pedestrians' perception of crowdedness. This research will be able to show to what extent this data relates to the experience of pedestrians, which can be used to analyse this data in future cases.

4.2.2. Event & environment data

In this section, the reason to gather certain Event & Environment factors is explained. This data will be referenced to as metadata henceforth. Normally, metadata is all the background data for which the main data gathered has to be controlled. In this case, all the environmental factors are dubbed 'metadata', because they are mainly control factors and they are measured with different methods than the survey or monitoring.

Light & Sound data

As was explained in Chapter 3, light and sound can change a persons mood and perception, therefore, it is important to include these factors in the research. Light and sound data can easily be measured with a smartphone application, named Physics Toolbox. It was chosen to measure intensity, opposed to tone/colour/ spectrum, because it is the most easily and accurately measured. Since no separate sensor is used, light and sound data have to be measured with intervals, for example every half hour. It is expected that light and sound conditions will not change that drastically within 30 minutes. Therefore, these measurements can then be used with an interval of half an hour. For every survey entry, the closest measurement is used. From each measurement, an average, minimum and maximum is derived.

Music type

Furthermore, music type is determined using the event timetable, for two reasons. First, the music type can influence a person's mood. Second, it could be related to the number of people that are attracted to a certain location. Music type is categorised in three categories: No music, Background music and Main act. A more specific distinction between genres is not made, because this would require too much time, it would require a value judgement and it would create too many categories.

Weather
For weather, no clear link to perception was found yet, but it is expected to have an influence. Furthermore, it is an important control factor, since the actual crowdedness can depend on the weather. The weather conditions can be derived from the historical database of Accuweather. The data required contains temperature, weather type and daytime (true/false) data per hour.

Location
In Figure 4.4, five types of typical event locations are distinguished. It is expected that depending on the location type, perception will be different. This has to do with a combination of factors, such as area size, type and number of attractions, purpose, music/sound and lighting. To find the influence of these characteristics, data should be gathered at different location types. Therefore, at each event, three different locations will be chosen to conduct the research. For all data, the location where this data is gathered is included as metadata. At the location, photographs will be made to get an impression of the location characteristics.

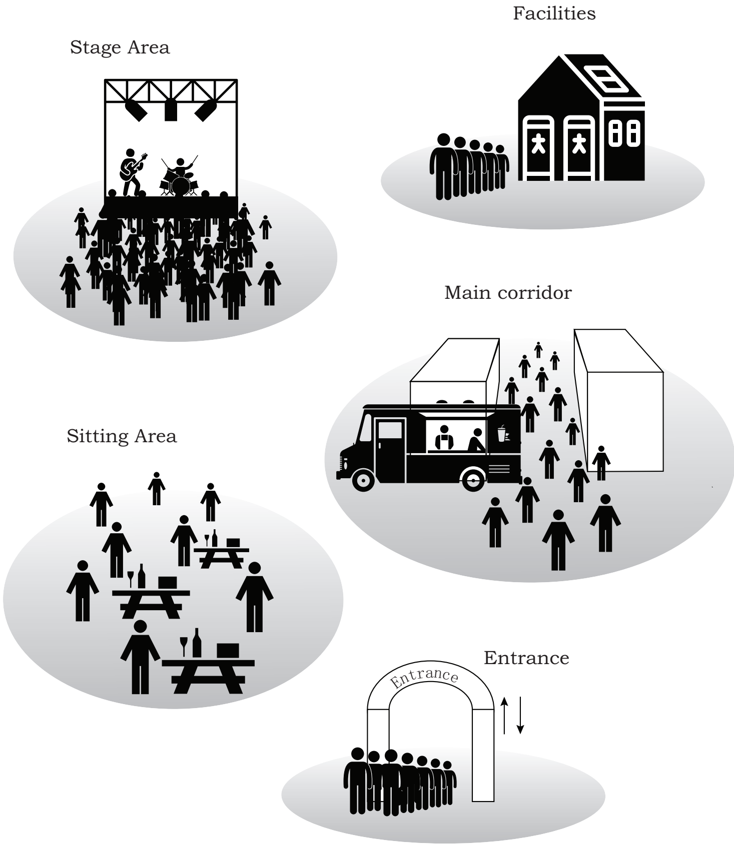

Figure 4.4: Five main festival location types

The Wi-Fi sensors and counting cameras as described in 4.2 are placed at strategic places at an event. For example, at entrance and exit routes, counting cameras are placed to determine in- and outflow. At main corridors, Wi-Fi sensors and counting cameras are placed to determine flow and density. At crowded standstill areas, Wi-Fi sensors are placed, to determine the density.

The location of the sensors is determined beforehand for this research, because it makes use of sensors that are placed for other studies. Therefore, for this research, the only thing that needs to be determined is at which of these locations surveys will be conducted to combine the data. The objective is to collect data at different location types (corridor, exit/entrance, main stage) in order to compare these location types in terms of perceived crowdedness. Per location, the aim is to collect Wi-Fi data and counting camera data, since they correspond to different variables (density and flow) that can be used to describe crowdedness. To combine the survey data with the cameras and Wi-Fi sensors, the surveys will be conducted at the same location. However, it should not be in view of the camera, since this could disrupt the results. In Section 4.5, the chosen locations per event are explained.

4.2.3. Perception, trip and personal data collection

As mentioned before, pedestrians' perception of crowdedness cannot be determined by observation, since this is an internal process. It might be possible to analyse facial expressions, but this type of research is not feasible within the scope of this project. Likewise, an experiment setting would require many resources and would give limited results. It would be possible to acquire information about perceived crowdedness with an experiment combined with a survey. This would have the benefit that all environmental factors can be controlled and specifically tested. However, it would require a very extensive experiment to simulate an event setting. This is not feasible for a thesis project.

Another option to discover pedestrians' perception would be to perform a stated preference survey. However, since perception is expressed in this thesis as *"the interpretation of external stimuli"*, it would be necessary to provide some external stimuli, for example video footage. However, this would only stimulate the visual and audio senses. Furthermore, seeing a crowd on a flat screen has a different effect than standing in the middle of the same crowd. In a previous thesis project, Galama (2016) found very different results concerning the influence of crowdedness between a revealed and stated preference research of the same event. Another way to perform a stated preference survey would be to send surveys to event visitors after they have visited an event. However, it is not realistic to expect that people can exactly recall their perception of crowdedness at specific locations and times.

Therefore, the best method to study perception of crowdedness is by conducting surveys during the event at specific locations. The added value of conducting a survey at a certain place and time, is that the people who are being questioned know how they feel at that moment. Also, factors like lighting and sound, might have an effect on a person subconsciously, meaning these factors will not influence them in a survey setting, but do influence them in reality. Therefore, the influence of these factors on perception can only be determined at an actual event. Furthermore, specific event locations can be researched and compared.

The downsides of conducting a survey during an event is limited amount of time available. This means only a limited number of responses can be collected, which leads to a lower number of respondents than can be collected in a survey after an event. Also, at an event, human labour is needed to approach people for a survey and record their answers. This could lead to bias in the answers, when people are not approached randomly and answer differently because of how a question is proposed. Furthermore, the visitors of the event might not like to spend their time on surveys. This may lead to lower participation than a survey that can be filled in at home, or it may lead to questions answered inattentively. Lastly, at an event there are an infinite amount of factors that influence a person's perception, not all of which can be included in the research. This unexplained variance can lead to lower correlations between explanatory factors and perception. In an experiment, all possible influencing factors are controlled for, decreasing the unexplained variance. Solutions to minimise the downsides of using a survey are presented in the survey design plan. In the survey specification, it is explained how the effects of these downsides are minimised.

4.3. Data collection: Survey specification

In Section 4.2, the reason for using a survey on location was explained. In this section, the number of respondents needed, the factors that will be included and the question form will be determined.

4.3.1. Determining number of variables and respondents

There are several methods to determine a desired number of respondents a to survey. First, a sample size can be determined to have a trustworthy reflection of a population. The formula Equation (4.1) and 4.2 can be used.

$$n = \frac{z^2 \cdot \hat{p}(1-\hat{p})}{\epsilon^2} \tag{4.1}$$

$$n' = \frac{n}{1 + \frac{z^2 \cdot \hat{p}(1-\hat{p})}{\epsilon^2 N}} \tag{4.2}$$

Where:

n = population size
n' = sample size
z = standard error
$\hat{p}$ = estimated standard of deviation
ϵ = margin of error

(Surveymonkey, 2018)

However, for this research, determining the population size is not as straightforward, because the 'population' is space and time dependent. Therefore, sample size will not be determined this way. The aim will be to acquire a large dataset (N>120) (Molin, 2018a).

Since the survey will be conducted at multiple locations per event, more data is required to obtain a representative view per location. It is probably not feasible to acquire large data sets (N>120) (Molin, 2018a) for multiple locations separately, because there is limited time to conduct the surveys at the events. Therefore, a maximum of three locations should be researched per event. The aim will be to collect at least 75 surveys per location.

Moreover, the number of respondents is important in relation to the number of variables that are tested. Common practice is to have 10 to 20 times the number of participants as there are variables (Inc, 2018). For example, if 20 questions are posed, 200 - 400 respondents are needed. This will be kept in mind while determining how many factors are included.

4.3.2. Factor & perception selection

The inclusion of factors is based on the relation with the perception of crowdedness or other crowd-related perceptions. The relation with the perception variables determines the *relevance* of a factor. When a significant relationship is found in multiple researches, it is necessary to take this factor into account, because not doing so would result in an incomplete explanation. When previous research provide contradicting results, it could be important to take that factor into account, because it is not completely understood yet. However, it could also mean that the factor is too complex to measure and the result will be largely dependent on the research method used. When there is little or no clear research performed yet, this could either be a knowledge gap, or a non-relevant factor. Knowledge about previous research can be found in Chapter 2.

The *feasibility* is determined by looking at previous research methods used and available research methods. One or more research approaches are suggested per factor. An overview is given in Table 4.2.

In the category Socio-demographics, Age, Gender and Residence were found to be relevant in relation to perceived Safety (Hoskam, 2017) and are easily included in a survey. Residence was also relevant in the research of Hoskam (2017) for perceived Crowdedness and Atmosphere. The relevance of Person height/size and Health are not clear for perception. The feasibility of including these factors is low, because they are quite personal. For determining Health, multiple questions are needed. Education level and Culture will not be included, because there are no clear signs that these influence perception of Crowdedness. Furthermore, it might be easy to determine cultural background based on country of origin/residence, but to understand someone's cultural *beliefs*, many questions are needed about a person's history.

Table 4.2: Overview relevance and feasibility of factors. *only included in the TT research. **only included in the RLD research

Category	Include	Factor	Relevance	Feasibility	Method
Socio-Demo	Yes	Age	High	High	survey
	Yes	Gender	High	High	survey
	Yes	Height/Person size	Unknown	Middle	survey
	Yes	Residence	Middle	High	survey
	No	Health	Middle	Low	survey
	No	Education level	Middle	Middle	survey
	No	Culture	Middle	Middle	survey
Personal	Yes	Emotional state	High	Middle	survey
	Yes	Stimulant usage	High	Middle	survey
	Yes	Familiarity	High	High	survey
	No	Decision style	Middle	Low	survey
	Yes	Trip purpose	High	High	survey
	Yes	Group type	High	High	survey
	Yes	Time spent*	Unknown	High	survey
Environment	No	Information	Low	Middle	Information
	No	Crowd composition	Unknown	Low	Observation
	Yes	Location	High	High	Observation
	Yes	Light*	High	Middle	Phone application
	Yes	Sound	High	Middle	Phone application
	Yes	Time of day/week	Middle	High	Metadata
	Yes	Weather	Middle	High	Accuweather
Crowdedness	Yes	Density	High	High	Wi-Fi sensor
	No	Speed	Middle	Middle	Wi-Fi and camera
	Yes	Flow	High	High	Counting camera
	Yes	Flow type	Unknown	Middle	Counting camera
	No	Collision/Impedance	High	Low	Observation
Perception	Yes	Crowdedness	High	Middle	survey
	Yes	Comfort	High	Middle	survey
	Yes	Safety	High	Middle	survey
	Yes	Atmosphere	High	Middle	survey
	Yes	Attractiveness	High	Middle	survey
	Yes	Crowdedness experience**	High	Middle	survey

In the category Personal state & Trip factors, Emotional state (Hoon Kim et al., 2010), Stimulant usage (Grolle, 2017), Familiarity (Hoskam (2017); Grolle (2017); Ton (2014)), Trip purpose (Hoskam (2017); Grolle (2017); Ton (2014); van Gelder (2018)) and Group type (Daamen et al. (2017); Hoskam (2017) Grolle (2017)) are marked as highly relevant. These are typical factors that are important at an event and are found to be significant in various researches.

Measuring a person's Decision style using a survey is difficult, since a person might not be aware of their own decision style. Furthermore, a mixture of decision styles can be applied by one individual. Emotional state and Stimulant usage might be difficult to record with a low number of questions and might not be answered willingly, so the feasibility is classified as *Middle*.

Finally, questions regarding perception are required for this research. Crowdedness (Hoskam (2017); Grolle (2017); van Gelder (2018)), Comfort (Landis et al. (2001); Madanat et al. (1994)), Safety (Landis et al. (2001); Hoskam (2017); Grolle (2017)), Atmosphere (Hoskam (2017); Grolle (2017)) and Attractiveness of the environment (Ariffin and Zahari (2013); Humpel et al. (2004); van Gelder (2018)) are all found to be important in relation to each other. The feasibility of these perceptions is classified as *Middle*, because they are difficult to express in numbers.

4.3.3. Determining question form

The survey design is based on example survey questions typically seen in research. The survey is designed to be filled in quickly, in order to keep the participants' patience and to be able to perform many surveys in a limited time frame. For example, typing is minimised (only for municipality) and questions that are not applicable are automatically skipped, such as group type when a person is alone. The questionnaire starts out with simple Socio-Demographic questions, which are easiest for people to fill in. Then, Personal state & Trip factors are addressed. Here, sensitive subjects (emotional state and substance usage) can be skipped. It has to be taken into account, that people might lie about their age. It is found that people are more honest when categories can be chosen (Bytheway, 2011). The following categories, also used by the Office of National Statistics in the UK (Bytheway, 2011) will be applied: 16-24, 25-44, 45-54, 55-64, 65-74, 75 and over.

The question about emotional state will use the emotions named in the Affect circle from Triandis (1977) as answers (2.3). The answers can be re-categorised into two binary variables by classifying the answers for every participant to arousal: active/not active and valence: pleased/displeased.

Familiarity has to be quantified in some way. A survey question could be targeted to find out whether the visitor has been at the location before, at the event before or at specific locations, stages and routes of the festival before. This will be specified per event.

As to Purpose, the question is formulated as follows: *"Where are you going at the moment?"*. The answers provide concrete examples, for example, *"walking around randomly"*, *"going to .... stage"*, *"going home"*, *"going to work"*, etc. For the analysis these will be re-categorised to: no purpose, a recreational purpose and an actual purpose.

Group type will be addressed using three questions. First, Group size will be determined, then Group type (family/friends/couple/colleagues/combined) and finally Group composition (only men/only women/combined).

The survey ends with five questions concerning perception. The questions are formulated in a similar way as in the survey of Hoskam (2017). They follow the format: *"How would you rate the level of* ***Crowdedness*** *at this location?"*. It is chosen to let respondents rate this on a 5-point likert scale. This is a common method psychological research. The full questionnaires can be found in Appendix G and J.

4.4. Factor & perception selection

In Table 4.2, an overview of all the factors is given. Feasibility and Relevance are rated *'Low, Middle or High'* based on the literary study from Chapter 3, the measurement methods and the researcher's own insights.

In conclusion, three types of data will be gathered simultaneously. Measured crowdedness will be gathered by Wi-Fi sensors and counting cameras continuously at fixed locations. At these locations, surveys will be conducted gathering socio-demographics, personal state & trip factors and perception of crowdedness and other crowd-related perceptions. The survey data will have a timestamp and a location attached, so it can be connected to the measured crowdedness. Event & environment factors will be gathered in two ways: Light and sound intensity will be measured every 30 min at the survey locations. Weather data is gathered from Accuweather per hour. Figure 4.5 shows a summary of all the data that is gathered which will be combined to be analysed simultaneously.

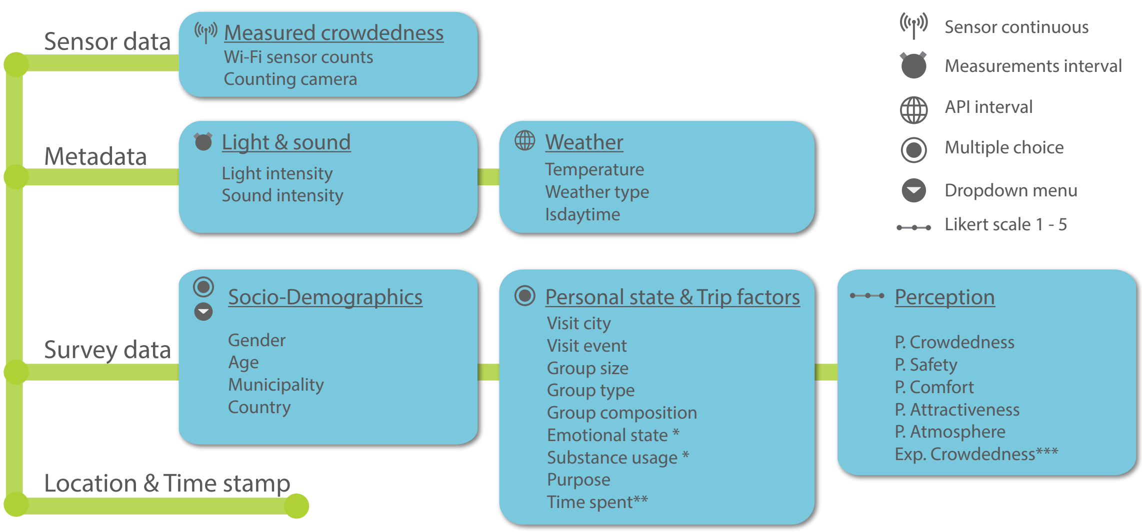

Figure 4.5: Summary data collection and data types: * not mandatory, ** only included in the TT case, *** only included in the RLD case.

4.5. Location and time selection

In this Section, the data collection is further specified for both events. In order to make the event comparable, the same sensors, survey and data processing methods are applied. Furthermore, at both events, surveys were conducted on three evenings on three locations.

4.5.1. Research plan TT Festival

This event took place from Wednesday till Sunday morning, June 27 - July 1. The research was conducted on the three busiest nights, which are Thursday, Friday and Saturday. On Thursday, there were five stages with a line-up. On Friday and Saturday, there were ten (TT Festival Assen, 2018). The pedestrian flows were expected to be different on these days, since other stage locations are used.
For this event, three locations were chosen to conduct the survey. These locations were chosen, because they are different location types and both a Wi-Fi sensor and a counting camera were present. The first one is the *'Kermis'* or fair. This is a location where many people walk by, to go from or to the city centre from the TT fair. The second location is *'Koopmansplein'*, which is near the main stage of the festival. The third location is *'Stationsstraat'*, which is an entrance path from the station to the event.

Figure 4.6: TT Festival: Sensor locations. Left Counting cameras, right Wi-Fi sensors

In Figure 4.6, the locations of all the sensors are shown. The sensors are spread over the terrain and cover almost all entrances and exits, often a counting camera and a Wi-Fi sensor are placed together. Location W3 *'Kermis'*, W4 *Koopmansplein* and W5 *'Stationsstraat'* were planned to be researched. However, location W5 *'Stationsstraat'*, seemed too quiet to be researched. Therefore, this location was changed to location W15 *'Markt'*. This is a location where a stage is present, although people are mainly there for the bars and the atmosphere. Unfortunately, this location was not equipped with a counting camera. A timetable for conducting the surveys is constructed in such a way that the three locations are covered at different times every night. The surveys were conducted by two persons at the same location at the same time. The full plan of Action for the TT Festival can be found in Appendix F. The survey topics as specified in Figure 4.5 are addressed. The full survey can be found in Appendix G.

4.5.2. Research plan Red light district

For the Red light district, research was done to find an appropriate date and time for the research, since the Red light district can be visited every day of the year. The aim is to gather a data-set that is comparable to the TT Festival.

In Figure 4.7, the number of people over time is shown. As can be seen, Friday and Saturday evening are by far the most crowded, with a peak value of over 6000 people. Sunday is also more crowded than the other weekdays in the afternoon. Therefore, it is chosen to conduct the research on Friday and Saturday evening, since the TT Festival research was also conducted in the evening. The chosen dates are Friday the 19th, Friday the 26th and Saturday the 27th of October.

As with the TT case, the research was executed on three evenings on three locations. The locations that were chosen are all equipped with a Wi-Fi sensor and counting camera. Furthermore, location GAWW-02 *'Oude Kennissteeg'* is a small alleyway in the middle of the area, location GAWW-06 *'Oudezijds achterburgwal'*

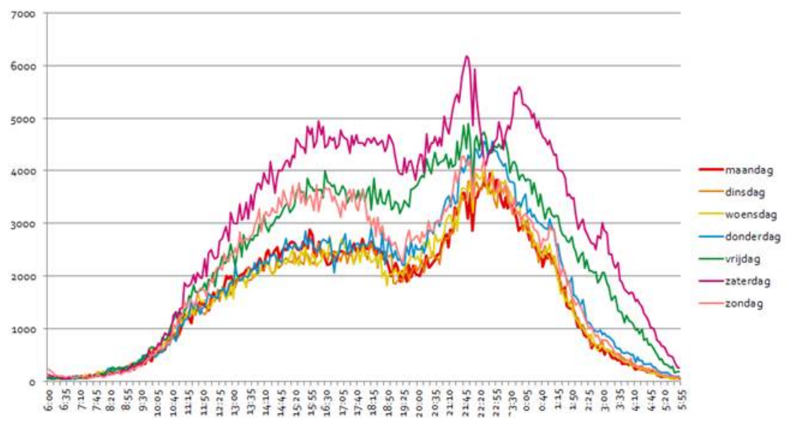

Figure 4.7: Average crowdedness over time at the Red Light District.(Municipality Amsterdam, 2018)

is a slightly broader street along a canal and location GAWW-07 *'Stormsteeg'* is an alleyway that can be seen as an exit/entrance to the red light district. Again, the research was conducted on three evenings, alternating the time of day between locations per every research day.

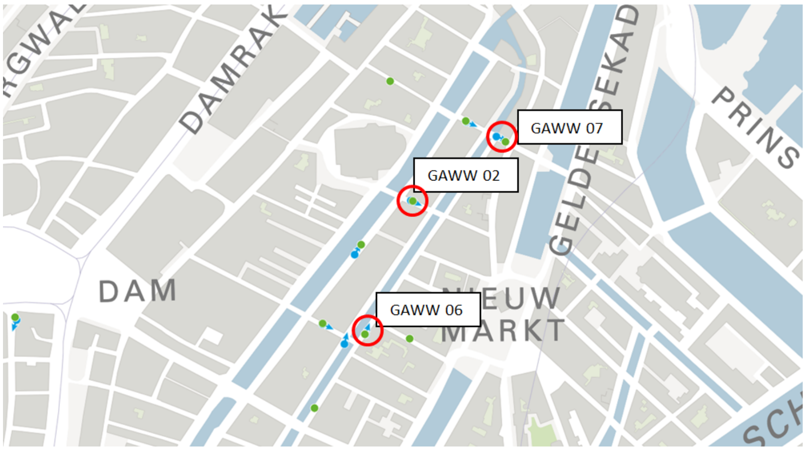

Figure 4.8: Red light district: Sensor locations. Blue arrows are counting cameras + orientation, green dots are Wi-Fi sensors

Since the research at the TT Festival already took place, survey questions could have been changed for the Red light district. However, it was chosen to keep the same questions, to be able to compare the two cases. Even so, one extra question was added to the end of the survey, addressing how the crowdedness is experienced, on a scale from one to five. One being very unpleasant and five being very pleasant. The question about time spent is left out, because this is more difficult to determine for the red light district. Pedestrians may have been walking through the city centre all day, passing through the Red light district multiple times. All questions, except substance usage have been changed from multiple answer to select one answer questions to make the data-set simpler.

4.6. Execution and Evaluation

In this section, the execution of the case studies is described. This background information will give insight in the data that is collected and will help to interpret the results that will be presented in Chapter 7.

4.6.1. TT Festival

Overall, the execution of this case study went according to plan. As a result of the pilot, some questions were adjusted. Furthermore, one survey location was changed. The Stationsstraat did not seem suitable as a survey location, because there were not that many pedestrians along this route as expected. Instead, the Markt (W15), was chosen as the third survey location. This location has a unique atmosphere. Many people gathered there for a drink, making it a crowded, but otherwise relaxed area. Unfortunately, this location was not equipped with a counting camera. Therefore, it will not be possible to determine the flow for this location. In Figure 4.9, some bar charts represent the data that was gathered.

Overall, the survey was conducted smoothly. Many people were willing to participate in the research. The general atmosphere was relaxed and pleasant. It became clear that many visitors are from Assen or the province of Drenthe and were regular visitors that participated in the event every day and every year. Many people visited the event with family members.

Figure 4.10 shows that the level of crowdedness is perceived omnifarious, ranging from not crowded at all to very crowded. The other perceptions are quite positive.

In Figure 4.9, it is shown that there are many frequent visitors and that there are people of all age groups present. Many people do not have a specific purpose, but are just wandering about. More than a quarter of the respondents were on his way to a specific stage.

From conducting the surveys, apart from the actual questions, some things were learned about the visitors of the event. First, people seemed to compare the current crowdedness with the crowdedness at an earlier time, the previous day or previous years. This lead to a variety of answers for perceived crowdedness compared to the actual crowdedness. It becomes clear that expectations, or beliefs, are very important in a person's perception. Therefore, this might have to be included in future research after all. Second, the question about comfort was generally filled in 4/5. It seemed as if the question was formulated too vague, since people often asked what was meant by this question. When answering the question about safety, participants often pointed out that they had seen a police officer or guard and therefore they felt safe. This indicates that people mainly think about social safety when asked this question.

The sensors have had some problems during the event. There are holes as well as peaks in the data. The peaks are often caused by police equipment. Missing measurements are caused by malfunctioning sensors and changing light conditions. Peaks and missing data are interpolated as described in Section 5.

The light and sound data had a few problems. First, the measurement device is not accurate enough to measure light in nighttime. Second, the measurements have not been executed accurately every half hour, some data points are therefore missing. Third, as can be seen from two measurements taken only two minutes after each other, the values can be very different every minute. On June 29th at the Kermis, light and sound data was collected at 21:05 and 21:07 facing other directions. The average values measured are respectively 99.09 dB vs. 95.59 dB and 65353 lux vs. 2030 lux. In future research, if light and sound data are chosen to be taken into account, accurate sensors on fixed locations performing continuous measurements are required.

The weather circumstances during the TT Festival were ideal. The weather was hot and sunny during the whole event. At the locations where the research was performed, no major incidents occurred. However, on Facebook a call-out was made to start a fight at one of the other locations (Doevenkamp). This was noticeable in the atmosphere there, which was uneasy. In the end, nothing happened, but the police and security were very much on the alert for troublemakers.

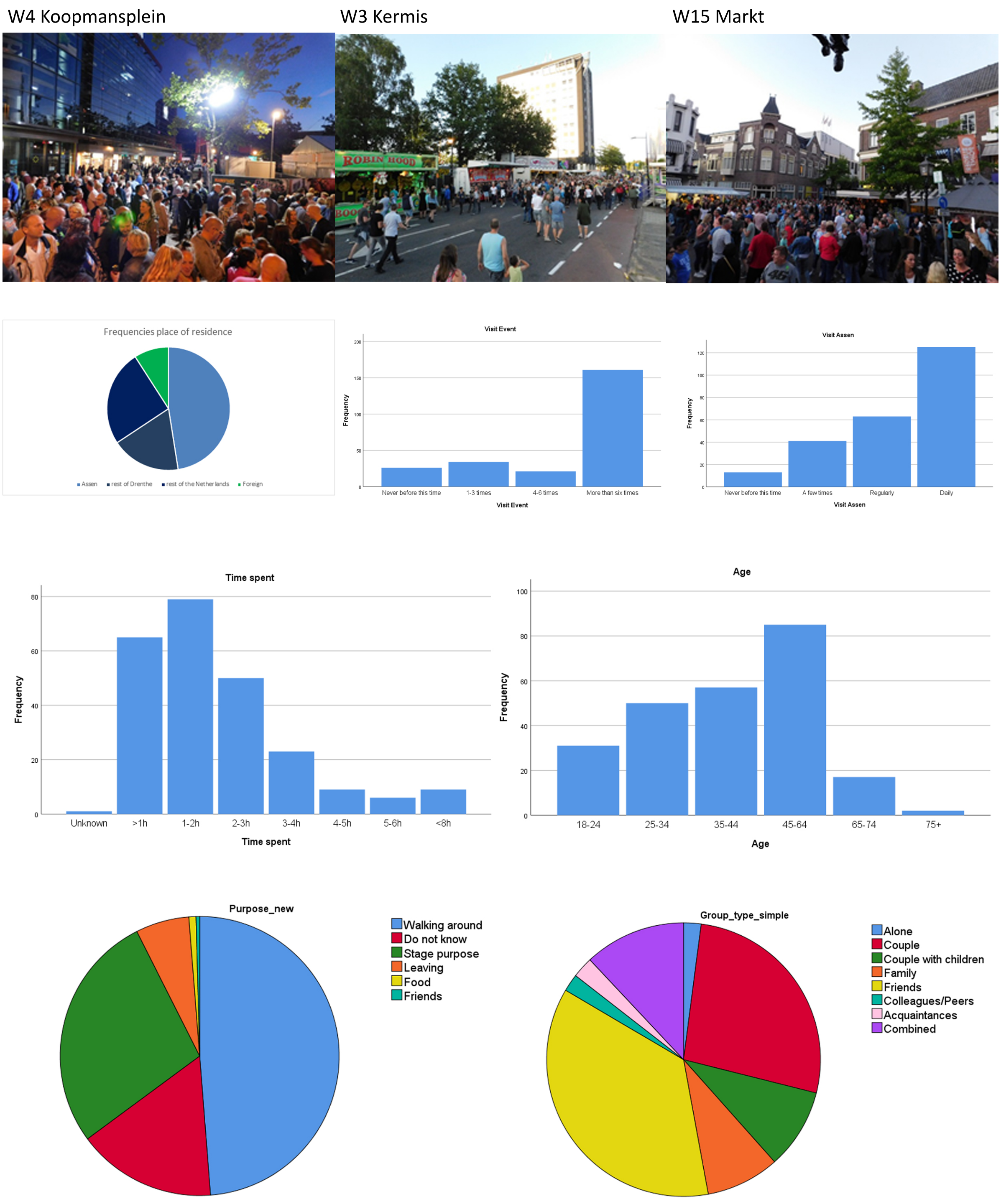

Figure 4.9: TT Festival: Info-graphic survey data

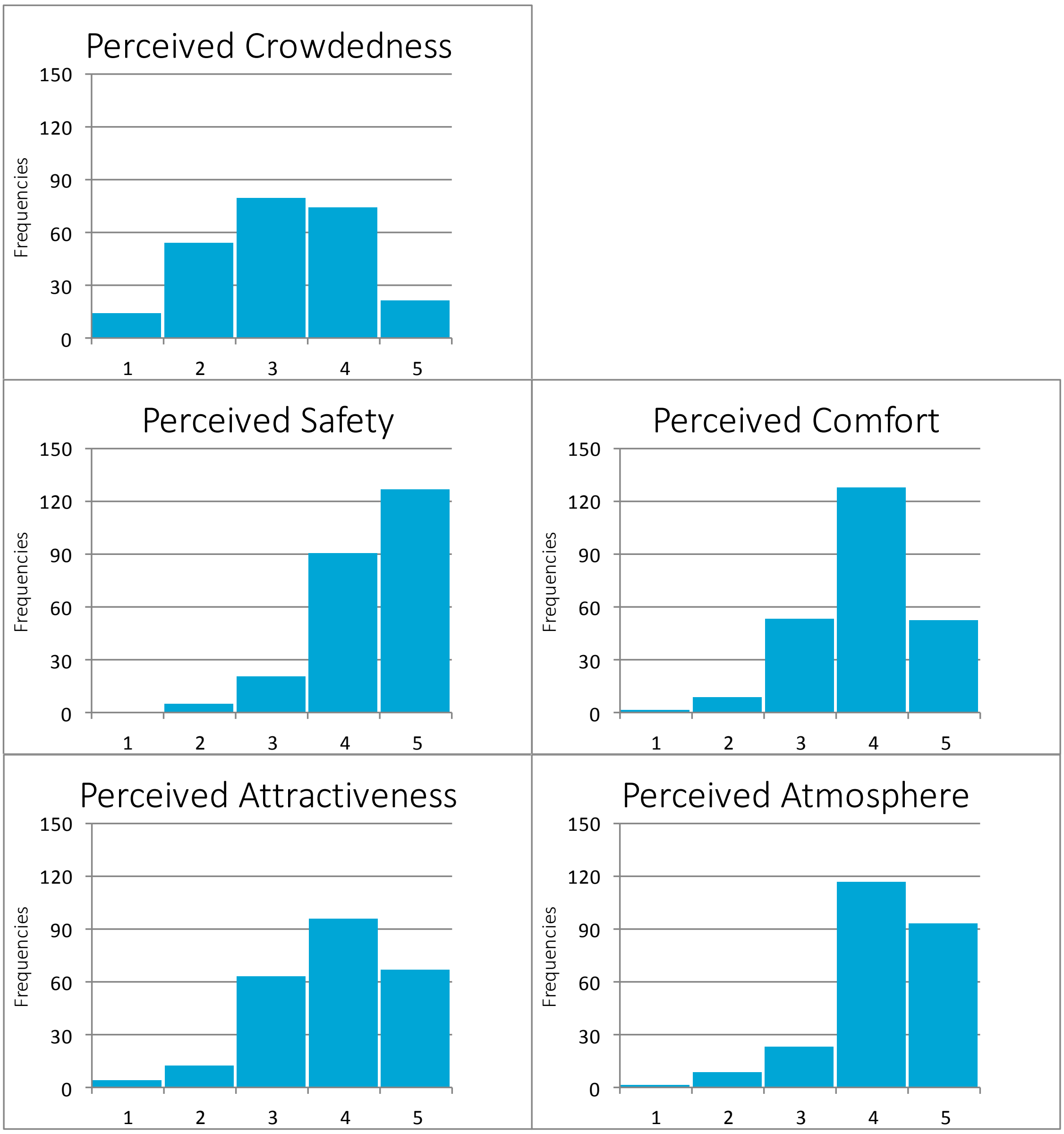

Figure 4.10: TT Festival: histograms perception

4.6.2. Red light district

Overall, the research at the Red light district was conducted successfully. The first day of the research, the weather was normal. That evening, the Amsterdam dance event was also happening in the city of Amsterdam. This was also mentioned by a few of the participants. Overall, this evening was less crowded for a Friday evening than normal (Gemeente Amsterdam, 2018a). The second day of the research it was raining, which resulted in a low number of surveys conducted that day (N=36). Furthermore, it was even less crowded than the first survey day. The last survey day was a Saturday. The weather was normal and it was very crowded.

Since it was overall still very crowded, it was difficult to find a place to stand and conduct the survey calmly. Taxis and Taxi bicycles were driving by on occasion leaving almost no space to stand. There were less people willing to participate in the research. It was also more difficult to approach people. When approached, many people completely ignored the surveyors and walked by. Still, there were enough people willing to participate pleasantly.

Contact was made with the hosts present, to notify them about the research. While conducting surveys at location GAWW-02 *'Oude Kennissteeg'*, some of the actions that they perform could be observed. For example, they asked people to walk on one side of the alley and people who were standing still were asked to do so further away from the small alley. This was quite necessary, since the alley way a bottleneck where the effective flow was 0 at some point.

Most of the pedestrians were tourists, as is also shown in Figure 4.11. This figure shows that there were people from all over the world. The frequencies are merely an indication, due to the small sample size (N= 182) and the bias in the data-set through willingness to participate. The tourists were often quite positive in their perception of Safety, Comfort, Attractiveness and Atmosphere. The experience of crowdedness was more often rated a bit lower. Residents of Amsterdam were often more negative in their perception. Only 11 respondents lived in Amsterdam.

As can be seen in Figure 4.12, the perceived crowdedness is rated higher than the TT Festival. The histograms for Safety, Comfort, Attractiveness and Atmosphere have a quite similar shape and show that overall, people had a positive perception. The question regarding the pleasantness of the number of people shows that opinions differ more.

Figure 4.11 shows that most people do not have a specific goal. Most respondents are young people (25-34). 53.8% of the respondents was male. The most common Group type was Friends, followed by Couples. Most groups were small (2-3 persons). There are quite some people by themselves. Most groups are mixed (54.8%), followed by groups of males (20%) and groups of females (15%).

The affect question was sometimes difficult for people to answer. The most frequent answer is Happy, followed by relaxed and neutral. It is expected that the word happy was chosen often, because it is a word most people know. Since the survey could only be taken in English or Dutch, this could influence the results. Some people wanted to express their surprise, confusion, or feeling weird, but these answer possibilities were not included. In those cases, people often chose for an answer such as relaxed, which is quite different.

Figure 4.11: Red light district: Info-graphic survey data

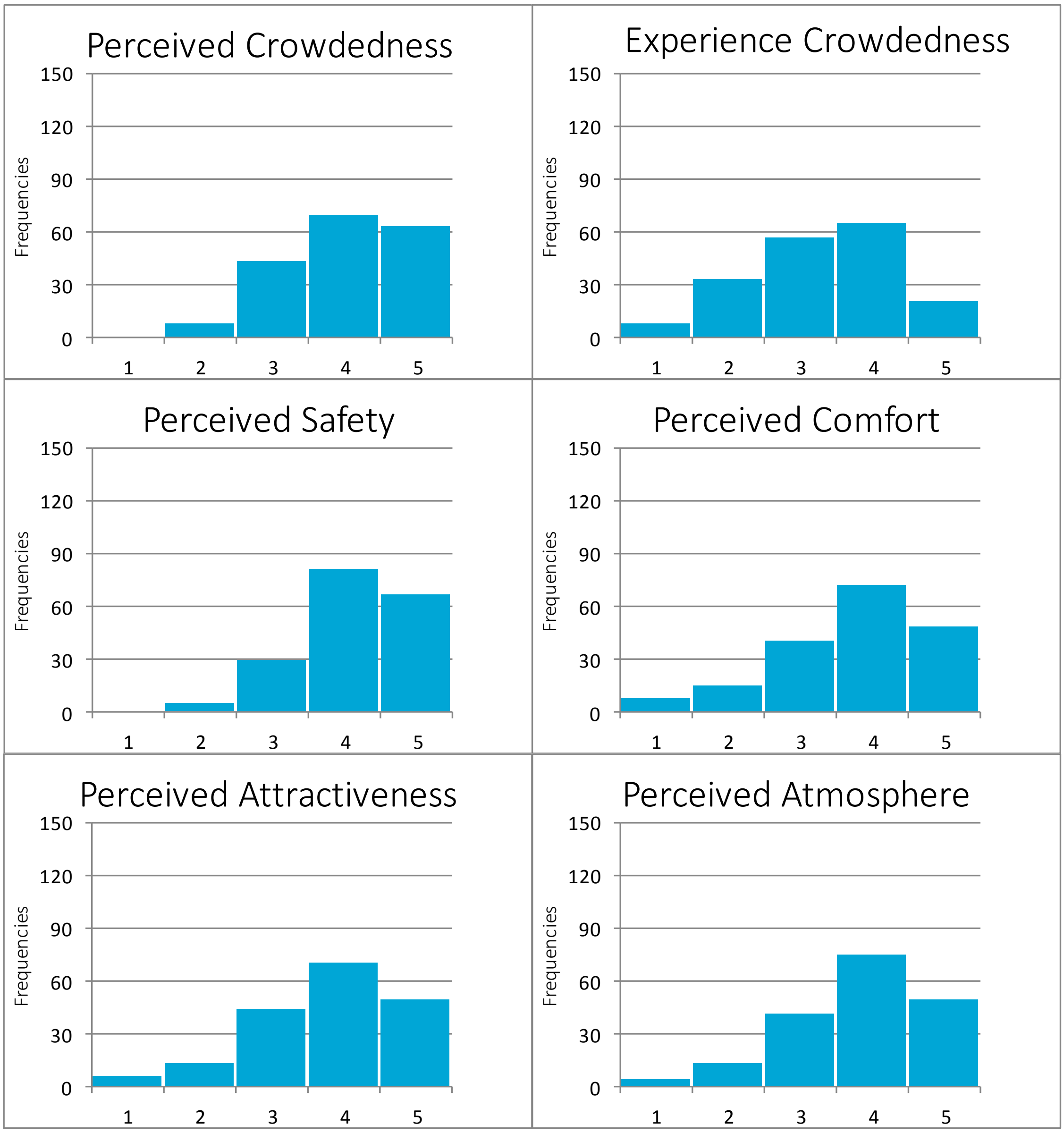

Figure 4.12: Red light district: histograms perception

5
Data processing method/Quantifying crowdedness

In Chapter 4, it was determined that Wi-Fi sensors and counting cameras would be used to collect data. How this data can be used to calculate macroscopic flow variables is explained in this chapter. In Section 5.1, the operation of a Wi-Fi sensor is explained. This knowledge is required to determine how the data has to be processed. In Section 5.2, it will be explained how and why certain processing steps were made. Section 5.3 explains which variables are chosen to represent crowdedness. The chapter ends with a short conclusion (Section 5.4).

5.1. Wi-Fi sensor operation specification

Wi-Fi sensors are a useful data collection tool that recognises MAC addresses of (mobile) devices that are active and nearby. The data collected from the Wi-Fi sensors contain hashed MAC-addresses, sensor IDs and the first and last detection time stamps. The Wi-Fi sensors have a range of approximately 25m (Duives et al., 2017), but the range is dependent on the number of signals picked up. The more signals there are, the smaller the range becomes. The MAC addresses are hashed, so the privacy of the people is not violated. The exact operation of a Wi-Fi sensor depends on the event, the location placement and the company who places the measuring devices (Daamen et al., 2018). This means that it is difficult to estimate exactly what percentage of the devices are measured. Furthermore, other Wi-Fi enabled devices, not corresponding to one person, could also be detected. For example a police officer can carry more than one device that transmits a MAC-address, resulting in a high number of measurements, while these do not provide insight on the number of people. Moreover, some newer types of smartphones use dynamic MAC addresses that change every time they are asked for identification (Duives et al., 2017), resulting in a higher number of unique devices measured. Therefore, the data received from Wi-Fi sensors needs to be calibrated. At the SAIL event, around one third of the counts of a camera were detected with the Wi-Fi sensors (Yuan et al., 2016), 50% of these were unique. The counting cameras at this event had an accuracy of maximally 98%. However, when the intensity of people increases, the accuracy decreases, to 92% in high density conditions.

5.2. Crowdedness quantification method

The monitoring data that is collected needs to be processed in such a way, that it will give us accurate intensities and flows at the survey locations. The following steps, based on previous work of (Daamen et al., 2016; Duives et al., 2015; Yuan et al., 2016; Duives et al., 2017) need to be taken in order to come to the desired data. This method is a mixture of earlier research, but has been slightly simplified and adjusted to fit in with this research objective.

1. Determine a time window to count the number of unique MAC addresses.
2. Filter raw data by means of a blacklist
3. Remove dynamic MAC addresses

4. Interpolate to estimate missing data or to remove high peaks
5. Determine accuracy of cameras by means of ground truth footage
6. Determine a conversion rate for the Wi-Fi data by using the data from the counting cameras.
7. Apply a Moving Average to smooth data and capture a certain time window.
8. Calculate desired variables to describe crowdedness and flow.
9. Connect the monitoring data to the survey data

5.2.1. Determine a time window for measurements

The raw Wi-Fi data is a list of MAC addresses and timestamps. It is not possible to compute densities per timestamp, because the number of devices that are detected per timestamp fluctuate too much. For example, one active device could be registered for only three timestamps in a minute, while the device was in that area the whole time. Therefore, a time window needs to be chosen to determine the unique number of MAC addresses for that amount of time. According to Duives et al. (2017), this parameter needs to be determined for specific use cases. In free flow conditions, a pedestrian can pass through the region a Wi-Fi sensor (approximately 50m) in 37.3 seconds Duives et al. (2017). So theoretically, after this length of time, the density could be completely different. However, it is not expected that the density will change so drastically, because at many places, the walking speed will be fairly slow and pedestrians will often stop. Therefore, a time window is chosen that sufficiently captures the change in density and also reflects the density experienced by pedestrians.

For both researched events, there is Wi-Fi data available, which has already been transformed into counts per time window. However, one data-set (Red Light District Amsterdam) is per minute, while the other one (TT Festival Assen) contains the number of unique devices that has passed the sensor in three and fifteen minutes per minute. Those data-sets cannot easily be translated into one another, because the unique devices that are measured can differ. To illustrate this, an example can be given. In Figure 5.1, we see an area where a Wi-Fi sensor registers the number of devices. For different time instances, there is another number of people. For the TT method, the time windows are overlapping. The number of unique devices (visualised by human icons with unique colour) measured in the first three minutes is $n(t_(1:3)) = 5$. With the RLD method, the number of unique devices are determined per minute. Because it resets after a minute, adding the first three measurements gives another total than the TT method, $n(t_(1:3)) = 7$.

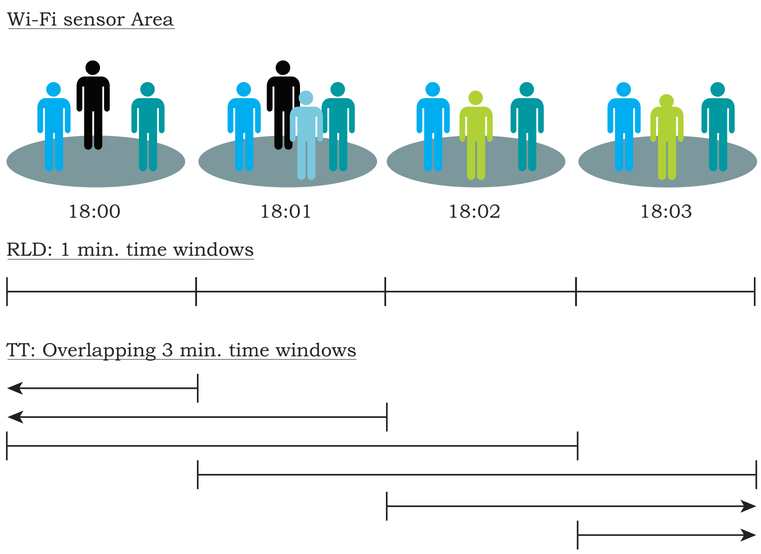

Figure 5.1: Wi-Fi sensor counting methods. Top: RLD method; 1-minute time window every minute. Bottom: TT method; 3-minute time window every minute

Furthermore, it was already stated in Section 4.2 that not all active devices might be detected, especially when it is more crowded. Other than that, there are also devices that are not registered at all, because they move through the Wi-Fi sensor area quickly. Therefore, it can be difficult to compare the results of these methods. The counting camera data for both events contains in- and outflow per minute. This data will be used with a moving average for three and fifteen minute time windows. This way, it is expected to correlate better with the three and fifteen minute Wi-Fi data.

Section 5.2.7 explains how the data of the TT Festival and the Red light district is edited to come to three and fifteen minute time windows.

5.2.2. Filter raw data by means of a blacklist

Both data-sets received have already been filtered by means of a blacklist. A blacklist is a set of MAC addresses that are known to cause noise and do not correspond to a person. For example stationary devices. These can by recognised, because they often occur in the measurements and always at the same sensor. For the Red light district data, this list is reset every night between 02:00 AM and 04:00 AM, and builds up throughout the day (D. de Wit, personal communication, 6 December 2018). The blacklist of the TT Festival is created during the whole event. When high peaks in the data occur, this can often be caused by a group of police forces. This can be validated by using camera footage. Figure 5.2 shows the difference between filtered (yellow and purple) and unfiltered (blue and red) data. The difference is enormous and is also divided unequally over time (more difference between filtered and unfiltered when it is crowded). This graph shows that this step is essential in the data processing.

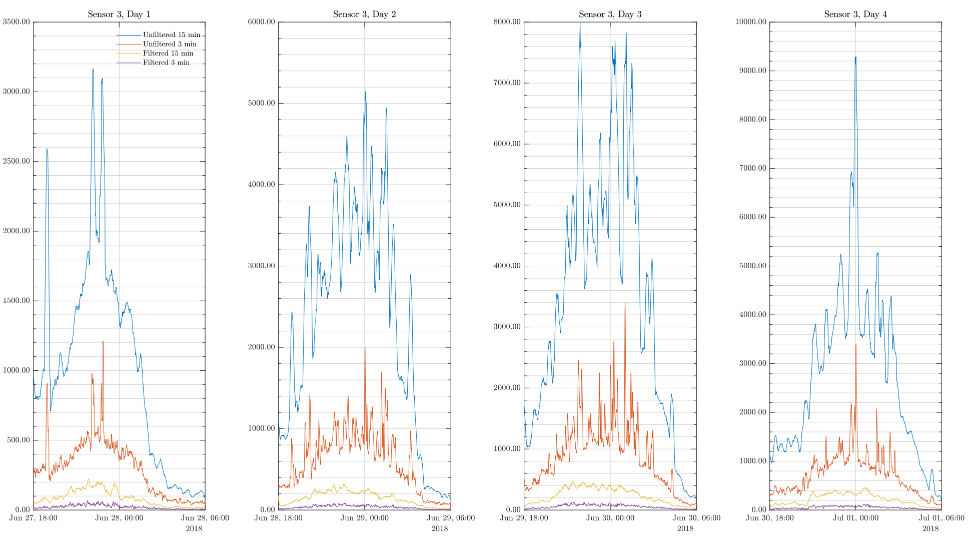

Figure 5.2: TT Festival, sensor 3 Kermis: Wi-Fi data filtered and unfiltered, 3 and 15 minutes

A problem in the TT case is that there are still high peaks that seem improbable. This can be caused by a dynamic MAC addresses. In step 4, the method that is used to remove these peaks is discussed.

5.2.3. Remove dynamic MAC addresses

Removing dynamic MAC addresses is possible using the MAC addresses and the bssid (hashed MAC address of the wireless access point). Distinct patterns can be found in this data using an algorithm, to spot the use of a dynamic MC address (Duives et al. (2017).

For the TT Festival, the data-set was used that still contained dynamic MAC addresses. The reason for this is that the procedure of removing them is quite complex and would take too much time to be included in this research. Because it is known that there is a higher number of measured unique devices, the conversion rate (see Section 5.2.6) will be different than when they would have been removed. However, it is expected that these types of devices are spread all over the event, so their influence on the data will not be too influencing. For the RLD data, it is unknown whether the dynamic MAC addresses are removed.

5.2.4. Interpolate missing data and sudden peaks

After the first few steps, there could still be missing data from malfunctioning sensors, or sudden high peaks that seem improbable. Therefore, in this step, interpolation for missing data is explained. Peaks are detected by an increase in counts higher than 50 in three minutes for the TT festival. Missing data is detected when there are more than three consecutive values of zero. When there is missing data for a certain time period, a line is drawn between the last and first data points that were collected that seem to fit the rest of the data. These alterations are only performed for times that correspond with survey times.

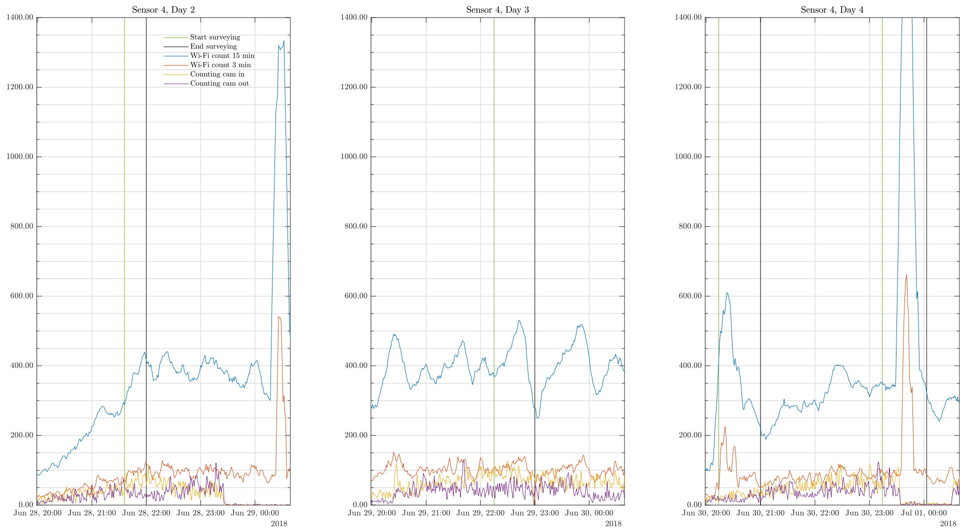

Figure 5.3: TT Festival, Sensor 4 Koopmansplein: Wi-Fi and counting camera data before interpolation

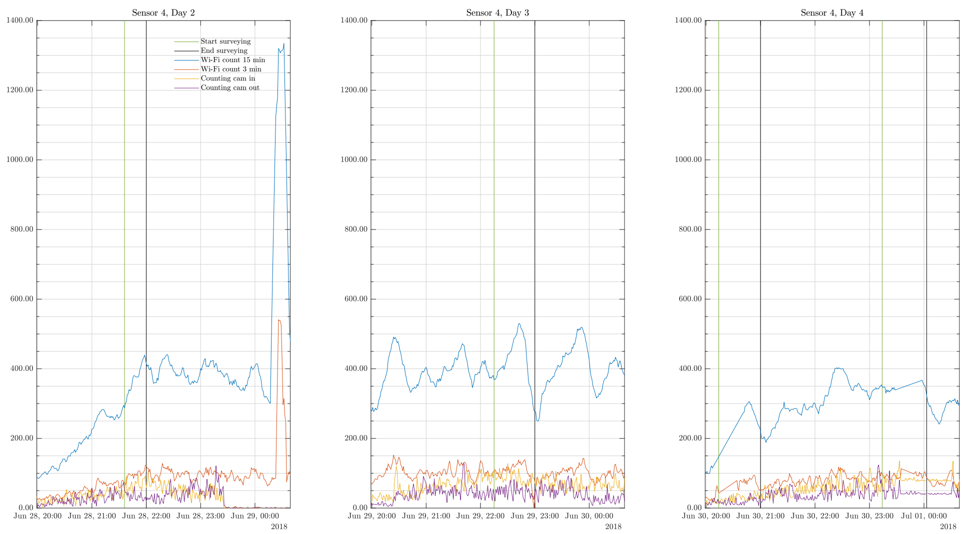

Figure 5.4: TT Festival, Sensor 4 Koopmansplein: Wi-Fi and counting camera data after interpolation

For the location Koopmansplein in the TT Festival, the data before and after this step is shown. As can be seen in Figure 5.3 and Figure 5.4, peaks have been removed in the Wi-Fi data on day 2 and day 4 and the missing counting camera data on day 4 is added. For the Red light district data, these adjustments were not necessary.

5.2.5. Determine accuracy counting camera

For the counting cameras, both data-sets contain in- and outflow per minute. The average accuracy of a counting camera of ViSense is 95% (Daamen et al., 2018). A counting camera can theoretically be 98% accurate, but goes down to 92% as the event becomes more crowded (Yuan et al., 2016). Accuracy is influenced by the type of camera, the settings, the weather, lighting and the location of the device. It is possible that there are false positives (example: a tree is recognised as a pedestrian) and false negatives (a pedestrian is not recognised).

To account for the accuracy of a counting camera, camera footage (of a video camera!) can be used as a ground truth. To validate the accuracy precisely, multiple location, times, and levels of crowdedness have to be checked. Then, a conversion factor has to be determined. For simplicity's sake, one constant conversion factor can be used. Otherwise, a conversion factor dependent of the level of crowdedness can be applied.

Since there is only limited time for this project, this step in the process has been skipped. It is expected that the variation between 98% and 92% accuracy does not influence the end results that drastically.

5.2.6. Determine and apply conversion rate

Wi-Fi sensors only measure a part of the crowd, but can be used to estimate density. Yuan et al. (2016) describes a method to estimate density between sensor location from Wi-Fi sensor and counting camera data. However, this method cannot be used, because it requires pairing devices (MAC addresses) between two sensors, which is not possible with the data available. Therefore, another method has to be found that can be used. For this purpose, a comparison with the counting camera data is made. In Figure 5.5 and 5.6, we see comparisons of this sort for the Red Light district, created by Gemeente Amsterdam (2018b). For both data types, the same time window is applied. The left axis shows the values of the counting cameras and the right axis those of the Wi-Fi sensor.

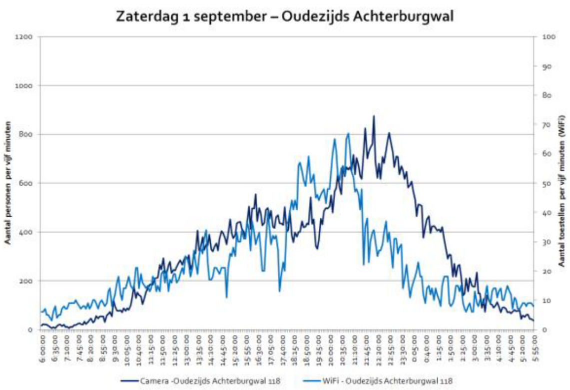

Figure 5.5: Red light district, sensor GAWW 06: Comparison Wi-Fi and counting camera data

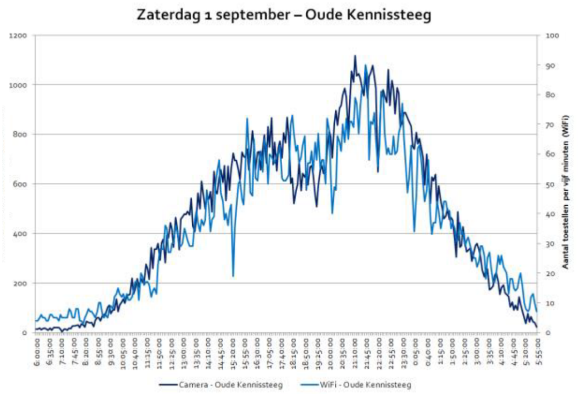

Figure 5.6: Red light district, sensor GAWW 02: Comparison Wi-Fi and counting camera data

Figure 5.6 shows a similar pattern for the Wi-Fi and counting camera data, but Figure 5.5 does not. It is expected that the pattern should be the similar, if the sensors are placed in a demarcated corridor where pedestrians walk by within the chosen time window. However, in reality this is not the case. First, a Wi-Fi sensor measures an area and a counting camera counts the pedestrians that walk by a certain point. In other words, they cover a different area. This difference becomes more important when a more open area is measured. For example, a Wi-Fi sensor that is installed on one side of a canal might detect devices on the other side of the canal as well. A counting camera covers a certain area more clearly. Next to this, the time window that is best to measure these counts might be different. In the graphs presented, it is not clear how and why a 5 minute time window was applied. Third, it is expected that both sensors handle standstill people differently.

To make the most trustworthy comparison, a comparison has to be made for a sensor that is in a walk-by (not standstill) area and the time window of the counting camera needs to be adjusted to the time window of the Wi-Fi sensor. For the TT Festival, sensor 1 is chosen for this purpose. It is not one of the locations where surveys are conducted, but it has both sensors and it is an exit/entrance route, not a place with activities. In Figure 5.7, the Wi-Fi camera data is shown for the same time window.

A conversion rate will be determined based on day 2 (20:00-23:00), day 3 (20:00-21:30) and day 4 (20:00-

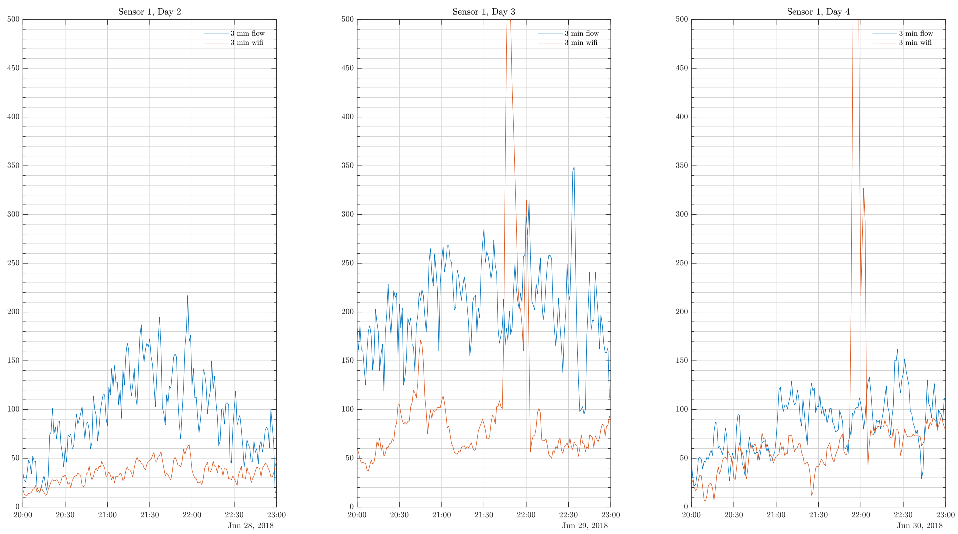

Figure 5.7: TT Festival Sensor 1: Comparison Wi-Fi and counting camera data

21:30), when the data seems normal. The conversion rate will be determined using the method of least squared errors, using the following formula:

$$minimize \quad MSE = \frac{1}{n}\sum_{t=1}^{n}\left(c \cdot w_t - cc_t\right)^2 \tag{5.1}$$

Where:

MSE = mean squared error
n = number of data points
c = conversion factor
w_t = wifi counts
cc_t = counting camera counts

As can be seen in Formula 5.1, it is chosen to apply one simple conversion factor, because it explains well and is easy to handle. However, this also means that some of the variance will be missed. The formula is solved by finding the minimum value for MSE by adjusting c. The conversion factor $c = 2.23$ for three minute Wi-Fi data and $c = 3.1$ for 15 minute Wi-Fi data is found.

For the Red light district, the calculation is made using one minute Wi-Fi data and one minute camera data of sensor 2 and 7. The conversion factors $c = 0.76$ and $c = 1.12$ are found. These conversion factors are unexpected, because in earlier research, camera counts were much higher than Wi-Fi counts for the same time window. It is assumed that a filtering step applying a conversion rate has already been taken for this data. Therefore, the RLD data is not adjusted with a conversion rate.

5.2.7. Apply a Moving Average to smooth data and capture a time window

It is assumed that pedestrians base their perception of crowdedness on crowdedness of the past x minutes. The time window on which the perception is based is uncertain and can vary between people. Moreover, change in perception is expected to be less volatile than one minute counts. Therefore, a moving average is applied. On top of that, an average value is less sensitive to errors in the data. A moving average calculates an average value for the Wi-Fi or counting camera counts, for a certain time window. The formula is presented below:

$$\hat{w}_t = \frac{1}{n}\sum_{t=1}^{n-1} w_{t+i} \tag{5.2}$$

Where:

$\hat{w}_t$ = simple moving average of w_t for time period n
n = number of data points
w_t = Wi-Fi count at time t

For both events, a moving average of three and fifteen minutes is applied for the counting camera data. For the Wi-Fi counts, a moving average of three, fifteen, thirty and sixty minutes will be applied. The reason for this difference is that it is assumed that Camera data, which can be used to calculate flow, is influencing pedestrians in a shorter term, while Wi-Fi data, which can be used to calculate density, is influencing pedestrians for a longer time.

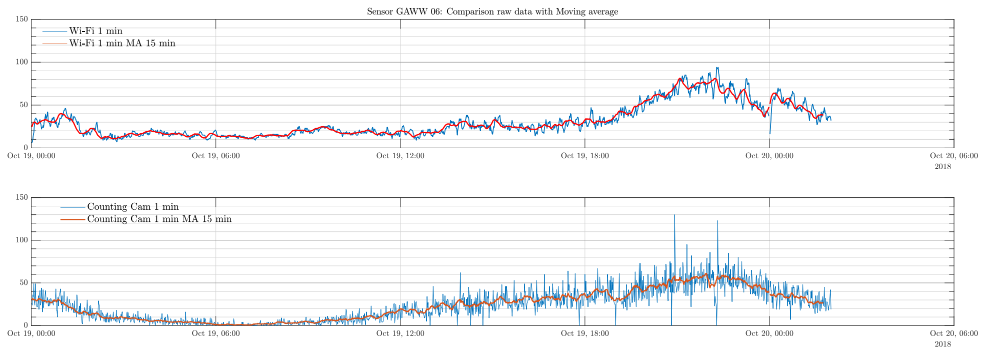

Figure 5.8: Red light district, sensor GAWW 06: Wi-Fi and counting camera data compared to Wi-Fi and counting camera data with a 15-minute moving average

In Figure 5.8, the difference between moving average data and the original data is shown. The data is smoothed, but still moves along the same trend. The longer a time window is chosen, the smoother the line will become. It is excepted that three and fifteen minute data will still capture enough of the fluctuations that occur in the density and flow and that extreme differences per minute are cancelled out.

5.3. Selection of variables to describe crowdedness

From the literature review (Chapter 2), it is learned that Flow and Density are highly relevant indicators of crowdedness and are related to perceived crowdedness. Therefore, Density and Flow will be estimated using the simple formulas stated in Equation (5.3) and (5.4). To determine area, Google earth was used. A radius of 25 meters was retained, while only counting the area where people could stand and where the reach of the sensor was not blocked by obstacles. The width of the passageways is determined from photos made during the research and Google earth. These are not very accurate measurements. For one, it is not known if the reach of the Wi-Fi sensor was exactly 25 meters in every direction. Other than that, determining the exact area where people can stand is an arbitrary process. Shy distance (distance kept from obstacles and buildings (Fruin, 1971)) and smaller temporary obstacles are not taken into account.

$$\hat{k}_t = \frac{\hat{w}_t}{A} \tag{5.3}$$

$$\hat{q}_{tot} = \frac{\hat{c}c_t}{w} \tag{5.4}$$

$$\hat{q}_{prop} = \frac{\hat{q}_{in} - \hat{q}_{out}}{\hat{q}_{tot}} \tag{5.5}$$

$$\hat{w}_{frac} = \frac{\hat{w}_t}{max(\hat{w})} \tag{5.6}$$

Where:

$\hat{k}$ = Density
$\hat{w}_t$ = Wi-Fi counts with a moving average
A = Area in m^2
$\hat{q}_{tot}$ = Flow
$\hat{cc}_t$ = Camera counts with a moving average
w = Width passageway
$\hat{q}_{prop}$ = Proportion of flow
q_{prop} = -1 if only outflow
q_{prop} = 1 is only inflow
$\hat{w}_{frac}$ = Proportion of $\hat{w}_t$ compared to the maximum $\hat{w}$

Because of these inaccuracies, it is chosen to use the Wi-Fi counts and the camera counts as crowdedness indicators as well. The Wi-Fi counts correspond to density and are expected to yield similar results. The Wi-Fi counts can be seen as density, because a Wi-Fi sensor counts the number of people in the area of the Wi-Fi sensor. The camera counts correspond to flow, the only difference being that the width of the passageway is not accounted for. Furthermore, another variable that presents a form of density is calculated in equation 5.6. The averaged Wi-Fi counts are divided by the maximum measured number of devices measured at one time instance during the event at the same sensor. It is assumed that this number comes close to the capacity of that area in terms of its function. For example, a passageway will never be as crowded as the area in front of a stage. Finally, flow type will be calculated by using the proportions of in- and outflow for the counting cameras (see Equation (5.5)).

5.4. Conclusion

This chapter provides insight into the processing steps that have been applied to the monitoring data. The data for the TT Festival and the Red light district are different in many ways. For one, the time window for the raw Wi-Fi counts of the TT Festival was in three and fifteen minutes. For the Red light district this was a one minute time window. Second, the blacklist of both events is set up differently. Third, a conversion rate is applied to the TT festival Wi-Fi data. It is expected that a conversion rate is applied to the RLD data as well, but the conversion factor might be determined differently.

Several choices have been made to come to the variables that represent the actual crowdedness. Time windows of three, fifteen, thirty and sixty minutes are chosen for the Wi-Fi data, in order to find out what fits best with pedestrians' perception. The variables that will be compared to the perception data are: local Wi-Fi counts, global Wi-Fi counts, local densities, local proportion of people compared to the maximum for that location, local camera counts, local flows and the proportion of in- and outflow.

Some of the processing steps are not performed as thoroughly as desired. For the TT Festival, the dynamic MAC addresses were not removed. For the Red light district it is not known whether this step is executed. For the TT Festival data, some extra interpolation was necessary to correct sudden peaks and missing data. Furthermore, in both cases, the data has not been validated using a ground truth, because of the limited time available for this part of the research. Also, the choice to use a simple conversion rate, opposed to a crowdedness dependent conversion rate is expected to influence the results. Variables such as the area of a Wi-Fi sensor were not determined accurately. All of these problems lead to less reliable data, which will be further discussed in Chapter 8. Overall, the data collection and processing could have been done more thoroughly, but the steps that have been followed are deemed to be sufficient to draw conclusions from this data. The differences between the data-sets, the possible shortcomings of the processing method and the choices that were made regarding the variables that represent the crowdedness will be further discussed in Chapter 8.

6

Model estimation/analysis method

The aim of this chapter is to find the appropriate way to model/analyse the data. This chapter will answer the following research sub-question:

How can we analyse/model the relationship between perception & experience of crowdedness and personal, event and trip characteristics?

The analysis method consists of two parts. First, the purpose of performing a statistical analysis is explained in Section 6.1. The aim of the analysis in SPSS is to gain an impression of the data gathered and the probable relations within. Second, the method and reasons to create a model are discussed (Section 6.2). This section will explain why a Structural Equation Model (SEM) is required for this research. Section 6.3 will further specify how SEM can be used to create a better understanding of the relations found and how a model has to be built. Section 6.3.5 gives a conclusion of this chapter answering the research sub-question.

6.1. SPSS statistical analysis

A statistical analysis has to be performed for this research for multiple reasons. First, it is useful to give an summary of the data that is gathered (see 4). Second, it is used to find one-on-one relations between perception of crowdedness and the explanatory variables, to get an indication which factors are useful to include in the model. For example, a test is performed to see if there is a relation between the age of participants and their perception of safety. Also, some answer sets to questions might have to be re-categorised. For example, the question: *Where are you going at the moment?* had eight possible answers. For this research, the aim of this question was to find out whether there is a difference in perception between people with a clear purpose or without a purpose. What is important to find out is how the answers should be re-categorised to extract a meaningful relation. Finally, an exploratory factor analysis is performed to determine how the perception variables are related to each other.

6.1.1. Bi-variate analysis

For the bi-variate relations, a few types of tests have been performed, to find the relation between ordinal, nominal and interval/ratio data combinations. There are four types of data available. The following table illustrates what are the characteristics of these date types (Molin, 2017a).

Table 6.1: Four levels of data types explained: Nominal, Ordinal, Interval and Ratio

Data type	**Characteristics**	**Example**
Nominal/Binary	Distinction between categories	Gender, Location type, Group type
Ordinal	Distinction and order	Perception, Group size, Time spent
Interval/Ratio	Distinction, order and equal differences	Density (pax/m^2), Sound intensity (dB)

The tests that are used are summarised in Table 6.2. These tests are further explained in Appendix H.

The next step is to create some scatterplots and regression tests for the quantified and perceived crowdedness. These can show the fit between these variables and to see whether this relation is linear.

Table 6.2: Summary of applied bi-variate tests

Statistical test	Data combination
Kendall's tau &	Ordinal - Ordinal
Spearman's Rank	Ordinal - Interval/Ratio
Mann Whitney U test	Binary - Ordinal Binary - Interval/Ratio
Kruskal Wallis	Nominal - Ordinal Nominal - Interval/Ratio
Bonferroni correction	Multiple tests, pairwise tests for multiple categories

6.1.2. Exploratory factor analysis

Factor analysis can be performed to find factors that are overlapping, to simplify the dataset (PCA) or to come to a more reliable latent variable (Factor analysis) (Molin, 2018b). Normally, in psychological research, multiple questions are asked regarding one latent/unknown variable. Perceptions, attitudes and intentions have to be measured with more than just one question to find an accurate value on a continuous scale. In other words, when it is desired to know how a person perceives safety in a crowd, questions like: 'How do you perceive social safety in the crowd? To what extent do you think safety is compromised in case of panic? How safe do you feel regarding the number of police and security here?' These could all be measurements for the one latent variable Safety.

In this research, 5-6 questions regarding perception on the crowd and surroundings are asked. It is expected that these questions are partially overlapping and might be seen as factors for one latent variable as well. Therefore, an exploratory factor analysis is performed in SPSS. If two or more perceptions are very much related, this indicates that they are in fact both caused by the same underlying latent variable. Modelling the relation in this way leads to a stronger model.

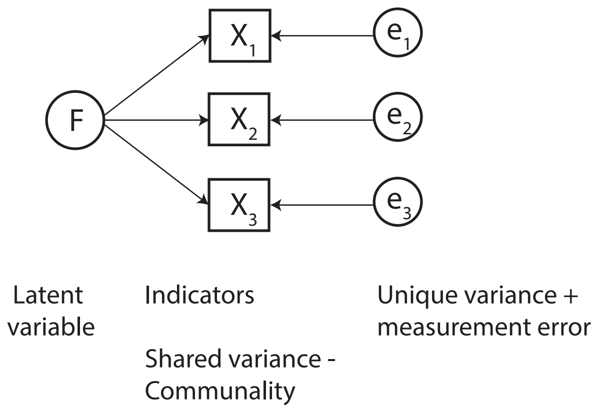

Figure 6.1: Factor model

In Figure 6.1, the construction of a factor model is shown. In this example, three variables are measured. The measured variables are indicated with rectangles. With these measured indicators, the unobserved, or latent variable is described (illustrated as a circle). The indicators are overlapping, but also have some unique variance, that cannot be explained by the latent variable. This is indicated by the error variable, which is also unobserved.

Figure 6.2 gives an example of three survey questions aimed to find the latent variable, perceived Safety. On the left side, the correlations that are found between these three questions is shown. On the right side, this is translated into a factor model, were the correlations between these questions are explained by the underlying variable, perceived Safety.

The exploratory factor analysis in this research will be used to see whether perceived Crowdedness, Safety, Comfort, Attractiveness of the environment, Atmosphere and Experience of crowdedness are actually ex-

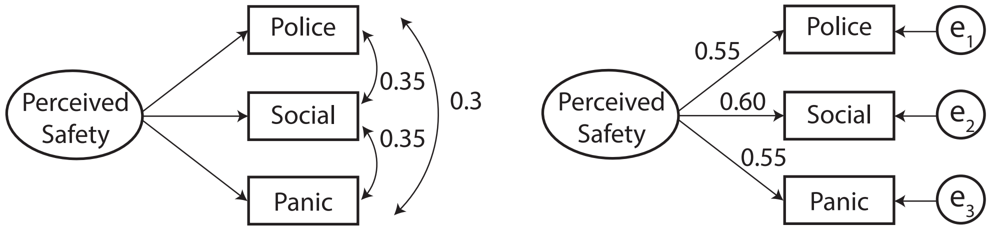

Figure 6.2: Example of a factor construct

plaining one latent factor, since they are all related to crowdedness in this research. The results of this exploratory factor analysis will be presented in Chapter 7. More explanation on factor analysis can be found in Appendix E.

6.2. Multivariate data analysis techniques

In order to find out which factors influence the different facets of perception and how the perception of crowdedness relates to the quantified crowdedness the following requirements have to be met:

1. The model can be based on theory/hypotheses.
2. The model can find the pure effect of a variable, controlled for other variables.
3. The model can detect a spurious effect.
4. The model can test indirect relations.
5. The model can include latent variables in a measurement model.
6. The model can make use of ordinal and nominal data together with interval data.

In the next Section, it is explained why these effects are important. In Section 6.2.2 and 6.2.4, multivariate regression and structural equation modelling are explained.

6.2.1. Why do we need to model control, spurious and indirect effects

Drawing conclusions only from simple bi-variate regression is not sufficient for multiple reasons. The effects that are missed in bi-variate analysis are illustrated in Figure 6.3 and are further clarified with examples in Figure 6.4.

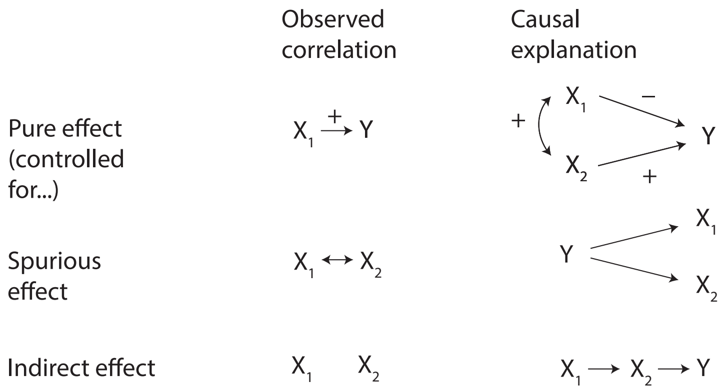

Figure 6.3: Pure, spurious and indirect effects

Direct effects can be found with a simple, bi-variate regression. The problem is that this does not consider causality. A correlation between two variables could mean that one causes the other, that the effect works both ways, or that it is caused by another variable (spurious effect). There could be correlations between the explanatory variables, which influence the relation between the explanatory variables and the perception variables. In a experimental choice set, the choice sets are designed in such a way that correlations between explanatory variables is avoided. Since a survey is used, it is possible that the independent variables are correlated.

In the first example in Figure 6.4, no significant direct relation between density and perceived safety is found using a bi-variate test, but from theory it is be expected that there is an indirect relationship between Density, perceived Crowdedness and perceived Safety. To find this relation, a multivariate model is required.

In the second example, a positive correlation between perceived Crowdedness and perceived Safety is observed. However, when tested in a multiple regression, controlling for perceived atmosphere, the pure effect of perceived Crowdedness on Safety is actually negative.

The third example illustrates how time of day is used to predict the perceived Comfort. However, this correlation is not a causal explanation. Actually, it is hypothesised that Comfort drops because of the time spent at the event. Logically, time spent is correlated with time of day, since an event starts at a certain time.

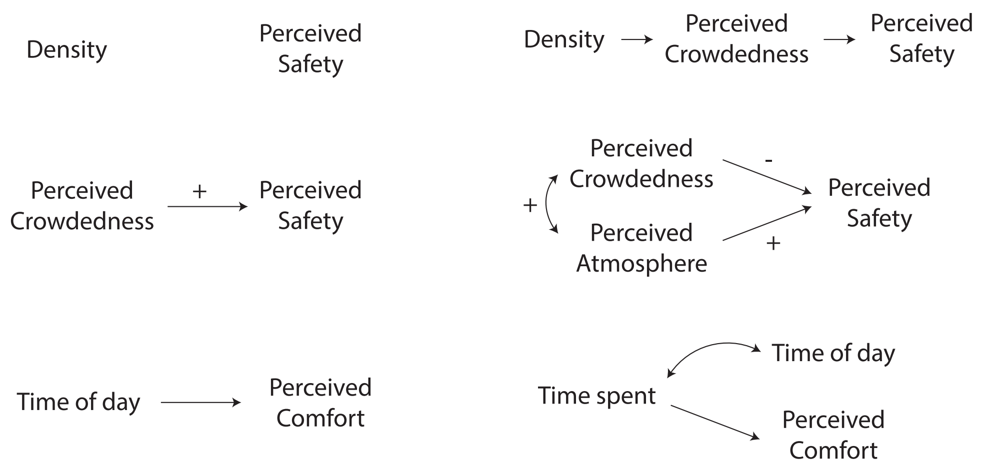

Figure 6.4: Examples of pure, spurious and indirect effects

Finding the indirect effects, pure effects and spurious effects, opposed to only correlations is very important to actually be able to understand the causal relation between variables. When the causal relation is understood, it is possible to influence the right factors in order to change pedestrians' perception in a positive way. In the next Section, the operation of a multivariate regression and a Structural Equation Model are explained. At the end of this section, it can be concluded which model is needed for this research.

6.2.2. Simple regression

Based on the outcomes of the bi-variate statistics, a multivariate regression can be set up. The purpose of this multivariate regression is to find the pure effects of each of the explanatory variables, and their interrelation with each other. What is meant by 'pure effect' is the actual relation between a dependent and an independent variable, while controlling for the other variables. A simple regression can be explained with the following equation:

$$\hat{Y} = C + \beta X \tag{6.1}$$

where:

$\hat{Y}$ = Dependent variable to be predicted
β = regression coefficient parameter
X = Independent variable or predictor
C = Constant, intercept

(Molin,2018a)

Simply stated, linear regression is the relation between the independent and dependent variable expressed as

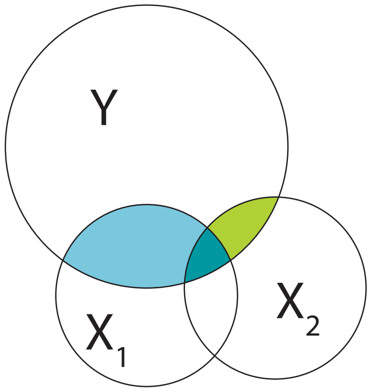

Figure 6.5: Regression with two predictors: blue and green are unique variance, turquoise is joint variance

a straight line. The constant C determines the starting point of the line and the regression coefficient shows the standardised increase of Y for one step of X. By estimating these two parameters a line is fitted that has the least residual error, also the method of least squares (Field, 2009). The formula that describes the actual relationship between the dependent and independent variables is the following:

$$Y_i = \beta_0 + \beta_i X + \epsilon_i \tag{6.2}$$

Where:

Y_i = Dependent variable
β_0 = Constant, intercept
β_i = Standardised regression coefficient
X = Independent variable
ϵ_i = Random error term

(Field, 2009)

The error term ϵ_i, represents the difference between the predicted $\hat{Y}$ and the actual Y_i. When a regression is performed, the explained variance R^2 is calculated to interpret how well the independent variable X explains the dependent variable Y. This is calculated by dividing the total sums of squares with the residual sum of squares (Field, 2009), as described in the equation below:

$$R^2 = 1 - \frac{SS_{tot}}{SS_{res}} \tag{6.3}$$

When the regression line fits the data perfectly, all the variance is explained and $R^2 = 1$. Otherwise, R^2 shows the part of the variance that is explained by X.

6.2.3. Multiple regression

A multiple regression contains the same basic components as described above, but with more than one independent variable. Multiple regression is used to explain a larger part of the dependent variable and to find the pure effect of each of the independent variables. When more independent variables are included, the explained variance R^2 will increase. However, this is not achieved by simply adding up the scores of the independent variables, because these independent variables could correlate with each other (Molin,2018c). This can be clarified in Figure 6.5.

As can be seen, both X_1 and X_2 can explain some of the variance of Y. The part where X_1 overlaps with Y (light blue) is the variance of Y explained by X_1. The green part is the unique variance of Y explained by X_2. The turquoise part is the joint variance of Y explained by X_1 and X_2 (Molin,2018c).

It is also possible to include binary variables in the multiple regression. In that case, predictor X is either 0 or 1. This means that for a simple regression using only one dummy variable, the outcome is either the constant C or $C+1*\beta$. It is possible to include nominal variables as well, by splitting them in separate dummy variables. The number of dummies required is the number of categories minus 1, since one category will be the reference point which has the constant as an outcome (Molin,2018d). To conclude, a multiple regression meets part of the requirements stated, but is not able to detect spurious and indirect effects. Furthermore, latent variables cannot be included.

6.2.4. SEM Model

A Structural Equation model is a combination of various models. A SEM model works with the same principles as multiple regression, but it can be used to model more complex relations. A SEM model consists of two parts, a structural model and a measurement model.

Path/structural models
A path model can be used to find direct, indirect, spurious and suppressor effects. These effects are all important to understand the perception of crowdedness. In a path model, the magnitude of the indirect effect is the multiplication of both path coefficients $\beta_1 * \beta_2$. Indirect effects will therefore be small, but they can be found.

Measurement model
The second part of a SEM model is a measurement model. This is a construct to include latent variables, that are not directly measurable. A measurement model has the same construct as was explained in Section 6.1.2. A measurement model should include at least two factors, but preferably three or more (Molin, 2017b). The factor loadings (the causal relation between the factor and the indicators) should be higher than 0.5 and preferably be higher than 0.7.

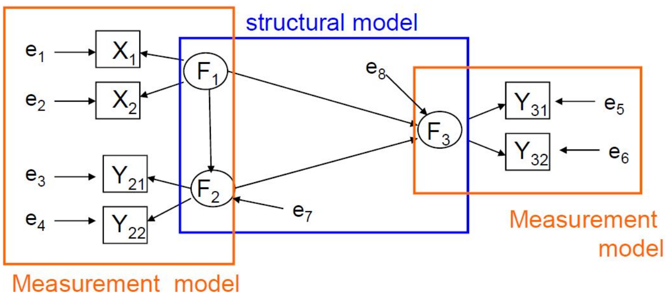

Figure 6.6: Structural Equation Model: Structural (path) model and measurement model combined

Figure 6.6 illustrates how a SEM model can be constructed. A SEM meets all of the requirements stated at the beginning of this section. The model can be based on theory, can find pure, indirect and spurious effects and can include constructs for latent variables.

6.2.5. Conclusion

Multivariate regression is a useful data analysis technique, which can test theories and can find pure effects of a predictor. However, it cannot test indirect relations and cannot include a latent variable. A SEM model does offer the possibility to include indirect relations and latent variables, with the use of a path model and a measurement model. Therefore, the data from the research will be analysed by using Structural Equation Modelling. It has a high explanatory power and can be used to analyse complex relations.

6.3. SEM building, testing and analysing

This section will explain how a SEM is created, fitted and analysed.

6.3.1. SEM modelling rules

When creating a model, a person needs to take into account the modelling conventions displayed in Figure 6.7 (Molin, 2017c). Furthermore, the difference between exogenous and endogenous variables is important. In a causal order, exogenous variables are not caused by any of the other variables in the model. For example, Socio-Demographic variables are not caused by any of the other variables, but they could be correlated to other variables. For example, age could be correlated with having a purpose. Endogenous variables are caused by other variables in the model. An endogenous variable can be recognised by a causal path coming in. Endogenous variables are always modelled with an error term, see also Figure A.2. This error variable represents the unique variance of the endogenous variable, that is not caused by the predictor variable. Two endogenous variables cannot be correlated, but need to be connected with a causal path. The only exception to this rule is when two endogenous variables are at the same level of a causal order such as the Theory of Planned Behaviour (Molin, 2017c). For example, the experience of crowdedness variables are on the same level of the causal order, as can be seen in the theoretical framework 3.3.

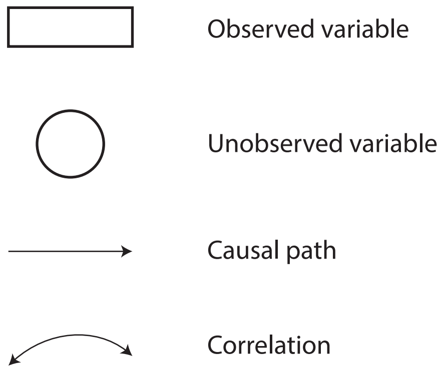

Figure 6.7: SEM model: Conventions in notation (Molin, 2017c)

6.3.2. Assessing a model fit

When a model is created, the model fit has to be assessed before the results can be interpreted. This can be done using the χ^2 value and the p-value of a model (Molin, 2017b). The χ^2 is calculated using formula 6.4.

$$\chi^2 = (N-1)|(S-\Sigma(\delta))| \tag{6.4}$$

Where:

χ^2 = Chi-squared distribution based on degrees of freedom
N = number of cases
S = Observed covariance matrix
$\Sigma(\delta)$ = the reproduced covariance matrix from model

(Molin, 2017b)

This test compares the covariance matrix of the individual relations to the relations modelled. The null hypothesis is that the model fits the data. Therefore, a model fit is indicated by a p-value > 0.05. A lower χ^2 indicates a higher model fit. As can be seen from looking at this equation, a higher number of cases N actually decreases the model fit. This is important to take into account, because this means that using the data of less respondents would increase the model fit, which does not seem logical.

The χ^2 is a useful indicator. However, for large and complex data-sets, it becomes difficult to satisfy the model fit assessed by this indicator (Kenny, 2015). Therefore, assessment based on other indicators might be necessary. This can also help to compare models. These indicators include measures of fit and measures of parsimony. Parsimony is considered, because a good model should not be overly complex. It should only include variables that make a significant difference. Below, a list of commonly used indicators and their use are explained:

- χ^2/df: Is suggested as a better test for goodness of fit for large models. However, it is unclear what ratio indicates a good fit (Arbuckle, 2010). Some researchers suggest that an adequate fit is a value lower than five. Others recommend using 2 or 3 as a boundary value (Arbuckle, 2010).
- GFi: The goodness-of-fit index measures the amount of variance and covariance in the observed covariance matrix that is predicted by the reproduced covariance matrix (Bian, 2012). Kenny (2015) suggests that this value should be larger than 0.9.
- CFI: The comparative fit index, compares the model to the null model (no model) (Arbuckle, 2010). Gaskin (2011) suggests that it should be larger than 0.9.

- PRATIO: the parsimony ratio penalises for lack of parsimony. The number of constraints in the model is divided by the number of constraints in the null model (Arbuckle, 2010). A lower PRATIO is better.
- PCFI. The PCFI is the result of applying the parsimony adjustment (PRATIO) to the CFI (Arbuckle, 2010). Gaskin (2011) suggest that this indicator should be larger than 0.8.
- RMSEA: The root mean square error of approximation divides the fit indicator by the degrees of freedom, therefore penalising model complexity (Arbuckle, 2010). Browne and Cudeck (1993) suggest that a model should not be implemented if the RMSEA is greater than 0.1.
- PCLOSE is the p-value for testing the null hypothesis that RMSEA is no greater than 0.05 (Arbuckle, 2010). According to Browne and Cudeck (1993), a PCLOSE value higher than 0.05 indicates a close fit.
- AIC: AIC stands for Akaike information criterion. For model comparison, the lower AIC reflects the better-fitting model. Also, the AIC gives a higher score to complex models, so it favours a parsimonious model. AIC is useful in combination with the maximum likelihood method (Arbuckle, 2010).
- BCC: The Browne-Cudeck criterion imposes a slightly greater penalty for model complexity (lack of parsimony) than AIC (Arbuckle, 2010). BCC should be close to 0.9 to consider good fit (Bian,2012).
- BIC: BIC is the Bayesian Information Criterion. It penalises for sample size and model complexity. It is recommended when sample size is large or the number of parameters in the model is small (Bian, 2012). In AMOS, it is only reported when means and intercepts are not explicit model parameters (Arbuckle, 2010).
- CAIC: Consistent AIC is comparable to BIC, but less strict. The lower the CAIC measure, the better the fit (Arbuckle, 2010).

From these indicators, the ones listed in Table 6.3 will be used, because they are directly available in the results that AMOS produces. Moreover, they have been used by experts in the field of SEM modelling before, so the boundary conditions are clear and together they give a reliable indication of model fit (Kenny, 2015). Furthermore, using more than one indicator ensures that a model is not over-fitted to satisfy one condition.

Table 6.3: SEM model fit: chosen boundary conditions for a good model fit

Indicator	**Chi-square**	**p-value**	χ^2/df	**GFI**	**CFI**	**PCFI**	**RMSEA**	**PCLOSE**
Boundary condition	As low as possible	>0.05	<2	>0.9	>0.9	>0.8	<0.1	>0.05

If the initially built model does not fit the data, one might first reconsider the theoretical explanation. Furthermore, the modification indices (MI) might be consulted. These indices are given for any possible relation between two variables. It indicates to what extent the χ^2 improves if that path is added to the model. As a rule of thumb, a MI>4 will significantly improve the model fit if added. However, this should only be done if it makes sense theoretically (Molin, 2017c).

If the model fits, it might still be possible to improve some relations and get a higher model fit. This is because the model is theory-based, not data driven, therefore it is uncertain whether an optimal χ^2 value is found. This is one of the difficulties of using Structural Equation modelling. The researcher has to consider whether it is more important that the model fits the theory well, or that the model fit is higher.

To see what might be possible to improve the model fit, one can look at the Critical ratios (C.R.) and p-values of the regression weights. The critical ratio is comparable to a t-value. It is calculated by dividing the ratio of the estimate by its standard error. The Critical ratio indicates how much larger the estimate is compared to its uncertainty. The larger this value, the more certain the estimate is (Kroesen, 2017a). If there are C.R. beneath 1.96, one can consider leaving out this path.

6.3.3. SEM model building

The models will be constructed using the following steps, inspired on the model building steps from Molin (2017c):

1. All perception variables are modelled according to the hypotheses in Chapter 3. This includes factor models if the results from the exploratory factor analysis suggest this.

2. The model is tested on its model fit. All paths should be significant and the model fit is determined by looking at the p-value of the Chi-square test. The p-value should be higher than 0.05.
3. When the perception part is modelled correctly, all personal, trip and event factors that were found significant in the bi-variate analysis are included as predictors, based on the theoretical framework (Chapter 3). Correlations are applied when they can be explained theoretically.
4. When the model does not fit, the p-values and critical ratios of the individual paths will be checked. Variables that do not have any significant relations ($p > 0.05$) to other variables will be removed.
5. Next, one by one, the most insignificant paths will be removed, each time running the model again to check if other relations are influenced.
6. When only significant relations are left, but the model fit based on the six indicator from Table 6.3 is not yet sufficient or when the researcher thinks the model could still be improved, the modification indices are consulted. Suggested paths with modification indices higher than 4 will be modelled and tested one by one to see the effects on the rest of the model.
7. Lastly, variables that were not significant according to the bi-variate analysis, but were theoretically expected to be related to perception, can be added to the model. One variable at a time can be added, based on the relations that were hypothesised.
8. The model is finished when all the steps have been performed, the six indicators show a sufficient model fit and the researcher thinks the relations are explained as good as possible with this data.
9. The results that will be discussed are the total explained variance (R^2) of the perception variables and the direct, indirect and total effects of the predictors. These can be used to interpret the results and evaluate the hypotheses.

Two events are researched, both possibly having other explanatory variables. Consequently, one model will not be able to capture all meaningful results. Therefore, a multitude of models shall be created. Since there are two events, it seems logical to make a best fitting model for both of these. However, creating a model that only applies to one event in one certain year is not useful to increase understanding of perceived crowdedness in general. Hence, another model shall be created that applies to both events. Also, a model that was initially created for the first event will also be tested and improved on data of the second event and vice versa. Concluding, five models will be created, with different goals and starting points. This can be used for future reference to try to predict the perception and experience of pedestrians at mass events.

Table 6.4: SEM model building: 5 model types

5 models				
Perfect model TT	**Starting model TT**	**Starting mix model**	**Starting model RLD**	**Perfect model RLD**
Uses all significant factors/correlations from the statistical analysis TT	Uses all significant factors/correlations that are present in RLD data as well	Uses all significant factors/correlations found in both cases	Uses all significant factors/correlations that are present in TT data as well	Uses all significant factors/correlations from the statistical analysis RLD

6.3.4. SEM model results

The results that will be interpreted are the total explained variance (R^2) of the perception variables and the direct, indirect and total effects of the predictors. These can be used to interpret the results and evaluate the hypotheses.

6.3.5. Conclusion

In conclusion, Structural Equation modelling will be used to analyse the data. It can be used to find the complex relations between all the factors included. Five models will be created, where two are event specific and the other three are applicable to both events. This way, it is possible to give a specific explanation for each event as well as to increase knowledge on pedestrians' perception at events in general. An initial model will be built, based on the theoretical framework. Then, insignificant paths and factors are removed one by one and paths that improve the model fit are added. With this modelling method, it is ensured that all relevant relations will be included in the final model. The models can be interpreted by looking at the direct, indirect and total effects of explanatory factors on the perception variables. This will show to what extent the personal, trip and event factors influence the perception.

6.3.6. Sidenote: Missing data

In all research, it is probable that a dataset is not fully complete. Missing data can be structural or random. This can be caused by malfunctioning sensors or non mandatory survey questions for example. There are three methods that are often applied in order to deal with missing data.

Listwise deletion is removing any record where one variable is missing. This is an easy method, but is has a major downside; A large part of the data will have to be removed. Therefore, a better method is *Pairwise deletion*. In this case, if a regression is tested between two variables, only the missing cases of one of them are excluded. A third approach is *data imputation*. Here a guess is made based on the data that is available. For example, the mean of the variable can be calculated. This value can then be placed at the missing data points (Arbuckle, 2010).

The software package AMOS, which will be used for estimating the model, can accept missing data when the estimation criterion Maximum Likelihood is used. In the AMOS user guide, Arbuckle (2010) gives an example of a model estimated with a complete dataset and another, exactly the same dataset, where a few random values have been excluded. The χ^2 value is slightly higher for the complete dataset, but both model estimates are significant.

In this research, there is missing data for one of the event locations. It is chosen to make use of the method that the software package AMOS provides. Listwise deletion was not a possibility, because then no data acquired at that event location could have been used.

III

Results & Conclusions

7

Results

In this chapter, the results of the analysis as described in Chapter 5 and Chapter 6 are presented. First, the correlations between the perception variables and the variables that were chosen to measure Crowdedness are given (Section 7.1). Second, the results of the Exploratory factor analysis (Section 7.2) are presented. The exploratory factor analysis is used to determine how the perception variables are related and consequently how they will be modelled in a SEM. Third, the results of the bi-variate analysis (Section 7.3) are discussed. Finally, the Structural equation models are elaborated upon in Section 7.5. These models provide insights in the pure effects of the explanatory factors and provide the base for the final interpretation and conclusions.

7.1. Quantification of Crowdedness

In this section, the variables that are chosen to quantify Crowdedness (Chapter 5) are tested. Not all of them can be included in the SEM model, because this would result in multicollinearity (Molin, 2018e). Therefore, only a limited number of measured crowdedness variables will be included in the final SEM model. Which of the variables are included is decided using the test results from the bi-variate analysis. The crowdedness variables that have the highest correlation to perception will be included. In Section 7.1.1, the results for the TT Festival are given and in Section 7.1.2, the results for the Red light district are elaborated upon.

7.1.1. TT festival

In Table 7.1, the correlations between variables that are used to describe Crowdedness and the perception variables are presented.

7.1.1.1 Density indicators

For the Wi-Fi counts, 3, 15, 30 and 60-minute moving averages are tested for local measurements. The table shows that the variable *'local 15-minute Wi-Fi counts'* has the strongest correlation with perceived Crowdedness ($\tau = .293$). A reason for this could be that pedestrians use their memories of the past 15 minutes to assess the level of Crowdedness. For perceived Safety, there is a weak negative correlation with the Wi-Fi counts, which is strongest for the 60-minute time window ($\tau = -.098$). This indicates the people feel a bit less safe when a place is more crowded. Furthermore, Attractiveness and Atmosphere are positively correlated with the Wi-Fi counts. Attractiveness is correlated the strongest with the Wi-Fi counts with a 3-minute moving average ($\tau = .135$), while Atmosphere has the strongest correlation with the Wi-Fi counts with a 60-minute moving average ($\tau = .141$). This could be interpreted as follows: Attractiveness of a location is assessed at the moment, while Atmosphere is experienced over a longer time period. However, the differences in correlations between the time windows are small. Therefore, this interpretation cannot be concluded with certainty. Overall, the findings suggest that the number of people present influences the perception of Attractiveness of the environment and Atmosphere. Regarding perceived Comfort, no correlation was found with local Wi-Fi counts.

Besides the local Wi-Fi counts, the global Wi-Fi counts with a time window of 60 minutes were found to be correlated with the perception variables. Here, a correlation with perceived Crowdedness is found ($\tau = .185$), but it is weaker than the local measurement. Contrary, the correlation with perceived Safety is stronger

Table 7.1: TT Festival: Correlations Perception - Quantified Crowdedness

		P. Crowded.	P. Safety	P. Comfort	P. Attractiveness	P. Atmosphere
WifiC3	Corr.	.198**	-0.041	-0.043	.135**	.112*
	Sig.	0.000	0.213	0.194	0.003	0.013
WifiC15	Corr.	.293**	-.094*	-0.041	.115**	.136**
	Sig.	0.000	0.031	0.207	0.009	0.004
WifiC30	Corr.	.289**	-.098*	-0.042	.120**	.141**
	Sig.	0.000	0.026	0.201	0.007	0.003
WifiC60	Corr.	.275**	-.098*	-0.043	.130**	.130**
	Sig.	0.000	0.027	0.195	0.004	0.005
allWifiC60	Corr.	.185**	-.139**	-.094*	0.037	.117**
	Sig.	0.000	0.003	0.030	0.225	0.010
ped/area15	Corr.	.192**	-0.018	0.013	-0.078	0.016
	Sig.	0.000	0.358	0.395	0.055	0.375
ped/area3	Corr.	.143**	0.011	-0.006	-0.060	0.007
	Sig.	0.002	0.415	0.455	0.110	0.442
vol/cap15	Corr.	.181**	-0.006	0.013	-.081*	0.014
	Sig.	0.000	0.456	0.395	0.049	0.389
vol/cap3	Corr.	.122**	-0.001	-0.024	-.095*	-0.014
	Sig.	0.006	0.496	0.318	0.027	0.394
camcount 3	Corr.	.247**	-.246**	-.178**	-0.026	.122*
	Sig.	0.000	0.000	0.002	0.330	0.024
camcount15	Corr.	.300**	-.271**	-.191**	-0.001	.124*
	Sig.	0.000	0.000	0.001	0.495	0.022
cam flow 15	Corr.	.248**	-.250**	-.149**	0.039	.115*
	Sig.	0.000	0.000	0.007	0.257	0.031
cam flow 3	Corr.	.263**	-.232**	-.155**	0.066	.108*
	Sig.	0.000	0.000	0.006	0.136	0.040
in/out15	Corr.	0.038	-0.036	-0.069	0.080	-0.051
	Sig.	0.259	0.283	0.129	0.091	0.205
in/out3	Corr.	.109*	-0.031	-0.046	0.092	-0.003
	Sig.	0.034	0.307	0.225	0.064	0.478

($\tau = -.139$). Moreover, it is correlated with perceived Comfort as well ($\tau = -.094$). On the other side, it is not correlated with Attractiveness. It was hypothesised that the correlations for global Wi-Fi counts would be lower for all perceptions, since the survey questions address the local perception (e.g. *"How would you rate the level of crowdedness at this location?"*).

Next, the correlation between density (ped/m^2) and number of pedestrians compared to the maximum number of pedestrians ($ped(t)/max(ped(t))$) and the perception variables are tested. There is a correlation between these variables and perceived Crowdedness. However, the correlation is less strong compared to the pure Wi-Fi counts. Furthermore, a weak negative correlation between Perceived Attractiveness and $ped(t)/max(ped(t))$ is found, which might indicate that areas nearly filled to capacity are found less attractive.

Since the variable *'15-minute local Wi-Fi counts'* has to strongest relation with perceived Crowdedness is and also strongly correlated with the other perception variables, this variable will be included as a density indicator in the Structural equation model.

7.1.1.2 Flow indicators

For the camera counts, a 3 and 15-minute moving average are tested. The 15-minute counts have the strongest correlation with all the perception variables. Perceived Crowdedness is correlated stronger with the 15-minute camera counts ($\tau = .300$) than with the 15-minute Wi-Fi counts, although the difference is small . Therefore, the Wi-Fi counts and camera counts are equally strongly correlated to perceived Crowdedness.

For perceived Safety, the correlation is stronger as well ($\tau = -.250$). A moderately strong relation with perceived Comfort is found as well ($\tau = -.155$), which indicates that the amount of movement of a crowd is negatively correlated with the perception of Safety & Comfort. The flow ($ped/min/m$) has the same correlations as the pure camera counts, but the correlations are all slightly weaker. Lastly, a only weak correlation between the proportion of in- and outflow and perceived Crowdedness is found. To conclude, *'15-minute local camera counts'* will be used in the SEM model, because this variable has the strongest correlations with the perception variables.

7.1.1.3 Scatter and simple regression

A simple regression is performed for the for the *'15-minute local Wi-Fi counts'* and the *'15-minute local camera counts'*, with perceived Crowdedness as the dependent variable. Figure 7.1 shows that the 15-minute Wi-Fi counts accounts for 18% of the variance in perceived Crowdedness ($R^2 = .180$). Figure 7.2 illustrates that the 15-minute camera counts account for 12% of the variance of perceived Crowdedness. This suggests that Wi-Fi counts are the better predictor for perceived Crowdedness, while the correlation was higher for the camera counts. This could have multiple reasons. First, the correlation is calculated using Kendall's rank correlation coefficient (Appendix D), while a simple regression seeks a linear relationship (Chapter 6). This means that the relation between the two variables is tested in a different way. Other than that, it is known that the same level of flow is possible at different levels of density (Chapter 2). Consequently, a low flow can correspond to a very deserted area or a very crowded area. Therefore, the relation between flow and perceived Crowdedness is less clear as well.

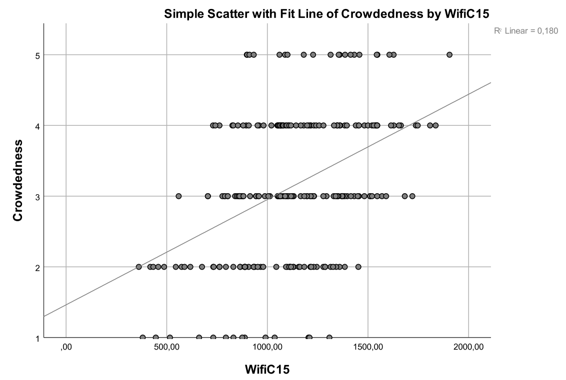

Figure 7.1: TT Festival: Regression 15-minute local Wi-Fi counts - P. Crowdedness

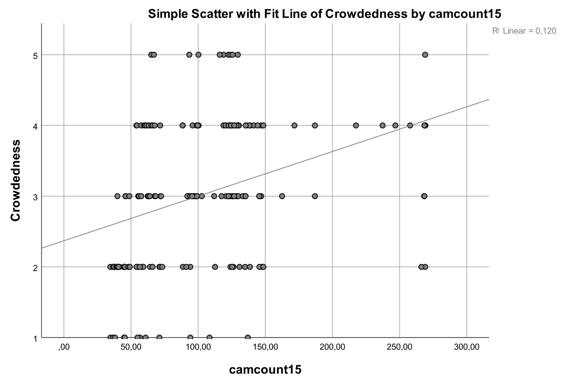

Figure 7.2: TT Festival: Regression 15-minute local camera counts - P. Crowdedness

In Figure 7.3, Wi-Fi counts and perceived Crowdedness are plotted over time. This figure shows that the perception seems to be different for the different locations (every jump in time corresponds to another location). Therefore, it is important to take location into account in the SEM. More scatter plots and regression lines can be found in Appendix B. There, the Wi-Fi counts and perceived crowdedness are plotted split per day and location.

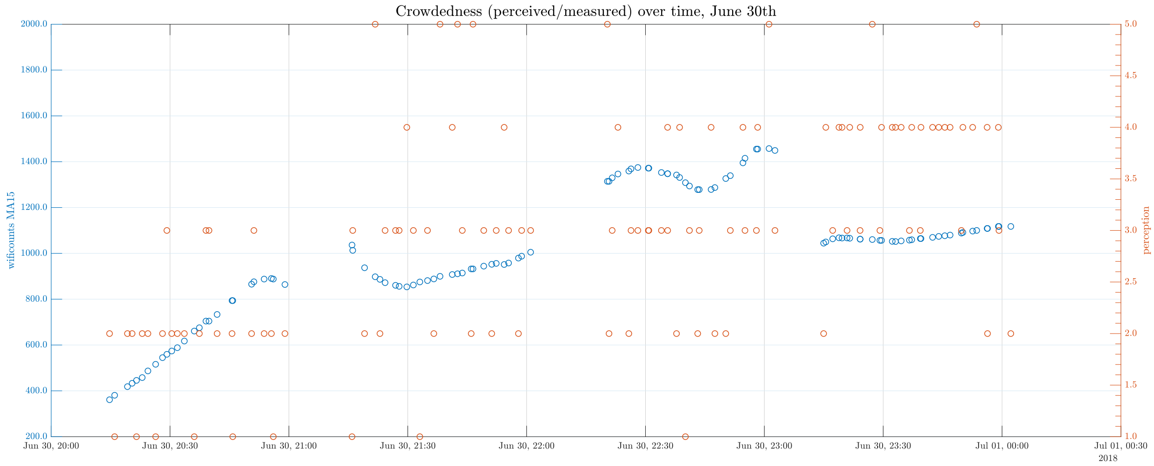

Figure 7.3: TT Festival: Scatter 15-minute Wi-Fi counts and P. Crowdedness over time, three locations, 20:00-21:00 Koopmansplein, 21:00 - 22:00 Kermis, 22:00 - 23:00 Markt, 23:00 - 00:00 Koopmansplein. June 30, 2018.

7.1.2. Red light district

Table 7.2 depicts the correlations between quantified crowdedness and perception on Crowdedness and other crowd related perceptions. Here, it is noticeable that mainly perceived Crowdedness is correlated with the quantified crowdedness variables, while in the case study of the TT Festival correlations were found between quantified crowdedness and the other perception variables as well.

Table 7.2: Red light district: Correlations Perception - Quantified Crowdedness

		P. Crowded.	P. Safety	P. Comfort	P. Attract.	P. Atmos.	Exp. Crowded.
WifiC3	Corr.	.205**	0.002	-0.046	-0.025	0.010	-0.066
	Sig.	0.000	0.488	0.207	0.328	0.427	0.118
WifiC15	Corr.	.215**	0.023	0.003	-0.012	0.022	-0.073
	Sig.	0.000	0.345	0.481	0.416	0.345	0.095
WifiC30	Corr.	.224**	0.008	-0.017	-0.034	-0.002	-0.070
	Sig.	0.000	0.442	0.383	0.271	0.486	0.105
WifiC60	Corr.	.226**	0.000	-0.019	-0.046	-0.024	-0.055
	Sig.	0.000	0.497	0.369	0.204	0.333	0.161
allWifiC60	Corr.	.292**	-0.011	0.008	-0.025	0.002	-0.053
	Sig.	0.000	0.422	0.445	0.328	0.487	0.171
vol/cap15	Corr.	.265**	-0.039	-0.054	-0.053	-0.010	-.118*
	Sig.	0.000	0.248	0.167	0.171	0.431	0.017
vol/cap3	Corr.	.224**	-0.024	-0.063	-0.039	0.006	-0.081
	Sig.	0.000	0.341	0.130	0.246	0.461	0.074
camcount 3	Corr.	.140**	0.039	0.036	-0.041	-0.036	-0.013
	Sig.	0.007	0.252	0.261	0.236	0.261	0.409
camcount15	Corr.	.162**	0.041	0.066	0.009	0.036	-0.015
	Sig.	0.002	0.239	0.120	0.437	0.264	0.398
cam flow 15	Corr.	.127*	0.062	0.050	0.010	-0.008	0.000
	Sig.	0.013	0.139	0.185	0.430	0.442	0.500
cam flow 3	Corr.	.097*	0.044	0.055	-0.032	-0.034	-0.018
	Sig.	0.045	0.225	0.163	0.286	0.276	0.375

7.1.2.1 Density indicators

For the local measurements, the correlation between the 60-minute Wi-Fi data and the perceived Crowdedness is the strongest (τ = .226). Furthermore, the correlation between the global 60-minute Wi-Fi data and perceived Crowdedness is even stronger ($\tau = .292$). This suggests that the Wi-Fi counts of the whole Red light district are a better indicator for perceived Crowdedness than the local crowdedness. This seems quite logical, since the event area is smaller and people are predominantly walking around, which means that they have been at various locations recently and they experience the area as one whole. The number of pedestrians compared to the maximum number of pedestrians measured in that area ($ped(t)/max(ped(t))$) has a slightly lower correlation with perceived Crowdedness compared to the global Wi-Fi counts ($\tau = .265$). A small negative correlation with Experienced Crowdedness is found as well ($\tau = -.118$). The density ($ped./m^2$) is not calculated for the Red light district, because determining the area that a Wi-Fi sensor measures is more difficult for the small alleyways.

In the final model, *15-minute local Wi-Fi counts* can be used, in order to compare the TT and RLD model better. Otherwise, *global 60-minute Wi-Fi counts* or $ped(t)/max(ped(t))$ would be a good option. In the end, *global 60-minute Wi-Fi counts* is chosen to be used in the model, because the correlation of this variable with perceived Crowdedness is the strongest.

7.1.2.2 Flow indicators

For the flow indicators, pure camera counts and the flow (ped/m) are compared with a moving average of 3 or 15 minutes. The 15 min camera counts are correlated with perceived Crowdedness the strongest ($\tau = .162$). The flow variables have a lower correlation. The proportion in and outflow is not calculated for the Red light district, because it did not yield many results in the TT case. Therefore, *15-minute camera counts* will be used in the model, just as in the TT model.

7.1.2.3 Scatter and simple regression

In Figure 7.4 and Figure 7.5, the chosen density and flow indicator are used as a predictor for perceived Crowdedness. The global 60 min Wi-Fi data accounts for 12.5% of the variance in perceived Crowdedness ($R^2 = .125$). 15 min camera counts account for 4.5% of the variance of perceived Crowdedness ($R^2 = .045$). The latter value is very low, which indicates describing the relation between perceived Crowdedness and "flow" linearly does not provide much insight.

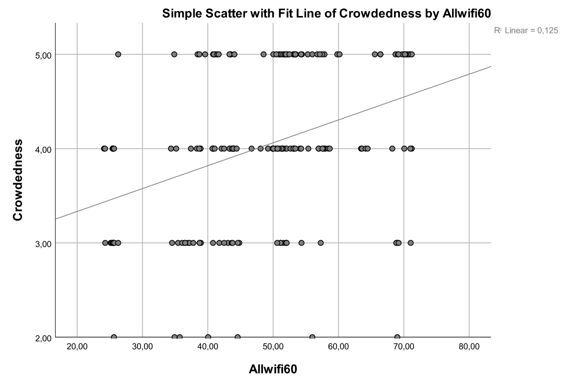

Figure 7.4: Red light district: Regression global 60-minute Wi-Fi counts - P. Crowdedness

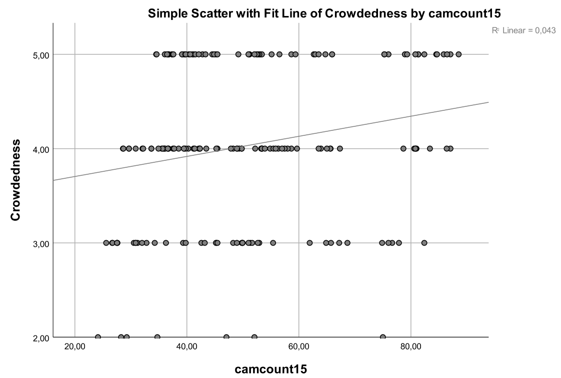

Figure 7.5: Red light district: Regression 15-minute camera counts - P. Crowdedness

Figure 7.6, the perceived Crowdedness and 15-minute Wi-Fi data of one evening are plotted over time. Three locations were researched that evening, respectively GAWW-06 *Oudezijds Achterburgwal*, GAWW-07 *Stormsteeg* and GAWW-02 *Oude kennissteeg*. The small breaks at 20:00 and 21:00 indicate a switch of location. It can be seen that the differences in perceived Crowdedness per location are less pronounced than at the TT Festival. Furthermore, it shows that there is quite some fluctuation in the measured Crowdedness. The perceived Crowdedness does not correspond well to the Wi-Fi counts at the end of the evening. However, when looking at the 1-minute data, there was a drop in the Wi-Fi counts around that time (B.15). More scatterplots can be found in Appendix B. There, the Wi-Fi counts and perceived crowdedness are plotted split per day and location.

For the SEM model, it is expected that Wi-Fi counts will be more closely related to the perceived crowdedness than the camera counts, but both variables will be tested.

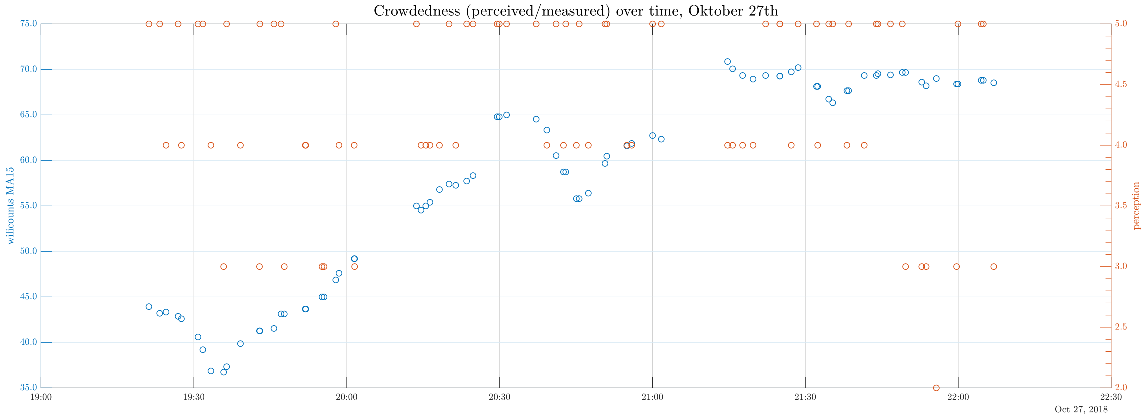

Figure 7.6: Red light district: Scatter 15-minute Wi-Fi counts and P. Crowdedness over time. 19:00 - 20:00 Oude Kennissteeg, 20:00 - 21:00 Stormsteeg, 21:00 - 22:15 Oudezuids Achterburgwal. October 27, 2018.

7.2. Exploratory factor analysis

In this analysis, exploratory factor analysis is used to see whether the six questions related to crowd perception and experience are in fact indicators of one or more factors. This is important to know how the relations between the perception variables can best be modelled. The full analysis can be found in Appendix E. In this section, the most important results are discussed.

The following boundary conditions have to be met in order to use variables as indicators for a latent variable:

- A latent variable should have at least two indicators, preferable three or more (Section 6.1.2)
- Factor loadings should be above 0.5. This indicates that the overlap of the indicators is sufficient (Section 6.1.2).
- Each indicator should only load on one factor. If there is a cross loading, the difference should be at least 0.2 (Appendix E).
- The total variance explained by the factors is preferable above 50%. (Appendix E)

The results are presented and discussed in this section.

7.2.1. TT Festival exploratory factor analysis

At the TT Festival, five questions related to perception were posed.

Table 7.3: TT Exploratory factor analysis: 5 perceptions included

Rotated factor matrix		
	Factor 1	Factor 2
P. Crowdedness	0.355	
P. Safety		0.576
P. Comfort		0.662
P. Attractiveness	0.627	
P. Atmosphere	0.750	
Variance explained	38.568%	

In Table 7.3, the results of an exploratory factor analysis with these five perception variables are shown. Table 7.3 indicates that the factor loading of Perceived Crowdedness is too low and the total variance explained by the factors (38.6%) is also low. Therefore, another exploratory factor analysis is performed, excluding the variable perceived Crowdedness.

Table 7.4: TT Exploratory factor analysis: 4 perceptions included, P. Crowdedness excluded

Rotated factor matrix		
	Factor 1	Factor 2
P. Safety		0.571
P. Comfort		0.657
P. Attractiveness	0.721	
P. Atmosphere	0.675	
Variance explained	44.457%	

In Table 7.4, the results of a second exploratory factor analysis is shown, in which the perception variables Safety, Comfort, Attractiveness of the environment and Atmosphere are included. Two factors, one consisting of the indicators Safety and Comfort and one of Attractiveness and Atmosphere, can explain 44,5% of the total variance. All factor loadings are above 0.5. Together, this indicates that perceived Safety & Comfort can be modelled as one factor, and perceived Attractiveness and Atmosphere can be seen as indicators for one factor.

7.2.2. Red light district exploratory factor analysis

For the RLD case, the same analysis is performed, only one extra variable was included in the survey; the experience of Crowdedness. This additional variable is included in this analysis as well. Table 7.5 shows the results of the initial test. In this case, not all factor loadings are higher than 0.5. Furthermore, there are cross loadings present for experienced Crowdedness. Since Crowdedness seems to have the least connection to the rest, another exploratory factor analysis is performed, excluding this variable. Furthermore, experienced Crowdedness was excluded, after another test showed that the loadings of Experienced Crowdedness are too low on all factors to be included as an indicator for a latent variable.

Table 7.5: RLD Exploratory factor analysis: 5 perceptions and 1 experience included

Rotated factor matrix			
	Factor 1	Factor 2	Factor 3
P. Crowdedness			-0.371
P. Safety		0.574	
P. Comfort	0.308	0.867	
P. Attractiveness	0.722		
P. Atmosphere	0.842	0.350	
Exp. Crowdedness	0.378		0.371
Variance explained	52.724%		

Table 7.6: RLD Exploratory factor analysis: 4 perceptions included

Rotated factor matrix		
	Factor 1	Factor 2
P. Safety		0.663
P. Comfort		0.780
P. Attractiveness	0.738	
P. Atmosphere	0.828	0.357
Variance explained	64.522%	

Table 7.6 illustrates that two factors explain 64.5% of the variance. Perceived Safety and Comfort both load high only on factor 2. Perceived Attractiveness and Atmosphere both load high on factor 1. Perceived Atmosphere also loads on factor 2, but this loading is very low and the difference in loading on the two factors is quite high. Therefore, it is chosen to use the same construct as the TT Festival case.

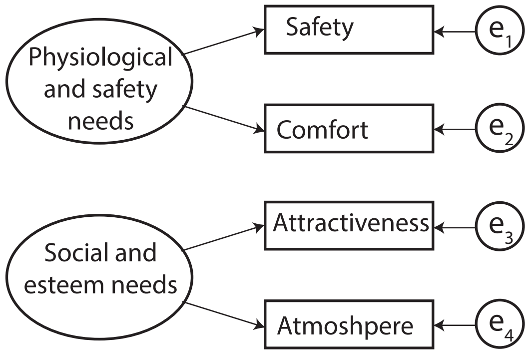

Figure 7.7: Exploratory factor analysis: resulting factor construct

7.2.3. Discussion

This analysis shows that perceived Crowdedness is different from the other perceptions in both case studies. This is important, because it learns us that the other perceptions are influenced in other ways by the explanatory factors.

Both in the TT Festival case and the RLD case, two latent factors can be extracted. This can be interpreted in the following way: Factor 2 connects perceived Safety and perceived Comfort. Both of these variables concern a person's physical experience of a crowd. In Maslow's pyramid (McLeod, 2007), they correspond to a person's most basic needs: Physiological and Safety needs. Factor 1 connects perceived Atmosphere and perceived Attractiveness. Both of these perceptions give an indication of how a person perceives an event and the crowd present. This corresponds to the higher levels of the pyramid: Social and esteem needs.

In the SEM model, the latent variables will be constructed as presented in Figure 7.7.

7.3. Bi-variate analysis results: Correlations and z-scores

The complete bi-variate analyses can be found in Appendix H and K. Here, an overview of the correlations and z-scores found in this analysis are presented in a Table 7.7 and 7.8 and Figure 7.9 and 7.10. Only significant correlations are included in the tables. In this section, the resulting correlations are interpreted. Please note, one-on-one correlations might not always show the pure effect of a variable. Additionally, this section determines which factors will be used in the models, based on the outcomes of this analysis.

7.3.1. TT Festival bi-variate results

The correlations presented in Table 7.7 are discussed per category in this section.

7.3.1.1 Correlations between perception variables

Table 7.7 indicates that several of the perception variables are correlated. However, perceived Crowdedness is not significantly correlated with Safety and Comfort. This could mean that Safety and Comfort are less related to perceived Crowdedness than expected or that the crowdedness was never that high that Safety and Comfort were negatively effected. Or, the survey question formulation was not specific enough. Perceived Crowdedness and perceived Attractiveness and Atmosphere are positively correlated, which confirms the hypothesis. Perceived Safety and Comfort are strongly correlated, as well as perceived Attractiveness and Atmosphere. This corresponds with the findings in Section 7.2.

7.3.1.2 Correlations with socio-demographics

In the category socio-demographics, the hypothesis that woman perceive Safety lower than men is confirmed by the bi-variate analysis. This could be explained by the difference in physical height between men and women, or by the different experience of social safety. Other than that, no significant differences between gender was found. For age, no correlations were found. This was unexpected, since it was hypothesised that younger people would have a more positive perception. The fact that the TT Festival is an event for all ages, where many groups consisted of people from different age categories could explain why no difference is found. Additionally, no relation between urbanisation level and perception was found. Based on this result, the hypothesis that a higher urbanisation level of a person's place of residence leads to a higher perception of

Table 7.7: Correlations and z-scores: TT Festival. Positive correlations in bold font

	P. Crowdedness	**P. Safety**	**P. Comfort**	**P. Attractiveness**	**P. Atmosphere**
P. Crowdedness				**τ = 0.150 p = 0.003**	**τ = 0.201 p = 0.000**
P. Safety			**τ = 0.342 p = 0.000**		
P. Comfort		**τ = 0.342 p = 0.000**		**τ = 0.190 p = 0.000**	**τ = 0.136 p = 0.009**
P. Attractiveness	**τ = 0.150 p = 0.003**		**τ = 0.190 p = 0.000**		**τ = 0.460 p = 0.000**
P. Atmosphere	**τ = 0.201 p = 0.000**		**τ = 0.136 p = 0.009**	**τ = 0.460 p = 0.000**	
Male		**z = 2.339 p = 0.019**			
Age					
Urbanisation level residence					
Foreign		**z = 2.961 p = 0.003**	**z = 2.163 p = 0.032**		
Visit Assen					
Visit Event	τ = -0.182 p = 0.001				
Purpose: Leaving	**z = 3.283 p = 0.000**		z = -2.084 p = 0.021		
Group size	**τ = 0.167 p = 0.002**		τ = -0.104 p = 0.037		**τ = 0.113 p = 0.027**
Group type					
Group composition: male vs female		**z = 2.642 p = 0.025**			
Pleased					
Activated			**z = 2.340 p = 0.009**		
Substances					
Time spent	**τ = 0.100 p = 0.030**				
Time of day	**τ = 0.352 p = 0.000**	τ = -0.184 p = 0.001	τ = -0.163 p = 0.003		**τ = 0.115 p = 0.040**
Time of week	H(2)= 6.157 p = 0.046				
Location: Markt vs Kermis				**z = 3.419 p = 0.002**	
Light intensity	τ = -0.349 p = 0.000			τ = -0.111 p = 0.043	τ = -0.164 p = 0.004
Sound intensity	**τ = 0.194 p = 0.000**				
Music type: headliner vs background		z = -2.004 p = 0.043			
Temperature	τ = -0.319 p = 0.000	**τ = 0.173 p = 0.002**	**τ = 0.122 p = 0.022**		τ = -0.162 p = 0.003
Weather type: Sunny vs clear	z = -4.849 p = 0.000	**z = 2.445 p = 0.007**	**z = 2.146 p = 0.016**		z = -2.093 p = 0.019

Crowdedness and a lower perception of Safety and Comfort cannot be confirmed. A reason for this result can be that perception of event crowdedness and urban crowdedness are based on separate habituation for event crowdedness and urban crowdedness. However, another reason for this result can be that the method of determining the urbanisation level is not sufficient, which will be further discussed in Chapter 8. Foreigners perceive Safety and Comfort higher, while the other perceptions are not significantly influenced by country of residence. This result could be explained by the fact the foreign people perceive Dutch events well-organised.

7.3.1.3 Correlations with personal state & trip factors

In the category Personal state & trip factors several correlations were found. The factor *Visit Event* correlates negatively with perceived Crowdedness. The factor *Visit Assen* is uncorrelated to the perception variables. This seems to indicate that people compare the level of Crowdedness to previous events or the previous day, but not to the normal Crowdedness in the city when there is no event. An urgent purpose, which included going home or going to the train station, has a positive correlation with perceived Crowdedness and a negative relation with Comfort. *Group size* correlates positively with perceived Crowdedness and perceived Atmosphere, but negatively with perceived Comfort. This differs from the hypothesis, but it can possibly be explained as follows: With a larger group, it is more difficult to stay together, because of the level of crowdedness. Therefore, Crowdedness is perceived to be higher and level of Comfort is lower. *Group type* did not yield any significant relations. *Group composition* did show a significant difference between groups of only men and only women. Groups of men perceive Comfort higher than groups of women. The answers regarding emotional state are split up in two binary variables; *Pleased* (yes/no) and *Activated* (yes/no). A relation between being activated and perceived Comfort was found. This results fits the hypothesis, however, it is surprising that this is the only correlation found. Substance usage (such as alcohol) is not significantly correlated with any of the perception variables. *Time spent* has a weak positive correlation with perceived Crowdedness. This is probably caused by the actual crowdedness that is higher later in the evening. Unexpectedly, *Time Spent* is not significantly correlated with Comfort.

7.1.3.4 Correlations with Event & Environment factors

In the category Event & Environment factors, *Time of day* has a strong positive correlation with Crowdedness, a moderate positive correlation with perceived Atmosphere and a moderate negative relation with perceived Safety & Comfort. For Crowdedness, this is assumed to be caused by the actual level of crowdedness. For Safety and Comfort, it fits the hypothesis that these are perceived lower at night. The variable *Time of week* distinguishes the three evenings that are researched. The result shows that Thursday was perceived to be the most crowded, Friday was perceived to be a bit less crowded and Saturday was perceived to be the least crowded. This could be explained by two things. One, since the layout of the event was different Thursday, the actual crowdedness per location was different. On Thursday, there were only five stages, while on Friday and Saturday, there were ten. The number of visitors might have been higher on Friday and Saturday, but the visitors were spread over a larger area. The second explanation is that most people seem to visit the event every evening and consequently get used to the crowdedness.

For the three locations where the survey was conducted, there was a significant difference for the perceived Attractiveness of the environment between the *Markt* and the *Kermis* location, where the location *Markt* was perceived more positively. As the *Markt* location had a very attractive view of a lighted Ferris wheel and also was a nicely decorated residing area, this is a logical result. Accordingly, the variable *Location* needs to be included in the SEM.

Furthermore, light and sound data was gathered. *Light intensity* correlates negatively with perceived Crowdedness. Furthermore, light intensity has a negative correlation with perceived Attractiveness & Atmosphere. This is all assumed to be caused by the effect of sunlight. The light measurements after nightfall gave no accurate measurements. Therefore, light intensity will not be taken into account in the model. *Sound intensity* and perceived Crowdedness are positively correlated, which corresponds to the hypothesis that noises increase the perceived Crowdedness. However, the correlation could also be explained by *time of day*. The music may have been louder in the evening. *Music type* was tested as well. A distinction between background music and headliners was made. Headliner music has a negative relation with perceived Safety. A reason for this could be because there is more movement towards the stage when a headliner is playing. It is chosen to take only sound intensity account in the SEM, because this correlation is strong and has a logical explanation.

Finally, the weather related variables are discussed. *Temperature* relates to perceived Crowdedness and Atmosphere negatively. This can be explained by the actual level of crowdedness. *Temperature* correlates positively with perceived Safety and Comfort, which is probably because of the difference between daytime and nighttime. Thus, temperature itself probably does not have much influence in this research. Finally the variable *Weather type* is reviewed. Since the weather during the whole event was constantly sunny, the variable *Weather type* only distinguishes two categories: sunny (day) and clear (night). Daytime correlates positively with Safety & Comfort, which confirms that the difference between day- and nighttime relates to the perception of Safety & Comfort. Hence, the factor *Weather type* will be included in the model.

To conclude, the results of the bi-variate analysis for the TT Festival justify that the following factors will be taken into account in the SEM model: Male, Foreign, Visit Event, Purpose, Group size, Group composition, Activated, Time spent, Sound intensity and Weather type. These factors have a significant and logical relation to the perception variables.

7.3.2. Red light district bi-variate results

The correlations presented in Table 7.8 are discussed per category below.

7.3.2.1 Correlations between perception variables

The correlations between the perception variables show that perceived Crowdedness is only correlated with the Experience of Crowdedness. This correlation is negative, which seems logical, as higher levels of Crowdedness lead to a less pleasant experience of the Crowdedness. It is quite unexpected that there are no other correlations with perceived Crowdedness. This could indicate that people, in the case of the Red light district, do not relate Safety, Comfort, Attractiveness of the environment and Atmosphere to the number of people present. It could also be caused by the survey question formulation, which will be further discussed in Chapter 8. Other than that, all perception variables are strongly positively correlated with each other. Safety & Comfort and Attractiveness & Atmosphere have the highest correlations, which is in line with the results from Section 7.2.

7.3.2.2 Correlations with Socio-demographics

In the category socio-demographics, several correlations are established. First of all, being a male correlates positively with perceived Safety and perceived Attractiveness. This could both be explained by the difference in physical height. Furthermore, women might also feel less safe overall as the environment of the Red light district is aimed at men. *Age* correlates positively with perceived Crowdedness and negatively with perceived Attractiveness and Atmosphere. This fits with the hypothesis identified in Section 3.2. Foreigners perceive a lower level of Crowdedness, but do perceive Safety, Comfort, Attractiveness and Atmosphere higher. It was expected that tourists would have a more positive perception. However, it was also expected that they would perceive the Crowdedness of the Red light district as higher, because they are unfamiliar with the Red light district. Amsterdammers, perceive a lower Atmosphere and experience a more unpleasant the level of crowding, compared to other Dutch citizens. This is logical, because other Dutch citizens probably have a recreational purpose, while Amsterdammers often have an urgent purpose. For the SEM, it is useful to include both the distinction between foreigners and Dutch citizens and the distinction between Amsterdammers and Dutch citizens, to capture the differences between these groups best.

7.3.2.3 Correlations with Personal state & Trip factors

For the personal state and trip factors, many significant correlations are found. To begin, visiting Amsterdam more often correlates negatively with all perception variables and Experience of Crowdedness. This corresponds to the hypothesis that unfamiliar people think Crowdedness is higher, but still perceive the other crowdedness related perceptions more positive. The variable *Visit Wallen* correlates negatively with perceived Attractiveness & Atmosphere. Since *Visit Amsterdam* affects more of the perception variables, this variable will be included in the model.

Next, the variable *Purpose* is discussed. Having an urgent purpose (train station, home/hotel, work) correlates negatively with all perception variables other than perceived Crowdedness. It is logical that a person experiences the crowd as more unpleasant. However, is was expected that this would also influence the perceived Crowdedness. Furthermore, there was no hypothesis concerning trip purpose and perceived Safety and Comfort. It seems as though people with a specific purpose tend to be more negative overall.

Table 7.8: Correlations and z-scores: Red light district. Positive correlations in bold font

	P. Crowded.	P. Safety	P. Comfort	P. Attractiveness	P. Atmosphere	Exp. Crowded.
P. Crowdedness						τ = -0.144 p = 0.012
P. Safety			**τ = 0.499 p = 0.000**	**τ = 0.203 p = 0.001**	**τ = 0.254 p = 0.000**	**τ = 0.245 p = 0.000**
P. Comfort		**τ = 0.499 p = 0.000**		**τ = 0.310 p = 0.000**	**τ = 0.446 p = 0.000**	**τ = 0.360 p = 0.000**
P. Attractiveness		**τ = 0.203 p = 0.001**	**τ = 0.310 p = 0.000**		**τ = 0.575 p = 0.000**	**τ = 0.317 p = 0.000**
P. Atmosphere		**τ = 0.245 p = 0.000**	**τ = 0.446 p = 0.000**	**τ = 0.575 p = 0.000**		**τ = 0.377 p = 0.000**
Exp. Crowdedness	τ = -0.144 p = 0.012	**τ = 0.254 p = 0.000**	**τ = 0.360 p = 0.000**	**τ = 0.317 p = 0.000**	**τ = 0.377 p = 0.000**	
Male		**z = 1.978 p = 0.025**		**z = 1.853 p = 0.032**		
Age	**τ = 0.115 p = 0.038**			τ = -0.186 p = 0.002	τ = -0.116 p = 0.035	
Foreign	z = -1.753 p = 0.042	**z = 2.787 p = 0.005**	**z = 3.795 p = 0.000**	**z = 2.328 p = 0.010**	**z = 2.311 p = 0.010**	
Amsterdammer					z = -1.977 p = 0.026	z = -2.160 p = =.016
Visit Amsterdam	τ = -0.136 p = 0.019	τ = -0.128 p = 0.026	τ = -0.129 p = 0.022	τ = -0.152 p = 0.009	τ = -0.157 p = 0.008	τ = -0.169 p = 0.004
Visit Wallen				τ = -0.113 p = 0.043	τ = -0.144 p = 0.015	
Purpose		z = -2.080 p = 0.019	z = -1.688 p = 0.046	z = -2.528 p = 0.006	z = -1.977 p = 0.024	z = -3.147 p = 0.001
Group size			τ = -0.165 p = 0.006			
Group type: Colleagues vs Friends	z = -3.534 p = 0.006					
Group type: Colleagues vs Couple	z = -3.604 p = 0.005					
Group composition						
Pleased		**z = 2.477 p = 0.013**	**z = 3.428 p = 0.001**	**z = 2.469 p = 0.014**	**z = 2.959 p = 0.003**	
Activated				**z = 2.086 p = 0.037**		
Substances: Marijuana		**z = 2.342 p = 0.019**	**z = 2.435 p = 0.015**	**z = 3.489 p = 0.000**	**z = 2.961 p = 0.003**	
Time of day	**τ = 0.174 p = 0.007**					
Date	**H(2)= 26.580 p = 0.000**					
Location						
Sound intensity			**τ = 0.149 p = 0.006**	**τ = 0.119 p = 0.022**		
Temperature	τ = -0.300 p = 0.000					
Weather type: Clear vs rainy	z = -4.387 p = 0.000					

Group size only has a negative relation to perceived Comfort. This is contradicting the hypothesis, but is agreeing with the results of the TT Festival. For *Group type*, it seems like a group of Colleagues perceive Crowdedness significantly lower than a group of friends or a couple. This could be because a group of Colleagues have another (recreational) trip purpose or because they are more familiar to the crowdedness.

The emotional state *Pleased* relates positively to perceived Safety, Comfort, Attractiveness and Atmosphere. This fits the hypothesis that positive emotions relate to a positive perception of crowd related variables. Since it affects many perception variables, it will be included in the model. Being *Activated* only correlates with perceived Attractiveness. This might be a causal relation where the perception of the environment causes a higher level of activation. Therefore, this variable will not be included as a predictor in the SEM.

Again, no relation between alcohol usage and the perception variables is found, which is unexpected. This confirms the suspicion that the survey question formulation might not have been sufficient. However, for Marijuana usage, a significant relation was found for Safety, Comfort, Attractiveness and Atmosphere. Marijuana users have a more positive perception, probably because they have a recreational purpose.

7.3.2.4 Correlations with Event & Environment factors

For the Red light district case, *Time of day* is only correlated with perceived Crowdedness. This seems quite logical for this data, since Section 7.1 illustrated that perceived Crowdedness was the only perception that was correlated with measured crowdedness. For the time of day during which the research was performed (between 19:00-22:30), most other Event & Environment factors did not change drastically. For the three different evenings, the 27^{th} of October was the most crowded, followed by October 19^{th}. For perceived Crowdedness, the distinction between the dates is in the same order of actual crowdedness. Therefore, this variable is explained away by actual crowdedness and does not have to be included in the model.

No results for the variable *Location* were found, meaning that the three locations researched were not perceived differently. This can be explained by the fact that the locations are quite close to each other and are all walking areas rather than residing areas.

Sound intensity correlates positively with perceived Comfort and Attractiveness. This will not be included in the SEM model, because it is not in line with the hypothesis. Furthermore, the measurement method was not trustworthy, which will be further discussed in chapter 8.

Temperature correlates negatively with perceived Crowdedness, which is again explained away by the measured Crowdedness. For weather type, a strong negative relation between rainy weather and perceived Crowdedness is found. This will be included in the model as a control factor for measured crowdedness, since it only rained on one day and this day was noticeably less crowded.

To conclude, the factors Gender, Age, Foreign, Amsterdammer, Visit Amsterdam, Purpose, Group size, Group type, Pleased, Activated, Marijuana and Rain have significant and understandable relations to the perception variables. Therefore, they will be used in the SEM model.

7.4. Discussion preliminary analysis

For the measured crowdedness, the variables that have the strongest correlation with perceived Crowdedness are the local Wi-Fi counts with a 15-minute moving average for the TT Festival, the global Wi-Fi counts with a 60-minute moving average for the Red light district and the camera counts with a 15-minute moving average for both events. A 15-minute moving average seems to capture the perception of pedestrians well overall, which indicates that this is a good time window to adopt for measuring crowdedness.

From the exploratory factor analysis, it can be concluded that in both cases, Perceived Safety & Comfort can be seen as indicator of one latent factor, which corresponds to physiological and safety needs. Perceived Attractiveness & Atmosphere can combined into one latent factor as well, corresponding to a person's social and esteem needs.

Based on the theoretical framework 3.2, hypotheses were tested with bi-variate data analysis techniques (Appendix D). These preliminary results give an indication of the relations that will be found in a model. All the variables included in the hypotheses that were confirmed by the bi-variate analysis will be added to the SEM model. When a significant relation was found that was not hypothesised, but can be logically interpreted, it is included as well. Data which seems unreliable, such as the light intensity data, is not included.

In Figure 7.9 and 7.10, the significant and relevant relations found in the bi-variate analysis for respectively the TT Festival and de Red Light District are shown. On one line, all the predictors for one perception variable are stated. For example, in Figure 7.9, *Group size*, Wi-Fi counts and Camera counts are significantly correlated with perceived Atmosphere.

A comparison between the events shows that although many of the same predictors are significantly related to one of the perception variables, the relations are not the same. For example, *Group size* is significantly correlated with perceived Crowdedness, Atmosphere and Comfort for the TT Festival, while at the Red light district, it is only correlated with Perceived Comfort. Moreover, in the Red light district case, perceived Crowdedness is less connected to the other perception variables and quantified crowdedness is only related to perceived Crowdedness. This could be caused by contradicting answers of tourists and residents, as illustrated in Table 7.9. The data indicates that tourists give similar answers to all the perception variables (mode 4/5 for all), while Amsterdammers think it is more crowded and less pleasant in every way. However, the number of respondents who lived in Amsterdam was too low to give a representative view of their perception.

Table 7.9: RLD: Most given answer perception, comparison Amsterdammer (yes/no)

Variable	Other N =171	Amsterdammers N=11
P. Crowdedness	4 Crowded	5 Very Crowded
P. Safety	4 Safe	4 Safe
P. Comfort	4 Comfortable	1 Very uncomfortable
P. Attractiveness	4 Attractive	3 Neutral
P. Atmosphere	4 Good Atmosphere	2 Bad Atmosphere
Exp. Crowdedness	4 Pleasant	3 Neutral

Figure 7.8 shows the mean of Experience of Crowdedness for every rank of Crowdedness. The means are split for foreigners and Dutch citizens. The figure shows that for foreigners, the relation between Perceived and Experienced Crowdedness is less pronounced. The mean experience of Crowdedness is the highest for an average perceived Crowdedness (3/5). This seems to fit the hypothesis that people think an event should be crowded, but not too much so. For Dutch citizens, the Experience of Crowdedness increases as the perceived Crowdedness decreases.

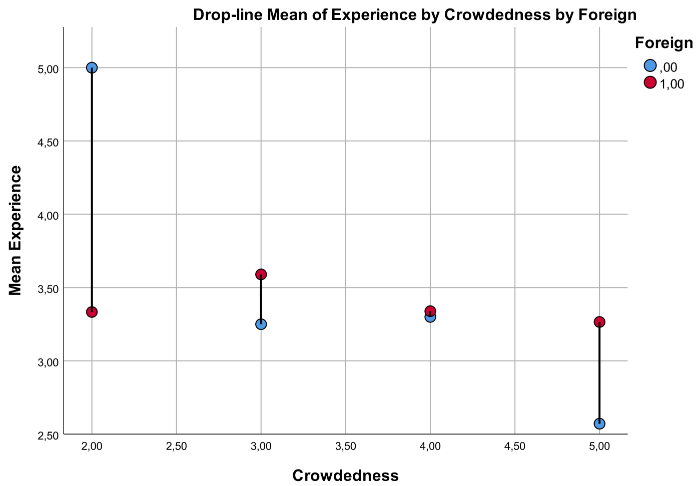

Figure 7.8: RLD: Mean Experienced Crowdedness by Crowdedness, split for Foreign (yes/no)

The missing connection between perceived Crowdedness and the other perceptions might lead to complications while building a combined model. However, in Chapter 6 it was explained that some relations might not be found with bi-variate analysis, but can be found with indirect effects in a SEM.

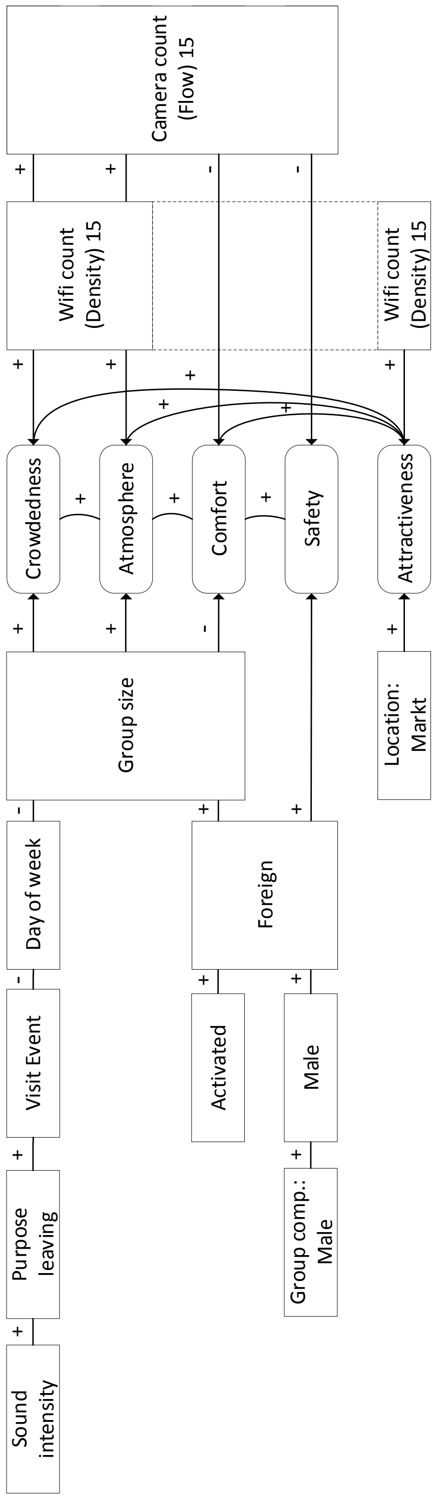

Figure 7.9: TT Festival: significant and relevant correlations

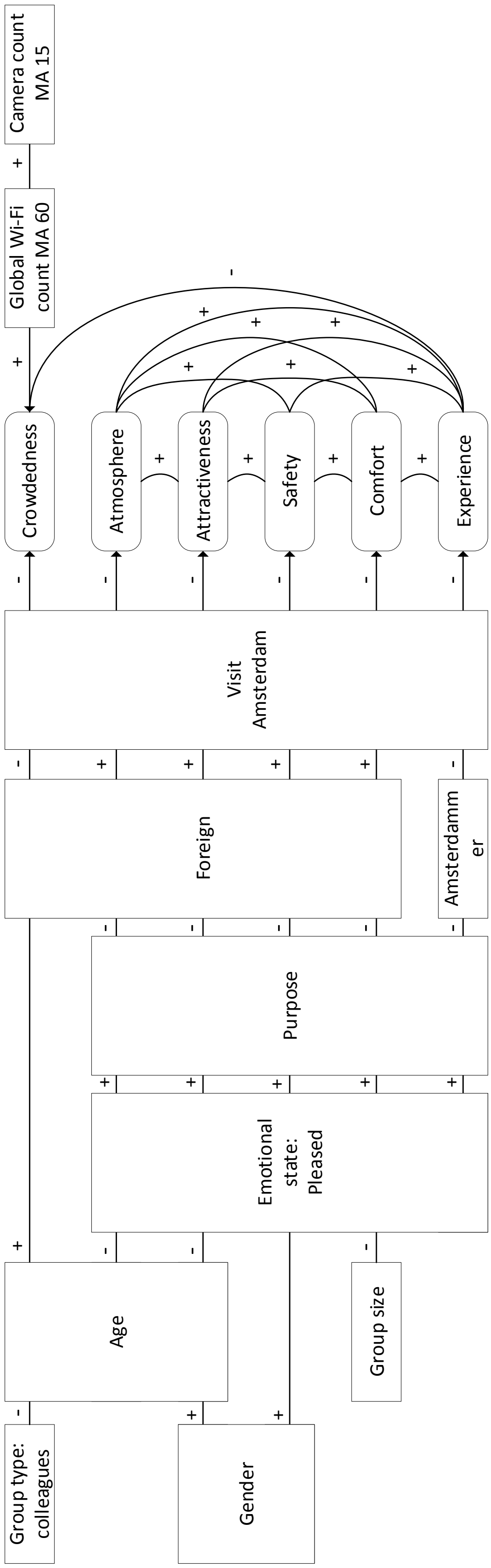

Figure 7.10: Red light district: significant and relevant correlations

7.5. Structural Equation Models

In this section, the Structural equation models for both events are presented. The modelling steps from Chapter 6 were followed to come to these models. The intermediate models can be found in Appendix C.

7.5.1. TT Festival best fit

In Figure 7.11, the final model for the TT case is presented. This is a visualisation of the SEM model that has been edited to be more easily interpreted. The AMOS visualisation can be found in Appendix C.

As can be seen, not all of the significant correlations from Figure 7.9 are included in this final model. They have been tested in a SEM, as can be seen in Appendix C. However, the relations between these predictors and the perception variables was not significant, controlled for the other factors that are included in the model. For example, *Time spent* did not have a direct relation to the perception variables. *Gender*, *Group size* and *Sound intensity* were insignificant compared to the other variables. The variable *Isdaytime* had some problems with multicollinearity.

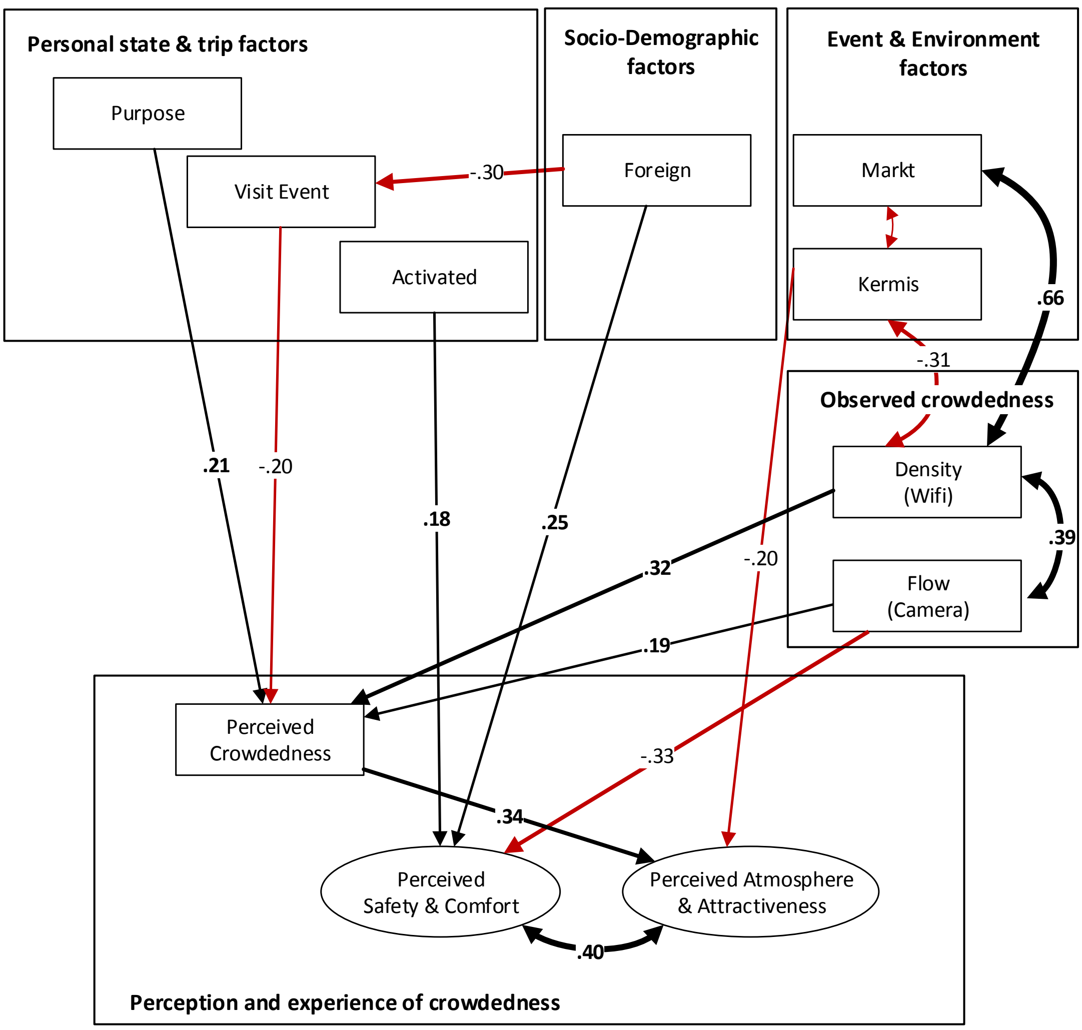

Figure 7.11: TT final model: Visual representation. Line thickness represents strength of the relation. A straight line with one arrow is a causal path, a curved line with two arrows is a correlation. A red line stands for a negative relation, a black line for a positive one. Oval shapes are latent variables.

Model fit

All the paths presented in Figure 7.11 are significant. Table 7.10 provides the model fit indicators hat were chosen in Chapter 6. As can be seen, most indicators are sufficient. The p-value is far above 0.05, which confirms the null hypothesis is that the SEM model fits the covariance matrix of the individual relations. Only the PCFI is not sufficient, which indicates that the model could be more parsimonious, for example by eliminating more variables or paths. However, in the view of the researcher, the model is sufficiently parsimonious. Eliminating more paths or variables would lead to a loss of information.

Table 7.10: TT model: Model fit indicators

Indicator	N	χ^2	**p-value**	**df**	χ^2/df	**GFI**	**CFI**	**PCFI**	**RMSEA**	**PCLOSE**
Boundary condition	-	low	>0.05	-	<2	>0.9	>0.9	>0.8	<0.1	>0.05
Model TT	194	72.394	0.113	59	1.227	-	.966	.626	.034	.840

Looking at Table 7.11, it can be concluded that 27% of the variance of the perceived Crowdedness is explained. In Section 7.1, we saw that Wi-Fi counts alone could explain 18% of the variance of perceived Crowdedness. Including more variables has improved the understanding of perceived Crowdedness substantially. Furthermore, Table 7.11 gives an overview of the total standardised effects of the predictor variables on the perception variables. These are the different causal paths that can be followed from one variable to the other. In this table, the latent variables are split up again.

Table 7.11: TT model: Total standardised effects

	Dependent				
Independent	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Foreign	0.060	0.181	0.139	0.014	0.014
Camera count MA 15	0.191	-0.240	-0.185	0.045	0.044
Wi-Fi count MA 15	0.322			0.075	0.074
Visit_event	-0.199			-0.046	-0.046
Purpose	0.206			0.048	0.048
Activated		0.130	0.100		
Kermis				-0.135	-0.134
Crowdedness				0.233	0.231
P. Safety & Comfort		0.721	0.555		
P. Attractiveness & Atmosphere				0.691	0.686
Explained variance %	27%	51.9%	30.8%	47.7%	47.1%

In the visualisation (Figure 7.11), causal paths, indirect relations and correlations are visible. These will be explained per category.

Perception variables

As can be seen in Figure 7.11, perceived Safety & Comfort and Perceived Atmosphere & Attractiveness are included in the model as latent variables. These two variables have to strong correlation with each other (β = .40). Perceived Crowdedness has a causal relation to perceived Atmosphere & Attractiveness (β = .34). This relation is modelled as causal, because this increased the model fit. Hence, a this causal relation shows that pedestrians that visit an event first form their perception of crowdedness. Based on this perception, perceived Attractiveness and Atmosphere are assessed. There is no direct relation between perceived Crowdedness and perceived Safety & Comfort in this model. However, through the path of perceived Attractiveness and Atmosphere, there is a correlation ($I = 0.40 \cdot 0.34 = .136$). This correlation is positive, because higher Crowdedness lead to a higher perceived Atmosphere and a high perceived Atmosphere is correlated with a high perceived Safety & Comfort. Based on this model, it cannot be concluded that perception of Crowdedness influences perception of Safety & Comfort. It is found that they are correlated in the SEM model, which was not found in the bi-variate analysis.

Quantified crowdedness

To represent crowdedness, 15-minute Wi-Fi counts and 15-minute camera counts are included in the model. They correspond to the macroscopic flow variables *Density* and *Flow*. The camera counts have a large chunk of missing data, because there was no counting camera at the *Markt* location. Therefore, the model was tested without this variable as well. However, including the camera counts leads to a higher percentage of explained variance as well as a higher model fit.

Wi-Fi counts and camera counts are strongly correlated ($\beta = 0.39$), which is the relation that can be illustrated in a fundamental diagram. For perceived Crowdedness, the strongest predictor is the Wi-Fi counts ($\beta = 0.322$). However, the camera counts provide a significant contribution to explaining perceived Crowdedness as well, controlled for the Wi-Fi counts. This means that these variables both explain an aspect of perceived Crowdedness. The Wi-Fi counts explain the number of people that is perceived in proximity. The camera counts explain the perceived Crowdedness related to the movements of the crowd and the ease of movement. Analysing them together increases the percentage of explained variance. Perceived Comfort & Safety are influenced strongly by the camera counts ($\beta = -.33$). This shows that more movement around an individual lowers their perceived Safety & Comfort. Perceived Atmosphere & Attractiveness is indirectly influenced by the Wi-Fi counts ($I = .108$) and camera counts ($I = .064$) through perceived Crowdedness.

Socio-demographic, personal state & trip factors

Just as was expected from the correlations, purpose influences perceived Crowdedness. The emotional state *Activated* influences the perception of Safety & Comfort. This shows that being in an active, happy state of mind makes a person's perception of Safety & Comfort more positive too. In this model, emotional state does not directly influence perceived Attractiveness & Atmosphere. This is an unexpected result, which is assumed to be caused by the survey question formulating.

Next, familiarity is discussed. As can be seen in the model, being foreign influences perceived Safety & Comfort positively, as was seen in the bi-variate analysis. Also, *Visit Event* influences perceived Crowdedness negatively, which was concluded from the bi-variate analysis as well. However, there is also an indirect path from *Foreign* through *Visit Event* to perceived Crowdedness. This shows that foreign people have visited the event on average less often compared to Dutch citizens. Consequently, they perceive Crowdedness slightly higher. *Gender* and *Group size* were eliminated from the SEM, because compared to the other factors, their influence on the perception variables was insignificant.

Event & Environment factors

In the model, the dummies *Markt* and *Kermis* are visible. The third location, *Koopmansplein* is not visible in the model, because with modelling categories, the number of dummies included should always be N-1. The paths from *Markt* and *Kermis* to the perception variables show the strength of the relation relative to the location *Koopmansplein*. The location *Kermis* has a negative impact on perceived Attractiveness & Atmosphere ($\beta = -0.20$) compared to the location *Koopmansplein*. Since there is no path from *Markt* to perceived Attractiveness & Atmosphere, there is no difference in perception between these two locations. The correlation between *Markt* and Wi-Fi counts shows that this location was more crowded compared to *Koopmansplein* and even more crowded compared to the *Kermis*.

Sound intensity was eliminated from the SEM, because compared to the other factors, its influence on the perception variables was not significant. Furthermore, the binary value for day or nighttime had some problematic effects on the model.

7.5.2. Red light district best fit

In Figure 7.12, the final model for the RLD case is presented. This model has been edited to be more easily interpreted, the AMOS visualisation can be found in Appendix C. As can be seen, not all of the significant correlations from Figure 7.9 are included in this model. They have been tested in a SEM, as can be seen in Appendix C, but were not found significant controlled for the other variables. The model seems more complex than the TT model. This is caused, among other things, by the dummies for group type that were included. Moreover, more predictors seem to have an effect on the perception variables in this case. To increase the readability of this model, different parts will be highlighted in this section.

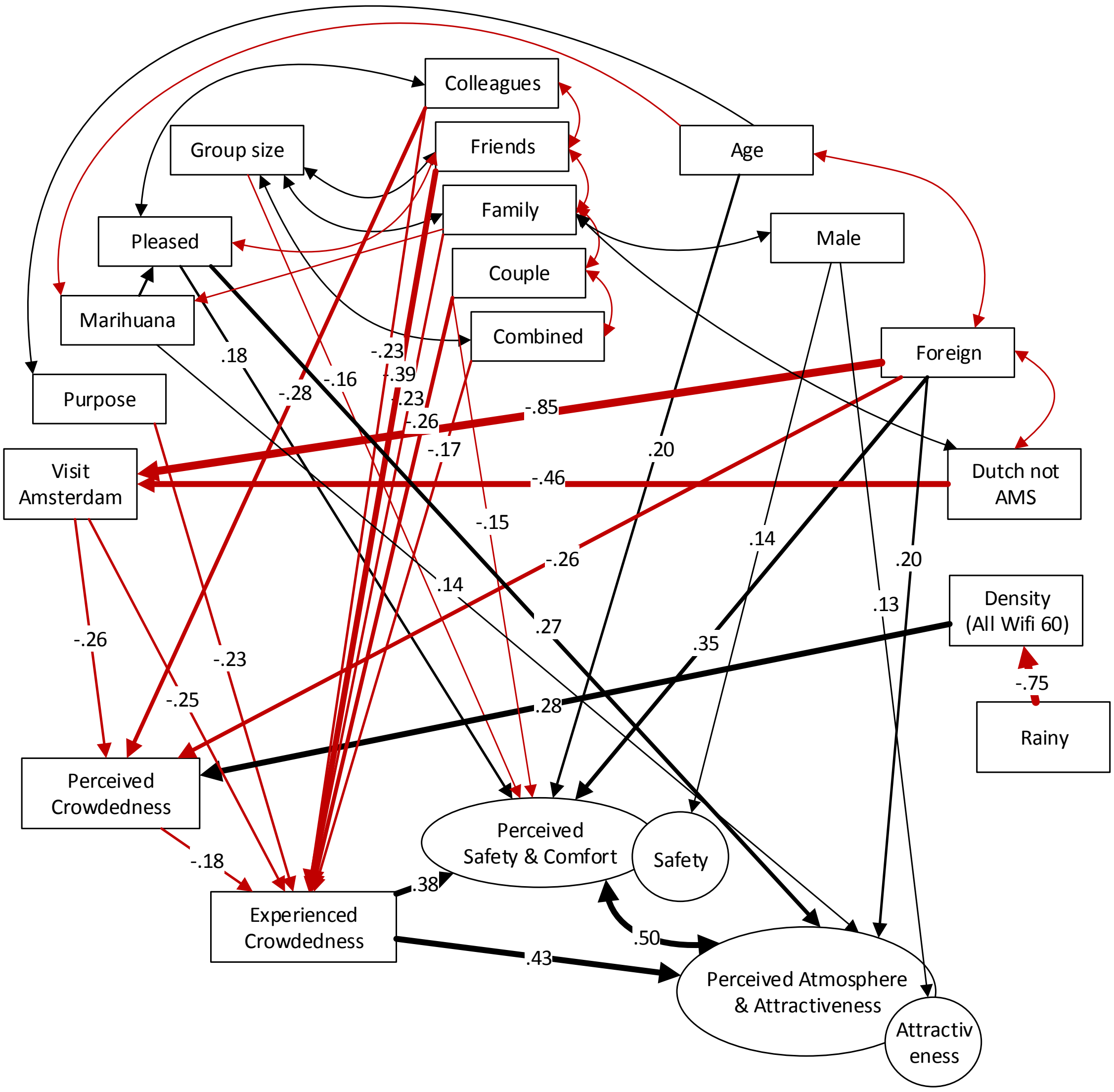

Figure 7.12: RLD final model: A visual representation. Line thickness represents strength of the relation. A straight line with one arrow is a causal path, a curved line with two arrows is a correlation. A red line stands for a negative relation, a black line for a positive one. Oval shapes are latent variables.

Model fit

In Table 7.12, the model fit indicators for the final model are presented. The model fit is very good. The p-value is far above 0.05. However, the Chi-square value is much higher than for the TT Festival. This means that there is more difference between the observed covariance matrix and the reproduced covariance matrix compared to the TT model. The PCFI for this model is higher than that of the TT, while the RLD model certainly does not look more parsimonious. However, since other fit indices have such a high score, the penalty for model complexity apparently does not outweigh the achieved goodness of fit.

Table 7.12: model RLD: model fit indicators

Indicator	N	χ^2	**p-value**	**df**	χ^2/df	**GFI**	**CFI**	**PCFI**	**RMSEA**	**PCLOSE**
Boundary condition	-	low	>0.05	-	<2	>0.9	>0.9	>0.8	<0.1	>0.05
Result	182	192.19	0.221	178	1.08	.918	.988	.761	.021	.997

Looking at Table 7.13, it can be read that 22.3% of the variance of perceived Crowdedness is explained. This is lower than the explained variance in the TT case. This is understandable when looking at Table 7.13. There are only a few variables that influence perceived Crowdedness.

Table 7.13: model RLD: total standardised effects

	Dependent					
Independent	Crowdedness	Experience	Safety	Comfort	Attractiveness	Atmosphere
Foreign	-0.039	0.222	0.275	0.408	0.213	0.276
Dutch_not_AMS	0.117	0.095	0.022	0.033	0.029	0.038
Age		-0.042	0.103	0.152	-0.043	-0.056
Gender			0.140		0.132	
WifiC15	0.246	-0.044	-0.010	-0.015	-0.013	-0.017
Visit_Amsterdam	-0.256	-0.207	-0.049	-0.073	-0.064	-0.083
Purpose		-0.230	-0.081	-0.119	-0.089	-0.116
Pleased			0.167	0.248	0.115	0.149
Combined		-0.165	-0.039	-0.058	-0.051	-0.067
Couple		-0.263	-0.155	-0.229	-0.082	-0.106
Family		-0.229	-0.058	-0.087	-0.091	-0.117
Friends		-0.392	-0.093	-0.138	-0.122	-0.158
Colleagues	-0.281	-0.183	-0.043	-0.064	-0.057	-0.074
Group_size			-0.098	-0.146		
Marijuana			0.025	0.036	0.116	0.150
Crowdedness		-0.176	-0.042	-0.062	-0.055	-0.071
Experience			0.238	0.352	0.311	0.402
PS & PCom			0.629	0.931		
PA & PAE					0.719	0.929
Explained variance %	22.3%	18.4%	41.6%	86.7%	53.7%	86.3%

Perception variables

As can be seen in the model, the construct of the perception variables is different than for the TT case. The main difference is the Experience of Crowdedness that is added to the model. Figure 7.13 shows that without this variable, it would not have been possible to connect Perceived Crowdedness to the other perception variables. What we see, it that there is a moderate negative relation between how crowded people think the district is and how pleasant they experience that level of Crowdedness. The reason this relation is not stronger is because many visitors still perceive the number of people as pleasant. The relation in reality is expected to be stronger, but it is not linear. The relation between experienced Crowdedness and the other perception variables is very strong, meaning that the more pleasant the Crowdedness is perceived, the higher levels of Safety e.g. are perceived. Through experienced Crowdedness, the effect of perceived Crowdedness on perceived Safety & Comfort is $I = -0.18 \cdot 0.38 = -0.068$ and the effect on perceived Attractiveness & Atmosphere is $I = -0.18 \cdot 0.43 = -0.077$.

Quantified Crowdedness

For measured crowdedness, only the global Wi-Fi counts are included in the model. In intermediate versions of the model, camera counts were included as well, but these did not have a significant relation to any of the perception variables, compared to the Wi-Fi counts. The reason for this is that the Wi-Fi counts and the

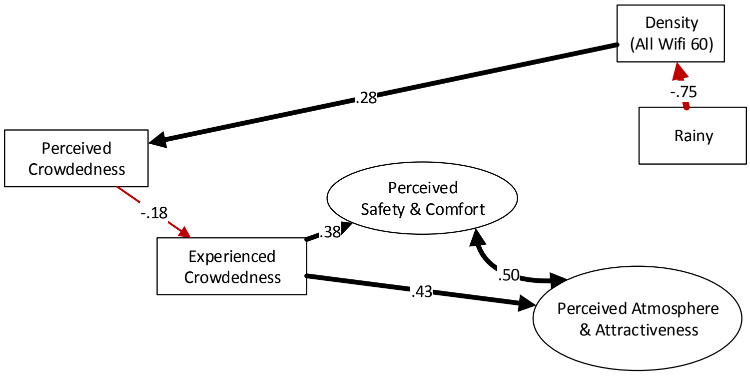

Figure 7.13: Final model RLD: Relations between perceptions and measured crowdedness

camera counts are very highly correlated ($\beta = 0.72$). A model using only camera counts would have been applicable as well, but the correlation with perceived Crowdedness would be slightly lower. This tells us that pedestrians' perception of Crowdedness is more related to Density (people nearby) than to Flow (people moving around). Also, the strongest relation with a time window of 60 minutes tells us that pedestrians' perception of Crowdedness is based on memory of a longer time period. The relation between the Wi-Fi counts and perceived Crowdedness is quite strong ($\beta = .28$), which means that people have a decent idea of the actual crowdedness.

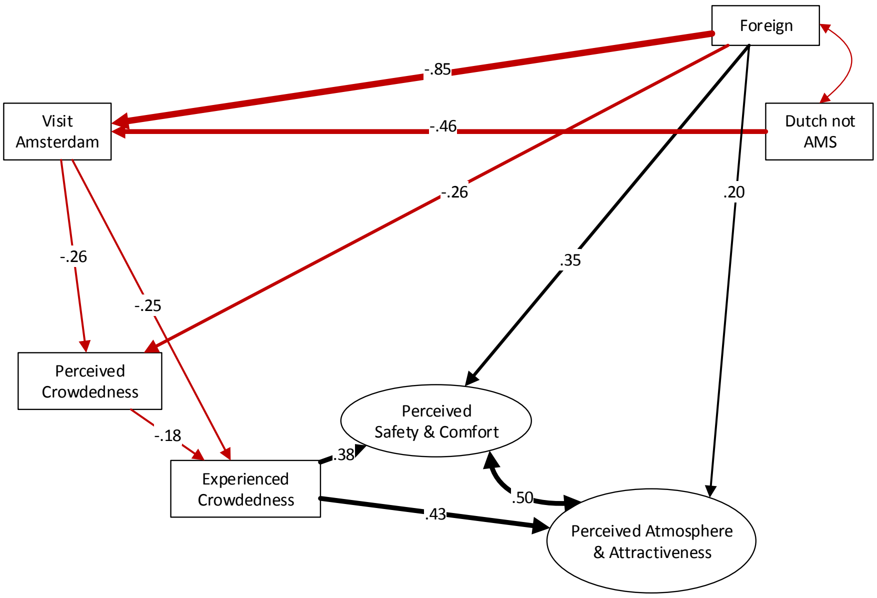

Figure 7.14: Final model RLD: Relations between perceptions and familiarity

Familiarity

In Figure 7.14, the predictor variables concerning familiarity are highlighted. We see that perceived Crowdedness is negatively influenced by the number of times a person has visited Amsterdam ($\beta = -0.26$). This means that familiarity with Amsterdam makes a person perceive Crowdedness lower. The effect of being foreign on perceived Crowdedness is modelled through two paths. The direct path shows that foreigners perceive Crowdedness lower ($\beta = -0.26$). However, since foreigners have visited Amsterdam less often, this effect is diminished. In Table 7.13, the total effect of the variable Foreign can be checked. This total effect is very small ($T = -0.039$). Being foreign does influence all perception variables directly or indirectly.

Furthermore, there is a variable present that represents Dutch citizens who do not live in Amsterdam. Since they have visited Amsterdam less often than people who live there, they perceive the Crowdedness higher ($I = 0.117$).

Concluding, familiarity has two effects. Crowdedness is perceived lower, because of familiarity with the number of people that are normally in the Red light district. Second, familiarity influences experience of Crowdedness and other perception variables negatively.

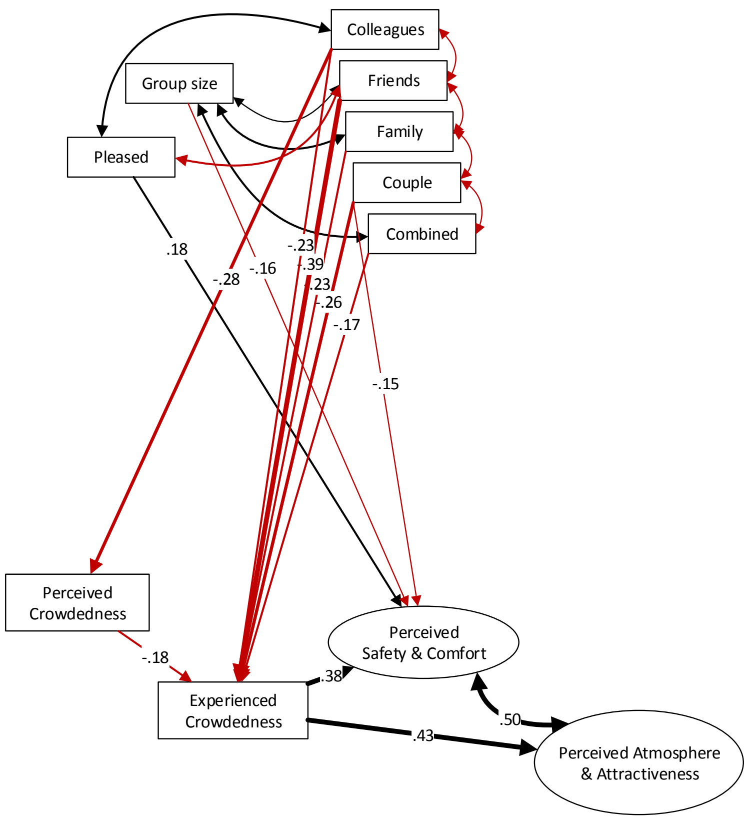

Figure 7.15: Final model RLD: Relations between perceptions and Group type

Group type

In Figure 7.15, the effects of *Group type* on perception are highlighted. Five group types are distinguished, which are compared to the control group *Alone*. One can see that groups have a more negative experience of Crowdedness compared to individual pedestrians. Also, *Group size* has a negative relation to perceived Safety & Comfort. This means that groups experience Crowdedness more negatively, because they fear they might lose group member and have to try hard to keep together. A group of colleagues perceive the Crowdedness lower than someone who is alone ($\beta = -0.28$). Additionally, Colleagues are the most pleased group. This can be interpreted by the goal of their visit, recreation. Remarkably, groups of friends seem to be the least pleased and also experience Crowdedness the most negatively. Finally, *Couples* perceive Safety & Comfort lower. This could be because a they do not know what to make of the red light windows.

Other Socio-demographic factors

For age, a moderate positive influence on perceived Safety & Comfort (β = .20) is found. This is a different finding than the result from the bi-variate analysis. There, a positive correlation with Crowdedness and a negative correlation with Atmosphere & Attractiveness was found. Apparently, these correlations can be explained away by the relation the variable *Age* has to other variables in the model. For example, *Age* is found to correlate negatively with being foreign and using marijuana, while it correlates with having an urgent purpose positively. In Table 7.13, the total effect of *Age* through various paths can be found. Indeed, a small negative effect on Experience, Attractiveness and Atmosphere is found.

An exception in the modelling rules is made, to connect *gender* to perceived Safety and perceived Attractiveness instead of connecting the variable *gender* to the latent variables perceived Safety & Comfort and perceived Atmosphere & Attractiveness. The reason for this modelling choice, it that it can be explained theoretically very well. In an area such as the red light district, it is logical that men would perceive the environment as more attractive. Furthermore, physical height plays a role in the difference in perception between men and women. Originally, the variable gender was connected to the latent variables, but in this case, the relation was not significant. As can be seen, the relation between gender and perception is not that strong, so it also could have been excluded without much loss of knowledge.

Other Personal state & trip factors
Other Personal state & trip factors that have not been discussed yet are the *Emotional state*, *Substance usage* and *Purpose*. The emotional state *Pleased* improves the perception of Perceived Safety & Comfort and Perceived Attractiveness and Atmosphere. The effect of alcohol was not found, but the effect of marijuana is positive on the variable *Pleased* and the perception of Atmosphere & Attractiveness. Marijuana is used for recreation, therefore these findings are quite logical. However, it would not have been unexpected to find a negative relation, because of paranoia. Both for emotional state and marijuana, it can be discussed whether they cause a positive perception, as is modelled, or simple correlate with this.

Trip purpose has a negative effect on experience of Crowdedness ($\beta = -0.23$). No direct effect on perceived Crowdedness is found, which means that pedestrians in this case to not overestimate the number of people, because they experience the number of people as unpleasant. A reason this relation was not found could be because everyone's perception of Crowdedness was quite high.

Event & Environment factors
Lastly, the event and environment factors will be discussed. Only *Rain* is included in the model, as a control factor for the measured crowdedness. This shows that rainy weather greatly lowers the number of people in the Red light district. No difference between the measurement locations was found. It is expected that the event settings actually have a large influence on perception, but these are not quantified and could only be found when compared to other event settings.

7.5.3. TT base, RLD base and mixed base

It has been attempted to create a model that would fit both events. However, these attempts have not been successful. The first attempt was started with a TT base using only the variables that were measured in both events, as was described in Chapter 6. For example, 15 min Wi-Fi data was used. Subsequently, the RLD data was loaded and tested. Step by step, non-significant paths were removed. After a few iterations, it became clear that some essential connections would not become significant, such as the relation between perceived Crowdedness and the other perception variables. Therefore, this model building process was terminated. For the RLD base, it was expected that the same problem would occur. In the TT survey, the question regarding the experience of Crowdedness was not yet included, therefore, the connection between perceived Crowdedness and the the perception variables cannot be made.

As an attempt to overcome this problem, a third option was tried, which was testing a combined data set, meaning that the data of the TT and the RLD were added together. With this combined dataset, was is possible to include variables such as experienced Crowdedness. Various combinations of models have been tried on this dataset. However, it was still not possible to come to a final model with a good model fit.

Even though the attempts to create a model applicable to both events have not been successful, lessons are learned from this fact. The way in which crowdedness is measured and quantified is very important. As can be seen by comparing these events, in one case a shorter time window on a local level relates best to perception of Crowdedness, in the other case a longer time window using global measurements is most applicable. This implicates that pedestrians' perception of Crowdedness is influenced by different underlying variables. It could be caused by the event size, the distance between locations or by the behaviour of the pedestrians (walking or standing still), but this cannot be concluded from the models.

8 Conclusions and recommendations

In this chapter, the conclusion of this research is given (Section 8.1). This answers the main research question. Next, in Section 8.2, the possible shortcomings of this research are discussed. Finally, in Section 8.3 recommendations for future research and recommendations for future practice are given.

8.1. Conclusions

The objective of this research was to gain a better understanding of pedestrians' perception of Crowdedness. The research question that will be answered in this section is:

"To what extent is a pedestrian's perception & experience of crowdedness influenced by personal, event and trip characteristics?"

This research based on two case studies shows how perception & experience of Crowdedness are influenced by personal, event and trip characteristics. Four main conclusions are drawn by comparing these case studies.

About the relation between perception of Crowdedness and the other perceptions and experiences that relate to Crowdedness, the following can be said: For both events, it was found that perception of Safety and comfort are so similar, that they can be seen as indicators for one latent variable. Likewise, Perceived Attractiveness of the environment and Atmosphere form one latent variable. The effect of perceived Crowdedness on the other perceptions is different for both cases. In the TT model, higher perceived Crowdedness leads to higher perceived Attractiveness & Atmosphere, meaning that Crowdedness has a positive effect on the perceived Attractiveness & Atmosphere. No effect of perceived Crowdedness on perceived Safety & comfort was found. In the RLD model, there is an indirect negative influence of perceived Crowdedness on perceived Safety, comfort, Attractiveness and Atmosphere. Furthermore, the experience of Crowdedness is negatively influenced by the perception of Crowdedness, meaning that a person who thinks it is more crowded also finds the number of people less pleasant.

Concerning the relation between quantified crowdedness and perceived Crowdedness, the following conclusions can be drawn: There is a relation between measured crowdedness and perceived Crowdedness. In the TT case, this relation is best brought forward by using 15-minute local Wi-Fi counts and 15-minute camera counts. For the Red light district, a strong influence of 60-minute global Wi-Fi counts on perceived Crowdedness was found. For both cases, Wi-Fi counts are more closely related to perceived Crowdedness than camera counts. This result is logical, since crowdedness is often quantified using the variable density ($ped./m^2$), which in this case the Wi-Fi counts represent. In the TT case, a strong negative connection between camera counts and perceived Safety & Comfort was found. This can be interpreted as follows: The more movement there is around a person, the less comfortable and safe they feel. Other ways to quantify crowdedness where less related to perception variables than pure Wi-Fi and camera counts in this research.

Another interesting finding from this research shows the different ways in which familiarity influences the perception and experience of Crowdedness. In both case studies, familiarity with the event (TT) or the city (RLD) made people perceive the level of Crowdedness lower, but also caused a more negative perception of Atmosphere & Attractiveness. This shows that expectations concerning an event influence a person's perception. Interestingly, the RLD model also shows that foreigners perceive a lower level of Crowdedness. However, since foreigners are on average less familiar with the city/event, the total effect of being foreign on the perception of Crowdedness is very small. In both cases, foreigners have a more positive perception of Comfort & Safety. At the Red light district, the overall experience of Crowdedness of foreigners is much more positive.

Finally, an important finding is made by comparing the events and event locations researched. At the TT Festival, three locations were researched; one location was mainly a passageway, one location was a passageway near the main stage and one location was a relaxed residing area with many stationary pedestrians. The TT model shows that controlled for the Crowdedness indicators, the perception of Atmosphere & Attractiveness of these locations is different. At the Red light district, three locations were researched as well, namely a very narrow alley, a street along the canal and an alley that is an exit/entrance of the Red light district. However, no difference in perception was found between these locations. This learns us that the function of a location is important with relation to the perceived Attractiveness & Atmosphere, while other location characteristics, such as width of the passageway did not yield significant differences in this research. Furthermore, for the Red light district global Wi-Fi counts are the best predictor of perceived Crowdedness, while for the TT Festival, local Wi-Fi counts are the best predictor. This indicates that it is important to think about the area for which Crowdedness needs to be captured. This depends on the size of the event, the location types, the behaviour of the people (walking around or standing still), the distribution of Crowdedness over the event and the characteristics of the rest of the event.

8.2. Discussion

In this discussion, the limitations of the chosen research method will be discussed. Especially, there will be a focus on how this research can be improved, given the knowledge about the results found. This research had a broad focus, in order to bring physical and psychological research together. The methods applied are perhaps uncommon, since there is no proven method for combining monitoring data with perception data in one model. There are many facets within this research, which could all be performed more thoroughly and could profit from the expertise of someone from that particular research field.

Several aspects of the research will be discussed, namely the theoretical framework chosen, the survey as a data collection method, the design of the survey and the formulation of survey questions, the monitoring data collection and processing, the metadata collection and processing, the limitations of Structural Equation Models and finally other modelling methods that could have been used.

8.2.1. Theoretical framework

Looking back at the theoretical framework it can be concluded that the theorised relations between the categories were identified correctly. For example, from all four categories, factors that explain perception and experience of Crowdedness could be found. Also, the influence of socio-demographics on personal state factors was found. For example, being foreign influences familiarity and older age influences trip purpose and drug usage. Additionally, the effect of Event & Environment factors on measured crowdedness is illustrated in the models by the factors Location and Rain. Despite this, the theoretical model can also be improved. In Figure 8.1, a new proposed theoretical framework is presented.

The new framework has same relations as the original framework, but a few things have been changed. First, perception and experience are more clearly distinguished. In this research, this distinction has not always been clear. In hindsight, also looking at the final models, the perception of Crowdedness is quite different from the other perception variables. The perception of Crowdedness is modelled and interpreted as a perception that is formed subconsciously, but is biased as to a person's background. The other perceptions could also have been named feelings or experiences. They are formed more consciously and contain a value judgement about the Crowdedness perceived. From the survey question regarding perceived Crowdedness, it cannot be determined yet if this perception is a positive or negative judgement. Crowdedness can either be seen as something good or bad. For Safety, Comfort, Attractiveness and Atmosphere, it is clear that a higher score relates to a better experience.

Also, it can be discussed whether emotions are the cause or the result of the Crowdedness experience. Therefore, in this revised model, a clear feedback loop is included from experience of Crowdedness to Per-

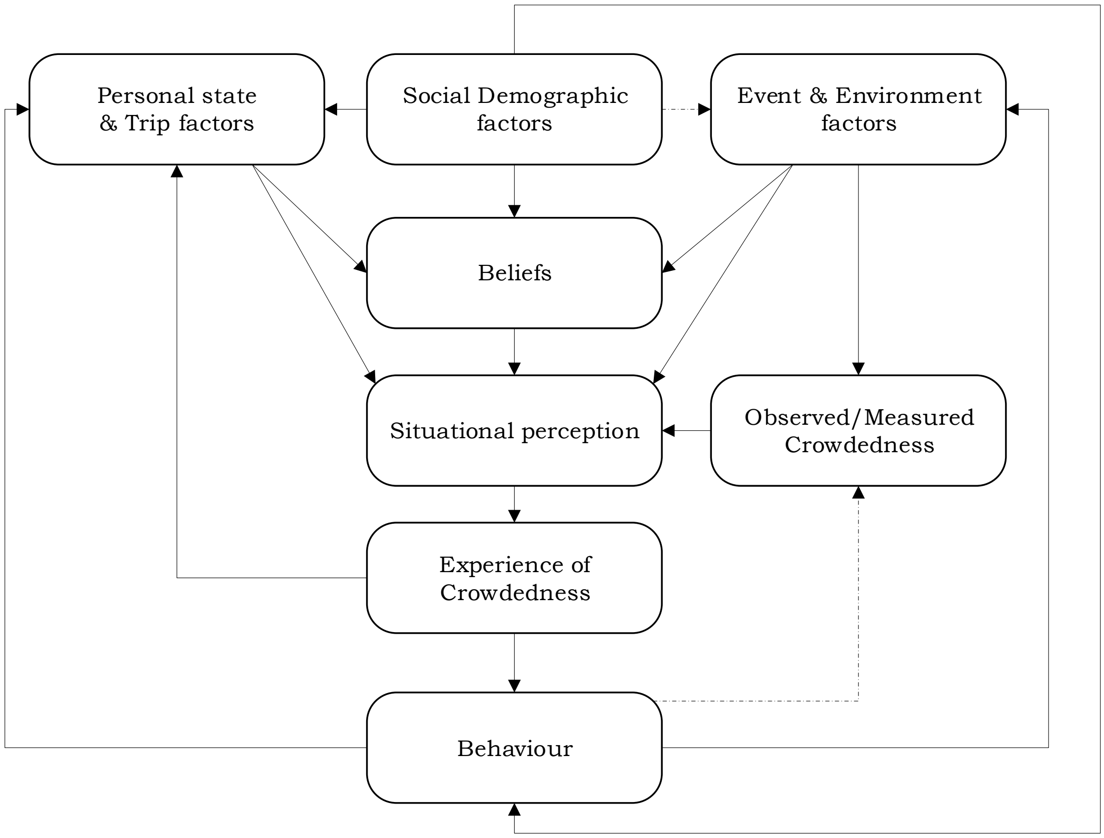

Figure 8.1: Revised theoretical framework. Dotted line is applicable only on crowd level

sonal state & Trip factors. Modelling this in a SEM is possible, but it makes the model non-recursive, thus making the model estimation more complex.

This model concerns the perception and behaviour of an individual, but can also be applied on the crowd level. In this case, the dotted line is relevant as well. The socio-demographics of the crowd, or the crowd composition, could influence the situational perception through the Event & Environment factors. Also, the behaviour of the crowd can change the observed/measured Crowdedness.

Furthermore, the importance or beliefs, or expectations should not be underestimated. This was noticeable while conducting the surveys. Respondents often said something like: "Well, compared to yesterday it is not that crowded." In this revised model, Personal state & Trip factors and Event & Environment factors influence beliefs and expectations, but also influence the situational perception directly. The difference can be illustrated with an example: Loud sounds could directly influence the perception of Crowdedness subconsciously, but the symbolic meaning of a location is interpreted by someone's beliefs. In this research, the scope was limited to perception, beliefs and behaviour were excluded. However, beliefs or expectations are probably an important factor to include in order to understand a person's perception.

8.2.2. Limitations of survey as a data collection method and execution

Although a survey was deemed to be the most effective way to discover personal characteristics and perceptions, the survey method has its shortcomings.

One drawback of conducting surveys on the street is that the surveyor can influence the results. This effect was tried to be minimised by approaching people for the survey as randomly as possible. However, only a certain type of person is likely to respond. On the other hand, this is also a problem for surveys that are filled in at home. In this research, people who are in a bad mood or in a hurry are expected to be less likely to respond, while their perception would be interesting. Furthermore, a bias arises when a respondent asks for an explanation for a certain question. This extra information is not given to all respondents and another surveyor might explain a question differently than the other. This was tried to be prevented by letting people interpret the questions themselves and by discussing beforehand with fellow surveyors which explanation should be given.

By randomly approaching people, another problems arises. In this research, some groups are under represented. For example, in the TT case, there were not enough foreign participants. In the RLD case, there were not enough Dutch citizens and residents of Amsterdam. This made it more difficult to analyse the differences between these groups. When a large dataset was gathered for all groups, it would have been possible to estimate separate models.

The reason why the relation between perceived Safety & Comfort and Crowdedness was not found directly could be because the researched locations were not crowded enough to make it seriously unpleasant and uncomfortable. However, it is impossible for a surveyor to research dangerously crowded situations. Also, it is not possible to conduct surveys close to a stage, since it is difficult to communicate there because of the noise and it is difficult to move around.

8.2.3. Survey design

In a survey, the resulting answers are largely dependent on the survey question formulation. The survey questions regarding Safety and comfort could have been made more specific, to avoid different interpretations. In the evaluation of the case studies, it became clear that the questions regarding Comfort and Safety were formulated in a vague manner. Respondents often pointed out that they felt safe, because they had seen police officers or hosts. Also, some respondents felt safe because there were many people around. For Comfort, separate questions for physical, physiological, facilities, security officers and social aspects could have been included. Now, respondents often asked what was meant with Comfort.

Also, more overlapping questions regarding Safety and Comfort could have been posed. The survey design did not include a real measurement model for latent variables, this construct was only thought of later. Addressing multiple questions to the subject of Safety, such as was illustrated in Chapter 6, could result in a stronger relation with perceived Crowdedness. However, in this case it has to be considered that the survey becomes longer.

Some of the factors that were expected to influence the perceived Crowdedness were not found significant in the analysis. For example, urbanisation level. A reason for this could be that Municipality, which was asked, is not the best way to determine this. For every Dutch municipality, the CBS urbanisation level was connected to the survey data. However, municipalities can have a large variation in urbanisation level locally, which is not accounted for in this way. The question could have been posed differently. For example, respondents could have been asked to give a grade to the level of urbanisation to their own residence. Or, they could have been asked if they live in a big, medium or small city. Then, urbanisation could also have been determined for foreigners.

Besides that, the effect of alcohol usage was not found. This was unexpected, because in previous studies, this effect was found. A possible explanation would be that the question is not precise enough. Instead of only addressing which stimulants are used, the amount could have been questioned. Many respondents who had drunk one beer during their dinner where now categorised with people who had trouble having a conversation because of their intoxication.

The question regarding emotional state could have been posed differently. People were not always able to select the emotion that they actually felt. For example, some people said they felt confused or hungry, which is not accounted for. Also, it seems as though foreigners chose the emotion *Happy* most, because this was a word that they recognised, while other words might be difficult to understand in a person's second language. However, the division of emotional states in *Pleased* and *Activated* seems to be effective in the RLD case. Still, it could be considered to leave out some similar emotions, like *Happy* and *Glad*.

In the TT case, the survey question regarding emotional state was still a multiple answer question, which made analysing the answer set more difficult. Therefore, this was changed for the RLD case. The same goes for the Group type. It is expected that no results were found for this factor at the TT, because it was a multiple answer question which was difficult to analyse.

8.2.4. Limitations of using Wi-Fi sensors and counting cameras

The monitoring data used had some drawbacks. First, there was some missing data which had to be corrected. No ground truth was used to validate the counts, which makes the research more unreliable. Many steps had to be taken in order to come to the variables that were chosen to describe Crowdedness. It is expected that a stronger relation could have been found when these steps where undertaken with more precise filtering methods. However, in this research, there was limited time available for data processing.

Furthermore, the filtering of the data was done in different ways for both events, which makes it more difficult to compare the results. For the TT case, the Wi-Fi counts were determined for overlapping time windows of three and fifteen minutes, while at the Red light district, they were collected every minute. Also, for the TT case, a conversion rate was calculated by the researcher, while for the RLD case, the conversion was already done, but it is uncertain how it has been done. For the RLD case, the monitoring data is less connected to the perception variables. If other filtering steps have been applied, these results might have been different.

The reason why the counts, and not the actual macroscopic flow variables (Density/Flow) are related to the perceived Crowdedness is unknown. It is assumed that this is because these variables are the least altered. Attempts to calculate density and flow were less successful, because of uncertainty in determining the area that a Wi-Fi sensor covers and the effective width of passageways.

8.2.5. Metadata collection and processing

The light and sound data had a few problems. First, the measurement device (a mobile phone) was not accurate enough to measure light intensity at nighttime. The flashing lights of the stages were not detected with this measurement method. As could be seen from two measurements taken only two minutes after each other, the values can be vary greatly every minute. Therefore, measurements at intervals of 30 minutes are not sufficient to capture the variance in light and sound intensity during an event. Also, the orientation of the measurement device was very important, for example, pointing a device towards a stage or the other way, which was not taken into account.

8.2.6. Limitations of Structural Equation Modelling

It was determined that to answer the research question, a Structural Equation Model had to be applied. However, Structural Equation Models are based on certain assumptions and rules.

For Structural Equation Models, it might be discussed that it is difficult to determine whether a model has reached a sufficient level of fit. In literature, many model fit indicators are provided, but there is no consensus amongst researchers on the boundary values for these indicators. Therefore, to ensure a good model fit, multiple model fit indicators were collected. In this way, it is ensured that the model satisfies the goodness of fit and is not overly complex. Furthermore, the modelling steps were determined beforehand and followed. However, with a SEM, no optimisation takes place, therefore it is never sure whether the best model for the data is found. On the other hand, this has the benefit that a model is not over-fitted to one dataset, because it should always be based on theory.

One important assumption in the model is that perceived Crowdedness causally influences the other perceptions. This effects the results significantly, because all factors that influence perceived Crowdedness now influence the other perceptions as well. Furthermore, the chosen construct with latent variables can be discussed. This construct was chosen to make the measurements of the perceptions more reliable, to make the connections stronger and to simplify the model. However, the perception of Safety & Comfort and the perception of Attractiveness & Atmosphere are not always influenced by all the factors in the same way. For example, in the RLD case, an exception was made for the effect of gender. In any case, it would have been better to think about latent constructs for perception variables before creating a survey.

Other than that, the modelling programme used, AMOS, can only find linear relations. For this reason, the negative relation between a *very crowded* perceived location and perceived Safety and Comfort might not be found. Also, AMOS only treats the data as either interval/ratio or binary data. The perception data was Ordinal, for which separate statistical methods are needed. However, in the field of psychological research, this type of Ordinal data is often used in Structural Equation models. The reason this is allowed, is because perceptions are in reality a value on a continuous scale, only the measurement method is ordinal. To include non-linear relations and use ordinal data, the software package Mplus could have been used.

In case of the TT event, there was missing data for the camera counts of one location. The effect this has on the model is unsure. It makes the relation of camera counts to perception more uncertain, since it is tested for a smaller sample.

8.2.7. Other models

To find the relations presented in the theoretical framework, another model could have applied as well, namely a Hybrid choice model. This model could have included behaviour or perceptions as an outcome of the other factors. The reason why a SEM was chosen, was because it was necessary to first increase knowledge about perception of Crowdedness and the factors that influence it, before a predicting model can be created. With the knowledge of this research, it becomes easier to make a selection of factors and perceptions that need to be included in such a model.

8.3. Recommendations

Finally, recommendations for future research and practice are given in this section. These are based on the conclusion and discussion provided in this chapter.

8.3.1. Recommendations for research

Data collection & processing

- In a follow up research, a survey should be designed to include measurement models for each of the perception variables, meaning that multiple questions that address different aspects of a perception such as Safety are included. For Safety, questions could be split up in social Safety, physical Safety and Safety by (police) control. By In this way, the effect of Crowdedness on Safety can better be distinguished.
- It is recommended to further research the effect of light and sound on perceived Crowdedness. In the TT case, some promising results were found. If light and sound data are chosen to take into account, accurate sensors on fixed locations and with fixed or predetermined orientations performing continuous measurements are required. For both light and sound, intensity can be measured, as well as fluctuations in intensities.
- To be able to compare different groups better, a larger dataset needs to be gathered. As a guideline, around N=100 respondents per social group are required. Then, it is possible to create separate models for different social groups. For example, in the RLD case, this would be necessary to understand the difference in experience between foreigners and Dutch citizens better.
- The question regarding substance usage has to include amounts for alcohol consumption. For example an answer set with ranks can be used (None, 1-3 drinks, 4-6 drinks, more than 6 drinks). This proved to work quite well for age. Also, to the knowledge of the researcher, none of the respondents chose not to answer the question about substance usage. Therefore, it seems to be not as sensitive a subject as was expected.
- When there is more time available, the processing of the monitoring data should be performed more thoroughly. Validating the data by comparing camera counts to manual counts would be appropriate. Methods for flow and density estimation such as described by Yuan et al. (2016) can be used. For this, the raw data including the MAC addresses is required. By using an algorithm that can pair MAC addresses between two Wi-Fi sensors, the number of devices between these sensors is determined. Then, a counting camera has to be used to find a penetration rate of the combined Wi-Fi sensors.
- Determining the width of the passageway more accurately can be done by simply bringing a tape-measure along during the research. The width has to be measured on a few points in the neighbourhood of the counting camera, since it may vary due to obstacles. Determining the area of a Wi-Fi sensor is more complex, since it varies with the number of devices measured.
- It is also useful to include in the survey whether a person was standing still or walking. If a person is walking, the direction of the movement has to be registered as well.
- To research areas that are not suitable for conducting surveys, a mobile phone application might be used.

Analysis

- More different types of events can be researched to gain a better understanding of the factors that play a role in different settings. In this case, location characteristics should be quantified consistently. For example, location function, location size, the proportion of people moving/standing still, the activities offered and the atmosphere should be noted.

- A hybrid choice model could be developed when a more concrete tool to predict perceived and experienced Crowdedness is desired. The factors density (Wi-Fi counts), flow (camera counts), country of origin, familiarity, trip purpose, group, emotions and location characteristics should be considered. Furthermore, a model that includes expectations and/or choice behaviour with relation to perception of Crowdedness can also be created based on the revised theoretical framework.

- To develop a new Level of Service system, piecewise linear regression can be used (Papadimitriou et al., 2010) to distinguish categories of Crowdedness that are perceived. This is a form of regression where breakpoints are allowed in a straight line to better fit the data. Papadimitriou et al. (2010) found that car drivers only perceived three categories of Crowdedness, while the LOS system had six categories.

8.3.2. Recommendations for practice

For both events, other results are found. Recommendations to increase pedestrians experience are given in this section. Furthermore, some recommendations for research can be considered to be executed by the event organisers, crowd managers and municipalities.

In both cases, it would be a good idea to develop a perception based LoS system. If Wi-Fi counts or camera counts are available these can be used to give an indication of the perceived and experienced Crowdedness. Additionally, knowledge about the location function and the crowd composition present can be used to further specify whether the density and flow at this location are on a desirable level. For example at the TT festival, a location such as *Markt* can have high levels of Density without decreasing the positive experience of Crowdedness, thus a high level of service. However, a high level of flow at this location might decrease positive experience of Crowdedness and thus the user based Level of Service. For the RLD case, a high flow might be an indicator of a more positive experienced Crowdedness, because it is possible to move and the pedestrians are not impeded. This all needs to be researched further. This research was exploratory and therefore does not yet provide concrete answers. Still, recommendations for developing a concrete system can be given.

Location function: Identify and separately assess the Crowdedness at different locations based on the function of that location. Separate walking areas, standstill areas and combined areas. Also identify the activities that are present at these locations.

Crowd composition: At every location or event, different groups of people are present. These different groups (people with recreational purpose vs people with an urgent purpose, familiar vs unfamiliar people, pleased vs unpleased people, large or small groups) have different perceptions of Crowdedness. Therefore, knowing who is present and in what proportion is very important. If this is known, user based Level of Service can be determined looking at the relations found in this research.

Other than developing a system that uses monitoring data, it can be useful in both cases to develop a mobile application for real-time research and crowd management. Such an app, that can also provide (real-time) information from the crowd managers to the people, can be used as follows: A person an occasion receives notifications, asking them one or two questions about their experience. Furthermore, a person can choose to give a notification when they do not feel comfortable or pleasant at a location. This notification system should be as simple as a few clicks and has to be anonymous, but does need to include location. It is not necessarily meant for real danger, because in this case, the police should be directly alerted. However, if many notification come in from one location, it can become clear that the atmosphere there is not optimal and action might be taken to improve this and to prevent anything from happening.

TT Festival

Overall, people perceived the Crowdedness at the event quite positively. The results of this research can be used to estimate perceived Crowdedness, Safety and comfort from monitoring data in future years. The best indicators to estimate perception and experience of Crowdedness from monitoring data are Wi-Fi counts over 15 minutes and camera counts with a 15 minute moving average. Together, they give insight in perceived Crowdedness, Safety and comfort. A next time, areas that are more troublesome could be researched, like Doevenkamp, using the mobile phone application method described above. Doevenkamp was a stage area that attracted younger people, because of the artists that performed here. During the event, this location was the main concern of the crowd management. This location was at times very crowded, which could be troublesome. Furthermore, there was speculation on social media about a fight that was planned at that location.

Red light district

Overall, the perception of the Red light district was positive. However, it is important to keep in mind that there is a major difference between Amsterdammers, Dutch citizens and foreigners.

The experience of pedestrians can be improved if the Crowdedness becomes lower. This can be achieved by effective crowd management. The efforts of the hosts seem to be effective in keeping people in line and improving the flow in the crowd, although this is rather a personal observation than a result of this research. In future research, the effects on perceived Crowdedness when hosts are present or not could be specifically researched.

A recommendation regarding the monitoring system is to gain more insight in the filtering steps that are applied to the counts, because they seem to influence the results that are found. Furthermore, it is recommended to gather Wi-Fi data for time window of three and fifteen minutes. In this way, the Wi-Fi counts are less similar to the camera counts and can provide some other insights. To understand pedestrians' perception and experience of Crowdedness now, the best indicator from the monitoring data gathered are the global Wi-Fi counts with a 60 minute moving average applied.

A final recommendation for the Red light district is to think about the division of functions over the various streets and alleyways. Based on this research, it cannot be concluded how these functions should be divided (activities/entertainment placement, one or two-directional passages), although this research does show that Amsterdammers perceive the Crowdedness higher than foreigners and this lowers their experience. For them, passageways with lower Crowdedness are desired.

9 Reflection

During my thesis project, I have learned many academic skills and competences that I did not possess before.

I have completed my bachelors at Industrial Design Engineering, where I learned to think creatively, visually and in a problem-solving way. However, it was only during my masters that I have learned to study and use papers, to write scientifically and to apply scientific research methods. Some of these skills still needed to be improved during my thesis.

For example, I often read and wrote down information, because it seemed interesting, without thinking whether this information was required for my research and why. Consequently, I have spent much time on writing down information that was not needed and had to rewrite parts of my thesis several times. For a next project, I will try to be more to the point from the beginning and think about the what should be written down and why before I start writing.

Furthermore, I could have made more choices earlier in the project, to limit the scope of this project. My project has been very broad, while focusing my efforts more selectively could have saved much time and might have led to more clear and understandable results.

For one part of the project in particular, I had underestimated the amount of work that would be needed. This part was the processing of the monitoring data. I expected that the raw data would be more easily used. However, many steps had to be taken in order to make the data usable. Steps that I did not think of before receiving the data. This meant that I spend some time figuring out the data and coming up with a plan. I had expected that I would be able to determine Flow and Density accurately, which in the end was not manageable within the scope of this research.

A final note of self reflection is that I tend to overcompensate for one small comment. I got sidetracked a few times when I received a remark, for which I then decided to completely change the report. For example, I have changed the combination of words to most accurately describe quantified Crowdedness and perceived Crowdedness at least four times and I have drafted around a hundred hypotheses and tested them all as correlations, before creating the final results. Before such drastic actions, I could have asked more about the remarks that have been given, in order to understand better what are the necessary steps to take.

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A

Travel behaviour models

In this Section, possible modelling paradigms and their accessory conceptual and measurement models are discussed. To describe travel behaviour, Kroesen (2017b) distinguishes six paradigms: Econometric, Psychological, Marketing, Geographical, Biographical and Sociological. In travel behaviour research, the Econometric paradigm is often used, because it lends itself well to choice modelling. It assumes a participant is completely informed and makes a rational decision. In Figure A.1, an example of a conceptual model is shown. In previous researches, this type of model was applied to develop a route/activity choice model for pedestrians (Galama, 2016) (Ton, 2014). Psychological attitudes can be taken into account, but are often neglected. The weights of the alternatives can be found out using a stated preference method, where participants are asked to choose between a number of alternatives which have different attribute values. Other than that, revealed preference can be used. In this case, the researcher has to give values to the attributes that are taken into account.

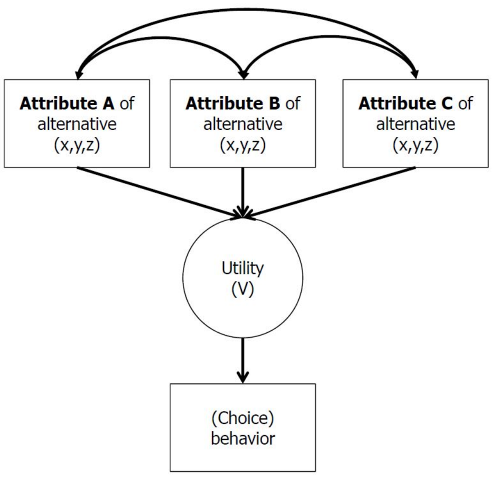

Figure A.1: Econometric conceptual model

Another paradigm that could be applied for this research is the psychological one. This focuses on the reason behind decisions, and therefore has a high explanatory power. However, the conceptual models are more complex and do not often lead to surprising insights. Compared to a discrete choice model, the causality between factors is less clear. Some famous psychological models are the Theory of Planned Behaviour, the Theory of Reasoned Action Fishbein and Ajzen (2011) and Social Learning Theory (Bandura, 1971). The theory of reasoned action takes behavioural factors, social norms, habit and perceived control into account. Social learning theory focuses on cognitive, environmental and behavioural factors. Psychological models can be structured using Structural Equation Modelling, as shown in A.2. This method was used by Hoon Kim et al. (2010) for their study at a festival to test the relations between perceived value, satisfaction and intention to revisit.

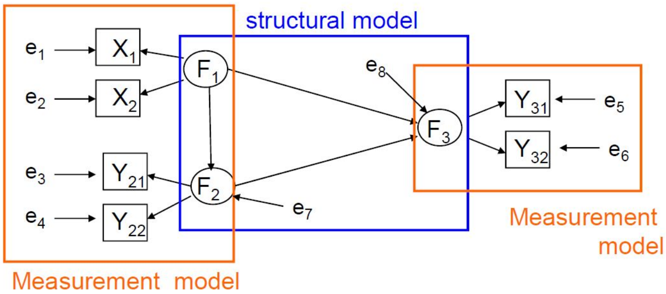

Figure A.2: Structural Equation Model

Choosing between these paradigms will have a very large influence on the outcomes of this research. However, since this research aims to identify the perception of the pedestrians, this seems to fit a psychological model better. However, if choice behaviour is to be modelled, an econometric approach is needed. Therefore, a combined model should also be considered. In Figure A.3, a conceptual model is shown that uses both choice modelling and structural equation modelling. The utility of a choice is determined through observed behaviour and the latent variables, such as perceptions are measured using Likert scale questions. According to Chorus and Kroesen (2014), the most popular type of Hybrid choice model, the integrated latent variable discrete choice model, is useful to gain a better understanding of the behaviour, but is not useful to determine policies. For example, a policy can try to change people's perception on comfort of public transport, but the relation between perception and behaviour goes both ways. People tend to have a biased view on the transportation mode that they already use. For this thesis project, it would be possible to apply a hybrid choice model, since the objective is to gain more insight in the perceived LoS of pedestrians at mass events and not to determine policies.

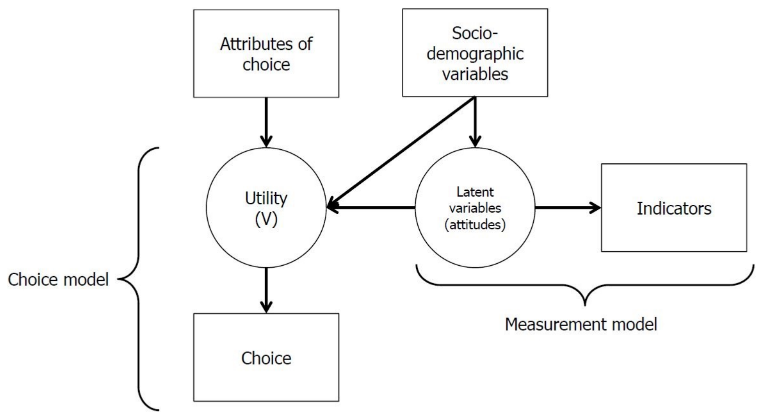

Figure A.3: Combined econometric and psychological model

In conclusion, the psychological paradigm seems most suited to apply for this research, since this paradigm can best capture perception. In econometric models, utility is not dependent on what information input a person receives, because it is assumed that a person bases his/her decision on complete and objective information. Therefore, a Structural Equation Model will be applied in this thesis project.

A.1. Psychological theoretical frameworks

In order to shape a theoretical framework, a few behavioural theories are elaborated in Appendix A. It is chosen to find a framework in the Psychological paradigm (see also Appendix A, since this offers the most options to include all factors mentioned in Section 2.6. The following renowned theories are discussed: The theory of Reasoned Action (Fishbein & Azjen, 1980), the theory of Planned Behaviour (Azjen, 1985), Social Learning theory (Bandura, 1977) and Habit (2006, Verplanken). The theory of Planned Behaviour will be applied for this research, for which a brief explanation isfound in the following section.

Theory of reasoned action

The theory of reasoned action was introduced by Fishbein and Azjen in 1980. It includes beliefs, attitudes, intention and behaviour as consecutive factors in a process to choose behaviour (see Fig A.4). Beliefs are divided into behavioural beliefs, which are the cost and benefits a certain type of behaviour could have according to the beliefs of the person. Together with evaluation the outcome, this forms a attitude towards this behaviour. Attitude is defined by Thurstone (1931) as: “the affect for or against a psychological object”.

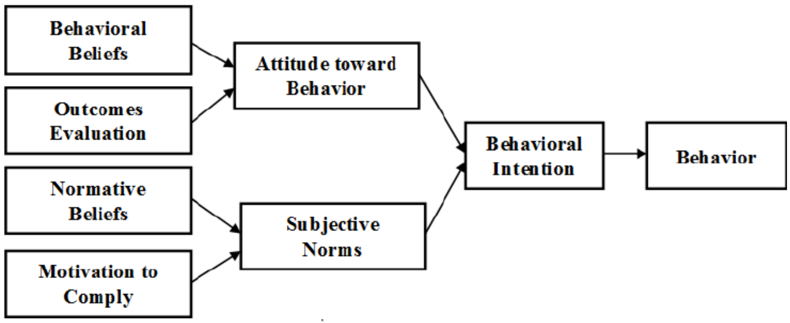

Figure A.4: The theory of Reasoned Action

Normative beliefs are the social norms that the person perceives. Together with the motivation to comply, this forms the subjective norms of this person. The intention, the behaviour that the person in question plans to do, is determined by the attitude towards behaviour and the subjective norms. Which of those two is more important depends per person. Furthermore, the intention will not always lead to the actual behaviour. However, in this theoretical framework, this cannot be seen clearly, because there seem to be no other factors involved.

Theory of planned behaviour

In order to take the earlier mentioned factors into account, the theory of planned behaviour was created as an elaboration on the theory of reasoned action. It has a new factor build into the framework, namely control beliefs and perceived behavioural control (see Figure A.5). The importance of this factor in behaviour is deemed very influencing, but has been described with various definitions that are not completely the same. Self-efficacy, helplessness, powerless, choice, decision freedom, locus of control and autonomy are some examples. The meaning of control beliefs according to Fishbein and Ajzen (2011) is the belief of a person that they have control over the things that happen in their lives. In other words, perceived behavioural control describes "a general sense of personal competence or perceived ability to influence events (e.g., Burger, 1989; Rodin, 1990)”

Perceived behavioural control influences the intention, but also the difference between intention and behaviour. Actual control is added as well. Background factors are shown to have influence on behavioural, normative and control beliefs. Additional factors that could be added are mentioned as well. Triandis (1977) adds habit and emotion to the framework. Fisher and Fisher (1992) add knowledge and Bagozzi and Warshaw (1990) add motivation and goal pursuit.

The term Affect is used to describe general mood and emotion state. It is different than attitude, which is an evaluation of a psychological object in terms of pleasant/unpleasant or like/dislike. Affect can influ-

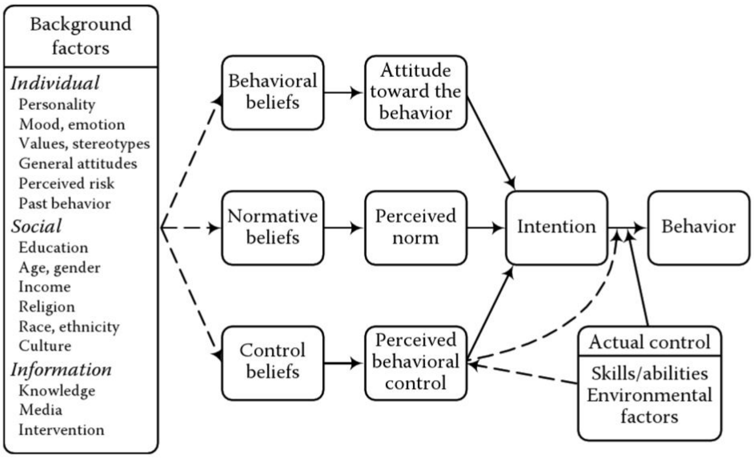

Figure A.5: Theory of planned behaviour

ence attitude, but it is assumed to be an indirect influence. Moods can be distinguished between pleasant and unpleasant and activation and deactivation (see Figure A.6. For example, feeling tired is an unpleasant, deactivated emotional state. When affect is included in a model, it should be included with the background factors. The same is true for including knowledge, habit and goal pursuit.

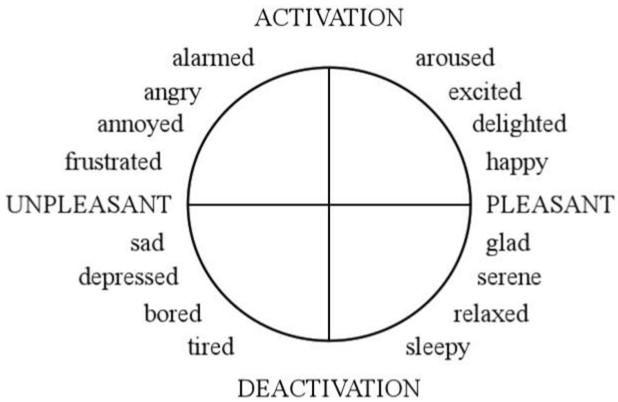

Figure A.6: Affect: Emotional states

Social learning

In 1971, Bandura introduced Social Learning theory. This theory explains behaviour as the outcome of a cognitive process, where learning is an important aspect. According to Bandura, behaviour can be learned by direct experience, observation of behaviour and by vicarious reinforcement. Vicarious reinforcement is a learning method where good behaviour is rewarded and/or undesired behaviour is punished. The information that is extracted from an observation depends on the cognitive processes at work. *Attention* is the first step in the learning process and is influenced by the perception and assumed importance of a subject. *Retention* is the ability to remember certain behaviour. *Reproduction* captures the cognitive and sensimotor abilities to implement the remembered behaviour. Finally, *Motivation* is determined by environmental and social factors and the expected outcome of the behaviour. This theory seems less applicable to this study, since the learning process is not a focus point, and only the motivation part includes those factors that are of interest.

Habit

In previous researches, the theory of Planned Behaviour proved to not be fully able to explain the difference between intention and actual behaviour. Therefore, Aarts et al. (1998) added the missing link: Habit. Habit formation involves the creation of associations in memory between actions and stable features of the context in which they are performed. Habits may be triggered by environmental cues, such as time of day or location, by internal states, such as particular moods and by the presence of typical interaction partners (Verplanken and Wood, 2006). Lastly, habits develop by the systematic experience of rewarding consequences. In other words, habits have a function in achieving a certain goal, that have been proven to work in the eyes of a persons that performs these habits (Aarts et al., 1998). Habit could be an important factor to take into account, since the factors that trigger habits are all present at an event (environment, location, personal state, group of friends). It could also influence a person on all three levels of decision making. On a strategic level, the decision to go the an event can be made because an individual goes to the event every year. On the tactical level, Srinivasan and Mahmassani (2000) show that people would rather use routes that are familiar with. The same is assumed to be probable for typical festival activities, such as visiting a certain stage multiple times. When possible, it would be useful to take habit into account in a theoretical framework.

From this short analysis, the theory of planned behaviour seems most applicable to this research. It has a clear structure that can take into account the environment, social demographics and personal state to determine perception. The social learning theory focuses on the cognitive process and the ways of learning, which would be interesting to know. However, it will require much knowledge of an individual and is therefore not realistic to achieve. Habit can be taken into account additionally, as it can explain part of the behaviour that individuals exhibits at an event.

B

Regression and scatter plots

B.1. TT Festival

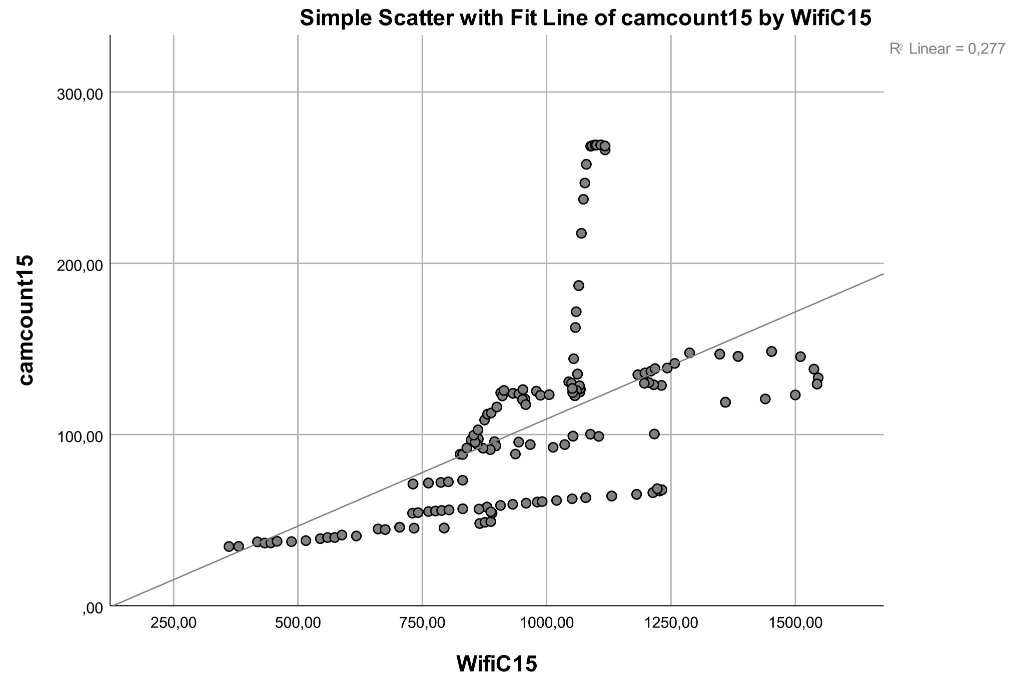

Figure B.1: TT: Wi-Fi counts - camera counts

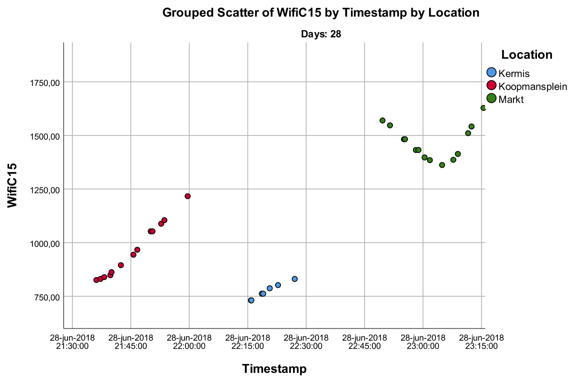

Figure B.2: TT: June 28, 2018. Wi-Fi counts - Time per location

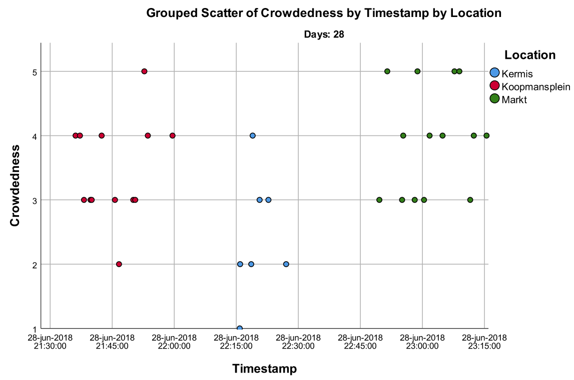

Figure B.3: TT: June 28, 2018. Perceived Crowdedness - Time per location

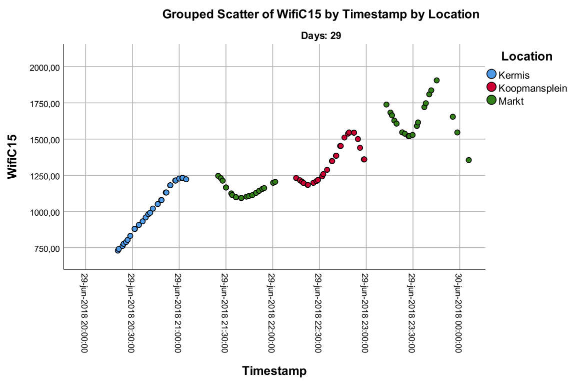

Figure B.4: TT: June 29, 2018. Wi-Fi counts - Time per location

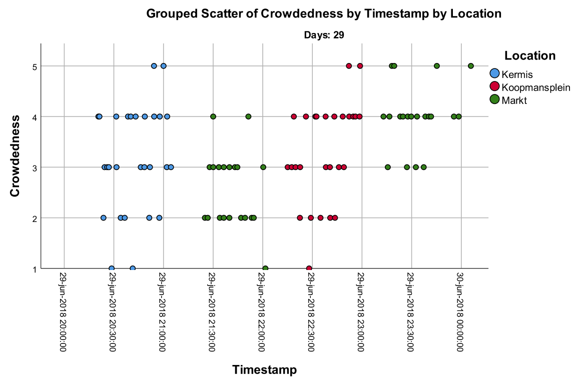

Figure B.5: TT: June 29, 2018. Perceived Crowdedness - Time per location

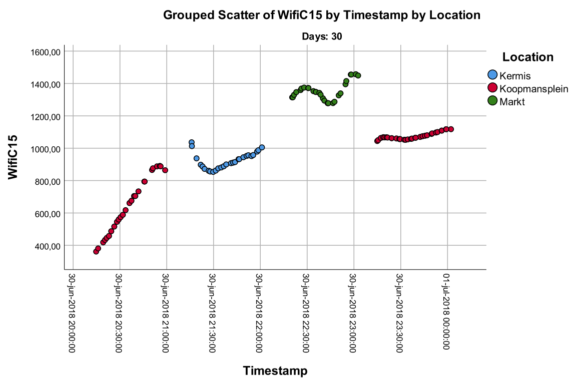

Figure B.6: TT: June 30, 2018. Wi-Fi counts - Time per location

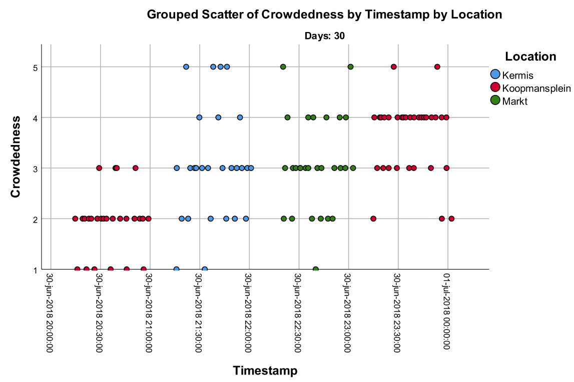

Figure B.7: TT: June 30, 2018. Perceived Crowdedness - Time per location

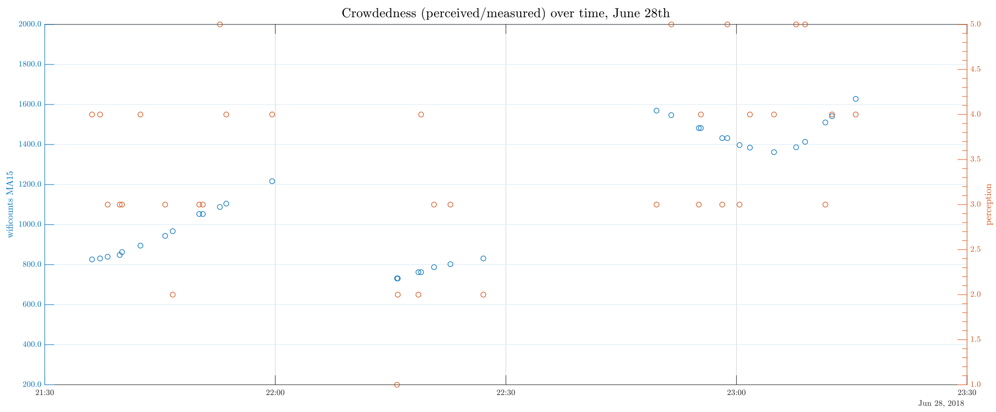

Figure B.8: TT: June 28, 2018. Wi-Fi & Perceived Crowdedness over time

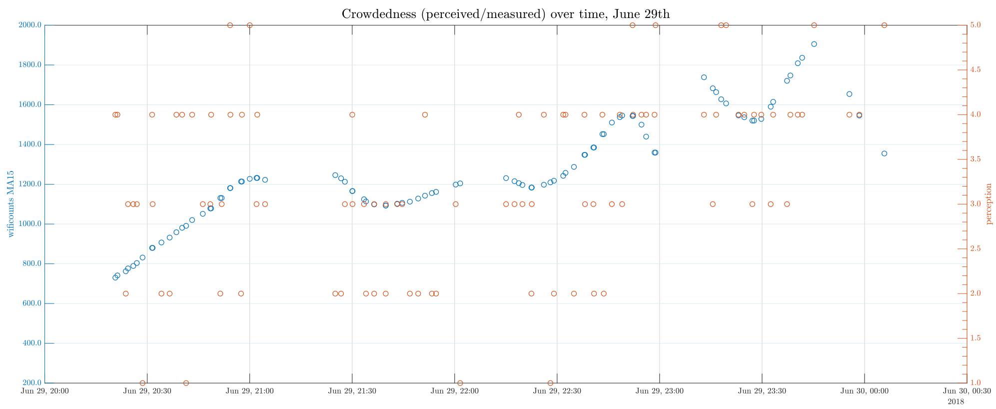

Figure B.9: TT: June 29, 2018. Wi-Fi & Perceived Crowdedness over time

B.2. Red light district

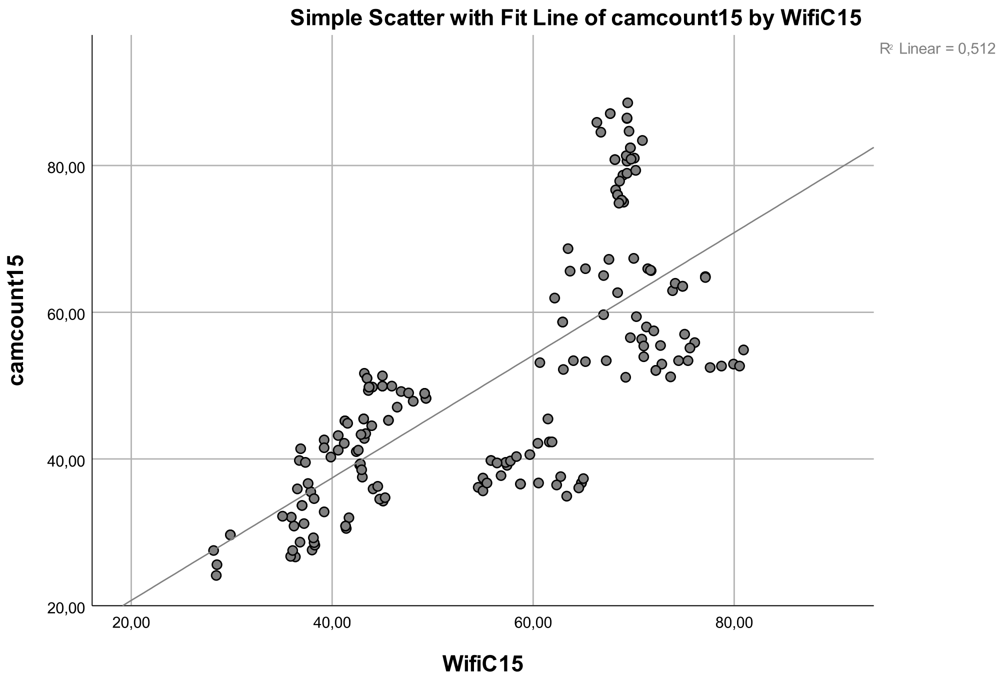

Figure B.10: RLD: Wi-Fi counts - camera counts

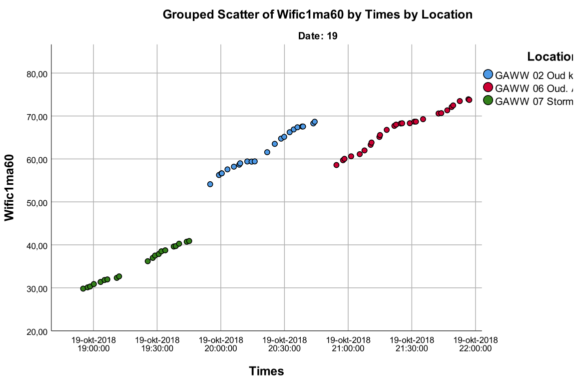

Figure B.11: RLD: October 19, 2018. Wi-Fi counts - Time per location

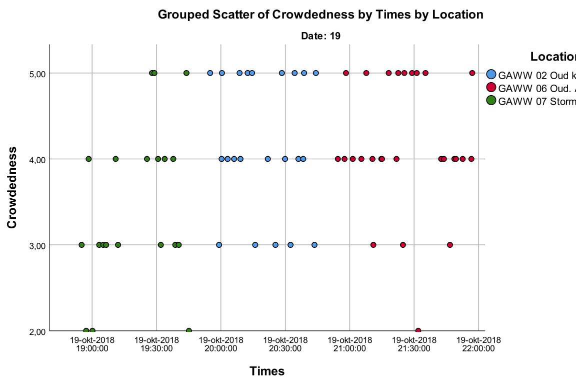

Figure B.12: RLD: October 19, 2018. Perceived Crowdedness - Time per location

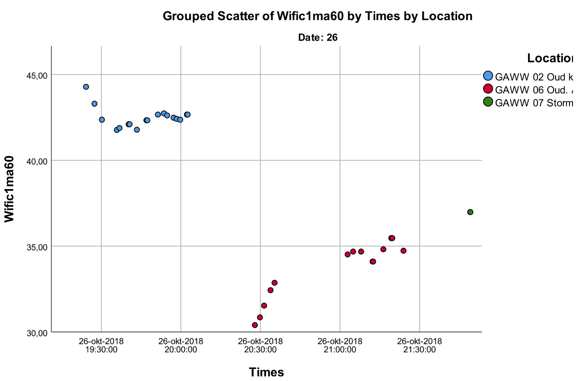

Figure B.13: RLD: October 26, 2018. Wi-Fi counts - Time per location

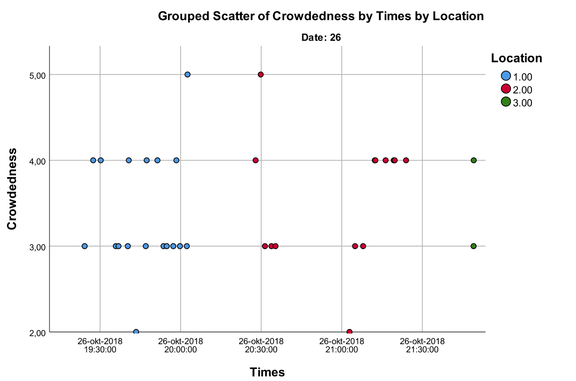

Figure B.14: RLD: October 26, 2018. Perceived Crowdedness - Time per location

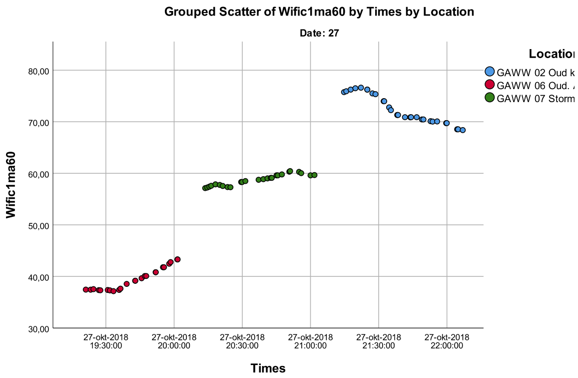

Figure B.15: RLD: October 27, 2018. Wi-Fi counts - Time per location

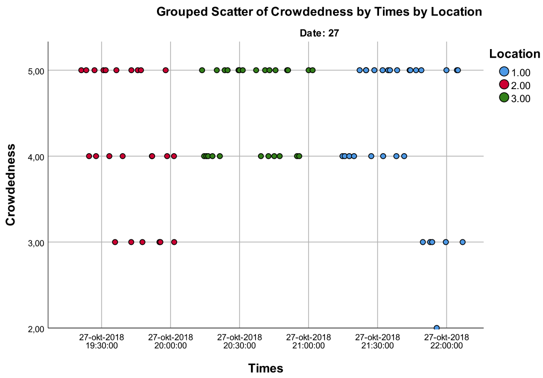

Figure B.16: RLD: October 27, 2018. Perceived Crowdedness - Time per location

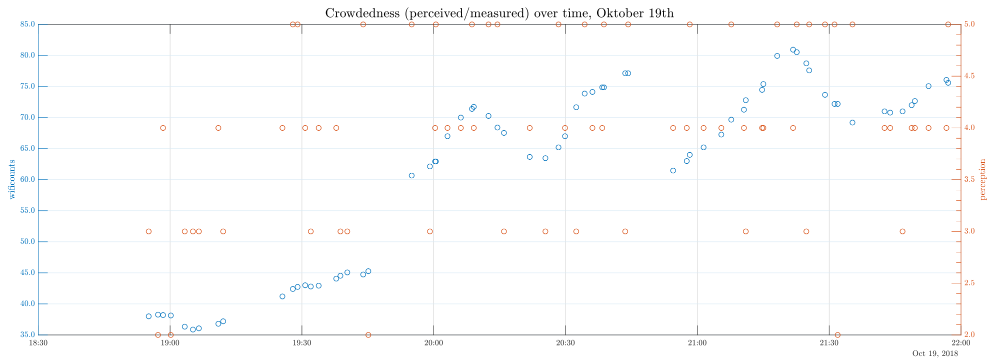

Figure B.17: RLD: October 19, 2018. Wi-Fi & Perceived crowdedness over time

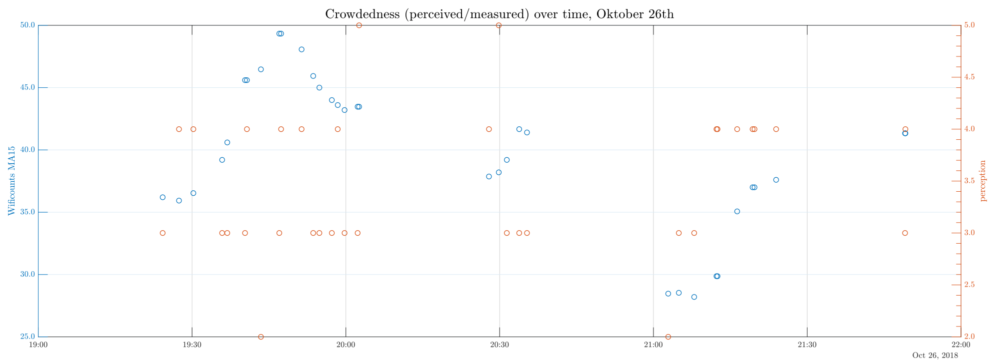

Figure B.18: RLD: October 26, 2018. Wi-Fi & Perceived crowdedness over time

C

Intermediate models

C.1. TT intermediate models

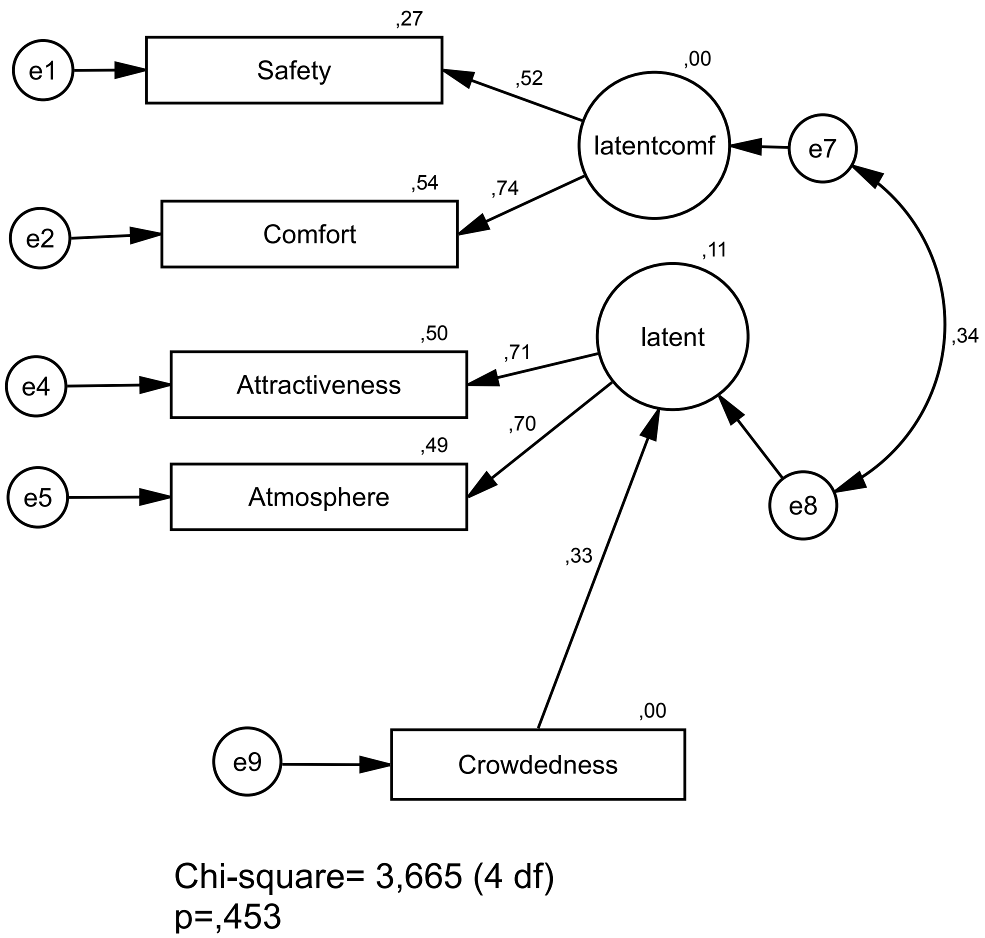

Figure C.1: TT Model 1: Perception variables in measurement model, significant

Figure C.1 shows the first model that is made, using only the perception variables. The latent construct was determined from the exploratory factor analysis. The figure shows that the loadings the the latent factors are sufficient. Furthermore, perceived crowdedness is directly related to the latent factor combining Attractiveness and Atmosphere.

Figure C.2 shows the first try for a full model, based on the hypotheses and the bi-variate analysis. As can be seen, it does not fit and there are some weak correlations. These will be removed in steps.

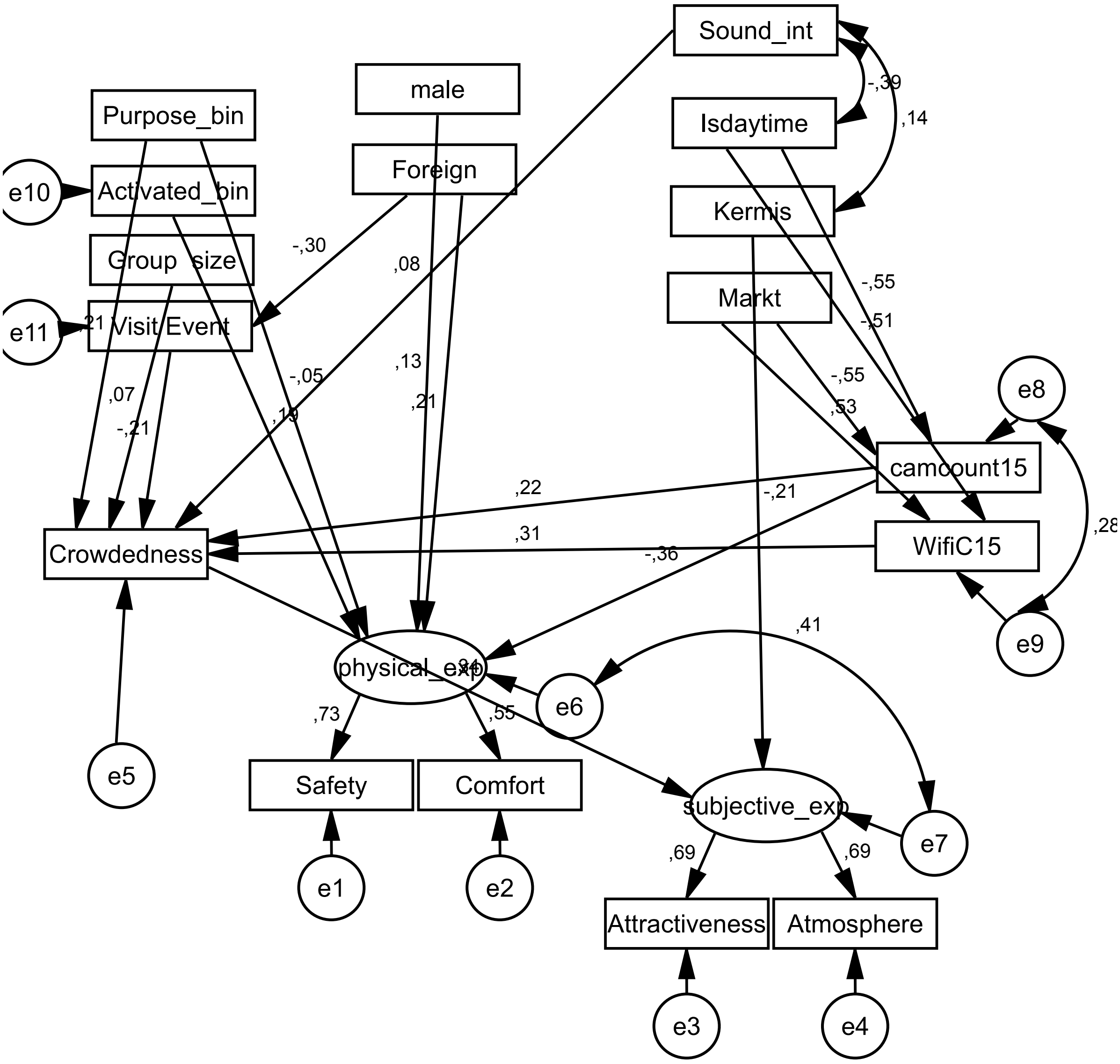

Figure C.2: TT Model 2: Full model based on theory, not significant

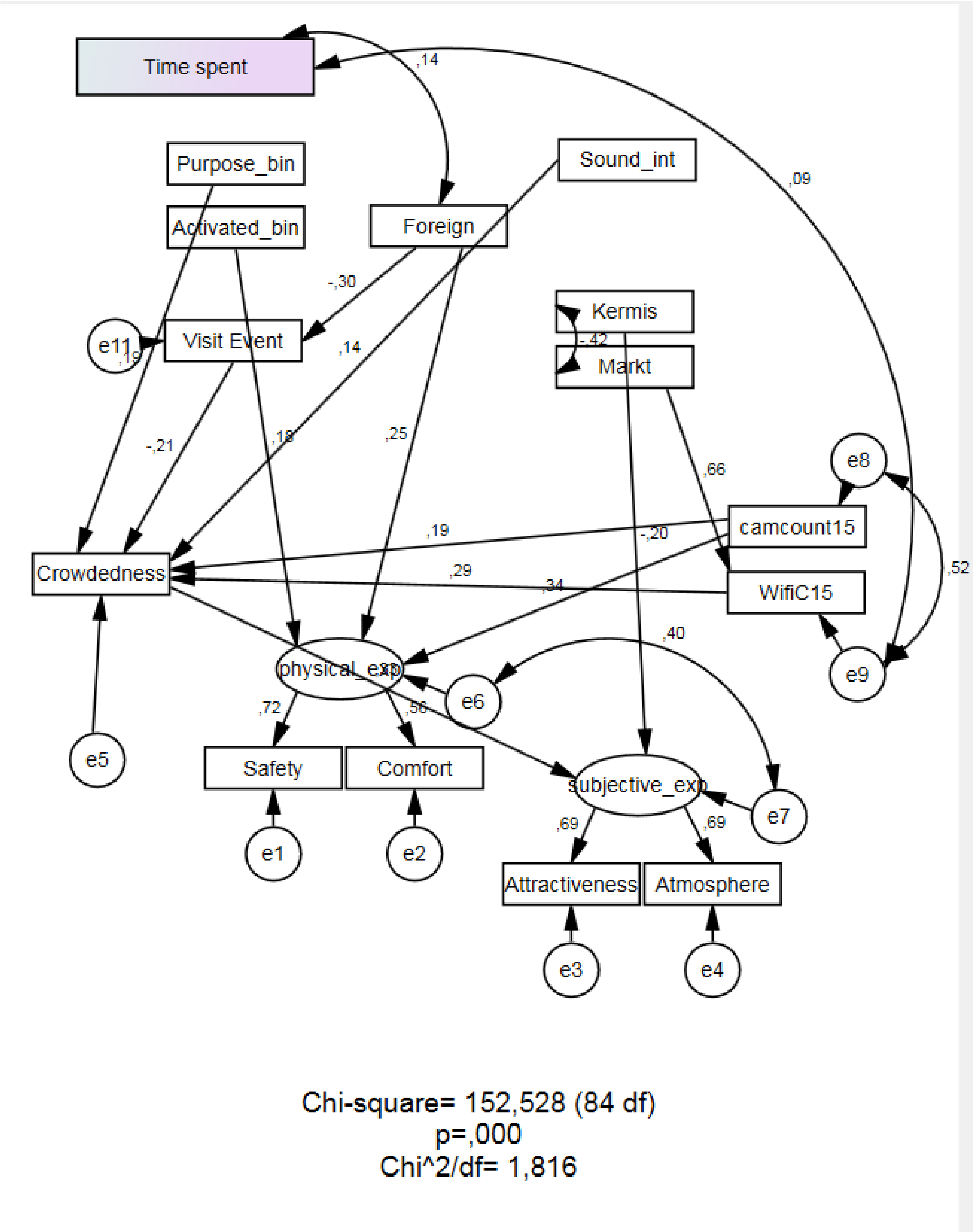

Figure C.3: TT Model 3: Intermediate model with time spent, not significant.

This model is not fitting according to the probability level, but looking at other indicators, it does. For example χ^2/df is below 2. All relations drawn are significant.

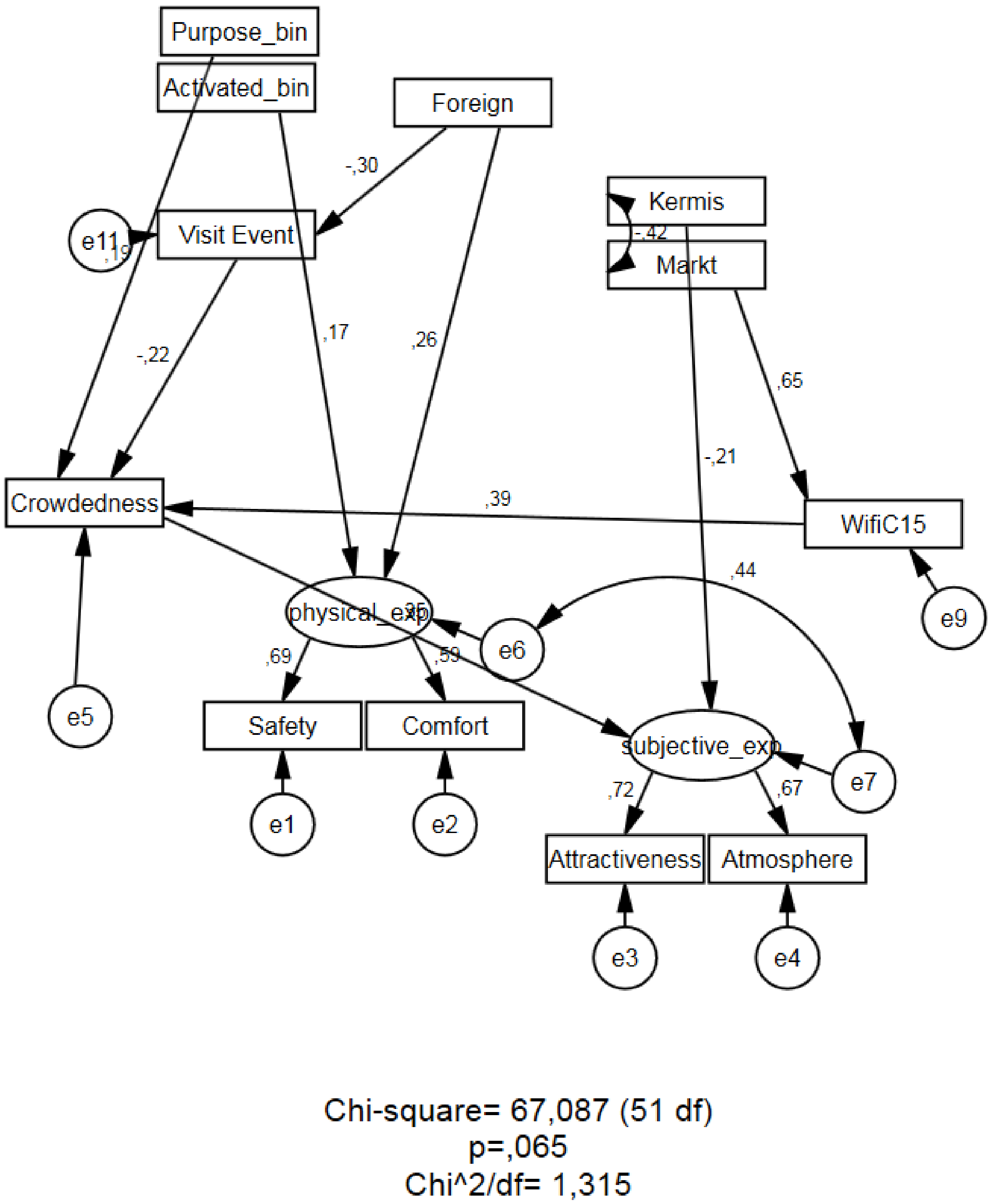

Figure C.4: TT Model 4: Intermediate model without camera counts, significant.

Here, a model is found that fits and only has significant relations. However, it is missing an the indicator flow.

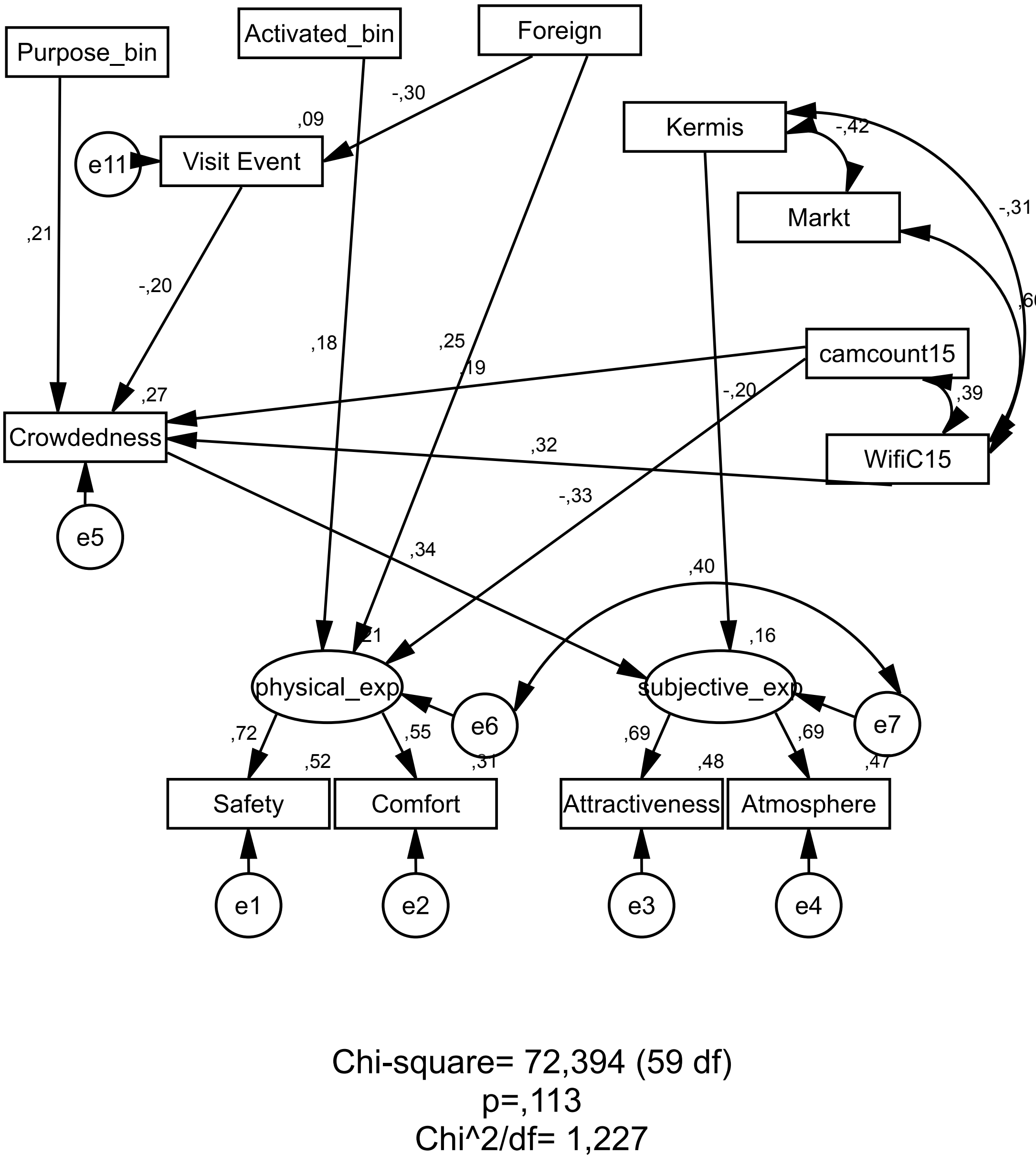

Figure C.5: TT Model 5: Final model

Figure C.5 represents the final model for the TT Festival.

C.2. RLD intermediate models

For the RLD case, a comparison between including the perception variables as separate entities and including them as latent variables is shown in Figure C.6 and Figure C.7. In Table C.1, their model fit indicators are compared.

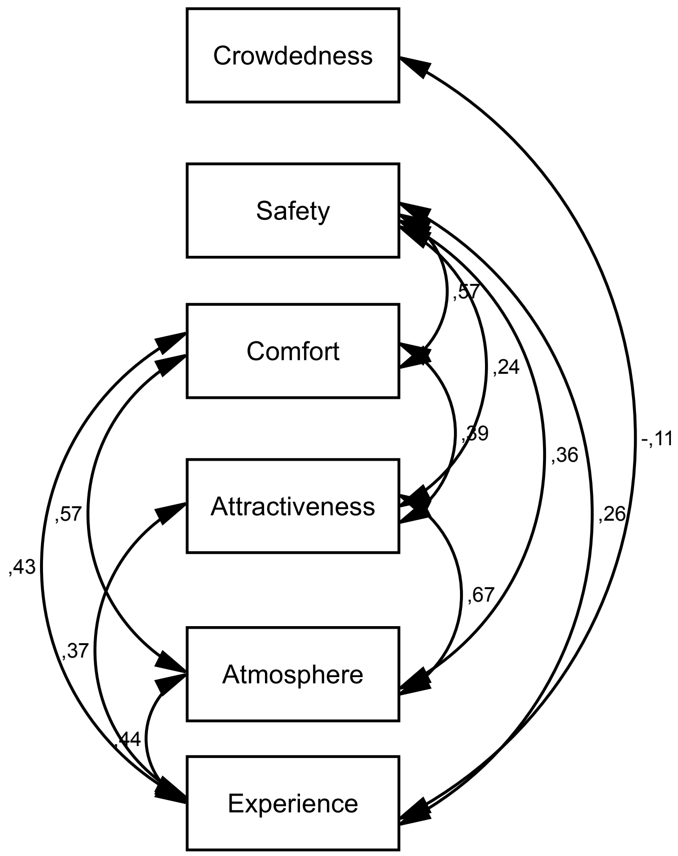

Figure C.6: RLD Model 0: Perception variables as correlations, significant

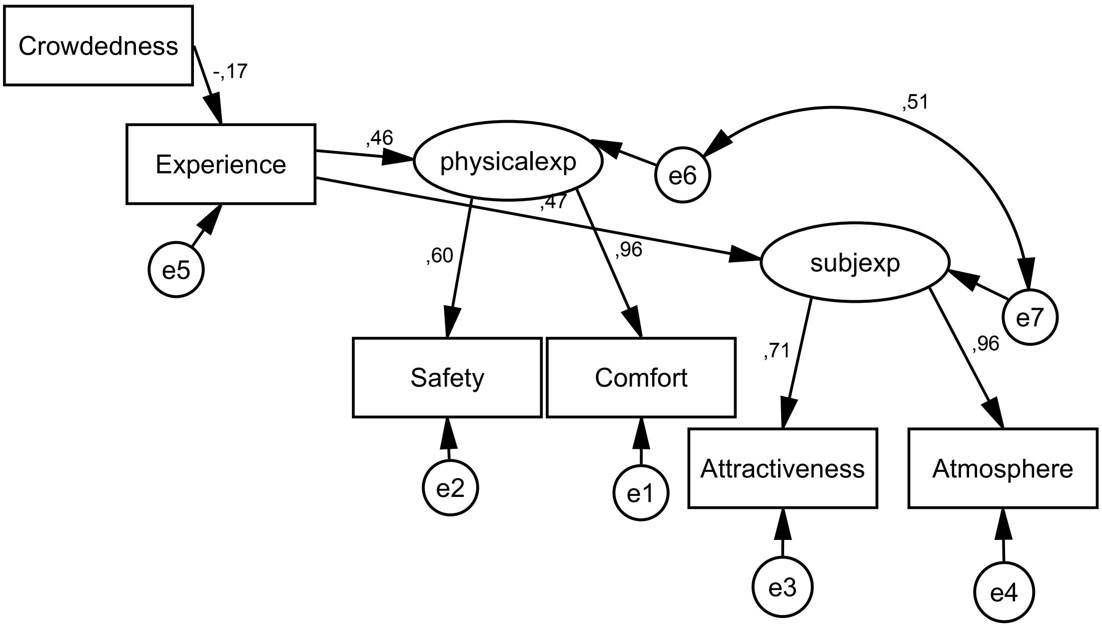

Figure C.7: RLD Model 1: Perception variables in measurement model, significant

Table C.1: SEM chosen boundary conditions for a good model fit

Indicator	Chi-square	p-value	df	Chi^2/df	GFI	CFI	PCFI	RMSEA	PCLOSE
Boundary condition	Low	>0.05	<2	>0.9	>0.9	>0.8	<0.1	>0.05	
Model 0	3.258	0.516	4	.814	.994	1.000	.267	.000	.707
Model 1	3.028	0.882	7	.433	.995	1.000	.467	.000	.961

Table C.1 shows that the model with a latent construct performs just as good or better on all indicators. The only indicator that is not satisfied is PCFI.

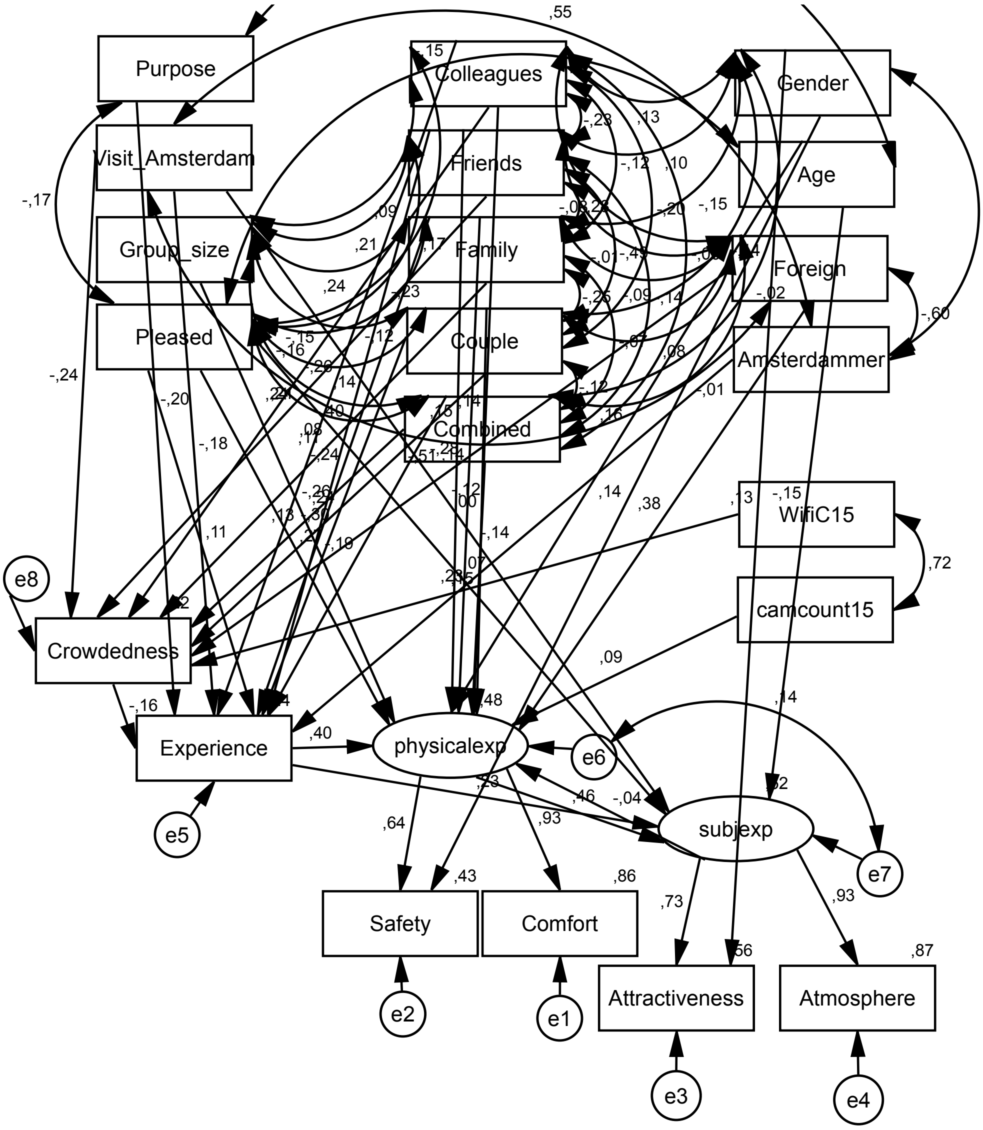

Figure C.8: RLD model 2: Full model based on theory, not significant

The full model based in theory is shown in Figure C.8. Many paths are insignificant and need to be removed.

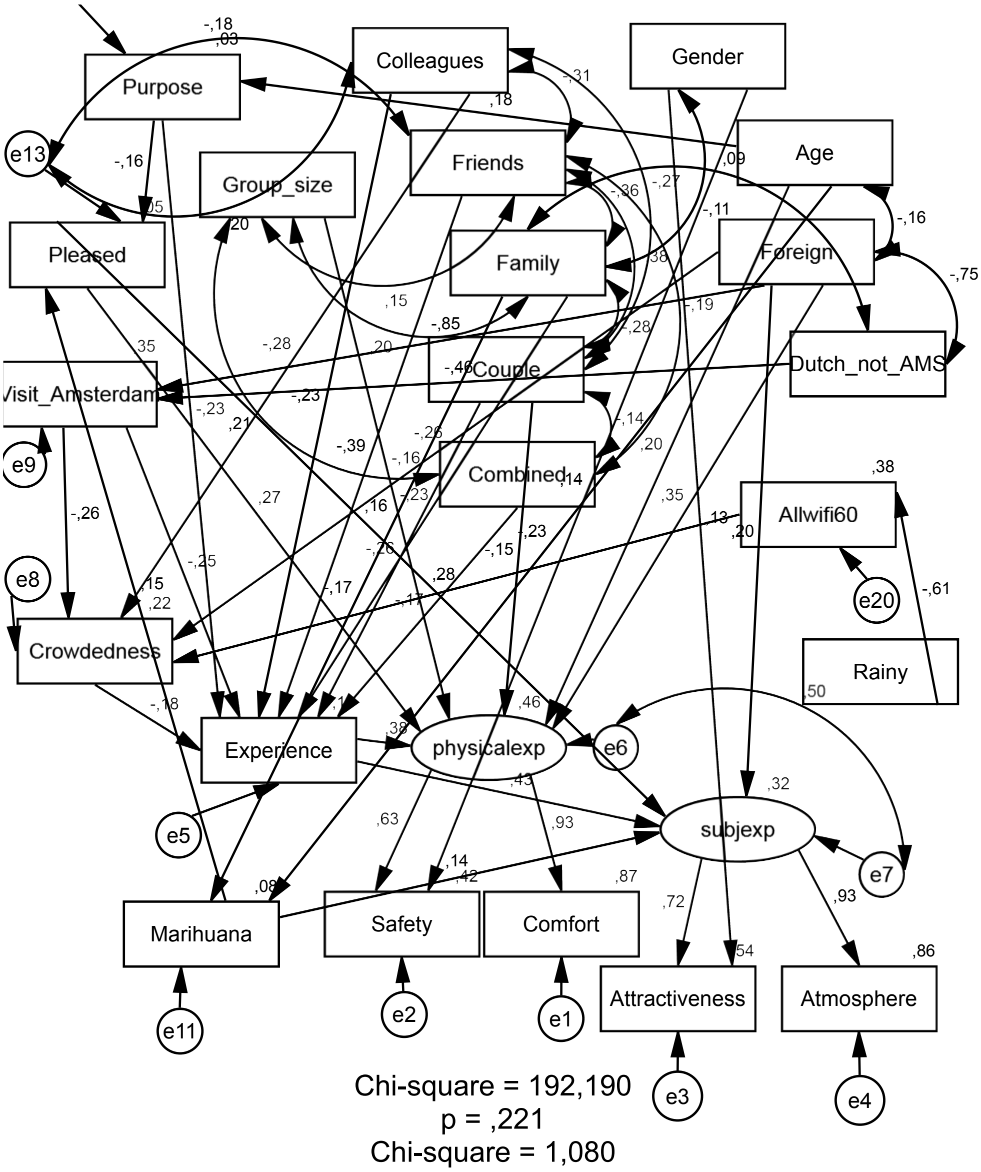

Figure C.9: Model RLD: Final model

Figure C.9 shows the final model for the Red light district.

D

Bi-variate data analysis techniques

D.

Bi-variate data analysis techniques

Especially the survey data requires specific statistical analysis. As can be seen in Table x, we are dealing with ordinal, nominal and binary data. In this section, the appropriate statistical tests are discussed.

Spearman's rho and Kendall's tau

For ordinal data, using a Pearson R test is not appropriate. The Pearson R test requires the use of minimally interval data to be accurate. Furthermore, it assumes that the data is normally divided, which is not the case for most of the variables. Spearman's rho is applicable to non-parametric data. Kendall's tau is another non-parametric test which is preferable when a dataset is small and there are many tied ranks. The dataset of the TT Festival contains 242 responses, making it a large data set (N>200) (Field, 2009). However, the ranks are indeed mostly tied. Therefore, both tests shall be used to draw conclusions.

The formulas are given below:

Spearman's ρ:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

Where:
d difference in rank
n sample size
(Lund research Ltd., 2018)

Kendall's τ:

$$\tau = \frac{C-D}{C+D}$$

C is the number of matching pairs (concordant) and D stands for the number of discordant pairs. (Statistics how to, 2016)

Chi square

A Chi square test can be used to find relations between two nominal variables. However, because the dataset is small, there is a larger chance that the Chi square test is not reliable (Field, 2009). Therefore, this test is not much used in this analysis.

Mann Whitney U test

The Mann Whitney U test is a non-parametric test can be used to find differences in outcomes compared for two groups. For example, the test can be used to see if there is a significant difference in perception between men and women (Field, 2009).

The test gives a rank to every score. The lowest rank is given to the lowest score, while the group is ignored. When there are tied scores, the ranks that would have been given are averaged over the number of tied scores. For example, if there the scores that would have received rank 2 and 3 have the same score, they would both get the rank 2.5.

Then, the outcomes are ordered according to rank. When there is no difference between the groups, this type of order would lead to a random division of the groups over the whole set. However, when one group has slightly higher scores, this becomes clear by this division. The same is true for the sum of ranks. When the ranks are divided equally between the groups, the sum of ranks should be similar.

The test statistic that is given at the end is based on the total sum of rank of the smallest group. The formula is given below:

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

Where:

R1 The sum of ranks of group 1

n1 The size of group 1

The output is the test also provides a significance value. In order to understand the outcome of a Mann-Whitney U test, a clustered bar plot might be added to make the distribution visible.

Kruskal Wallis

The Kruskal Wallis test has the same principles as the Mann Whitney U test, only it can be used for more than two groups. The outcome value H. Then, it is clear that there is a significant difference, between which groups this is still needs to be tested. For this goal, Mann Whitney U tests can be used. However, this involves performing many tests, which not only time consuming, but also increases the chance of a type 1 error. Therefore, a Bonferroni correction has to be applied in this case (Field, 2009).

Bonferroni Correction

In this analysis, the Bonferroni correction is applied by multiplying the significance value with the number of tests that are performed. For example, the rating of Crowdedness is compared between the three locations. To test all the combinations, three tests have to be performed, meaning that the p-value is multiplied by three. After the correction, the test is significant when $p < 0.05$. A bonferroni correlation is applied to prevent type 1 errors, meaning that a significant relation is found while there is none. The more tests that are performed, the more chance on type 1 errors.

E

Exploratory factor analysis

E.

Factor analysis

In this analysis, exploratory factor analysis is used to see whether our 6 questions related to crowd perception and experience are in fact indicators of one or more factors. The exploratory factor analysis is performed in SPSS using Principal axis factoring and varimax rotating, as suggested by Molin (2017)

The tables show the following:

KMO and Bartlett's test:
This is performed to see whether the variables are adequate for a factor analysis. The significance should be below 0.05 (Gaskin, 2010) and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy should be above 0.5 (Williams et al., 2010) .

Communalities:
Here, the initial communalities give the explained variance per variable using the other ones. The extraction value is found after the factor analysis. This is the shared variance with the other indicator belonging to the factor. These values should be above 0.25 (Molin, 2018b).

Total variance explained:
Shows the number of factors that are created. The number of factors is either decided by eigenvector larger than 1, or the number of factors is determined by the researcher. The cumulative percentage in the final column shows how well the factor can explain the variables. This should be above 50% (Gaskin, 2010).

(Rotated) factor matrix:
Gives the factor loadings. It is desired that each indicator only loads on one factor. If there are cross loading, this is OK if the difference is larger than 0.2 (Gaskin, 2010). A indicator is taken into account when it loads at least 0.5, but preferably 0.7 (Molin, 2018b).

TT Festival

Test 1: five perception variables included

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,580
Bartlett's Test of Sphericity	Approx. Chi-Square	136,410
	df	10
	Sig.	,000

From the KMO and Bartlett's Test, it can be concluded that the variables are adequate for factor analysis. KMO is above 0.5 and the p-value of Bartlett's test of sphericity is 0.00, meaning the variables are adequate for factor analysis.

Communalities

	Initial	Extraction
Crowdedness	,083	,136
Safety	,153	,331
Comfort	,173	,444
Attractiveness	,275	,443
Atmosphere	,274	,574

The communality for perceived crowdedness is below 0.25. This is not adequate.

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1,775	35,495	35,495	1,234	24,671	24,671	1,088	21,761	21,761
2	1,326	26,525	62,020	,695	13,897	38,568	,840	16,807	38,568
3	,788	15,769	77,789						
4	,620	12,400	90,189						
5	,491	9,811	100,000						

Two factors have an eigenvalues above 1. Together, they explain 38,6% of the shared variance. This is a bit low.

Rotated Factor Matrix[a]

	Factor	
	1	2
Crowdedness	,355	
Safety		,576
Comfort		,662
Attractiveness	,627	
Atmosphere	,750	

The loadings are divided neatly. However, the load of Crowdedness is too low. Since we already saw in the communalities that Crowdedness was not sufficient, a new test will be performed where this indicator is excluded.

Test 2: Perceived crowdedness excluded

Communalities

	Initial	Extraction
Safety	,149	,329
Comfort	,171	,447
Attractiveness	,268	,544
Atmosphere	,246	,459

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1,708	42,702	42,702	1,176	29,410	29,410	,994	24,850	24,850
2	1,178	29,458	72,159	,602	15,047	44,457	,784	19,607	44,457
3	,621	15,516	87,675						
4	,493	12,325	100,000						

Rotated Factor Matrix[a]

	Factor 1	Factor 2
Safety		,571
Comfort		,657
Attractiveness	,721	
Atmosphere	,675	

.

Now, we see that the extraction communalities are sufficient (above 0.25).Also, 44,5% of the variance is explained, which is a bit low, but acceptable. The factor loading are divided in Safety and Comfort and Attractiveness and Atmosphere. The loadings are above 0.5. Therefore, this result will be used in the final model.

Amsterdam

Test 1: Six perception variables included

The first test is performed with all six perceptions and no rotation.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,737
Bartlett's Test of Sphericity	Approx. Chi-Square	308,519
	df	15
	Sig.	,000

Here, we see that a significance of 0.00 indicates that a factor analysis is adequate.

Communalities

	Initial	Extraction
Crowdedness	,035	,024
Safety	,329	,273
Comfort	,505	,567
Attractiveness	,464	,420
Atmosphere	,575	,668
Experience	,272	,321

The extraction communalities are not all above 0.25, which means that Crowdedness is less related to the rest of the perceptions.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,791	46,515	46,515	2,274	37,897	37,897
2	,992	16,530	63,045			
3	,897	14,955	78,000			
4	,645	10,757	88,757			
5	,395	6,585	95,343			
6	,279	4,657	100,000			

One factor explains 37.9% of the shared variance.

Factor Matrix[a]

	Factor
	1
Crowdedness	-,156
Safety	,523
Comfort	,753
Attractiveness	,648
Atmosphere	,818
Experience	,566

In the factor matrix, we see factor loadings below 0.5. Therefore, another run will be done, choosing to find 3 factors and using rotations to spread the factors loadings more evenly.

Test 2: six perceptions included, 3 factors extracted

Communalities

	Initial	Extraction
Crowdedness	,035	,143
Safety	,329	,375
Comfort	,505	,871
Attractiveness	,464	,571
Atmosphere	,575	,833
Experience	,272	,370

We see that Crowdedness still forms a problem, because it is below 0.25. This means that the value does not have much in common with the rest.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,791	46,515	46,515	2,449	40,825	40,825	1,499	24,984	24,984
2	,992	16,530	63,045	,513	8,545	49,370	1,325	22,085	47,069
3	,897	14,955	78,000	,201	3,354	52,724	,339	5,655	52,724
4	,645	10,757	88,757						
5	,395	6,585	95,343						
6	,279	4,657	100,000						

Three factors are extracted, that explain 52% of the shared variance. This is an OK value, but it could be higher.

Rotated Factor Matrix[a]

	Factor		
	1	2	3
Crowdedness			-,371
Safety		,574	
Comfort	,308	,867	
Attractiveness	,722		
Atmosphere	,842	,350	
Experience	,378		,371

As can be seen in the rotated factor matrix, Crowdedness and Experience do not load high on any factor. Another test is performed excluding Crowdedness.

Test 3: Perceived crowdedness excluded, 3 factors extracted

Communalities

	Initial	Extraction
Safety	,328	,408
Comfort	,505	,821
Attractiveness	,464	,637
Atmosphere	,574	,753
Experience	,260	,370

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,759	55,181	55,181	2,405	48,104	48,104	1,381	27,617	27,617
2	,899	17,984	73,165	,506	10,129	58,233	1,271	25,422	53,039
3	,665	13,301	86,466	,077	1,543	59,776	,337	6,737	59,776
4	,396	7,927	94,394						
5	,280	5,606	100,000						

Rotated Factor Matrix[a]

	Factor 1	Factor 2	Factor 3
Safety		,610	
Comfort		,817	
Attractiveness	,761		
Atmosphere	,764	,357	
Experience	,334		,421

In this test, we see that three factors are created, explaining 59,8% of the variance of the indicators. In the rotated factor matrix, we see that one factor is created by Safety and Comfort and one factor is created by Attractiveness and Atmosphere. Experience loads on two factors, but both factor loadings are too low to take into account. Therefore, two latent variables will be created, and Crowdedness and Experience will be kept separate. One test will be performed to confirm this construct.

Test 4: Perceived and experienced crowdedness excluded, 2 factors extracted

Communalities

	Initial	Extraction
Safety	,328	,464
Comfort	,479	,730
Attractiveness	,456	,577
Atmosphere	,565	,810

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Factor	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,417	60,435	60,435	2,094	52,358	52,358	1,377	34,426	34,426
2	,893	22,332	82,767	,487	12,164	64,522	1,204	30,096	64,522
3	,409	10,217	92,983						
4	,281	7,017	100,000						

Rotated Factor Matrix[a]

	Factor	
	1	2
Safety		,663
Comfort		,780
Attractiveness	,738	
Atmosphere	,828	,352

Now, we see that 64.5% of the variance is explained and the factor loadings are all above 0.5. The cross loading of Atmosphere on factor 2 is lower than 0.5 and the difference with the loading on factor 1 is larger than 0.2.

Conclusion

In both cases, two latent factors can be extracted. One that connects Safety and Comfort. Both of these variables concern a person's physical experience and a psychological experience of the social norms of the crowd.

Atmosphere and Attractiveness of the environment both give an indication of how a person perceives an event and the crowd present.

F

Plan of action TT Festival

Plan van Aanpak: Enquêteren TT Festival 2018

In dit plan van aanpak staat kort beschreven hoe ik het onderzoek naar de perceptie van evenement bezoekers ga uitvoeren. Dit onderzoek is deel van mijn afstudeerproject aan de TU Delft onder begeleiding van Dorine Duives.

Team

We zullen met twee personen vanuit het team van de TU Delft enquêtes afnemen. We zullen voornamelijk samen op dezelfde plek enquêtes afnemen. Mochten er gedurende het evenement vragen zijn ben ik altijd bereikbaar op onderstaand nummer:

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Onderzoek

Om erachter te komen hoe mensen in de menigte drukte ervaren en welke factoren daarbij een rol spelen nemen we vragenlijsten af. Een voorbeeld van de vragenlijst kan in Bijlage: Vragenlijst gevonden worden. Vervolgens wordt de data van de vragenlijsten vergeleken met de monitoring data die verzameld is. Het is daarom belangrijk dat de vragenlijsten worden afgenomen in de buurt van de videocamera's. Van de camerabeelden wordt eens in het kwartier bekeken hoe druk het is en hoe de menigte zich beweegt. Als laatste zullen er ook eens in het half uur licht en geluidsintensiteit metingen worden uitgevoerd met behulp van een applicatie op een smartphone. Het doel is om in ieder geval 250 enquêtes af te nemen. Voor het onderzoek zullen mensen willekeurig worden aangesproken. Enquêtes zullen alleen worden afgenomen vanaf een leeftijd van 18 jaar. De enquêtes zullen bij voorkeur elektronisch worden afgenomen op tablets. Voor de zekerheid worden ook papieren exemplaren meegenomen.

Voorbereiding

1. Vragenlijst testen en tijdsduur noteren.
2. Controleer of alle benodigde materialen er zijn, controleer of de apparatuur werkt en dat de batterijen volledig opgeladen zijn.

Benodigde materialen:

- 2x tablets
- 1x dongel
- 2x oplaadkabel
- 2x powerbank
- 50x survey geprint NL
- 10x survey geprint EN
- 2x klembord
- 4x pen
- 2x notitieblok
- 2x telefoon met applicatie: Phyiscs toolbox

Locaties

Op drie locaties van het festivalterrein zijn videocamera's aanwezig, richting de TT Kermis (C3), richting Station Assen (C5) en op het Koopmansplein (C4). Dit zijn de plekken waar de enquêtes zullen worden afgenomen. Bij Station Assen vertrekken treinen en een groot aantal bussen, waaronder speciale TT lijnen en nachtbussen.

1 Plattegrond TT Festival Assen 2018 met monitoring apparatuur

Planning

Om de daadwerkelijke test soepel te laten verlopen, wordt op donderdag eerst een pilot test gedaan. Hierbij wordt gekeken of de bezoekers de vragen begrijpen en willen beantwoorden en hoe lang het invullen duurt. Eventueel kunnen er dan nog aanpassingen worden gedaan. Ook kan zo worden getest of de tablets en smartphone applicaties naar behoren werken. Tijdens de meetdagen worden de drie locaties afgewisseld. De enquête zal bij de locatie van het station op dag 1 vroeg worden gehouden, wanneer een grote instroom wordt verwacht en op dag 2 juist laat op de avond, wanneer wordt verwacht dat er veel mensen zullen vertrekken.

Pilot dag: donderdag 28 juni 2018

1. Aankomst rond 14.30, spullen wegbrengen.
2. Verkennend rondje over het terrein lopen met camera, beste plekken uitkiezen voor enquête.
3. Op de drie locaties enquête 10x afnemen en licht en geluidsmetingen uitvoeren.
4. Noteren welke vragen onduidelijk waren, eventueel aanpassingen maken. Noteren hoe lang het invullen van de enquête kost.

Meetdag 1: vrijdag 29 juni 2018

1. Enquêtes afnemen, ongeveer 1 enquête in twee minuten.
2. Om het half uur licht en geluidsmeting uitvoeren.
3. Overige observaties over speciale omstandigheden noteren.

Tijd	Locatie
18:30-20:30	Station
20:30-21:00	pauze
21:00-22:30	Koopmansplein
22:30-23:00	pauze
23:00-00:30	Kermis

Meetdag 2: zaterdag 30 juni 2018

1. Enquêtes afnemen, ongeveer 1 enquête in twee minuten.
2. Om het half uur licht en geluidsmeting uitvoeren.
3. Overige observaties over speciale omstandigheden noteren.

Tijd	Locatie
19:00-20:30	Koopmansplein
20:30-21:00	pauze
21:00-22:30	Kermis
22:30-23:00	pauze
23:00-01:00	Station

G

Survey questions TT Festival

Enquête: Evenement ervaring

In te vullen door enquête afnemer:

*Vereist

1. **Locatie**

Markeer slechts één ovaal.

- Kermis
- Koopmansplein
- Markt
- Anders: ______

2. **Language** *

Markeer slechts één ovaal.

- Nederlands

- Engels *Na de laatste vraag in dit gedeelte ga je naar vraag 20.*

3. **Geslacht** *
Markeer slechts één ovaal.

- man
- vrouw
- Anders: ____________

Algemene Informatie

Hallo, Ik doe voor mijn afstudeerproject bij de universiteit Delft onderzoek naar voetgangers bij evenementen. Zou je mij willen helpen door mee te doen aan een korte vragenlijst over dit evenement? Het duurt ongeveer twee minuten. Als je een vraag tegenkomt die je niet wil beantwoorden kunnen we deze overslaan. Ik kan ook een stuk met u meelopen terwijl we de enquête invullen.

4. **In welke leeftijdscategorie valt u:** *
Markeer slechts één ovaal.

- 18-24
- 25-34
- 35-44
- 45-64
- 65-74
- 75+

5. **In welke gemeente woont u:** *

____

6. **Hoe vaak bent u in Assen geweest?** *
Markeer slechts één ovaal.

- Nooit voor vandaag
- Een aantal keer
- Regelmatig
- Dagelijks

7. **Hoe vaak bent u naar TT Festival Assen geweest?** *
Markeer slechts één ovaal.

- Nooit voor vandaag
- 1-3 keer
- 4-6 keer
- Meer dan 6 keer

8. **Met hoeveel mensen bent u hier?** *

Markeer slechts één ovaal.

- ( ) Alleen *Ga naar vraag 11.*
- ( ) Kleine groep (2-3)
- ( ) Middelgrote groep (4-6)
- ( ) Grote groep (7+)

Groepsvorm

9. **Hoe kennen jullie elkaar?**

Vink alle toepasselijke opties aan.

- [ ] Stel
- [ ] Gezin met kinderen
- [ ] Familie
- [ ] Vrienden
- [ ] Collega's/medestudenten
- [ ] Bekenden
- [ ] Anders: ____________________

10. **Wat is de samenstelling van deze groep?**

Markeer slechts één ovaal.

- ( ) Alleen mannen
- ( ) Alleen vrouwen
- ( ) Gemengd

11. **Kies de woorden die het best passen bij hoe u zich nu voelt:**
meerdere antwoorden mogelijk
Vink alle toepasselijke opties aan.

- [ ] Neutraal
- [ ] Opgewonden
- [ ] Uitgelaten
- [ ] Enthousiast
- [ ] Blij
- [ ] Verheugd/Vrolijk
- [ ] Ontspannen
- [ ] Sereen/Rustig
- [ ] Slaperig
- [ ] Moe
- [ ] Verveeld
- [ ] Depressief
- [ ] Verdrietig
- [ ] Gefrustreerd
- [ ] Geërgerd
- [ ] Boos
- [ ] Gealarmeerd/Paniekerig
- [ ] Anders: ____________________

12. **Bent u op dit moment onder invloed van een van de volgende middelen:**
meerdere antwoorden mogelijk
Vink alle toepasselijke opties aan.

- [ ] Geen middelen gebruikt
- [ ] Alcohol
- [ ] MDMA
- [ ] Marihuana
- [ ] Anders: ____________________

13. **Waar gaat u nu/hierna naartoe?** *

Markeer slechts één ovaal.

- Weet nog niet
- Rondlopen
- Trein station
- Parking Weierstraat
- Mainstage
- RadioNL
- 538 DJ's on tour
- Jupiler stage
- Action on wheels
- Actifood stage
- Hotel de Jonge stage
- Burning rubber oil plein
- Plantage onverwacht
- TT Kermis
- Guts and Glory
- TT laan merchandise
- Anders: ____________________

14. **Hoe lang bent u al op dit evenement aanwezig?** *

Markeer slechts één ovaal.

- Weet ik niet
- Minder dan een uur
- 1-2 uur
- 2-3 uur
- 3-4 uur
- 4-5 uur
- 5-6 uur
- Meer dan 6 uur

15. **Hoe schat u de drukte op deze locatie in?** *

Markeer slechts één ovaal.

	1	2	3	4	5	
heel rustig						heel druk

16. **Hoe schat u de veiligheid op deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel onveilig	( )	( )	( )	( )	( )	heel veilig

17. **Hoe schat u het comfort op deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel oncomfortabel	( )	( )	( )	( )	( )	heel comfortabel

18. **Hoe schat u de aantrekkelijkheid van deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel onaantrekkelijk	( )	( )	( )	( )	( )	heel aantrekkelijk

19. **Hoe schat u de sfeer van deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel ongezellig	( )	( )	( )	( )	( )	heel gezellig

Stop met het invullen van dit formulier.

General Information

Hi, I'm doing my thesis project about the perception of event visitors at Delft University of Technology. Would you like to help me by filling in a short survey? It takes about 2 minutes. If there is a question that you would not like to answer it can be skipped. I can also walk a bit with you while you fill in the survey.

20. **What is your age category?** *
Markeer slechts één ovaal.

( ) 18-24
( ) 25-34
( ) 35-44
( ) 45-64
( ) 65-74
( ) 75+

21. **Country:** *

Markeer slechts één ovaal.

- Afghanistan
- Albania
- Algeria
- American Samoa
- Andorra
- Angola
- Anguilla
- Antigua and Barbuda
- Argentina
- Armenia
- Aruba
- Australia
- Austria
- Azerbaijan
- The Bahamas
- Bahrain
- Bangladesh
- Barbados
- Belarus
- Belgium
- Belize
- Benin
- Bermuda
- Bhutan
- Bolivia
- Bosnia and Herzegovina
- Botswana
- Brazil
- Brunei
- Bulgaria
- Burkina Faso
- Burundi
- Cambodia
- Cameroon
- Canada
- Cape Verde
- Cayman Islands
- Central African Republic

- Wallis and Futuna
- Western Sahara
- Yemen
- Zambia
- Zimbabwe
- Other

22. **City:** *

23. **How many times have you visited the city Assen?** *
Markeer slechts één ovaal.
- Never before this time
- A few times
- Regularly
- Daily

24. **How many times have you visited TT festival Assen?** *
Markeer slechts één ovaal.
- Never before this time
- 1-3 times
- 4-6 times
- More than 6 times

25. **With how many people are you here?** *
Markeer slechts één ovaal.
- Alone *Ga naar vraag 28.*
- Small group (2-3)
- Medium sized group (4-6)
- Large group (7+)

Group

26. **What is your relation with these people?**
Vink alle toepasselijke opties aan.

- [ ] Couple
- [ ] Couple with children
- [ ] Family
- [ ] Friends
- [ ] Colleagues/Fellow students
- [ ] Acquaintances
- [ ] Anders: ____________________

27. **What is the composition of your group?**
Markeer slechts één ovaal.

- ( ) Only men
- ( ) Only women
- ( ) Mixed group

28. **Choose the words that best describe how you feel right now:**
multiple answer selection possible
Vink alle toepasselijke opties aan.

- [ ] Neutral
- [ ] Aroused
- [ ] Excited
- [ ] Delighted
- [ ] Happy
- [ ] Glad
- [ ] Serene
- [ ] Relaxed
- [ ] Sleepy
- [ ] Tired
- [ ] Bored
- [ ] Depressed
- [ ] Sad
- [ ] Frustrated
- [ ] Annoyed
- [ ] Angry
- [ ] Alarmed
- [ ] Anders: ____________________

29. **Are you currently under the influence of one of the following substances?**
multiple answer selection possible
Vink alle toepasselijke opties aan.

- [ ] No substances used
- [ ] Alcohol
- [ ] MDMA
- [ ] Marihuana
- [ ] Anders: ____________________

30. **Where are you going at the moment?** *
Markeer slechts één ovaal.

- ( ) I don't know yet
- ( ) Walking around randomly
- ( ) Train station
- ( ) Mainstage
- ( ) RadioNL stage
- ( ) 538 DJ's on tour
- ( ) Jupiler stage
- ( ) Action on wheels
- ( ) Parking Weierstraat
- ( ) Actifood stage
- ( ) Hotel de Jonge stage
- ( ) Burning rubber oil square
- ( ) Plantage onverwacht
- ( ) TT Fair (Kermis)
- ( ) Guts and Glory
- ( ) TT lane (merchandise)
- ( ) Anders: ____________________

31. **For how long are you at this festival at the moment?** *
Markeer slechts één ovaal.

- ( ) I don't know
- ( ) Less than an hour
- ( ) 1-2 hours
- ( ) 2-3 hours
- ( ) 3-4 hours
- ( ) 4-5 hours
- ( ) 5-6 hours
- ( ) More than 6 hours

32. **How would you rate the level of crowdedness at this location?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
Very uncrowded	◯	◯	◯	◯	◯	Very crowded

33. **How would you rate the level of safety at this location?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
very unsafe	◯	◯	◯	◯	◯	very safe

34. **How would you rate the level of comfort at this location?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
Very uncomfortable	◯	◯	◯	◯	◯	Very comfortable

35. **How would you rate the level of attractiveness at this location?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
Very unattractive	◯	◯	◯	◯	◯	Very attractive

36. **How would you rate the ambiance level at this location?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
Very bad ambiance	◯	◯	◯	◯	◯	Very good ambiance

H

Statistical analysis TT

H.

Exploratory bi-variate analysis

Analysis of survey and monitoring data from TT Festival 2018

In this analysis, the initial results of the research of the TT Festival 2018 are presented. First, the data processing is discussed. Before the data can be analysed, it is necessary to filter out incorrect data. Then, the statistical tests that are used are explained. After that the analysis starts with some general descriptives, to provide the reader with some insight in the type of data collected. In the final section, hypotheses about perception and the explanatory variables are tested. All the significant relations are summarized in the conclusion, which will also contain recommendations for the next steps in the research.

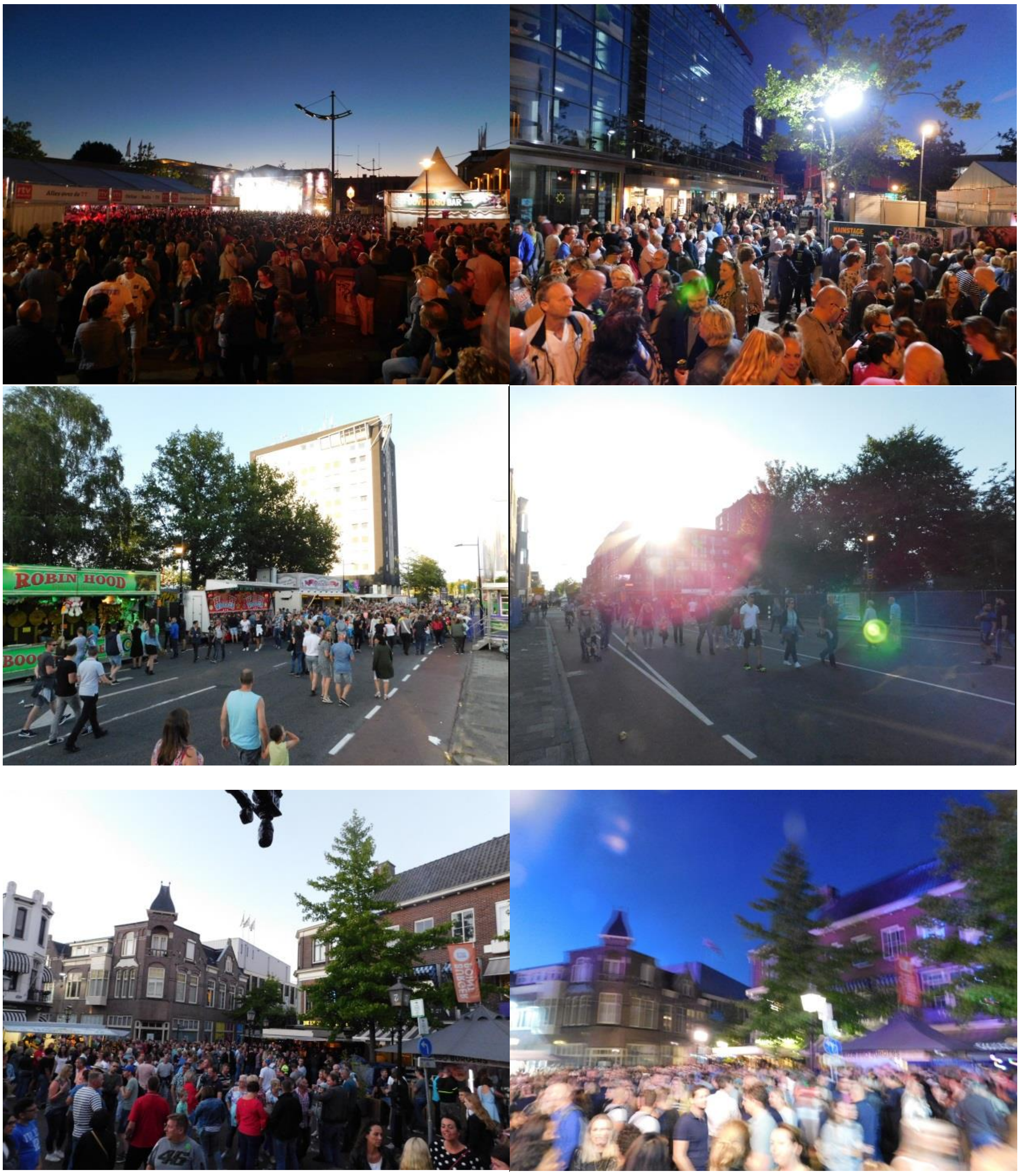

Figure 1: Survey locations top to bottom: Koopmansplein, Kermis, Markt.

Symbols

Table 1: Symbols

Symbol	Meaning
M	Mean
Mdn	Median
Mo	Mode
N	Total sample size
n	Subsample size
p	p-value, asymptotic significance
α	Significance level
z	Z score
df	Degrees of freedom
ρ	Spearman's rho
τ	Kendall's tau
X^2	Chi
H()	Kruskal Wallis Chi square
mR	Mean rank
U	Mann Whitney U test statistic

Raw data filtering

In order to transform the raw survey data to data ready to be processed, to following steps have been taken:

1. Remove pilot tests from data set.
2. Check dataset manually for missing answers.
3. Correct misspelled answers (eg. Municipalities) using the 'find&replace' command in Excel.
4. Convert all string answers to numbers in Matlab.
5. Add variables, such as Urbanization level.
6. Recategorize multiple answer question into usable categories (Purpose, Group type, Substance usage, Affect) with SPSS or Matlab

The recategorization is performed in order to use the data in different ways. Per category, it is explained why this is done.

Purpose

The survey question regarding purpose gave examples of the stages that were present at the event. However, most people answered that they were in fact walking around randomly, eg without a purpose, or did not know where they were going. Therefore, the number of stages that were mentioned are too low to draw conclusions from.

Group type

This variable contains 7 categories that could be chosen, with multiple answers possible. This creates a complex variable, since combined categories did not occur often. Therefore, it is chosen to combine all the multiple answer responses into one category. Furthermore, the categories acquaintances and colleagues are added together.

Affect

For simplicities sake, the affect variables are recoded into two dummy variables for activation and pleasant, according to the theory of Triandis (1977). However, the original emotional state is kept as well.

General Descriptives

The survey had 242 participants, spread over three days and three locations. At the event itself, there was an estimate of 160.000 people (RTV Drenthe, 2018). The survey can therefore not be seen as a sample of the event population. The number of surveys per location is not completely equal, as can be seen in Table 2. The locations of the Wi-Fi sensors are shown in Figure 2.

Table 2: Survey location frequencies

Location	Sensor	Frequency	Percent
Kermis	**W3**	62	25,6%
Koopmansplein	**W4**	98	40,5%
Markt	**W15**	82	33,9%
Total		242	100%

Figure 2: Map with Wi-Fi sensor locations

At the 'Kermis', the lowest number of surveys are conducted (N=62). However, this is assumed to be enough to compare the three locations. However, it has to be taken into account that the locations were also visited at different times. The surveys were conducted between 20:00 and 00:00 o'clock on Thursday 28 June 2018, Friday 29 June 2018 and Saturday 30 June 2018. As can be seen in Figure 3, the division of the timestamps over the locations is not equal. Also, at the 'Markt' location, there is no data available between 20:00-21:00, while at the 'Kermis', there is no data available between 22:00-23:00.

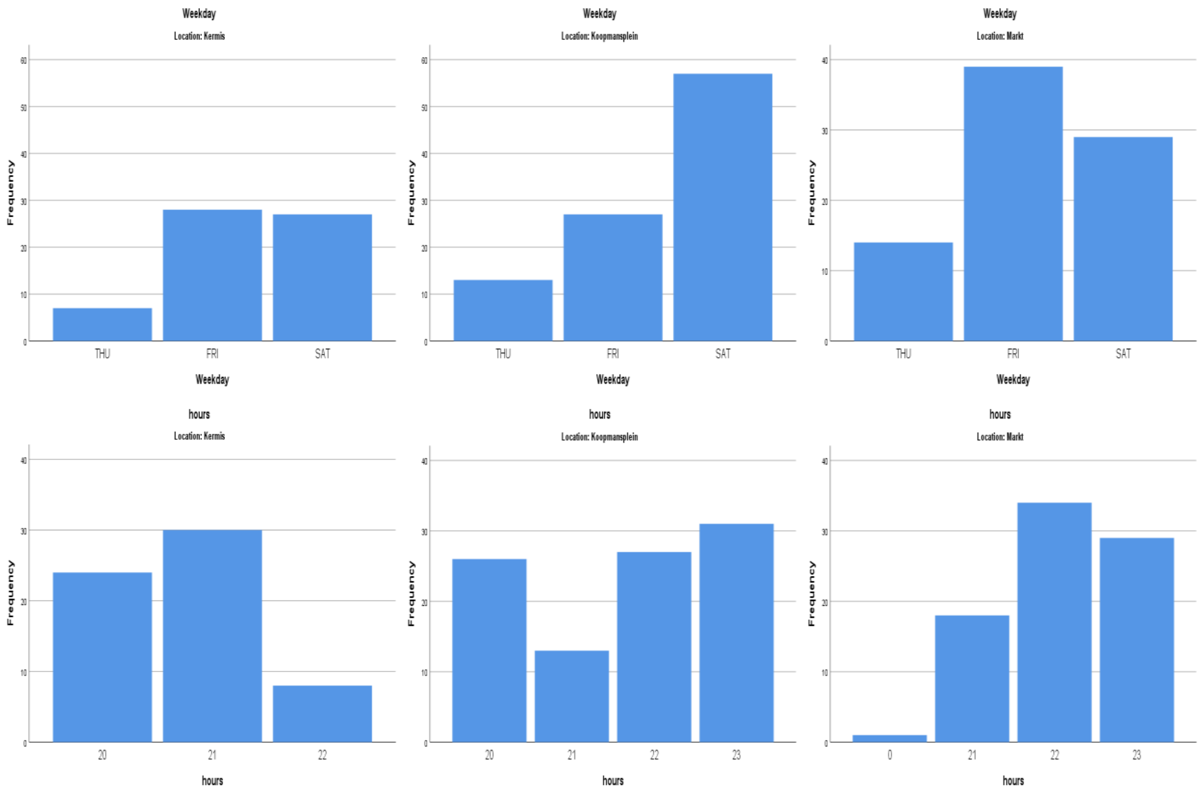

Figure 3: Weekday and time of day frequencies

The results in Table 3 show that most of the participants visit Assen daily (Mo=4 *'Daily'*, Mdn=4 *'Daily'*) and have visited the event more than six times (Mo=4 *'More than 6 times'*, Mdn=4 *'More than 6 times'*). These results show that many visitors of the event live in the neighbourhood of Assen and often visit the event. The question regarding place of residence showed that 159 of the respondents live in the Province Drenthe, of which 115 live in Assen (see Figure 4). A relatively small part of the participants was foreign (9,1%). When the survey is performed, participants had spent 1-2 hours on average (Mo=3 '*1-2 hours*', Mdn=3 '*1-2 hours*').

Table 3: General descriptives ordinal variables

	Median	**Mode**	**Min**	**Max**
Visit_Assen	4 *'Daily'*	4 *'Daily'*	1 *'Never'*	4 *'Daily'*
Visit_Event	4 *'More than six times'*	4 '*More than six times'*	1 *'Never'*	4 *'Daily'*
Time_Spent	3 '*1-2 hours'*	3 '*1-2 hours'*	1 *'Unknown'*	7 *'More than 6h'*
Group_size	2 *'Small group 2-3 p'*	2 *'Small group 2-3 p'*	1 *'Alone'*	4 *'Large group 7+'*
Age	3 '35-44'	4 '45-64'	1 '18-24'	6 '75+'

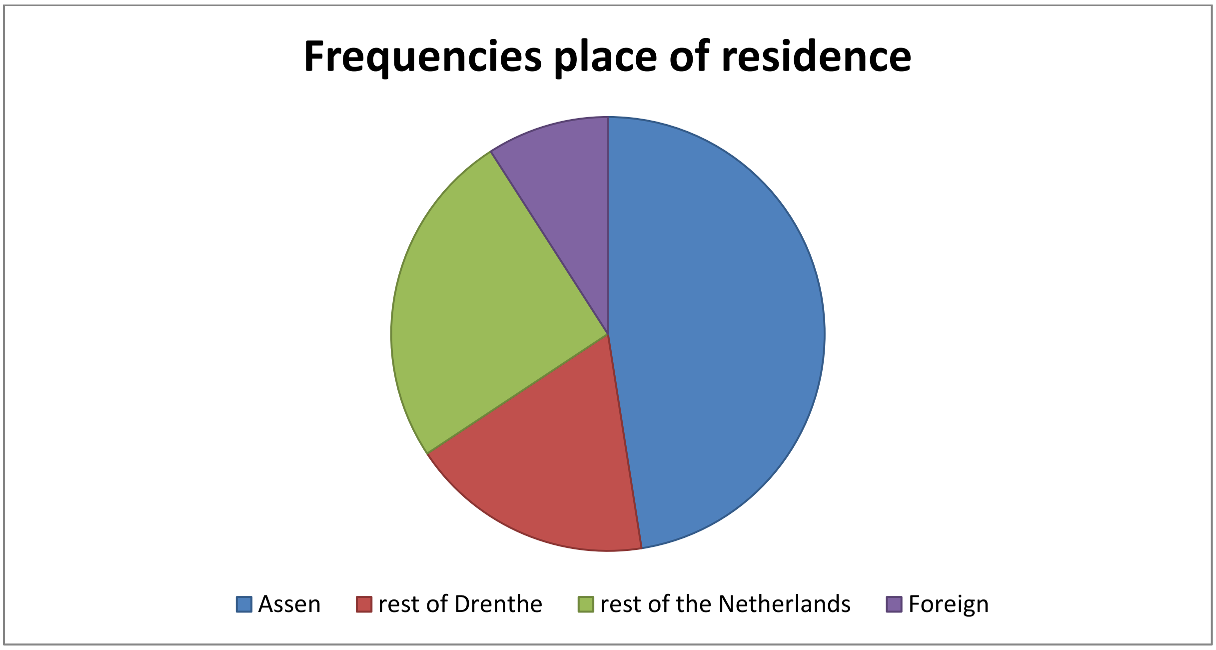

Figure 4: Frequencies place of residence

In Figure 5, the frequencies of the age groups are shown. As can be seen, surveys were collected in all age categories. The percentage of participants aged over 65 is relatively small, but this seems realistic for events. The group aged from 45-65 is the largest, but this is also the largest bin, covering 20 years. The age groups were chosen like this to provide meaningful categories concerning lifestyle and identity (Bytheway, 2011). The gender division was male (50,4%), female (49,2%).

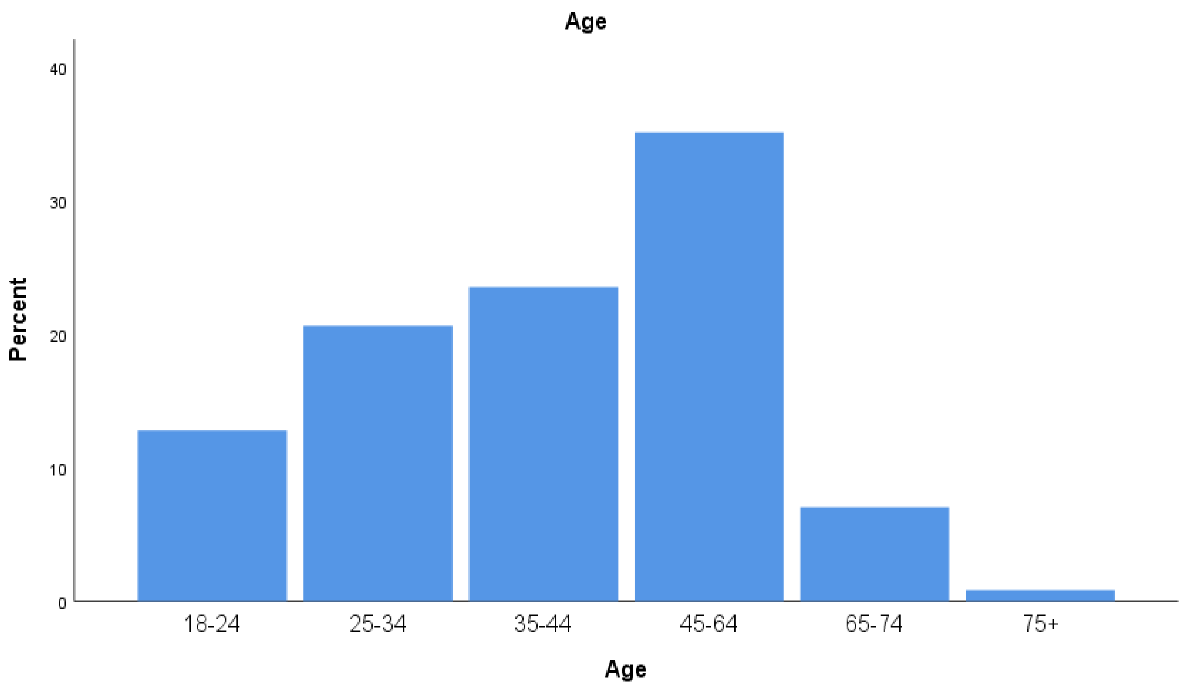

Figure 5: Age frequency distribution

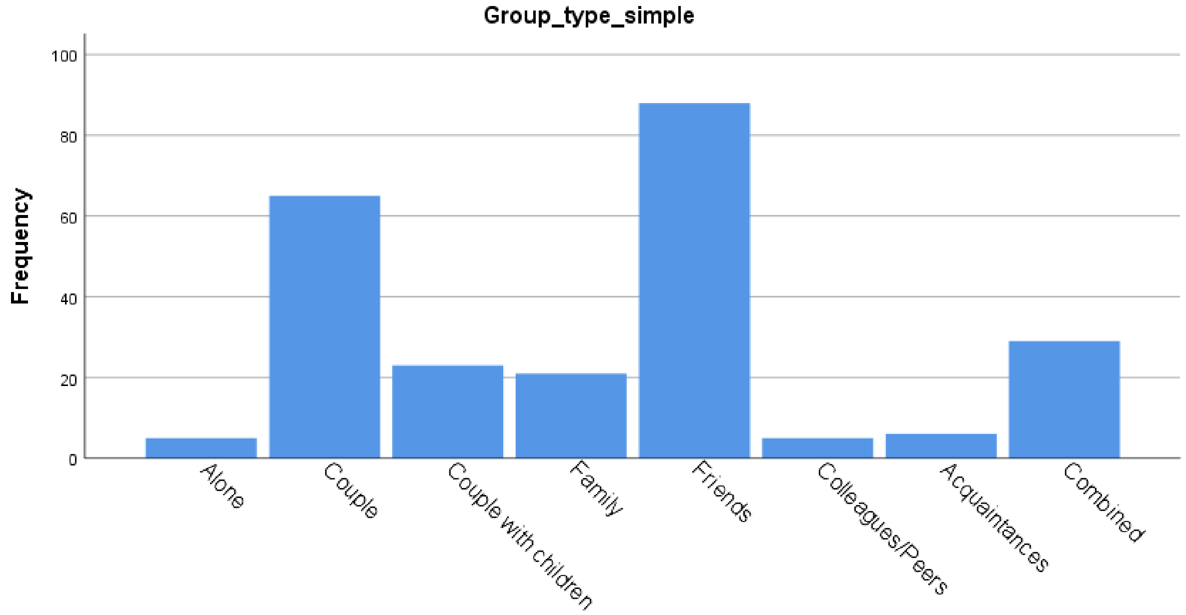

Figure 6: Group type frequency distribution

The group types can be found in Figure 6. The last category, 'combined', was created for participants who selected multiple answers. Since the amount of unique combinations was too high, it was chosen to simply categorise them all as a combined group. The most common group size is a small group (2-3 persons), see Figure 7. This is quite logical, since in Group type, the number of couples is also high.

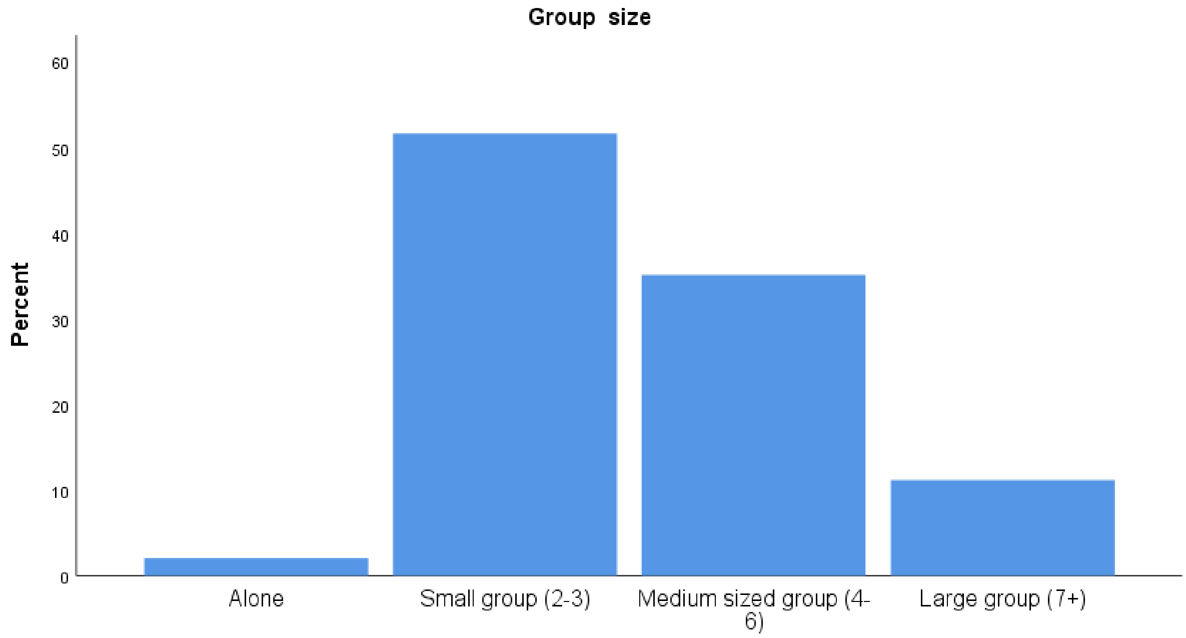

Figure 7: Group size frequency distribution

In Figure 8, trip purposes are displayed. It is noteworthy that the number of people 'walking around randomly' is relatively high. Furthermore, the amount of people who do not know where they are going is also high, which can be seen as more or less the same answer. Some of the participants were stationary, their answers also belong in the category 'unknown'.

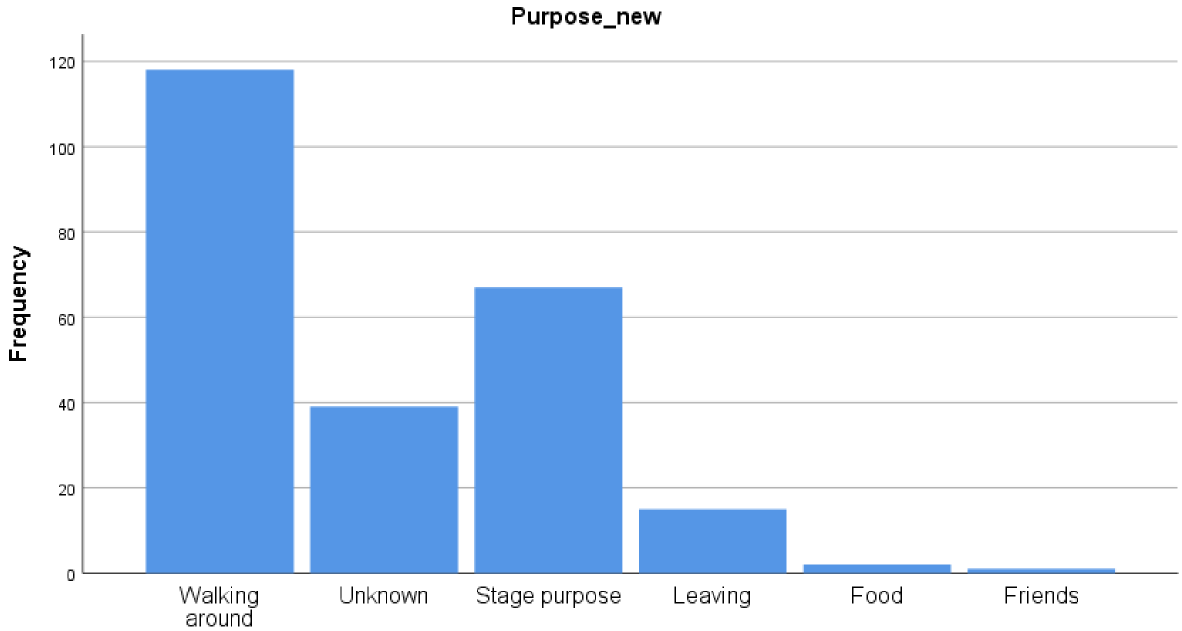

Figure 8: Purpose frequencies

58,7% of the participants had consumed alcohol at the time of the survey. Other substances were used in such small percentages, that they are not useful for analysis. For Affect, participants could select more than one answer. Happy, Relaxed, Delighted and Glad are mentioned most often, see Figure 9. Due to a fault in the survey, the Dutch version did not have the option 'Serene' as an answer. To use emotional state, it is chosen to categorize the emotions, according to Triandis (1977). The result is a division in the pleasantness (not pleasant, neutral, pleasant) and activation (not activated, neutral, activated).

Table 4: Summary Affect

	Yes	Neutral	No
Activated	103	52	87
Pleased	227	14	1

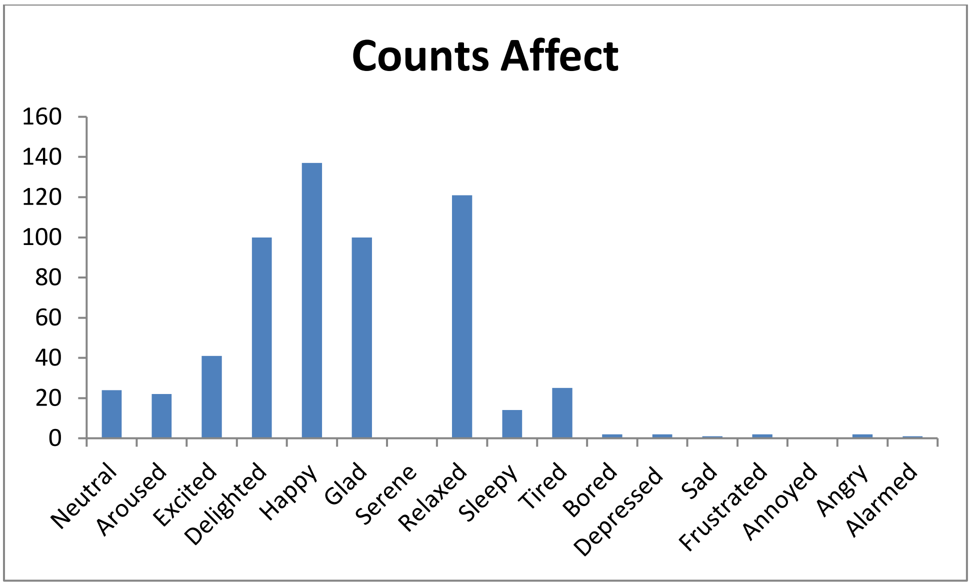

Figure 9: Affect frequencies

Finally, the frequencies of the perception values are given. As can be seen, crowdedness has another type of division than the other perception variables. It seems to have a normal distribution. However, without a comparison to actual crowdedness, no conclusions can be drawn yet. During the survey, it seemed as if answers were not very consistent with other participants at the same time and place. The other perception variables have a slightly skewed distribution. In general, this means that participants of the survey had a positive perception at the time of the survey.

Table 5: Perception general descriptives

	Median	Mode	Skewness	Kurtosis
Perceived Crowdedness (PC)	3	3	-0,131	-0,624
Perceived Safety (PS)	5	5	-1,108	0,903
Perceived Comfort (Pcom)	4	4	-0,506	0,396
Perceived Attractiveness (PAE)	4	4	-0,599	0,120
Perceived Atmosphere (PA)	4	4	-1,024	1,388

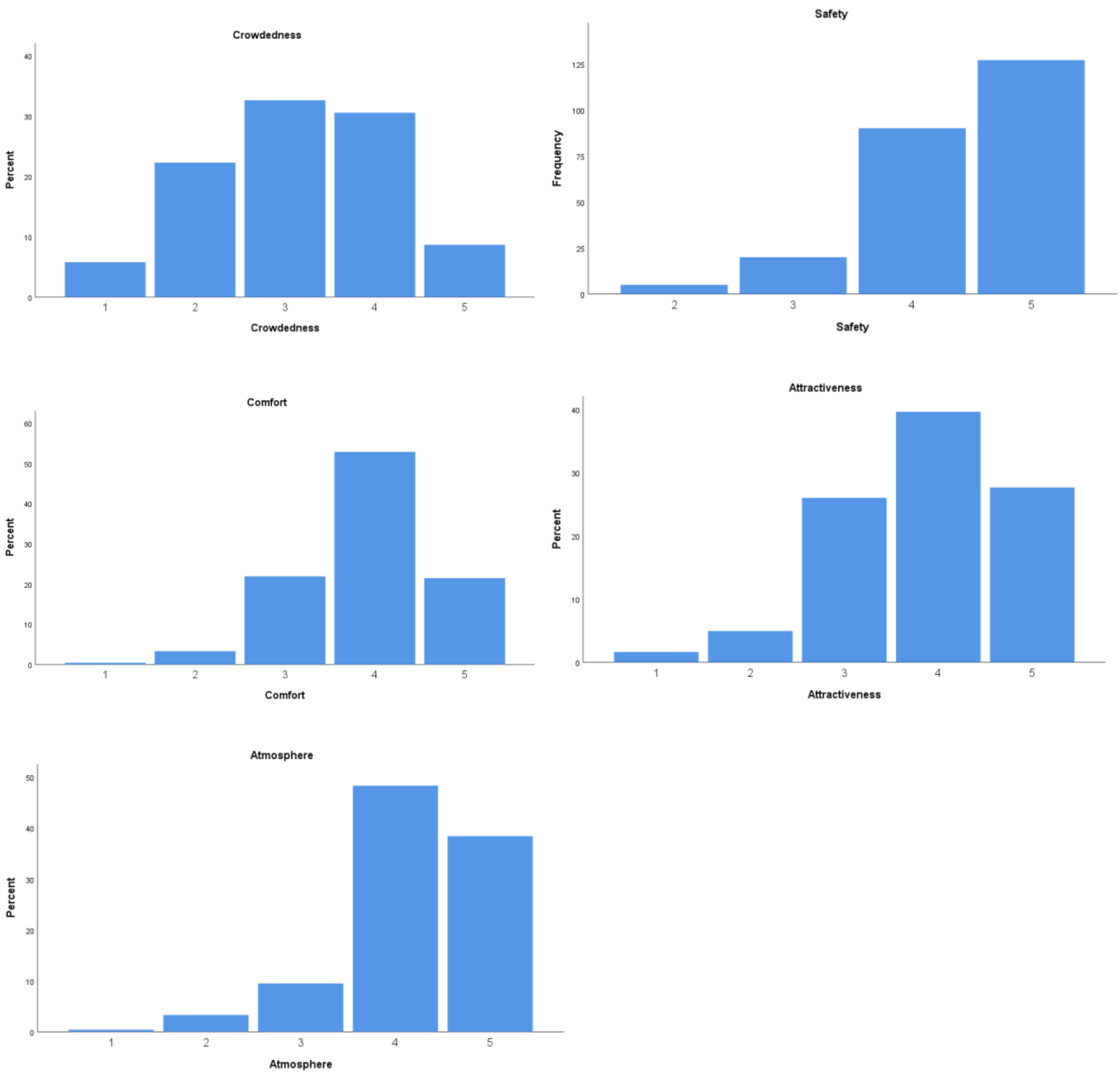

Figure 10: Perception distributions

Correlations

In order to start analysing the relations in the dataset, expected relations between two variables are considered. With the new variables created, there are 22 variables that results from the survey alone, meaning there are (22*22) / 2 – 22 = 220 possible relations that could be explained and tested. It is chosen to start with the relations that seem most relevant and interesting, which are the relations between the explanatory variables and the perception.

Perception

Perception

First the correlations within the five types of situational perception are tested. The following hypotheses were drafted for these correlations:

1. Crowdedness
    a. Safety: (non linear) In crowded places (avg. above 4) safety will be perceived as lower.
    b. Comfort: (non linear) In crowded places (avg. above 4) comfort will be perceived as lower.
    c. Attractiveness Environment: People who perceive crowdedness as higher, perceive atmosphere as higher as well.
    d. Atmosphere: People who perceive crowdedness as higher, perceive atmosphere as higher as well.
2. Safety
    a. Comfort: People who perceive a place as more comfortable will also perceive it as safer.
    b. Attractiveness Environment: People who perceive a place as safe will also perceive it as attractive.
    c. Atmosphere: : People who perceive a place as safe will also perceive the atmosphere being higher.
3. Comfort
    a. Attractiveness Environment: Pedestrians who rate Comfort higher will also rate the Attractiveness of the environment higher.
    b. Atmosphere: Pedestrians who rate Comfort higher will also rate the Atmosphere higher.
4. Attractiveness Environment
    a. Atmosphere: Pedestrians who rate the Attractiveness of the environment higher will also rate the Atmosphere higher.

Since the data gathered on perception is ordinal, Spearman correlation and Kendall's Tau are used. The relations are tested one-tailed, since all hypotheses are directional.

Table 6: Perception correlations

	PC	PS	Pcom	PAE	PA
Kendall's tau					

	Crowdedness	Corr.	1,000	-0,081	-0,050	,150**	,201**
		Sig.		0,075	0,181	0,003	0,000
	Safety	Corr.	-0,081	1,000	,342**	0,088	0,065
		Sig.	0,075		0,000	0,063	0,134
	Comfort	Corr.	-0,050	,342**	1,000	,190**	,136**
		Sig.	0,181	0,000		0,000	0,009
	Attractiveness	Corr.	,150**	0,088	,190**	1,000	,460**
		Sig.	0,003	0,063	0,000		0,000
	Atmosphere	Corr.	,201**	0,065	,136**	,460**	1,000
		Sig.	0,000	0,134	0,009	0,000	
Spearman's rho							
	Crowdedness	Corr.	1,000	-0,095	-0,060	,175**	,228**
		Sig.		0,071	0,175	0,003	0,000
	Safety	Corr.	-0,095	1,000	,370**	0,099	0,071
		Sig.	0,071		0,000	0,063	0,136
	Comfort	Corr.	-0,060	,370**	1,000	,215**	,150**
		Sig.	0,175	0,000		0,000	0,010
	Attractiveness	Corr.	,175**	0,099	,215**	1,000	,498**
		Sig.	0,003	0,063	0,000		0,000
	Atmosphere	Corr.	,228**	0,071	,150**	,498**	1,000
		Sig.	0,000	0,136	0,010	0,000	

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

There are multiple significant correlations found. The significance is the same for both tests, therefore the Spearman's test will be used to discuss the results. The strongest relationship found is between '*Attractiveness*' and '*Atmosphere*' (ρ=0,498, p=0,000). Furthermore, '*Comfort*' and '*Safety*' are closely related (ρ=0,370, p=0,000). Hypotheses 1c, 1d, 2a, 3a, 3b and 4a are confirmed while the null hypotheses are rejected. Hypotheses 1a and 1b have to be tested in another way. Hypotheses 2b and 2c rejected, since there is no correlation between '*Safety*' and '*Attractiveness*' & '*Atmosphere*'.

Survey questions

Residence

The variable Country is used to see if there is difference between Dutch people and internationals. It is chosen to compare only between foreigners and inhabitants, because the counts per country were too low ($N_{country} < 5$, $N_{foreign}=22$). It is expected that internationals will perceive Crowdedness higher. For the other perceptions, it is expected that there is a difference, but the direction is unknown.

1. Foreigners will perceive the Crowdedness higher.
2. Foreigners will have another situational perception.

From the Mann-Whitney U test, it can be concluded that ‘*Safety*’ and ‘*Comfort*’ are perceived significantly different by foreigners and inhabitants (Safety: U=1589, p=0.003, z=-2.961) (Comfort: U=1802, p=0.032, z=-2.163) . The mean rank of ‘*Safety*’ for foreigners is mR=159.3, while the mean rank for inhabitants is mR=117.7. This would mean that foreigners perceive the event to be safer. *‘Comfort’* is also perceived higher by foreigners. ‘*Crowdedness*’ was not found to be significant, therefore Hypothesis 1 is discarded.

Next, residence is further researched for Dutch inhabitants. The variables Province, Municipality (Appendix D) and Urbanization level (Appendix A) are used. Hypotheses are:

1. Pedestrians from regions with a low urbanization level will perceive Crowdedness higher.
2. Pedestrian form regions with a high urbanization level will perceive Comfort higher.
3. Pedestrian form regions with a high urbanization level will perceive Safety higher.

For Urbanization levels and perception, no significant correlations are found. Therefore, Hypotheses 1, 2 and 3 are discarded. Also, place of residence does not significantly change a person’s perception on the TT Festival event.

Familiarity

The variables Visit Assen and Visit Event give an indication of familiarity. The following hypotheses were formulated concerning Familiarity:

1. People who are familiar with the event will compare the crowdedness with their expectation based on previous visits. People familiar with the city will compare it with the normal situation. People who have visited the event more often perceive Crowdedness as lower.
2. People who are familiar will perceive comfort higher.
3. People who are familiar will perceive safety higher.
4. People who are familiar will perceive the attractiveness of the environment higher.
5. People who are familiar will perceive the atmosphere higher.

All hypotheses predict a direction of the correlation, except Crowdedness, since Crowdedness depends on actual Crowdedness/perceived Crowdedness of previous editions or on a normal day in the city. In Table 8, correlations (Kendall’s tau) are shown:

Table 7: Correlations perception - Familiarity

		Familiarity	
		Visit Assen	Visit Event
Crowdedness	Corr.	-,037	-,182**
	Sig.	,252	,001
Safety	Corr.	-,003	,058
	Sig.	,480	,164
Comfort	Corr.	-,007	,016

	Sig.	,453	,389
Attractiveness	Corr.	-,034	-,073
	Sig.	,272	,098
Atmosphere	Corr.	,019	,024
	Sig.	,374	,343

As can be seen, the only found significant correlation is between Crowdedness and Visit event ($\tau=-0.182$, $p=0.001$). This relation is negative, meaning that people who have visited the event more often perceive the Crowdedness lower.

Gender

For gender, there were two hypotheses, based on the previous study of Grolle (2007):

1. Women are more extreme in their perception of safety.
2. Men perceive the Atmosphere higher.

With the Mann-Whitney U test, only Safety gave a significant result ($U=6125$, $p=0.019$, $z=-2.339$). Looking at the mean ranks, Men (130.30) and Women (111.47), it appears that Men perceive the Safety higher than Women. This is also illustrated in Figure 12.

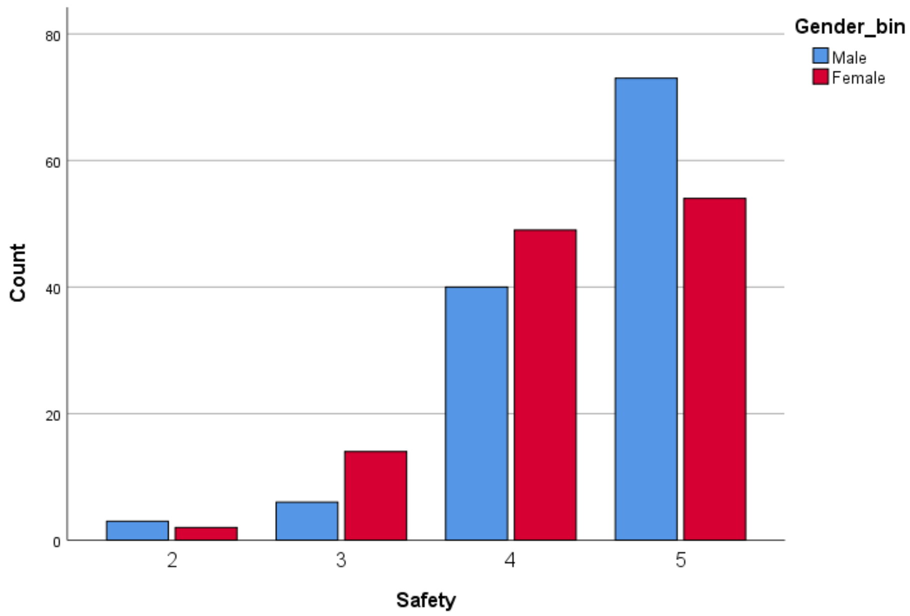

Figure 12: Safety distribution clustered by Gender

Purpose

For trip purpose, there were two hypotheses:

1. People with a trip purpose perceive the crowdedness higher.
2. People with a trip purpose perceive the comfort lower.

The relations between trip purpose and perception are all tested with the Kruskal Wallis test. The results can be seen in Table 9. The results give a difficult to explain overview. For example, visitors who are leaving the event rate the crowdedness the highest (mR=176.77) and Comfort the lowest (mR=88.23). These results are perfectly explanatory. But for Attractiveness and Atmosphere, the visitors who are leaving actually give the highest ratings. Therefore, the effect of the category purpose is analysed further.

Table 9: Kruskal-Wallis test Perception – Purpose

Ranks

	Purpose-short	N	Mean Rank
Crowdedness	Walking around randomly	118	111,82
	Do not know	39	139,65
	Purpose activity	70	115,86
	Leaving	15	176,77
	Total	242	
Comfort	Walking around randomly	118	129,69
	Do not know	39	107,06
	Purpose activity	70	122,86
	Leaving	15	88,23
	Total	242	
Attractiveness	Walking around randomly	118	118,19
	Do not know	39	144,74
	Purpose activity	70	110,46
	Leaving	15	138,63
	Total	242	
Safety	Walking around randomly	118	115,61
	Do not know	39	121,23
	Purpose activity	70	134,75
	Leaving	15	106,67
	Total	242	
Atmosphere	Walking around randomly	118	120,53
	Do not know	39	131,88
	Purpose activity	70	113,39
	Leaving	15	140,00
	Total	242	

Test Statistics[a,b]

	Crowdedness	Comfort	Attractiveness	Safety	Atmosphere
Kruskal-Wallis H	15,879	8,044	8,015	4,998	3,459
df	3	3	3	3	3

Asymp. Sig.	,001	,045	,046	,172	,326

In Figure 13, a clustered bar chart shows the distribution of Crowdedness ratings for the different categories. As can be seen, only '*Leaving*' has a high skewness and a higher rating overall. Also, a Bonferroni correction is applied. For the complete analysis, see Appendix F. As can be seen in Table 10, with a Bonferroni correction, there are two significant results for the rating of Crowdedness between purpose groups. Between Walking around randomly- Leaving (p=0.003) and Purpose activity-Leaving p=0.009. For Attractiveness and Comfort, no significant results were found after the Bonferroni correction, see Appendix F.

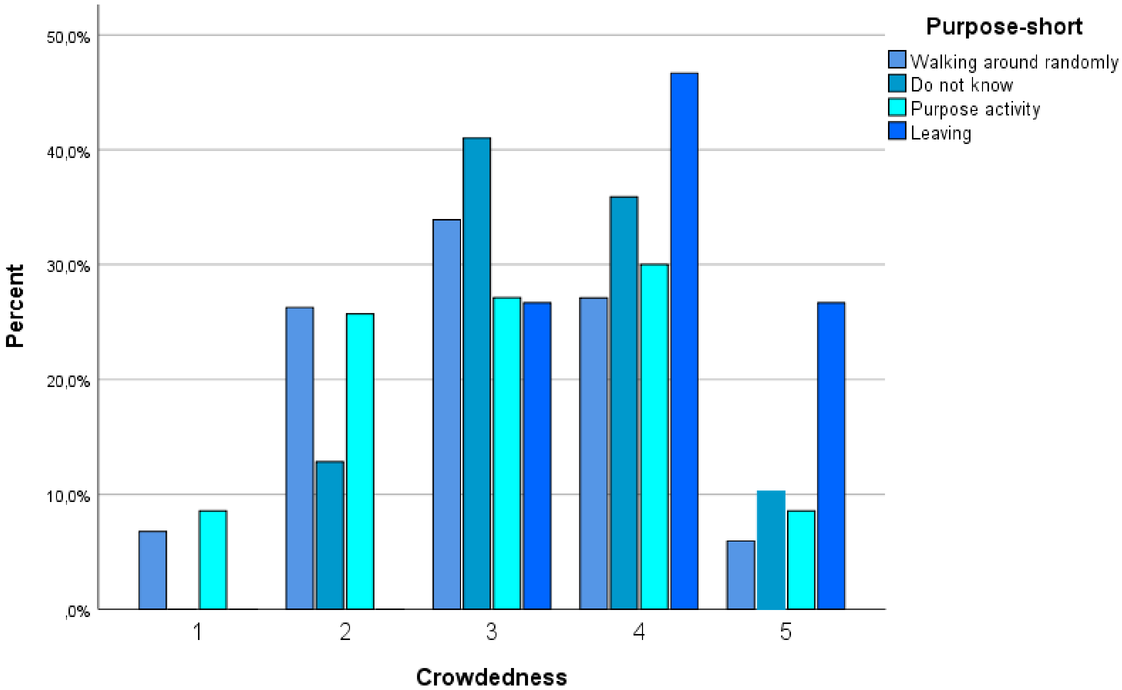

Figure 13: Purpose distribution over Crowdedness ratings

Table 10: Pairwise compsarison Crowdedness - Purpose

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Walking around randomly-Purpose activity	-4,046	10,156	-,398	,690	1,000
Walking around randomly-Do not know	-27,836	12,433	-2,239	,025	,151
Walking around randomly-Leaving	-64,949	18,452	-3,520	,000	,003
Purpose activity-Do not know	23,790	13,451	1,769	,077	,462
Purpose activity-Leaving	-60,902	19,153	-3,180	,001	,009
Do not know-Leaving	-37,113	20,452	-1,815	,070	,417

After the Red light district case study, it appeared that categorizing purpose to only an urgent purpose (going home, going to the station and going to work) was significantly different from the bother categories. Therefore, purpose can be recoded as a binary variable. For this case, this means that the purpose *'leaving'* is opposed to the rest. The results can be found in Appendix F and table 11. Now, a relation between *Crowdedness* (z=3.28 ,p=0.00)and *Comfort* (z=-2.08, p=0.021) is found. Hereby, the two hypotheses are confirmed.

Table 11: Mann-Whitney U test purpose (yes/no)

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	873,500	1480,000	1203,500	1445,500	1425,000
Z	-3,283	-,945	-2,084	-1,032	-1,160
Exact Sig. (2-tailed)	,001	,355	,041	,336	,271
Exact Sig. (1-tailed)	,000	,196	,021	,172	,142

Group

The three variables group type, group size and group composition are correlated with one another and are therefore discussed together. Hypotheses concerning group are the following:

1. People who are part of a larger group perceive the crowdedness to be lower. Groups of men will perceive the crowdedness lower.
2. People who are part of a larger group perceive comfort to be higher.
3. Larger group feels perceives safer. Group of men perceive safer.
4. Larger groups perceive atmosphere as higher.

Table 11: Correlations Perception – Group size

	Group size

		Kendall	Spearman
Crowdedness	Corr.	,167***	,190**
	Sig.	0,002	0,001
Safety	Corr.	0,039	0,043
	Sig.	0,252	0,252
Comfort	Corr.	-,104*	-,115*
	Sig.	0,037	0,037
Attractiveness	Corr.	0,045	0,051
	Sig.	0,215	0,214
Atmosphere	Corr.	,113*	,125*
	Sig.	0,027	0,026

There is a correlation between '*Crowdedness*' and '*Group size*' (ρ=0.190, p=0.001). However, it is opposite to hypothesis 1. The reversal can be explained. In a larger group, there are more people in a person's direct environment. This quite logically leads to a higher perception of Crowdedness. In this case, '*Crowdedness*' is probably not perceived as a nuisance. '*Comfort*' is actually perceived lower by larger groups (ρ=0.115, p=0.037). However, the correlation is not that strong. '*Atmosphere*' is indeed perceived higher (ρ=0.125, p=0.026). There is no significant relation to '*Safety*'.

Table 12: Kruskal-Wallis results Perception – Group composition

Ranks

	Group composition	N	Mean Rank
Crowdedness	Only men	38	104,68
	Only women	29	104,33
	Mixed group	170	124,70
	Total	237	
Comfort	Only men	38	138,83
	Only women	29	129,48
	Mixed group	170	112,78
	Total	237	
Attractiveness	Only men	38	109,42
	Only women	29	133,47
	Mixed group	170	118,67
	Total	237	
Safety	Only men	38	141,01
	Only women	29	101,03
	Mixed group	170	117,14
	Total	237	
Atmosphere	Only men	38	108,89
	Only women	29	130,86

	Mixed group	170	119,24
	Total	237	

Test Statistics[a,b]

	Crowdedness	Comfort	Attractiveness	Safety	Atmosphere
Kruskal-Wallis H	4,502	6,295	2,263	7,528	2,042
df	2	2	2	2	2
Asymp. Sig.	,105	,043	,323	,023	,360

Next, group composition was tested with a Kruskal Wallis test. A significant relation between Group composition and Comfort & Safety was found. Therefore, these differences are studied further. Table 13 shows the significant results, test results can be found in Appendix G. As can be seen in Table 13, a group of men perceives more higher safety than groups of Women.

Table 13: Pairwise comparison Safety – Group Composition

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Only women-Mixed group	-16,110	12,332	-1,306	,191	,574
Only women-Only men	39,979	15,135	2,642	,008	,025
Mixed group-Only men	23,869	11,014	2,167	,030	,091

Concerning group type, no relation to perception was found. This could have multiple reasons. First, defining a group type was more difficult than expected. There are many different types of groups and there are also combinations possible, such as Family + Friends. Also, the categorization might have been performed in such a way that the difference between the groups actually becomes less meaningful. Finally, as can be seen, there were no hypotheses concerning group type, so it might just be a bad explanatory variable.

Affect

Concerning Affect, the following hypotheses were drafted:

1. Deactivated and unpleasant emotions make people perceive crowdedness higher
2. Pleased, activated people perceive comfort higher.
3. Pleased, activated people perceive safety higher.
4. Pleased, activated people perceive the Attractiveness of the environment higher.
5. Pleased, activated people perceive Atmosphere higher.

The levels of Pleasantness and Activation were tested, see Appendix H. For Activation and Safety, a relation was found ($z= 2.34$, $p=0.009$), meaning that activated people indeed perceive safety higher. Unfortunately, no other relations were found. Therefore, the separate binary variables for all emotions were tested. The significant results can be found in Table x. The results show some of the expected relations, but not all. A reason could be because for some emotional states, there was a low count, see Figure 9 in General descriptives.

Table 14: Mann Whitney U test outcomes, significance exact two-tailed.

Affect					
	Crowdedness	**Safety**	**Comfort**	**Attractiveness**	**Atmosphere**
Neutral		z=-2.39 p =0.016			z= -2.40 p =0.016
Aroused				z=2.094 p =0.037	z=2.20 p =0.030
Excited		**z=3.03** **p =0.002**	z=1.75 p=0.079		z=2.52 p =0.011
Happy			z=2.46 p =0.013		

Substances

Concerning Substance usage, the following hypotheses were drafted:

1. People who have used alcohol will estimate the crowdedness lower (or more extreme). Other substances might have an opposite effect.
2. Alcohol users will have more extreme opinions about comfort.
3. Alcohol users will perceive higher safety.
4. Alcohol users will perceive the attractiveness of the environment higher.
5. Alcohol users will perceive the atmosphere higher.

However, no correlation between Alcohol usage and perception are found. A reason could be that the amount of alcohol is important, rather than a binary Alcohol or not. Other substances were used in such small amounts that it is not reliable for data analysis.

Metadata

Time

The variable time is expected to have a major influence on the perception of the visitors of the event. However, this is not because of time itself, but because other circumstances change over time, such as actual crowdedness, music type and other activity related variables. The hypotheses concerning time will be tested two-tailed, because most of them are not directional.

1. Crowdedness: There are certain peaks in densities on certain times during the day, depending on the attractions (artists), start/end time event
2. Safety: At later hours, safety may be perceived as lower.
3. Comfort: People who are present longer perceive comfort to be lower.
4. Attractiveness may vary in time, due to location characteristics
5. Atmosphere may vary in time, later at night better atmosphere

Again, Kendall's tau and Spearman's rho are used to find the correlations:

	Time

		Kendall	Spearman
Crowdedness	Corr.	,352**	,412**
	Sig.	0,000	0,000
Safety	Corr.	-,184**	-,209**
	Sig.	0,001	0,001
Comfort	Corr.	-,163**	-,187**
	Sig.	0,003	0,004
Attractiveness	Corr.	0,066	0,077
	Sig.	0,225	0,231
Atmosphere	Corr.	,115*	,132*
	Sig.	0,040	0,041

Table 15: Correlation Perception - Time

There is a strong significant relation between *'Crowdedness'* and Time (ρ=0.412, p=0.000). This could probably be explained by the actual crowdedness. Therefore, this hypothesis has to be researched further. Between Time and '*Safety*' & '*Comfort*', there is a negative correlation. This fits with the hypotheses. For '*Comfort*', the hypothesis is that the correlation is actually explained by the time spent at the event and not purely by the time of day. However, Time spent is not significantly correlated with Comfort. Time spent only has a weak correlation with '*Crowdedness*' (ρ= 0.116 p=0.036), see Appendix A.

As for day of the week/event day, there were no hypotheses. However, the impression of the survey taker was that the crowdedness was estimated lower every day. Therefore, this relation was also tested two-tailed, with a Kruskal-Wallis test (see Appendix B). The relation between weekday and Crowdedness was found to be significant (H(2)=6.157, p=0.046), but because this was calculated with Monte Carlo simulation, there is some uncertainty ($CI_{.99}$ lowerbound p=0.40, upperbound p=0.51).

Location

To test if there are correlations between location and perception, a Kruskal-Wallis test is performed. It is expected that Location will influence perception, due to location characteristics, such as sound, light, and attractions. The outcome of the test shows that only for '*Attractiveness*', there is a relation (H(2)=11.688, p=0.003). A relation between location and attractiveness of the environment is quite logical, since there are physical differences between the locations. As can be seen in Figure 11, the Kermis was considered the least attractive. This can be explained by the type of attractions. At the Kermis, there was loud noise from the attractions. Furthermore, the Kermis was arranged differently than the years before, which was mentioned by a few of the respondents to be an unpleasant change. With the Bonferroni correction for multiple tests, only the difference between Kermis and Markt is significant (p=0.002), see Appendix C.

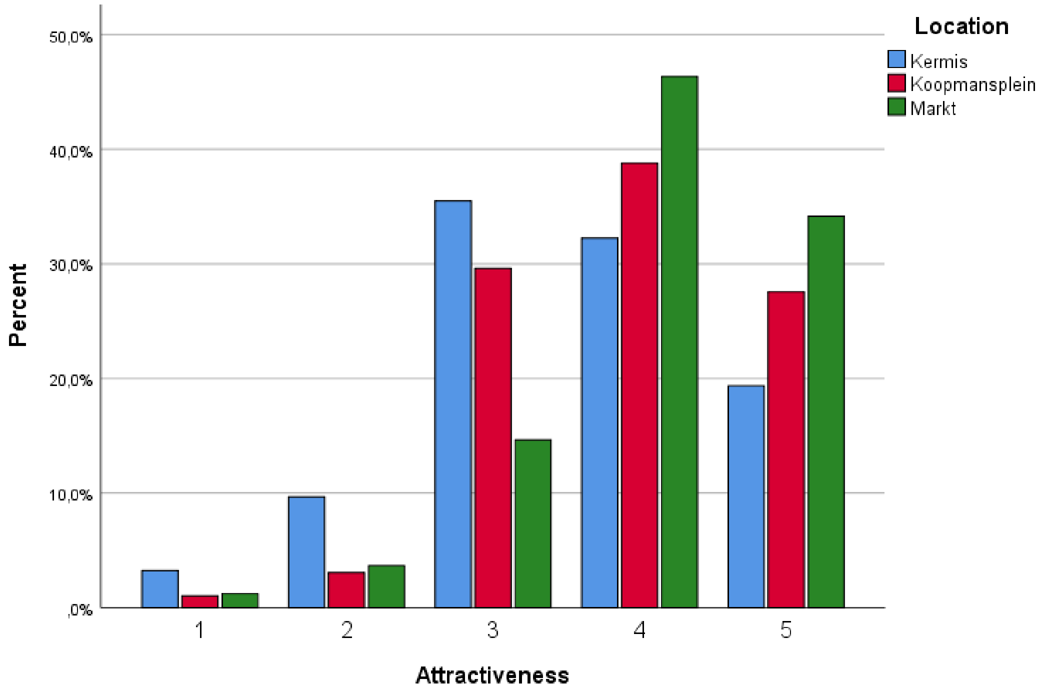

Figure 11: Perceived Attractiveness distribution clustered by location

Light & Sound

Table 16: Correlations light, sound and monitoring data

Correlations

		Sound_dif	Sound_int	Light_dif	Light_int	hours	camcount15	WifiC15
Sound_dif	Pearson Correlation	1	-,693**	-,316**	,039	,189**	,314**	-,351**
	Sig. (2-tailed)		,000	,000	,584	,006	,000	,000
	N	212	212	203	203	210	130	212
Sound_int	Pearson Correlation	-,693**	1	,237**	-,032	,159*	-,193*	,361**
	Sig. (2-tailed)	,000		,001	,648	,021	,028	,000
	N	212	212	203	203	210	130	212
Light_dif	Pearson Correlation	-,316**	,237**	1	-,153*	-,452**	-,339**	-,100
	Sig. (2-tailed)	,000	,001		,029	,000	,000	,154
	N	203	203	203	203	201	121	203
Light_int	Pearson Correlation	,039	-,032	-,153*	1	-,535**	-,547**	-,668**
	Sig. (2-tailed)	,584	,648	,029		,000	,000	,000
	N	203	203	203	203	201	121	203
hours	Pearson Correlation	,189**	,159*	-,452**	-,535**	1	,818**	,662**
	Sig. (2-tailed)	,006	,021	,000	,000		,000	,000
	N	210	210	201	201	239	158	239
camcount15	Pearson Correlation	,314**	-,193*	-,339**	-,547**	,818**	1	,526**

	Sig. (2-tailed)	,000	,028	,000	,000	,000		,000
	N	130	130	121	121	158	160	160
WifiC15	Pearson Correlation	-,351**	,361**	-,100	-,668**	,662**	,526**	1
	Sig. (2-tailed)	,000	,000	,154	,000	,000	,000	
	N	212	212	203	203	239	160	242

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Weather

For the weather, three types of data were used. Temperature, weather type and day or nighttime were registered once an hour from Accuweather. The following hypotheses were created for the relation between weather and perception:

- Atmosphere and Attractiveness are higher as there is sunny warm weather.
- At night, atmosphere is perceived higher.
- When there is sunny, warm weather, crowdedness is perceived lower.
- At daytime, safety and comfort are higher.

Table 17: Correlation temperature - perception

Correlations

			Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Temperature
Kendall	Temperature	Correlation Coefficient	-,319**	,173**	,122*	-0,066	-,162**	1,000
		Sig. (2-tailed)	0,000	0,002	0,022	0,211	0,003	
		N	242	242	242	242	242	242
Spearman	Temperature	Correlation Coefficient	-,389**	,201**	,144*	-0,080	-,191**	1,000
		Sig. (2-tailed)	0,000	0,002	0,025	0,217	0,003	
		N	242	242	242	242	242	242

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 18: Mann-Whitney U test Weather type

Ranks

	Weather_type	N	Mean Rank	Sum of Ranks
Crowdedness	Sunny	107	97,93	10478,50
	Clear	135	140,18	18924,50

	Total	242		
Safety	Sunny	107	132,58	14186,00
	Clear	135	112,72	15217,00
	Total	242		
Comfort	Sunny	107	131,39	14059,00
	Clear	135	113,66	15344,00
	Total	242		
Attractiveness	Sunny	107	116,62	12478,50
	Clear	135	125,37	16924,50
	Total	242		
Atmosphere	Sunny	107	111,86	11969,50
	Clear	135	129,14	17433,50
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	4700,500	6037,000	6164,000	6700,500	6191,500
Wilcoxon W	10478,500	15217,000	15344,000	12478,500	11969,500
Z	-4,849	-2,445	-2,146	-1,018	-2,093
Asymp. Sig. (2-tailed)	,000	,014	,032	,309	,036
Exact Sig. (2-tailed)	,000	,014	,032	,309	,036
Exact Sig. (1-tailed)	,000	,007	,016	,157	,019
Point Probability	,000	,000	,000	,000	,000

a. Grouping Variable: Weather_type

Since the whole event it was sunny weather, the variable weather type and isdaytime both only give two categories, respectively sunny/clear and true/false. Therefore, the relations found are the same. As can be seen in table 18, weather type correlates with all except Attractiveness. Crowdedness is perceived higher at night, which was actually true. To find out if the perception is actually different controlled for the actual amount of people, multiple regression is required. Safety and Comfort are indeed perceived higher at daytime, which agrees with the hypothesis. Atmosphere is perceived lower during the daytime. This also fits the hypothesis. In the second hypothesis about Atmosphere, it was expected that sunny warm weather increased atmosphere. However, this is meant as opposed to other daytime weather, like rain or clouds. This hypothesis cannot be tested, because no other weather type was measured. The same goes for Attractiveness of the environment. The temperatures show the same relations as the weather type.

Tabel 19: Mann Whitney U test Music type

Ranks

	Music_type	N	Mean Rank	Sum of Ranks
Crowdedness	headliner	63	118,72	7479,50
	background music	179	122,48	21923,50
	Total	242		
Safety	headliner	63	107,87	6796,00
	background music	179	126,30	22607,00
	Total	242		
Comfort	headliner	63	114,90	7238,50
	background music	179	123,82	22164,50
	Total	242		
Attractiveness	headliner	63	121,11	7630,00
	background music	179	121,64	21773,00
	Total	242		
Atmosphere	headliner	63	113,04	7121,50
	background music	179	124,48	22281,50
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	5463,500	4780,000	5222,500	5614,000	5105,500
Wilcoxon W	7479,500	6796,000	7238,500	7630,000	7121,500
Z	-,381	-2,004	-,955	-,054	-1,225
Asymp. Sig. (2-tailed)	,703	,045	,340	,957	,221
Exact Sig. (2-tailed)	,705	,043	,346	,951	,221
Exact Sig. (1-tailed)	,352	,023	,172	,478	,113
Point Probability	,000	,001	,002	,002	,003

a. Grouping Variable: Music_type

In music type, three categories were made: No music, background music and headliner. This distinction was chosen because it captures the most important variety. Categorizing music per genre would have been too much labour, while there are not that many different measurements, so finding significant relations would be improbable. From the Mann Whitney U test, it appears that only Safety is significantly correlated with music type (z=-2,00 , p=0,45). This relation seems to imply that Safety is perceived lower when a headliner is playing. Since this is the only relation found with perception, it is difficult to say if this is the actual relationship. It was expected that Atmosphere would be mostly influenced by the music type. A reason that other relations are not found could be because the surveys were conducted not close to the stage. Pedestrians who are walking about are perhaps less influenced by the music then active listeners who stand close to the stage. A negative relation between a headliner and safety could be explained by the people getting more rowdy.

Overview significant relations

In conclusion, many relations between the variables were found. Not all of the variables had a significant relation, such as Urbanization level, Age, Visit Assen, Time spent Group size, Affect and Substances. Some of these are still important, because they relate to the other explanatory variables. However, for constructing a multivariate regression, the relations that are found in this analysis will be fitted.

Table 15: Overview results survey

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Crowdedness	1			τ=0.150 p=0.003	τ=0.201 p= 0.000
Safety		1	τ=0.342 p=0.000		
Comfort		τ=0.342 p=0.000	1	τ=0.190 p=0.000	τ=0.136 p=0.009
Attractiveness	τ=0.150 p=0.003		τ=0.190 p=0.000	1	τ=0.460 p=0.000
Atmosphere	τ=0.201 p= 0.000		τ=0.136 p=0.009	τ=0.460 p=0.000	1
Time of day	τ=0.352 p=0.000	τ=-0.184 p=0.001	τ=-0.163 p=0.003		τ=0.115 p=0.040
Time of week	H(2)=6.157 p=0.046				
Location				H(2)=11.688 p=0.003	
Country		U=1589 p=0.003	U=1802 p=0.032		
Visit Event	τ =-0.182 p=0.001				
Gender		U=6125 p=0.019			
Purpose leaving	H(3)=15.879 p=0.001				
Group composition		H(2)=7.528 p=0.023			
Group size	τ =0.167 p=0.002		τ =-0.104 p=0.037		τ =0.113 p=0.027

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Appendix

0. Data set

Variable	Question	Data type
Timestamp	Timestamp	Scale
Location	Location	Nominal
Crowdedness	How would you rate the level of crowdedness at this location?	Ordinal
Safety	How would you rate the level of safety at this location?	Ordinal
Comfort	How would you rate the level of comfort at this location?	Ordinal
Attractiveness	How would you rate the level of attractiveness at this location?	Ordinal
Atmosphere	How would you rate the ambiance level at this location?	Ordinal
Language	Language:	Binary
Country	Country:	Nominal
Municipality	In which municipality do you live?	Nominal
Urbanized	CBS data	Scale
Gender	Gender:	Binary
Age	What is your age category?	Ordinal
Purpose	Where are you going at the moment?	Nominal
Visit_Assen	How many times have you visited the city Assen?	Ordinal
Visit_Event	How many times have you visited TT festival Assen?	Ordinal
Group_size	With how many people are you here?	Ordinal
Group_comp	What is the composition of your group?	Nominal
Group_type	What is your relation with these people?	Nominal
Time_spent	For how long are you at this festival at the moment?	Ordinal
Substances	Are you currently under the influence of one of the following substances?	Nominal
Neutral	Choose the words that best describe how you feel right now:	Binary
Aroused		Binary
Excited		Binary
Delighted		Binary
Happy		Binary
Glad		Binary
Serene		Binary
Relaxed		Binary
Sleepy		Binary
Tired		Binary
Bored		Binary
Depressed		Binary
Sad		Binary
Frustrated		Binary
Annoyed		Binary
Angry		Binary
Alarmed		Binary
Pleased		Binary
Activated		Binary

A. Correlations

			Atmosphere	Age	Visit Assen	Visit Event	Group size	Time spent	Urbanization
Kendall's tau_b	Crowdedness	Corr	,201**	,034	-,037	-,182**	,167**	,100*	0,026
		Sig.	,000	,260	,252	,001	,002	,030	0,311
		N	242	242	242	242	242	242	242
	Safety	Corr	,065	,096*	-,003	,058	,039	,031	-0,059
		Sig.	,134	,044	,480	,164	,252	,289	0,141
		N	242	242	242	242	242	242	242
	Comfort	Corr	,136**	-,031	-,007	,016	-,104*	,090	-0,013
		Sig.	,009	,288	,453	,389	,037	,051	0,404
		N	242	242	242	242	242	242	242
	Attractiveness	Corr	,460**	,017	-,034	-,073	,045	-,055	-0,011
		Sig.	,000	,376	,272	,098	,215	,155	0,415
		N	242	242	242	242	242	242	242
	Atmosphere	Corr	1,000	-,062	,019	,024	,113*	,011	0,050
		Sig.	.	,134	,374	,343	,027	,422	0,178
		N	242	242	242	242	242	242	242
	Age	Corr	-,062	1,000	,136**	,219**	-,163**	-,014	-0,062
		Sig.	,134	.	,007	,000	,002	,398	0,115
		N	242	242	242	242	242	242	242
	Visit Assen	Corr	,019	,136**	1,000	,408**	-,081	-,042	,294**
		Sig.	,374	,007	.	,000	,081	,222	0,000
		N	242	242	242	242	242	242	242
	Visit Event	Corr	,024	,219**	,408**	1,000	,007	,073	0,055
		Sig.	,343	,000	,000	.	,454	,094	0,157

		N	242	242	242	242	242	242	242
	Group size	Corr	,113*	-,163**	-,081	,007	1,000	,107*	-0,021
		Sig.	,027	,002	,081	,454	.	,027	0,352
		N	242	242	242	242	242	242	242
	Time spent	Corr	,011	-,014	-,042	,073	,107*	1,000	0,061
		Sig.	,422	,398	,222	,094	,027	.	0,118
		N	242	242	242	242	242	242	242
	Urbanization level	Corr	,053	-,075	,289**	,041	-,018	,075	1,000
		Sig.	,175	,079	,000	,234	,374	,080	.
		N	242	242	242	242	242	242	242
Spearman's rho	Crowdedness	Corr	,228**	,039	-,043	-,209**	,190**	,116*	0,030
		Sig.	,000	,271	,253	,001	,001	,036	0,320
		N	242	242	242	242	242	242	242
	Safety	Corr	,071	,110*	-,004	,062	,043	,035	-0,069
		Sig.	,136	,044	,474	,167	,252	,294	0,144
		N	242	242	242	242	242	242	242
	Comfort	Corr	,150**	-,035	-,008	,017	-,115*	,104	-0,018
		Sig.	,010	,292	,453	,394	,037	,054	0,393
		N	242	242	242	242	242	242	242
	Attractiveness	Corr	,498**	,018	-,038	-,082	,051	-,065	-0,014
		Sig.	,000	,389	,277	,101	,214	,156	0,413
		N	242	242	242	242	242	242	242
	Atmosphere	Corr	1,000	-,071	,020	,026	,125*	,012	0,059
		Sig.	.	,137	,380	,346	,026	,423	0,181
		N	242	242	242	242	242	242	242

	Age	Corr	-,071	1,000	,156**	,255**	-,187**	-,016	-0,078
		Sig.	,137	.	,008	,000	,002	,404	0,112
		N	242	242	242	242	242	242	242
	Visit Assen	Corr	,020	,156**	1,000	,446**	-,090	-,050	,343**
		Sig.	,380	,008	.	,000	,081	,218	0,000
		N	242	242	242	242	242	242	242
	Visit Event	Corr	,026	,255**	,446**	1,000	,007	,084	0,065
		Sig.	,346	,000	,000	.	,454	,096	0,157
		N	242	242	242	242	242	242	242
	Group size	Corr	,125*	-,187**	-,090	,007	1,000	,124*	-0,024
		Sig.	,026	,002	,081	,454	.	,027	0,355
		N	242	242	242	242	242	242	242
	Time spent	Corr	,012	-,016	-,050	,084	,124*	1,000	0,074
		Sig.	,423	,404	,218	,096	,027	.	0,127
		N	242	242	242	242	242	242	242
	Urbanization level	Corr	,059	-,091	,323**	,048	-,020	,087	1,000
		Sig.	,178	,078	,000	,231	,377	,088	.
		N	242	242	242	242	242	242	242

Correlations

			hours	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Kendall's tau_b	Sound_dif	Correlation Coefficient	0,103	-0,071	-0,058	-0,090	0,044	0,014
		Sig. (2-tailed)	0,054	0,182	0,298	0,098	0,416	0,799
		N	210	212	212	212	212	212

	Sound_int	Correlation Coefficient	0,083	,194**	-0,014	0,044	0,027	0,002
		Sig. (2-tailed)	0,119	0,000	0,795	0,420	0,616	0,974
		N	210	212	212	212	212	212
	Light_dif	Correlation Coefficient	-0,007	,133*	-0,094	-0,059	-0,090	0,022
		Sig. (2-tailed)	0,906	0,016	0,106	0,298	0,110	0,705
		N	201	203	203	203	203	203
	Light_int	Correlation Coefficient	-,788**	-,349**	0,088	0,059	-,111*	-,164**
		Sig. (2-tailed)	0,000	0,000	0,123	0,292	0,043	0,004
		N	201	203	203	203	203	203
	hours	Correlation Coefficient	1,000	,362**	-,189**	-,156**	0,074	,132*
		Sig. (2-tailed)		0,000	0,001	0,005	0,176	0,020
		N	239	239	239	239	239	239
Spearman's rho	Sound_dif	Correlation Coefficient	0,135	-0,101	-0,073	-0,116	0,056	0,021
		Sig. (2-tailed)	0,050	0,141	0,287	0,091	0,415	0,759
		N	210	212	212	212	212	212
	Sound_int	Correlation Coefficient	0,110	,253**	-0,017	0,058	0,033	0,000
		Sig. (2-tailed)	0,112	0,000	0,806	0,402	0,628	0,995
		N	210	212	212	212	212	212
	Light_dif	Correlation Coefficient	0,011	,172*	-0,111	-0,070	-0,113	0,027
		Sig. (2-tailed)	0,873	0,014	0,114	0,324	0,109	0,698
		N	201	203	203	203	203	203
	Light_int	Correlation Coefficient	-,894**	-,444**	0,110	0,072	-,139*	-,202**
		Sig. (2-tailed)	0,000	0,000	0,118	0,306	0,049	0,004

		N	201	203	203	203	203	203
	hours	Correlation Coefficient	1,000	,424**	-,215**	-,178**	0,087	,151*
		Sig. (2-tailed)		0,000	0,001	0,006	0,181	0,020
		N	239	239	239	239	239	239

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

B. Time of day/week

Ranks

	Weekday	N	Mean Rank
Crowdedness	THU	34	139,29
	FRI	94	127,14
	SAT	113	110,38
	Total	241	
Safety	THU	34	125,57
	FRI	94	120,80
	SAT	113	119,79
	Total	241	
Comfort	THU	34	117,97
	FRI	94	121,43
	SAT	113	121,56
	Total	241	
Attractiveness	THU	34	135,00
	FRI	94	123,36
	SAT	113	114,83
	Total	241	
Atmosphere	THU	34	121,81
	FRI	94	121,60
	SAT	113	120,26
	Total	241	

Test Statistics[a,b]

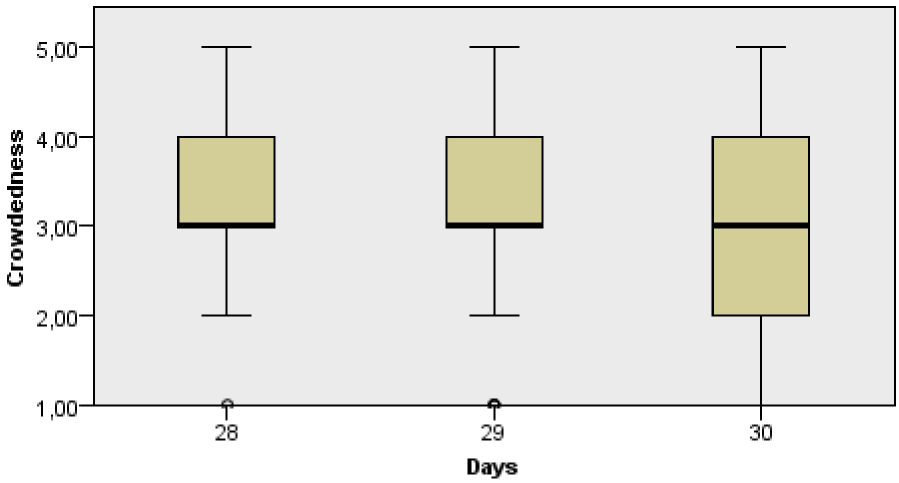
			Crowded-ness	Safety	Com-fort	Attractive-ness	Atmos-phere
Kruskal-Wallis H			6,157	,226	,090	2,632	,029
df			2	2	2	2	2
Asymp. Sig.			,046	,893	,956	,268	,985
Monte Carlo Sig.	Sig.		,046[c]	,892[c]	,960[c]	,262[c]	,982[c]
	99% Confidence Interval	Lower Bound	,040	,884	,955	,251	,978
		Upper Bound	,051	,900	,965	,274	,985

a. Kruskal Wallis Test

b. Grouping Variable: Weekday

c. Based on 10000 sampled tables with starting seed 2000000.

Independent-Samples Kruskal-Wallis Test



Total N	242
Test Statistic	7,434
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	,024

1. The test statistic is adjusted for ties.

C. Location

Ranks

	Location	N	Mean Rank
Attractiveness	Kermis	62	99,71
	Koopmansplein	98	121,57
	Markt	82	137,89
	Total	242	

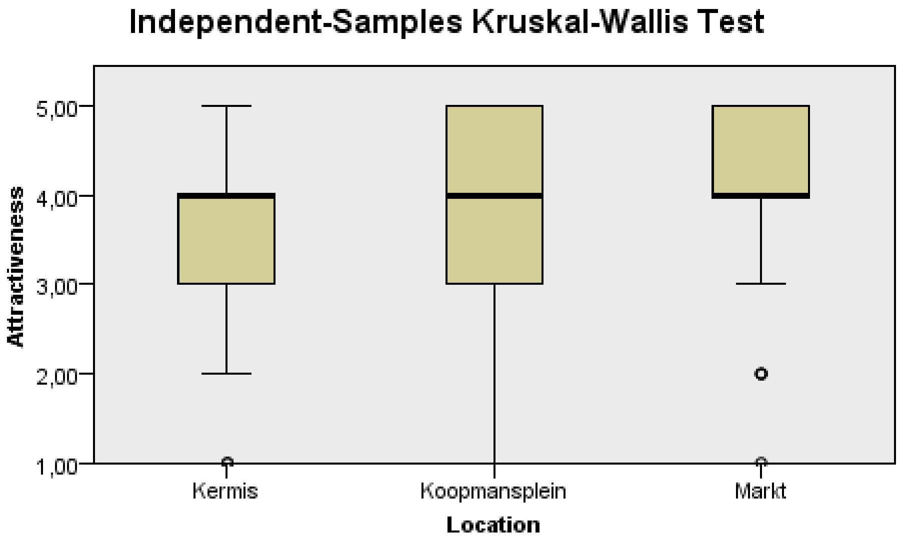
Test Statistics[a,b]

	Attractiveness
Kruskal-Wallis H	11,688
df	2
Asymp. Sig.	,003

a. Kruskal Wallis Test

b. Grouping Variable: Location

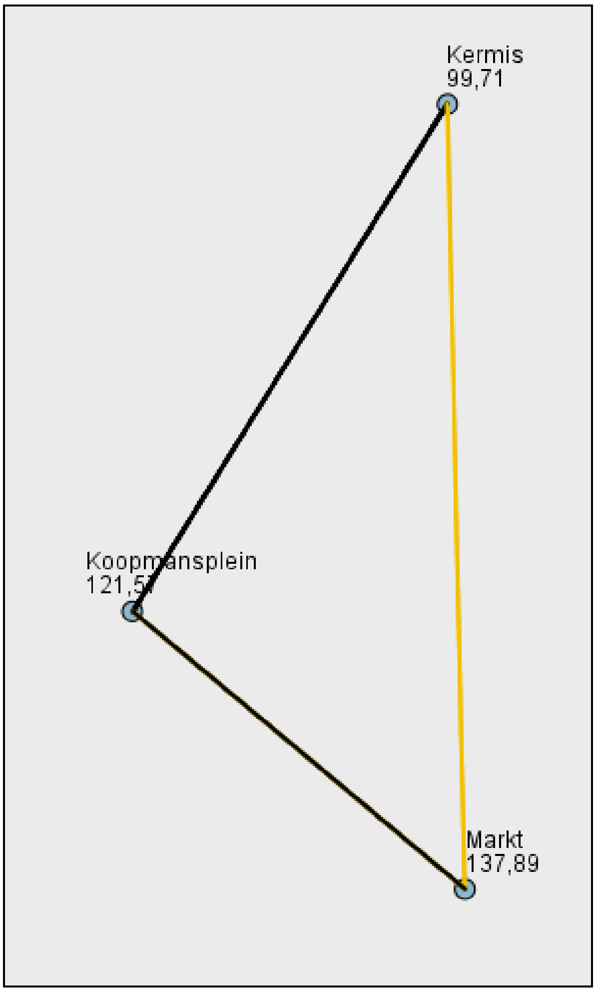
Attractiveness Pairwise



Total N	242
Test Statistic	11,688
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	,003

1. The test statistic is adjusted for ties.

Pairwise Comparisons of Location



Each node shows the sample average rank of Location.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Kermis-Koopmansplein	-21,862	10,768	-2,030	,042	,127
Kermis-Markt	-38,181	11,168	-3,419	,001	,002
Koopmansplein-Markt	-16,319	9,932	-1,643	,100	,301

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

D. Residence

Ranks

	Country_bin	N	Mean Rank	Sum of Ranks
Crowdedness	1,00	220	120,26	26457,50
	2,00	22	133,89	2945,50
	Total	242		
Safety	1,00	220	117,72	25899,00
	2,00	22	159,27	3504,00
	Total	242		
Comfort	1,00	220	118,69	26112,50
	2,00	22	149,57	3290,50
	Total	242		
Attractiveness	1,00	220	121,01	26621,50
	2,00	22	126,43	2781,50
	Total	242		
Atmosphere	1,00	220	122,80	27016,00
	2,00	22	108,50	2387,00
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	2147,500	1589,000	1802,500	2311,500	2134,000
Wilcoxon W	26457,500	25899,000	26112,500	26621,500	2387,000
Z	-,905	-2,961	-2,163	-,366	-1,003
Asymp. Sig. (2-tailed)	,365	,003	,031	,715	,316
Exact Sig. (2-tailed)	,368	,003	,032	,706	,323
Exact Sig. (1-tailed)	,185	,001	,017	,357	,162
Point Probability	,000	,001	,000	,010	,008

a. Grouping Variable: Country_bin

Ranks

	Mun_bin	N	Mean Rank	Sum of Ranks
Crowdedness	Assen	115	126,80	14582,50
	Other	127	116,70	14820,50
	Total	242		
Safety	Assen	115	124,00	14259,50
	Other	127	119,24	15143,50

	Total	242		
Comfort	Assen	115	119,83	13781,00
	Other	127	123,01	15622,00
	Total	242		
Attractiveness	Assen	115	120,83	13896,00
	Other	127	122,10	15507,00
	Total	242		
Atmosphere	Assen	115	123,37	14187,00
	Other	127	119,81	15216,00
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	6692,500	7015,500	7111,000	7226,000	7088,000
Wilcoxon W	14820,500	15143,500	13781,000	13896,000	15216,000
Z	-1,166	-,589	-,386	-,148	-,433
Asymp. Sig. (2-tailed)	,243	,556	,699	,882	,665

a. Grouping Variable: Mun_bin

E. Gender

Ranks

	Gender_bin	N	Mean Rank	Sum of Ranks
Safety	1,00	122	130,30	15896,00
	2,00	119	111,47	13265,00
	Total	241		

Test Statistics[a]

	Safety
Mann-Whitney U	6125,000
Wilcoxon W	13265,000
Z	-2,339
Asymp. Sig. (2-tailed)	,019

a. Grouping Variable: Gender_bin

F. Purpose

Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Walking around randomly	118	74,35	8773,50
	Do not know	39	93,06	3629,50
	Total	157		
Comfort	Walking around randomly	118	82,67	9754,50
	Do not know	39	67,91	2648,50
	Total	157		
Attractiveness	Walking around randomly	118	74,73	8818,50
	Do not know	39	91,91	3584,50
	Total	157		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	1752,500	1868,500	1797,500
Wilcoxon W	8773,500	2648,500	8818,500
Z	-2,327	-1,949	-2,159
Asymp. Sig. (2-tailed)	,020	,051	,031
Exact Sig. (2-tailed)	,020	,052	,030
Exact Sig. (1-tailed)	,010	,026	,015
Point Probability	,000	,000	,000

a. Grouping Variable: Purpose-short

Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Walking around randomly	118	93,48	11031,00
	Purpose activity	70	96,21	6735,00
	Total	188		
Comfort	Walking around randomly	118	96,43	11378,50
	Purpose activity	70	91,25	6387,50
	Total	188		
Attractiveness	Walking around randomly	118	96,76	11418,00
	Purpose activity	70	90,69	6348,00
	Total	188		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	4010,000	3902,500	3863,000
Wilcoxon W	11031,000	6387,500	6348,000
Z	-,345	-,692	-,779
Asymp. Sig. (2-tailed)	,730	,489	,436
Exact Sig. (2-tailed)	,730	,487	,438
Exact Sig. (1-tailed)	,365	,247	,219
Point Probability	,001	,002	,002

a. Grouping Variable: Purpose-short

Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Walking around randomly	118	62,98	7432,00
	Leaving	15	98,60	1479,00
	Total	133		
Comfort	Walking around randomly	118	69,60	8213,00
	Leaving	15	46,53	698,00
	Total	133		
Attractiveness	Walking around randomly	118	65,69	7751,50
	Leaving	15	77,30	1159,50
	Total	133		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	411,000	578,000	730,500
Wilcoxon W	7432,000	698,000	7751,500
Z	-3,505	-2,411	-1,163
Asymp. Sig. (2-tailed)	,000	,016	,245
Exact Sig. (2-tailed)	,000	,019	,243
Exact Sig. (1-tailed)	,000	,009	,112
Point Probability	,000	,002	,008

a. Grouping Variable: Purpose-short

Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Do not know	39	61,74	2408,00
	Purpose activity	70	51,24	3587,00

	Total	109		
Comfort	Do not know	39	50,50	1969,50
	Purpose activity	70	57,51	4025,50
	Total	109		
Attractiveness	Do not know	39	64,71	2523,50
	Purpose activity	70	49,59	3471,50
	Total	109		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	1102,000	1189,500	986,500
Wilcoxon W	3587,000	1969,500	3471,500
Z	-1,730	-1,208	-2,517
Asymp. Sig. (2-tailed)	,084	,227	,012
Exact Sig. (2-tailed)	,083	,227	,012
Exact Sig. (1-tailed)	,041	,115	,006
Point Probability	,000	,001	,000

Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Do not know	39	24,85	969,00
	Leaving	15	34,40	516,00
	Total	54		
Comfort	Do not know	39	28,65	1117,50
	Leaving	15	24,50	367,50
	Total	54		
Attractiveness	Do not know	39	28,13	1097,00
	Leaving	15	25,87	388,00
	Total	54		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	189,000	247,500	268,000
Wilcoxon W	969,000	367,500	388,000
Z	-2,123	-,956	-,514
Asymp. Sig. (2-tailed)	,034	,339	,607
Exact Sig. (2-tailed)	,034	,360	,596
Exact Sig. (1-tailed)	,020	,180	,305
Point Probability	,005	,016	,024

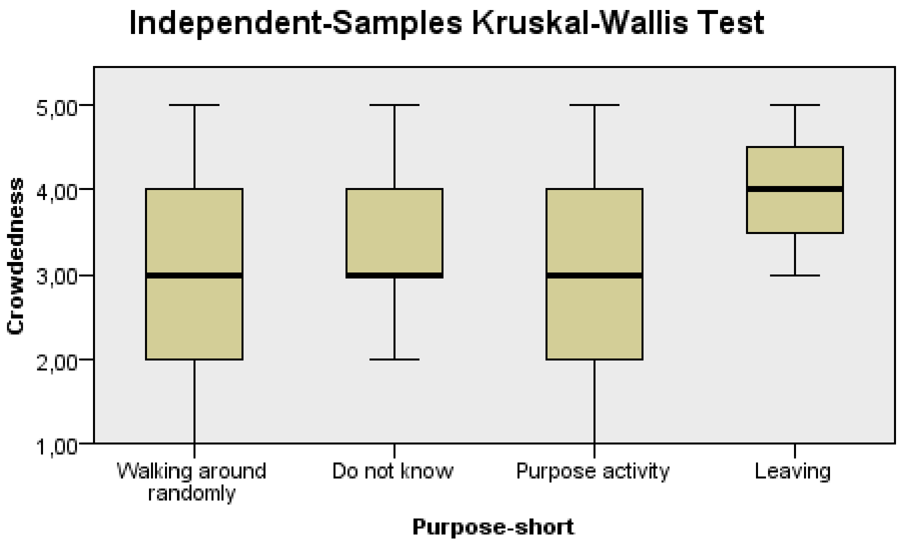
Ranks

	Purpose-short	N	Mean Rank	Sum of Ranks
Crowdedness	Purpose activity	70	39,41	2758,50
	Leaving	15	59,77	896,50
	Total	85		
Comfort	Purpose activity	70	45,10	3157,00
	Leaving	15	33,20	498,00
	Total	85		
Attractiveness	Purpose activity	70	41,19	2883,00
	Leaving	15	51,47	772,00
	Total	85		

Test Statistics[a]

	Crowdedness	Comfort	Attractiveness
Mann-Whitney U	273,500	378,000	398,000
Wilcoxon W	2758,500	498,000	2883,000
Z	-3,001	-1,829	-1,546
Asymp. Sig. (2-tailed)	,003	,067	,122
Exact Sig. (2-tailed)	,002	,063	,123
Exact Sig. (1-tailed)	,001	,038	,058
Point Probability	,000	,005	,005

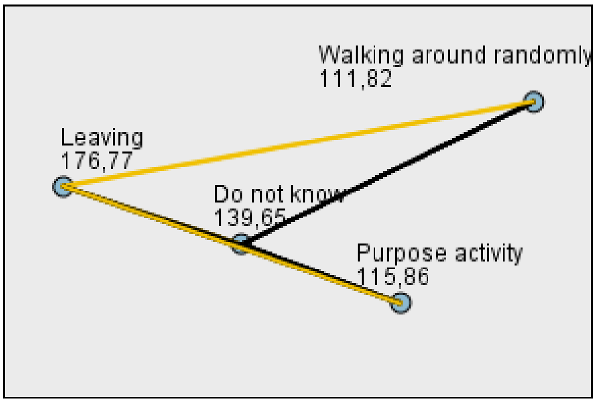
Crowdedness Pairwise



Total N	242
Test Statistic	15,879
Degrees of Freedom	3
Asymptotic Sig. (2-sided test)	,001

1. The test statistic is adjusted for ties.

Pairwise Comparisons of Purpose-short



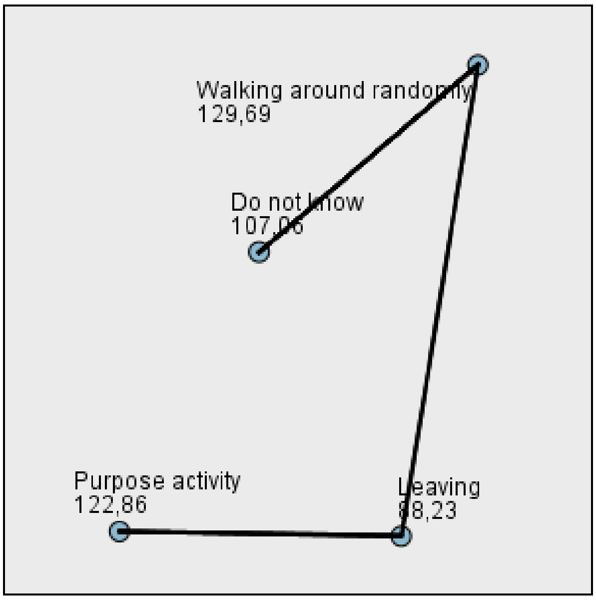
Each node shows the sample average rank of Purpose-short.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Walking around randomly-Purpose activity	-4,046	10,156	-,398	,690	1,000
Walking around randomly-Do not know	-27,836	12,433	-2,239	,025	,151
Walking around randomly-Leaving	-64,949	18,452	-3,520	,000	,003
Purpose activity-Do not know	23,790	13,451	1,769	,077	,462
Purpose activity-Leaving	-60,902	19,153	-3,180	,001	,009
Do not know-Leaving	-37,113	20,452	-1,815	,070	,417

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Comfort Pairwise

Pairwise Comparisons of Purpose-short



Each node shows the sample average rank of Purpose-short.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Leaving-Do not know	18,831	19,395	,971	,332	1,000
Leaving-Purpose activity	34,624	18,163	1,906	,057	,340
Leaving-Walking around randomly	41,462	17,499	2,369	,018	,107
Do not know-Purpose activity	-15,793	12,756	-1,238	,216	1,000
Do not know-Walking around randomly	22,631	11,791	1,919	,055	,330
Purpose activity-Walking around randomly	6,838	9,631	,710	,478	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attractiveness Pairwise

Each node shows the sample average rank of Purpose-short.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Purpose activity-Walking around randomly	7,722	10,011	,771	,441	1,000
Purpose activity-Leaving	-28,169	18,881	-1,492	,136	,814
Purpose activity-Do not know	34,279	13,260	2,585	,010	,058
Walking around randomly-Leaving	-20,447	18,190	-1,124	,261	1,000
Walking around randomly-Do not know	-26,557	12,257	-2,167	,030	,182
Leaving-Do not know	6,110	20,161	,303	,762	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Ranks

	Purpose_bin	N	Mean Rank	Sum of Ranks
Crowdedness	,00	227	117,85	26751,50
	1,00	15	176,77	2651,50
	Total	242		
Safety	,00	227	122,48	27803,00
	1,00	15	106,67	1600,00
	Total	242		
Comfort	,00	227	123,70	28079,50
	1,00	15	88,23	1323,50
	Total	242		
Attractiveness	,00	227	120,37	27323,50
	1,00	15	138,63	2079,50
	Total	242		
Atmosphere	,00	227	120,28	27303,00
	1,00	15	140,00	2100,00
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	873,500	1480,000	1203,500	1445,500	1425,000
Wilcoxon W	26751,500	1600,000	1323,500	27323,500	27303,000
Z	-3,283	-,945	-2,084	-1,032	-1,160
Asymp. Sig. (2-tailed)	,001	,345	,037	,302	,246
Exact Sig. (2-tailed)	,001	,355	,041	,336	,271
Exact Sig. (1-tailed)	,000	,196	,021	,172	,142
Point Probability	,000	,005	,003	,007	,025

a. Grouping Variable: Purpose_bin

G. Group

Group size * Group composition Cross tabulation

			Group composition				
			0	Only men	Only women	Mixed group	Total
Group size	Alone	Count	5	0	0	0	5
		Exp. Count	,1	,8	,6	3,5	5,0
		Std Residual	**15,2**	-,9	-,8	-1,9	
	Small group (2-3)	Count	0	22	20	83	125
		Exp. Count	2,6	19,6	15,0	87,8	125,0
		Std Residual	-1,6	,5	1,3	-,5	
	Medium sized group (4-6)	Count	0	12	8	65	85
		Exp. Count	1,8	13,3	10,2	59,7	85,0
		Std Residual	-1,3	-,4	-,7	,7	
	Large group (7+)	Count	0	4	1	22	27
		Exp. Count	,6	4,2	3,2	19,0	27,0
		Std Residual	-,7	-,1	-1,2	,7	
Total		Count	5	38	29	170	242
		Exp. Count	5,0	38,0	29,0	170,0	242,0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
Pearson Chi-Square	247,246 [a]	9	,000	,000		

Likelihood Ratio	54,354	9	,000	,000		
Fisher's Exact Test	44,989			,000		
Linear-by-Linear Association	11,562[b]	1	,001	,001	,000	,000
N of Valid Cases	242					

a. 9 cells (56,3%) have expected count less than 5. The minimum expected count is ,10.

b. The standardized statistic is 3,400.

Ranks

	Group_type_short	N	Mean Rank
Crowdedness	,00	5	83,40
	1,00	65	117,11
	2,00	23	136,07
	3,00	21	115,67
	4,00	88	122,68
	5,00	11	118,91
	6,00	29	128,00
	Total	242	
Comfort	,00	5	102,30
	1,00	65	119,42
	2,00	23	134,24
	3,00	21	117,81
	4,00	88	132,52
	5,00	11	77,09
	6,00	29	105,45
	Total	242	
Attractiveness	,00	5	104,10
	1,00	65	113,30
	2,00	23	145,85
	3,00	21	118,24
	4,00	88	125,38
	5,00	11	106,36
	6,00	29	119,91
	Total	242	
Safety	,00	5	100,40
	1,00	65	115,12
	2,00	23	141,20
	3,00	21	113,79
	4,00	88	125,13

	5,00	11	114,82
	6,00	29	120,93
	Total	242	
Atmosphere	,00	5	73,90
	1,00	65	114,22
	2,00	23	138,17
	3,00	21	122,67
	4,00	88	123,83
	5,00	11	118,23
	6,00	29	126,14
	Total	242	

Test Statistics[a,b]

	Crowdedness	Comfort	Attractiveness	Safety	Atmosphere
Kruskal-Wallis H	3,427	11,288	5,372	4,243	5,516
df	6	6	6	6	6
Asymp. Sig.	,754	,080	,497	,644	,479

a. Kruskal Wallis Test

b. Grouping Variable: Group_type_short

Ranks

	Group composition	N	Mean Rank	Sum of Ranks
Comfort	Only men	38	35,33	1342,50
	Only women	29	32,26	935,50
	Total	67		
Safety	Only men	38	38,88	1477,50
	Only women	29	27,60	800,50
	Total	67		

Test Statistics[a]

	Comfort	Safety
Mann-Whitney U	500,500	365,500
Wilcoxon W	935,500	800,500
Z	-,700	-2,663
Asymp. Sig. (2-tailed)	,484	,008
Exact Sig. (2-tailed)	,503	,008
Exact Sig. (1-tailed)	,254	,004

Point Probability	,016	,001

a. Grouping Variable: Group composition

Ranks

	Group composition	N	Mean Rank	Sum of Ranks
Comfort	Only men	38	123,00	4674,00
	Mixed group	170	100,36	17062,00
	Total	208		
Safety	Only men	38	121,63	4622,00
	Mixed group	170	100,67	17114,00
	Total	208		

Test Statistics[a]

	Comfort	Safety
Mann-Whitney U	2527,000	2579,000
Wilcoxon W	17062,000	17114,000
Z	-2,285	-2,184
Asymp. Sig. (2-tailed)	,022	,029
Exact Sig. (2-tailed)	,024	,031
Exact Sig. (1-tailed)	,012	,015
Point Probability	,001	,001

a. Grouping Variable: Group composition

Ranks

	Group composition	N	Mean Rank	Sum of Ranks
Comfort	Only women	29	112,22	3254,50
	Mixed group	170	97,91	16645,50
	Total	199		
Safety	Only women	29	88,43	2564,50
	Mixed group	170	101,97	17335,50
	Total	199		

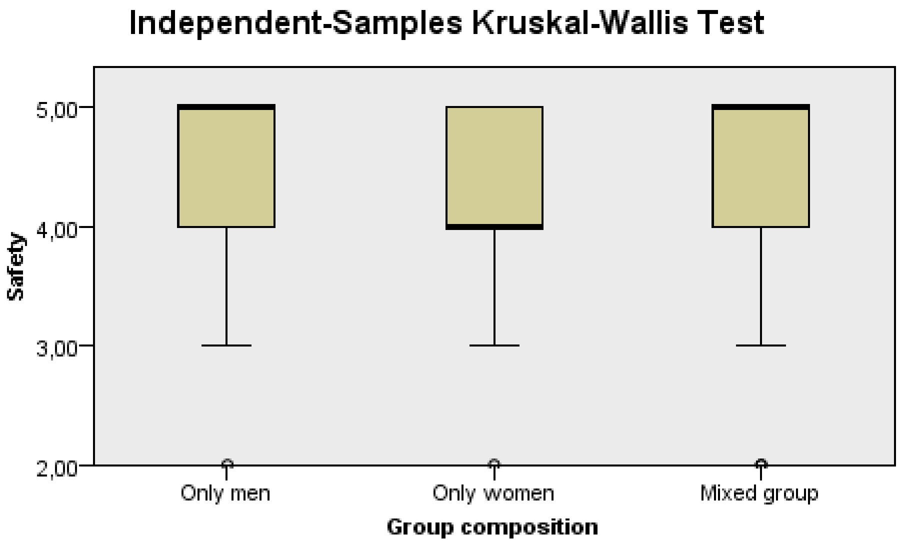
Test Statistics[a]

	Comfort	Safety
Mann-Whitney U	2110,500	2129,500
Wilcoxon W	16645,500	2564,500

Z	-1,362	-1,295
Asymp. Sig. (2-tailed)	,173	,195
Exact Sig. (2-tailed)	,174	,200
Exact Sig. (1-tailed)	,088	,100
Point Probability	,007	,007

a. Grouping Variable: Group composition

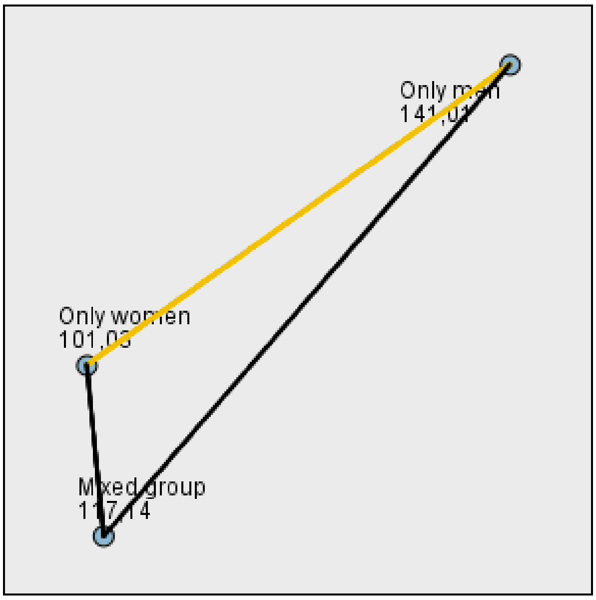
Safety pairwise



Total N	237
Test Statistic	7,528
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	,023

1. The test statistic is adjusted for ties.

Pairwise Comparisons of Group composition

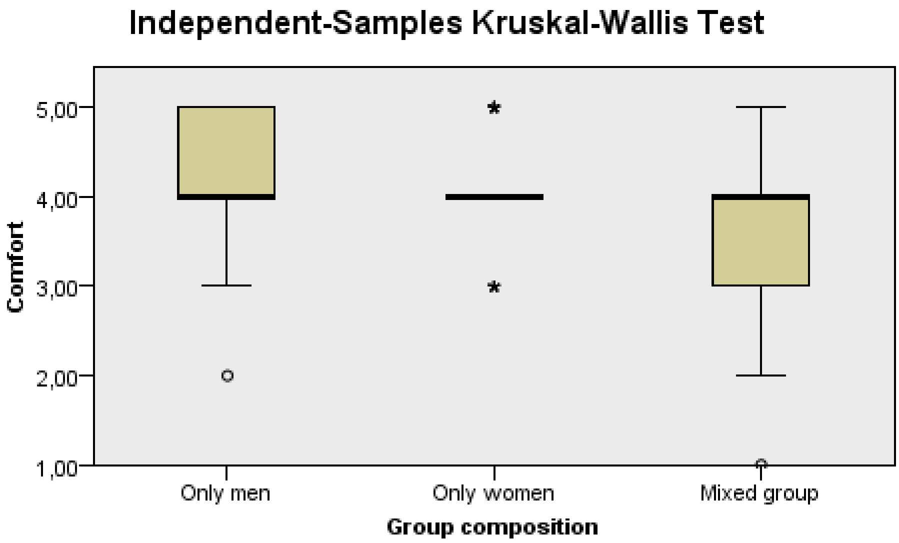


Each node shows the sample average rank of Group composition.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Only women-Mixed group	-16,110	12,332	-1,306	,191	,574
Only women-Only men	39,979	15,135	2,642	,008	,025
Mixed group-Only men	23,869	11,014	2,167	,030	,091

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

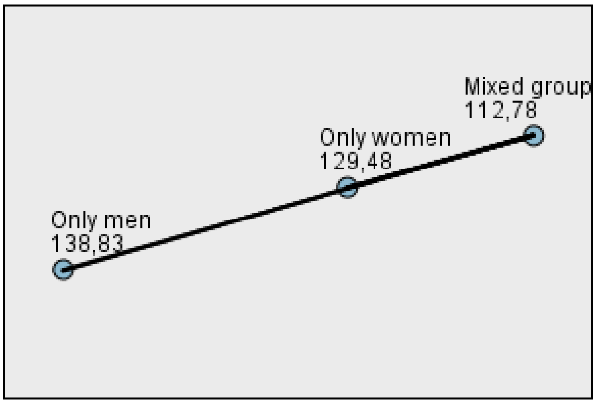
Comfort Pairwise



Total N	237
Test Statistic	6,295
Degrees of Freedom	2
Asymptotic Sig. (2-sided test)	,043

1. The test statistic is adjusted for ties.

Pairwise Comparisons of Group composition



Each node shows the sample average rank of Group composition.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Mixed group-Only women	16,703	12,587	1,327	,184	,553
Mixed group-Only men	26,050	11,242	2,317	,020	,061
Only women-Only men	9,346	15,448	,605	,545	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

H. Affect

Pleased Mann Whitney U test

Ranks

	Activated	N	Mean Rank	Sum of Ranks
Crowdedness	0	52	73,68	3831,50
	1	103	80,18	8258,50
	Total	155		
Safety	0	52	74,52	3875,00
	1	103	79,76	8215,00
	Total	155		
Comfort	0	52	79,02	4109,00
	1	103	77,49	7981,00
	Total	155		
Attractiveness	0	52	80,76	4199,50
	1	103	76,61	7890,50

	Total	155		
Atmosphere	0	52	82,23	4276,00
	1	103	75,86	7814,00
	Total	155		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	2453,500	2497,000	2625,000	2534,500	2458,000
Wilcoxon W	3831,500	3875,000	7981,000	7890,500	7814,000
Z	-,884	-,787	-,224	-,574	-,918
Asymp. Sig. (2-tailed)	,377	,431	,823	,566	,358
Exact Sig. (2-tailed)	,378	,437	,817	,568	,362
Exact Sig. (1-tailed)	,189	,222	,413	,277	,184
Point Probability	,000	,015	,002	,002	,003

a. Grouping Variable: Activated

Activated Mann Whitney U test

Ranks

	Activated_bin	N	Mean Rank	Sum of Ranks
Crowdedness	,00	139	115,58	16065,00
	1,00	103	129,50	13338,00
	Total	242		
Safety	,00	139	113,36	15757,00
	1,00	103	132,49	13646,00
	Total	242		
Comfort	,00	139	118,09	16415,00
	1,00	103	126,10	12988,00
	Total	242		
Attractiveness	,00	139	123,63	17185,00
	1,00	103	118,62	12218,00
	Total	242		
Atmosphere	,00	139	120,77	16786,50
	1,00	103	122,49	12616,50
	Total	242		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere
Mann-Whitney U	6335,000	6027,000	6685,000	6862,000	7056,500
Wilcoxon W	16065,000	15757,000	16415,000	12218,000	16786,500
Z	-1,590	-2,344	-,964	-,581	-,208

Asymp. Sig. (2-tailed)	,112	,019	,335	,561	,835
Exact Sig. (2-tailed)	,112	,019	,328	,557	,838
Exact Sig. (1-tailed)	,056	,009	,163	,279	,419
Point Probability	,000	,000	,001	,000	,005

a. Grouping Variable: Activated_bin

Plan of action Red Light District

Plan of Action: Survey Red Light District

This plan of action briefly describes my proposed research at the Red Light District in Amsterdam. This research is part of my thesis at TU Delft under the daily supervision of Dorine Duives and Yufei Yuan.

Survey team

The surveys will be performed by me and a colleague of the university. Both of us will be wearing TU Delft shirts to make clear we are not a commercial organization.

Elise Zuurbier
Transport, Infrastructuur en Logistiek
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Contact municipality

Permission for this research and the provision of the monitoring data is done by the Department of 'Verkeer & Openbare Ruimte' of the municipality of Amsterdam. Furthermore, for conducting surveys no specific permission is required. Before starting the research, contact with the team leader of the hosts is made, to inform him/her about the research and discuss which locations would be the most efficient.

Joost van Dijk
Adviseur Verkeersmanagent
+31 6 13 56 85 14

Eelco Thiellier
Projectmanager Crowd Monitoring System Amsterdam
+31 6 29 59 85 00

Research

To find out how people experience crowdedness and other Level of Service measures and which factors influence this experience, surveys will be conducted at crowded event locations. An example of the survey can be found in *Appendix : Survey*. Next to a survey, monitoring data is gathered. The results of the survey are compared to the monitoring data, mainly in terms of experienced crowdedness and actual crowdedness. Therefore, it is important to conduct the survey near to a sensor. Furthermore, a light and sound intensity measurement is performed every half hour and actual weather data is gathered per hour. The goal is to gather 250 responses, approaching people as randomly as possible by stepping to the nearest person after conducting one survey. The surveys will be filled in on tablets, to improve the process for survey participant and researcher. The survey participants can fill in the survey themselves or give their answers to the researcher. Paper versions of the survey will be brought along as well, in case of failure of devices. Only adults (age 18 and up) will be considered for the survey. Therefore, age is one of the first questions. When a person is younger than 18, the survey will be aborted, because of a question about substance usage. The survey will be available in Dutch and English.

Preparation

1. Testing the survey questions and duration of the survey.
2. Check whether all electrical appliances are working and all necessary material is present.

Neccessary :

- 2x tablets
- 2x dongel
- 2x charging cable
- 2x powerbank
- 50x survey printed NL
- 50x survey printed EN
- 2x clipping board
- 4x pen
- 2x note block
- 2x smartphone with application: Physics toolbox

Locations

The surveys will be conducted near monitored locations, in such a way that the flow at these locations is least obstructed. Furthermore, it is undesirable to influence the measurements of the monitoring devices. Therefore, a position will be chosen that is not in view of the counting camera. At the red light district, there are many active counting cameras and Wi-Fi sensors. In Figure 1 (Maps Amsterdam, 2018), the locations of the various sensors are shown. Locations where there is both a counting camera and a Wi-Fi sensor are circled. These are locations that will be considered for conducting surveys.

Sensors GAWW 01, 02 and 03 are all in parallel alleys. One of these three will probably serve best as a survey location. this will be determined during the pilot. Sensors GAWW 04 and GAWW 06 are in the broader streets along the canal. One of both of these locations can be used to conduct surveys. The last sensor combination is GAWW 07, which is in continuation of GAWW 01. This location might be considered as well during the pilot. However, GAWW 02, 04 and 07 are not exactly on the same location, so this might influence the results.

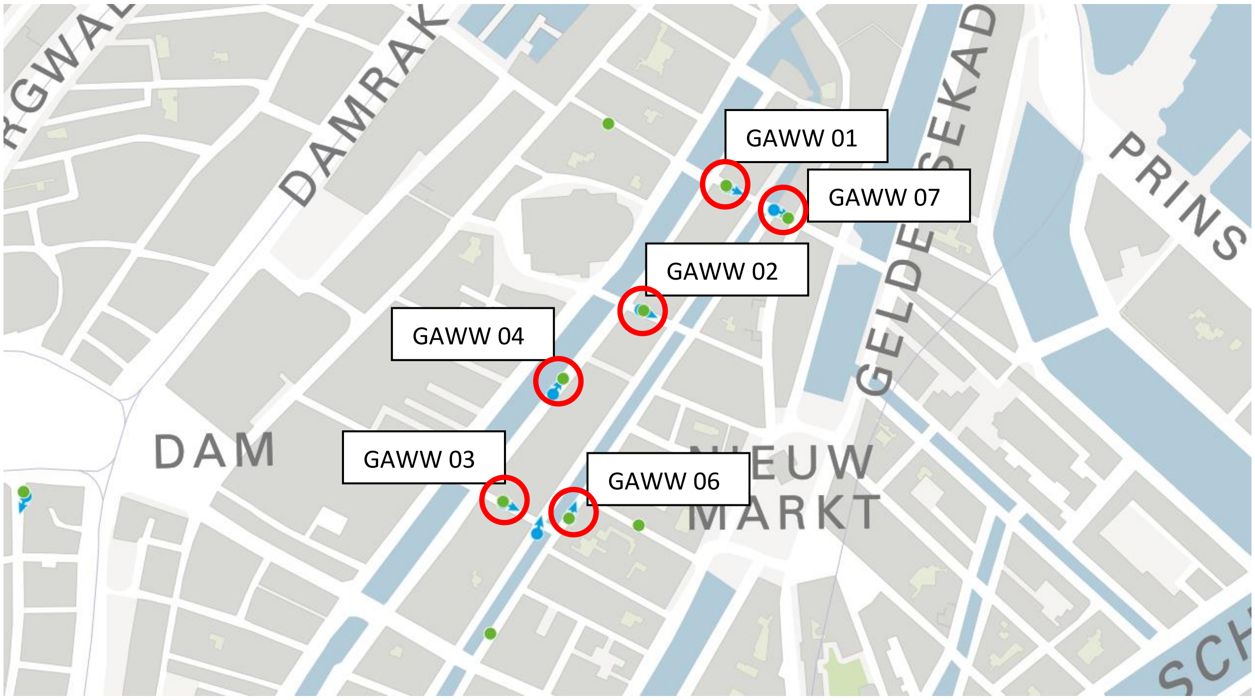


Figure 1 Monitoring devices at the Red light district. Green dot is Wi-Fi sensor, blue arrowed dots are counting cameras

Planning

Before the pilot test, the survey is already evaluated by discussion with supervisors and by asking colleagues and friends to fill in the survey. Furthermore, a previous version of the survey has already been used at the TT Festival 2018 in Assen. To make sure the research will run smoothly, a pilot test will be performed first. During the pilot, the best survey locations and time of day will be determined. Second, the pilot is meant to see whether people are willing to participate in a survey, if they understand the questions and how long it takes the participants to answer the questions. Survey questions could be adjusted after the pilot. Finally, the pilot is meant to test if all the devices are working.

Pilot: Friday 19 October 2018

1. Arrival at 18:00
2. Walk around the area to spot the sensors and to choose the best locations to conduct surveys
3. Speak with hosts about the best places and times to conduct surveys and how to approach people in a best way.
4. Conduct ten surveys at three locations and perform light and sound intensity measurements.
5. Notate which survey questions were unclear and how long the surveys took. Possibly adjust unclear questions.
6. End pilot around 22:30

Research day 1: Friday 26 October 2018

1. Conducting surveys. A survey takes about 2 minutes.
2. Perform a light and sound measurement every half hour.
3. Notate observations about the general atmosphere and any notable events that transpired.

Time	Location
17:30	Arrive at station
18:00	start surveying at location 1
19:15	surveying at location 2
20:15	break
21:00	surveying at location 3

Research day 2: Saturday 27 October 018

1. Conducting surveys. A survey takes about 2 minutes.
2. Perform a light and sound measurement every half hour.
3. Notate observations about the general atmosphere and any notable events that transpired.

Time	Location
17:30	Arrive at station
18:00	start surveying at location 3
19:15	surveying at location 1
20:15	pauze
21:00	surveying at location 2

J

Survey questions RLD

Enquête: Druktebeleving wallen

In te vullen door enquête afnemer:

*Vereist

1. **Locatie**

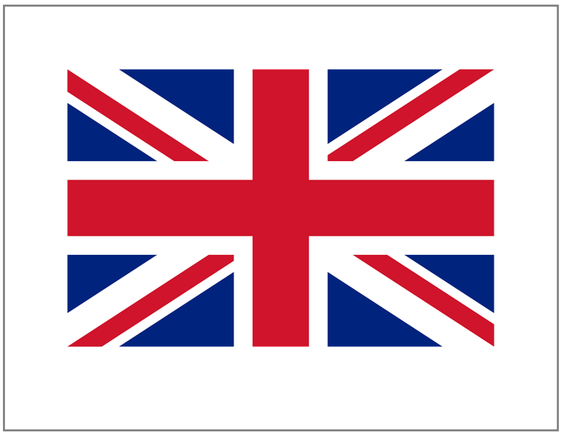
Markeer slechts één ovaal.

- GAWW 01
- GAWW 02
- GAWW 03
- GAWW 04
- GAWW 06
- GAWW 07
- Anders: ____________________

2. **Language** *

Markeer slechts één ovaal.

- Nederlands



- Engels *Na de laatste vraag in dit gedeelte ga je naar vraag 19.*

3. **Geslacht** *
Markeer slechts één ovaal.

- man
- vrouw
- Anders: ____________________

Algemene Informatie

Hallo, Ik doe voor mijn afstudeerproject bij de universiteit Delft onderzoek naar voetgangers bij evenementen en drukke plekken. Zou je mij willen helpen door mee te doen aan een korte vragenlijst over dit evenement? Het duurt ongeveer twee minuten. Als je een vraag tegenkomt die je niet wil beantwoorden kunnen we deze overslaan. Ik kan ook een stuk met u meelopen terwijl we de enquête invullen.

4. **In welke leeftijdscategorie valt u:** *
Markeer slechts één ovaal.

- 18-24
- 25-34
- 35-44
- 45-64
- 65-74
- 75+

5. **In welke gemeente woont u:** *

____

6. **Hoe vaak bent u in Amsterdam geweest?** *
Markeer slechts één ovaal.

- Nooit voor vandaag
- Een aantal keer
- Regelmatig
- Dagelijks

7. **Hoe vaak bent u in het Wallengebied geweest?** *
Markeer slechts één ovaal.

- Nooit voor vandaag
- Een aantal keer
- Regelmatig
- Dagelijks

8. **Met hoeveel mensen bent u hier?** *
Markeer slechts één ovaal.

- Alleen *Ga naar vraag 11.*
- Kleine groep (2-3)
- Middelgrote groep (4-6)
- Grote groep (7+)

Groepsvorm

9. **Hoe kennen jullie elkaar?**
Markeer slechts één ovaal.

- Stel
- Gezin met kinderen
- Familie
- Vrienden
- Collega's/medestudenten
- Gecombineerde groep
- Anders: ____________________

10. **Wat is de samenstelling van deze groep?**
Markeer slechts één ovaal.

- Alleen mannen
- Alleen vrouwen
- Gemengd

11. **Kies het woord dat het best past bij hoe u zich nu voelt:**
Markeer slechts één ovaal.

- Neutraal
- Opgewonden
- Uitgelaten
- Enthousiast
- Blij
- Verheugd/Vrolijk
- Ontspannen
- Sereen/Rustig
- Slaperig
- Moe
- Verveeld
- Depressief
- Verdrietig
- Gefrustreerd
- Geërgerd
- Boos
- Gealarmeerd/Paniekerig
- Anders: ____________________

12. **Bent u op dit moment onder invloed van een van de volgende middelen:**
meerdere antwoorden mogelijk
Vink alle toepasselijke opties aan.

- [ ] Geen middelen gebruikt
- [ ] Alcohol
- [ ] MDMA/XTC
- [ ] Marihuana
- [ ] Anders: ______________________

13. **Waar gaat u nu naartoe?**
Markeer slechts één ovaal.

- ( ) Weet nog niet
- ( ) Naar het (Trein) station
- ( ) Rondlopen in het Wallengebied
- ( ) Naar een andere toeristische attractie
- ( ) Naar werk/studie
- ( ) Naar huis/hotel
- ( ) Naar een bar/club
- ( ) Naar een restaurant/Gaan eten
- ( ) Anders: ______________________

14. **Hoe schat u de drukte op deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel rustig	( )	( )	( )	( )	( )	heel druk

15. **Hoe schat u de veiligheid op deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel onveilig	( )	( )	( )	( )	( )	heel veilig

16. **Hoe schat u het comfort op deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel oncomfortabel	( )	( )	( )	( )	( )	heel comfortabel

17. **Hoe schat u de aantrekkelijkheid van deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel onaantrekkelijk	( )	( )	( )	( )	( )	heel aantrekkelijk

18. **Hoe schat u de sfeer van deze locatie in?** *
Markeer slechts één ovaal.

	1	2	3	4	5	
heel ongezellig	◯	◯	◯	◯	◯	heel gezellig

Stop met het invullen van dit formulier.

General Information

Hi, I'm doing my thesis project about the experience of crowdedness of pedestrians at Delft University of Technology. Would you like to help me by filling in a short survey? It takes about 2 minutes. If there is a question that you would not like to answer it can be skipped. I can also walk a bit with you while you fill in the survey.

19. **What is your age category?** *
Markeer slechts één ovaal.

- ◯ 18-24
- ◯ 25-34
- ◯ 35-44
- ◯ 45-64
- ◯ 65-74
- ◯ 75+

20. **Country:**
Markeer slechts één ovaal.

- ◯ Netherlands
- ◯ Belgium
- ◯ France
- ◯ Germany
- ◯ United Kingdom
- ◯ United states of America
- ◯ China
- ◯ Japan
- ◯ South-Korea
- ◯ Other

21. **How many times have you visited the city Amsterdam?** *
Markeer slechts één ovaal.

- ◯ Never before this time
- ◯ A few times
- ◯ Regularly
- ◯ Daily

22. **How many times have you visited the Red Light District?** *

Markeer slechts één ovaal.

- Never before this time
- A few times
- Regularly
- Daily

23. **With how many people are you here?** *

Markeer slechts één ovaal.

- Alone *Ga naar vraag 26.*
- Small group (2-3)
- Medium sized group (4-6)
- Large group (7+)

Group

24. **What is your relation with these people?**

Markeer slechts één ovaal.

- Couple
- Couple with children
- Family
- Friends
- Colleagues/Fellow students
- Combined group
- Anders: ______________________

25. **What is the composition of your group?**

Markeer slechts één ovaal.

- Only men
- Only women
- Mixed group

26. **Choose the word that bests describes how you feel right now:**
Markeer slechts één ovaal.

- Neutral
- Aroused
- Excited
- Delighted
- Happy
- Glad
- Serene
- Relaxed
- Sleepy
- Tired
- Bored
- Depressed
- Sad
- Frustrated
- Annoyed
- Angry
- Alarmed
- Anders: ____________________

27. **Are you currently under the influence of one of the following substances?**
multiple answer selection possible
Vink alle toepasselijke opties aan.

- [ ] No substances used
- [ ] Alcohol
- [ ] MDMA
- [ ] Marihuana
- [ ] Anders: ____________________

28. **Where are you going at the moment?** *
Markeer slechts één ovaal.

- I don't know yet
- Walking around randomly
- To the (Train) station
- To see the Red Light Disctrict
- To another touristic attraction
- To work/school
- To Home/hotel
- Anders: ____________________

29. **How would you rate the level of crowdedness at this location? ***
Markeer slechts één ovaal.

	1	2	3	4	5	
Very uncrowded	⬭	⬭	⬭	⬭	⬭	Very crowded

30. **How would you rate the level of safety at this location? ***
Markeer slechts één ovaal.

	1	2	3	4	5	
very unsafe	⬭	⬭	⬭	⬭	⬭	very safe

31. **How would you rate the level of comfort at this location? ***
Markeer slechts één ovaal.

	1	2	3	4	5	
Very uncomfortable	⬭	⬭	⬭	⬭	⬭	Very comfortable

32. **How would you rate the level of attractiveness at this location? ***
Markeer slechts één ovaal.

	1	2	3	4	5	
Very unattractive	⬭	⬭	⬭	⬭	⬭	Very attractive

33. **How would you rate the atmosphere at this location? ***
Markeer slechts één ovaal.

	1	2	3	4	5	
Very bad atmosphere	⬭	⬭	⬭	⬭	⬭	Very good atmosphere

K

Statistical analysis RLD

K.

Exploratory bi-variate analysis

Analysis of survey data from the Red light district

To find out how people perceive crowdedness at a place like the Red Light District, a survey was conducted on three evenings in October. Three locations close to counting cameras and Wi-Fi sensors were chosen to conduct this research. In this report, the results of the survey are discussed. Since it is generally not appreciated in this area, no pictures were made during the surveys. Figure 1 illustrates how a busy night may look like.

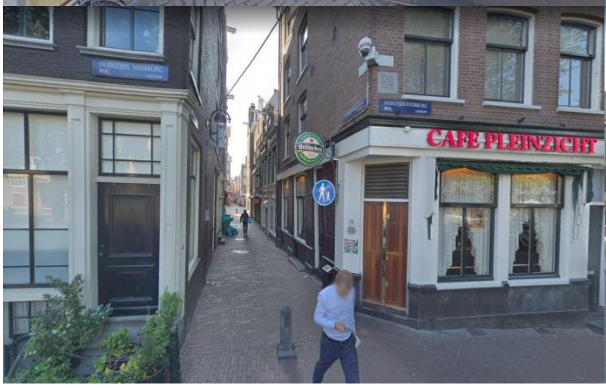
Figure 1 Crowded evening Red Light District. Foto Marcel Wogram, 2018.

Overall, the atmosphere that was sensed during the survey was generally safe. The many tourists that were walking around were a very mixed type of people. Some people were just walking around, others came to visit a bar or another attraction. Overall, the public was not very rowdy around the survey times. It usually took a few approaches before someone was found who was willing to answer a few questions. Many people did not even react or look up when spoken to. It seems as though people are still less comfortable talking to someone unknown in this area.

In the slightly broader streets, bicycles and vehicles with permission are allowed. There were some cycle taxis who raced dangerously through the crowd.

It was very noticeable that some local citizens were very annoyed by all the tourists. Some of them were on bicycles and were having a hard time passing through the crowd.

The surveys were held on Fridays and a Saturday, which are the most crowded evenings. On Friday the 19^{th} of October, surveys were held from 19:00-22:00. During this week, the Amsterdam Dance event was also an attraction throughout the whole city. It seemed to be more quiet than normal (Report Amsterdam). On Friday the 26^{th} of October, surveys were held again. However, due to bad weather, there were fewer surveys conducted as was planned. Furthermore, the rain and the cold temperature felt, it seemed to be more quiet than normal. The last surveying night was Saturday the 27^{th}. This was the most crowded day.



The three chosen locations are shown in the following pictures. The *Stormsteeg* is a small alley that can be seen as an entrance/exit of the Red Light District. Through this alley, a few cars, such as cabs are allowed. Other than that, there was a bit more space available compared to other locations. Surveys were held with people walking in or out of this alley. In the middle a picture shows the *Oude Kennissteeg,* a very narrow alleyway in the middle of the Red Light disctrict. During the surveys, the alley was often completely blocked to a standstill. At the entrance, a host was advising people to walk on the right side of the alley for better throughput. The surveys were held with people walking in or out of the alley. The third location was on one of the main streets of the districts next to a canal, *Oudezijds Achterburgwal.* During the research, a part of de road near the canal was fenced off for construction works. Although this street is a little more broad than the other alley, there are a lot of obstacles and sometimes vehicles going through.

General Descriptives

The survey had 182 participants, spread over three days and three locations. It is estimated that there are around 10.000 visitors to the area daily. Therefore, the surveys cannot be seen as a sample to describe the daily population in the area. The aim was to cover the three locations equally on different moments every night. As can be seen in Table 1, the *Stormsteeg* has had fewer respondents.

Table 1: Frequencies of survey locations

Location

	Frequency	Percent
Oude Kennissteeg	69	37,9
Oudezijds Achterburgwal	65	35,7
Stormsteeg	48	26,4
Total	182	100,0

In total, the respondents came from 48 different countries. In Table 2, the top 7 is shown. The Netherlands are still the most represented (15,9%), of which 11 people (6%) actually lived in Amsterdam. Most visitors had been in Amsterdam before, but the mode for visiting the Red light district was 'Never before this time'.

Table 2: Top 7 most frequent countries

Country	Frequency	Percent
Netherlands	29	15,9%
United Kingdom	17	9,3%
Spain	15	8,2%
France	14	7,7%
Germany	13	7,1%
United States	9	4,9%
India	7	3,8%

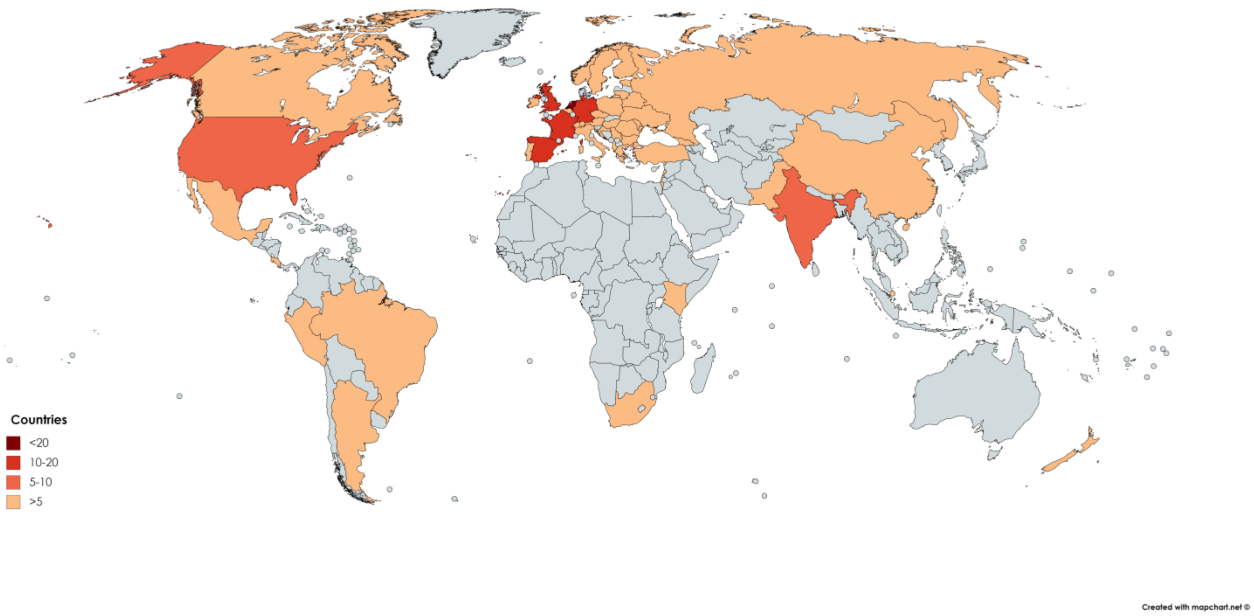
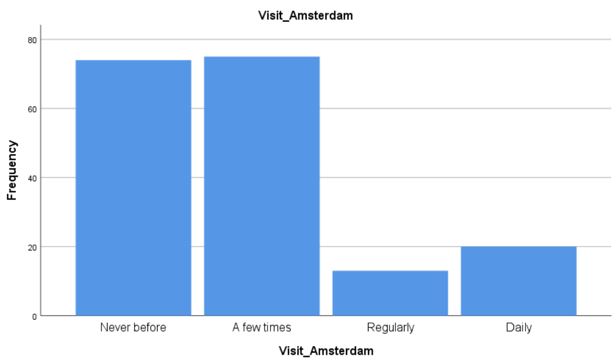
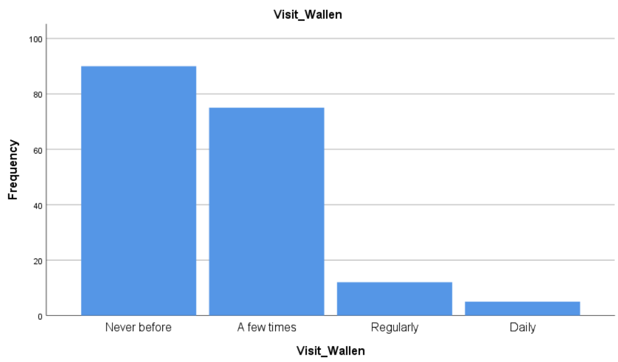


Figure 1: Countries of origin of respondents





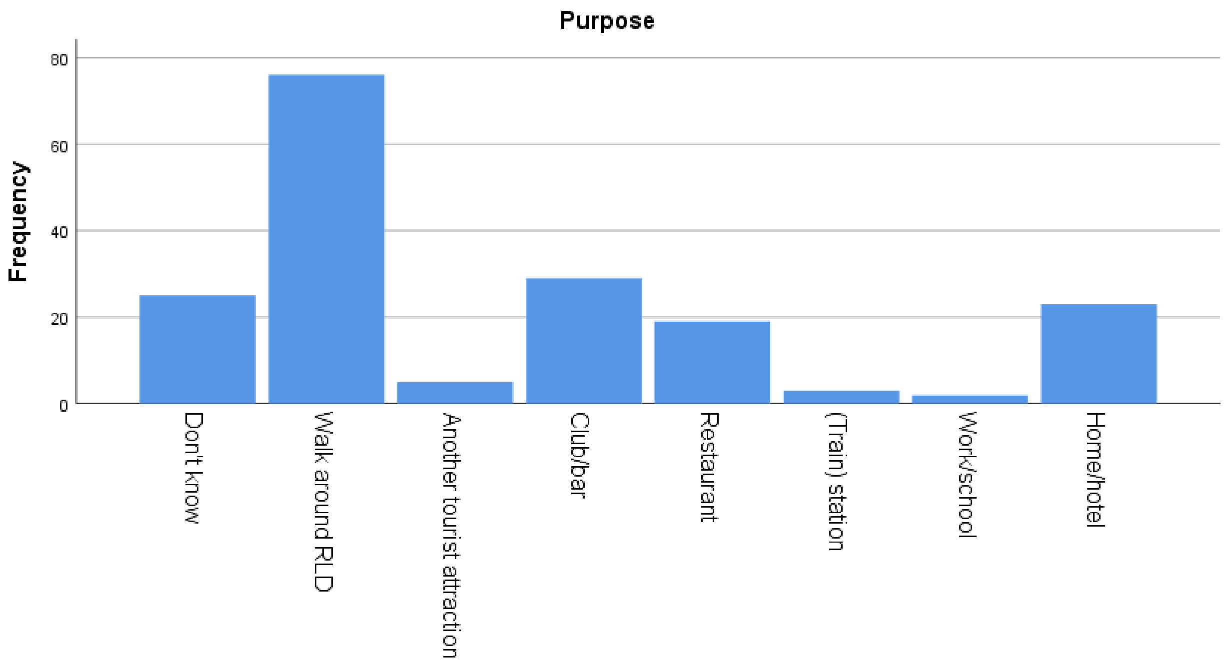


Figure 2: Trip purpose

In Figure 2, the distribution of answers for trip purpose are shown. Most people don't have a specific goal. It is expected that this will lead to a higher rated experience.

The emotional states are divided. The most given answer is Happy, followed by relaxed and neutral. It is expected that the word happy was chosen often, because it is a word most people know. Since the survey could only be taken in English or Dutch, this could influence the results. Furthermore, it seemed as though people were generally positive, because as a tourist visiting a place for recreation, you want to have a positive experience. One last note about this question is that some participants would said they felt weird, confused or uncomfortable, but these answers were not possible. As can be seen, the pleased and excited emotions were chosen the most, but there are also some negative answers given.

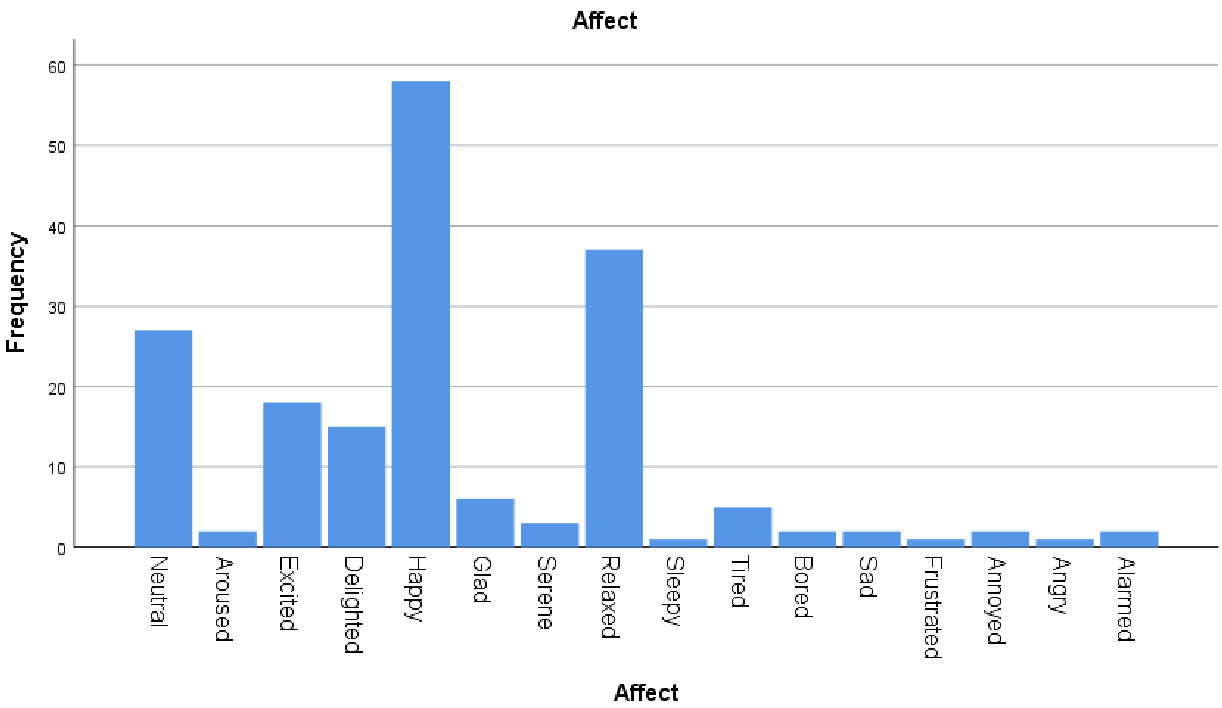


Figure 3: Affect

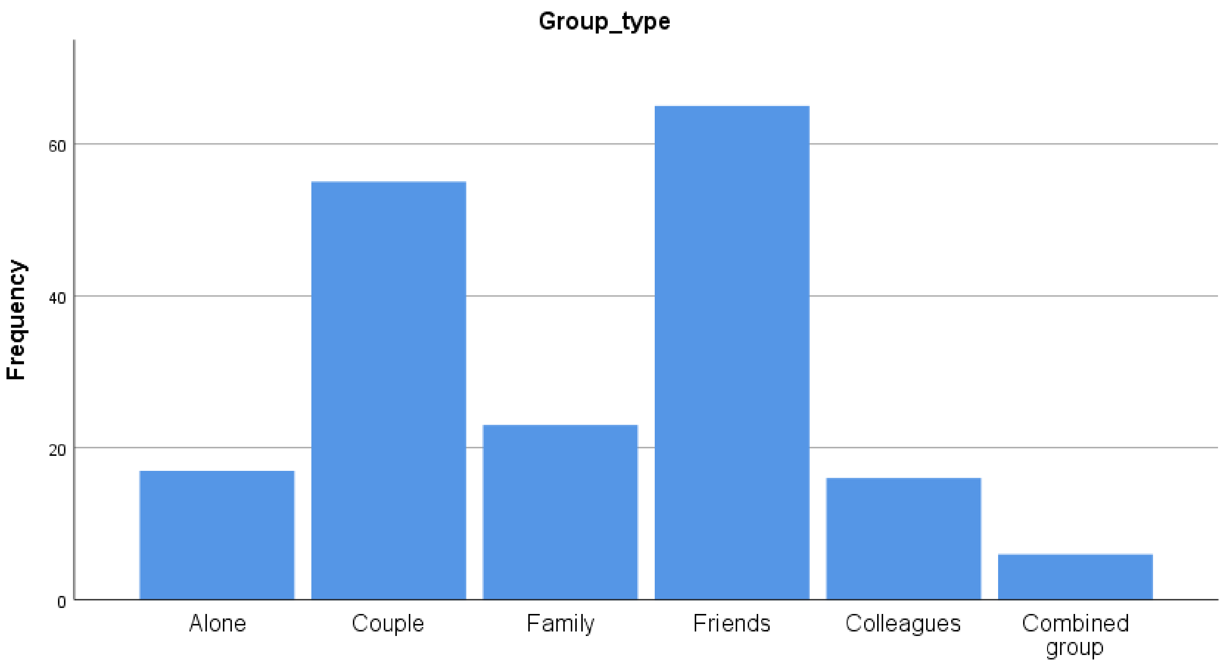


Figure 4: Group type

Most respondents are young people (25-34). 53,8% of the respondents was male. The group type most common was Friends, followed by Couples. Most groups were small (2-3 persons). There are quite some people by themselves. Most groups are mixed 54,8%, followed by groups of males (20%) and groups of females (15,%).

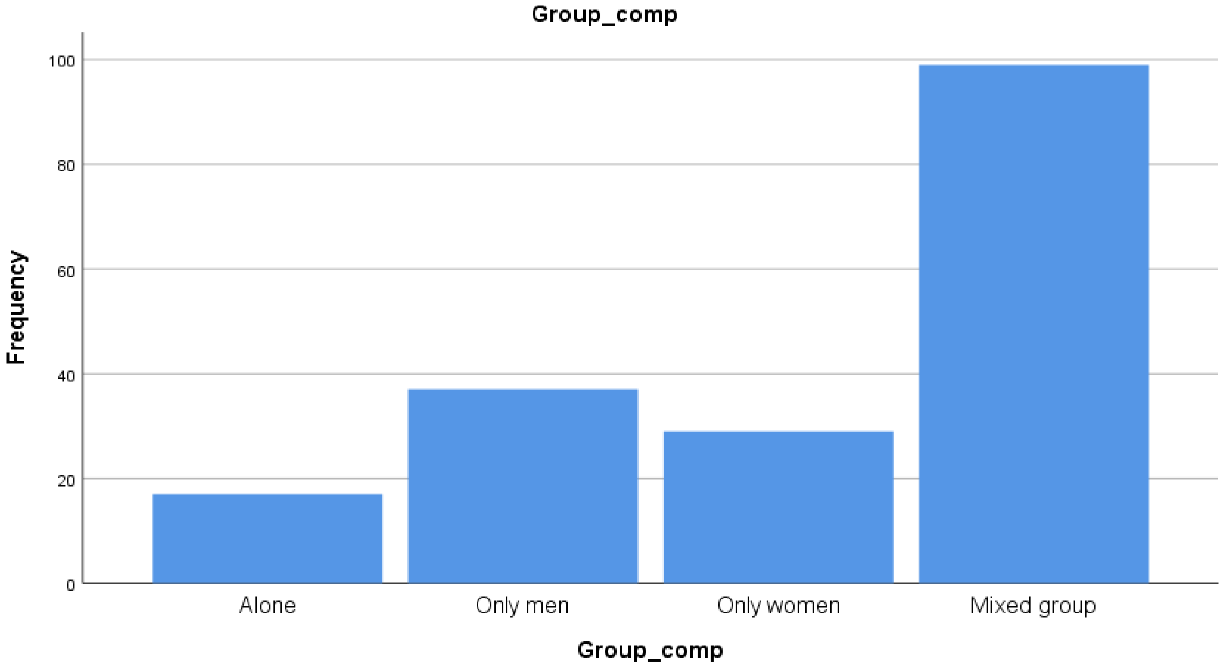


Figure 5: Group composition

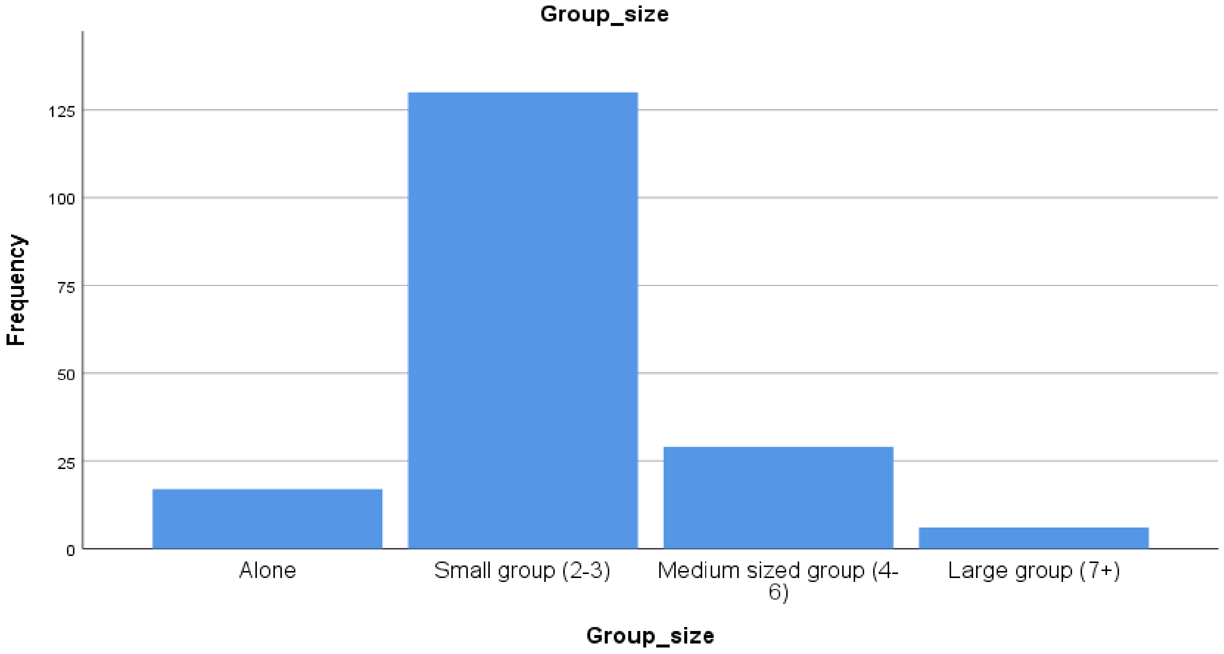


Figure 6: Group size

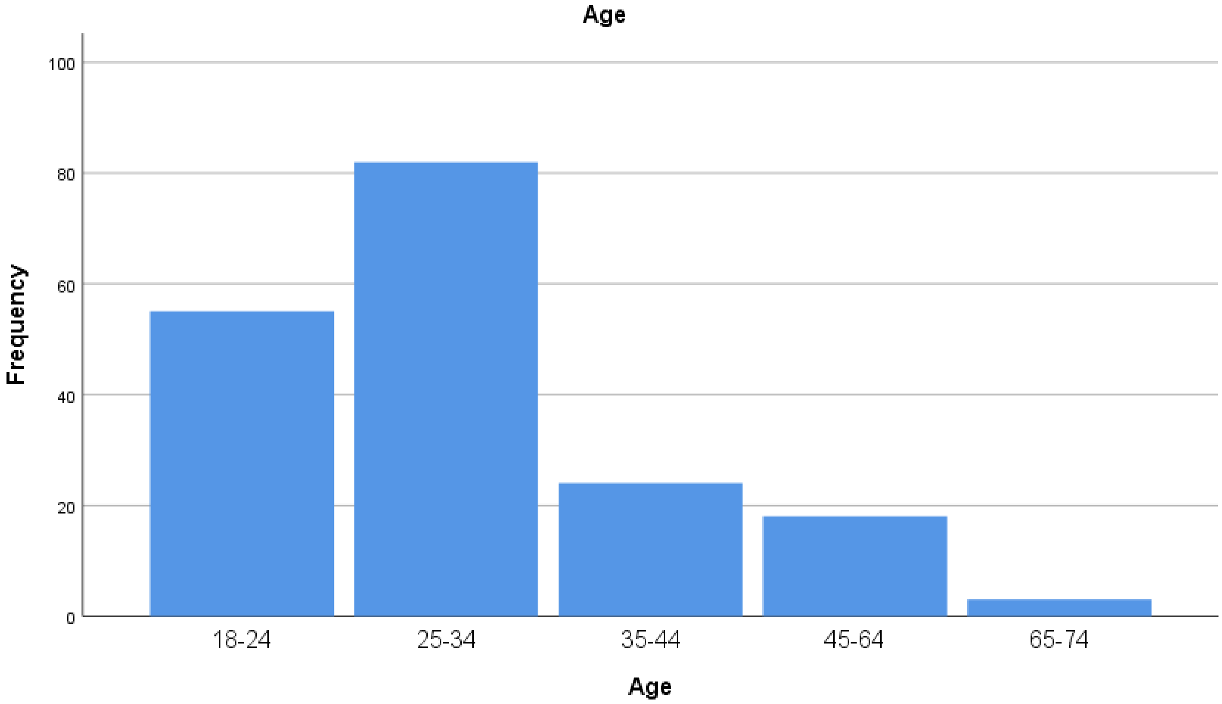
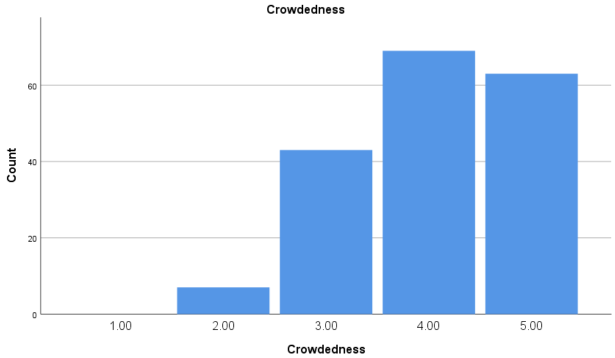
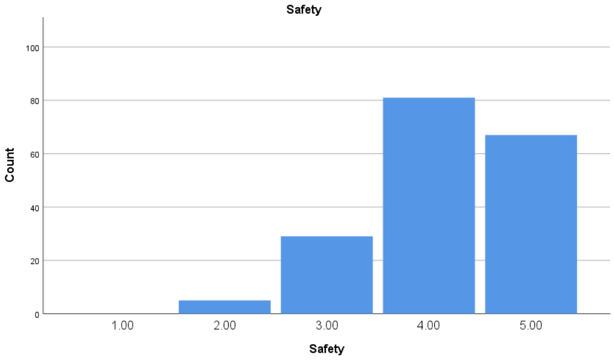
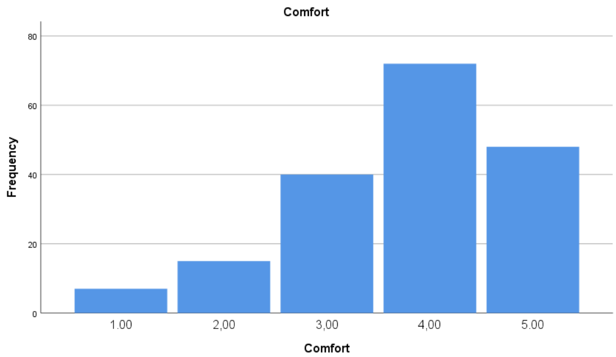


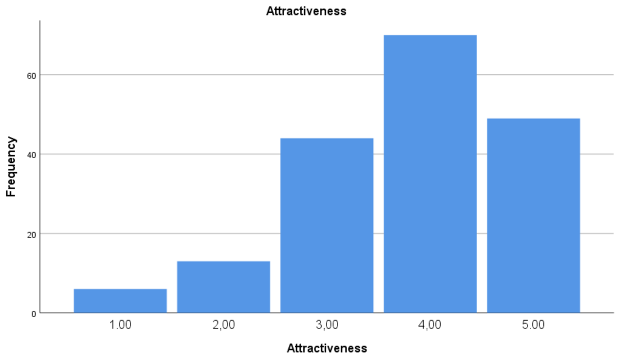
Figure 7: Age frequencies

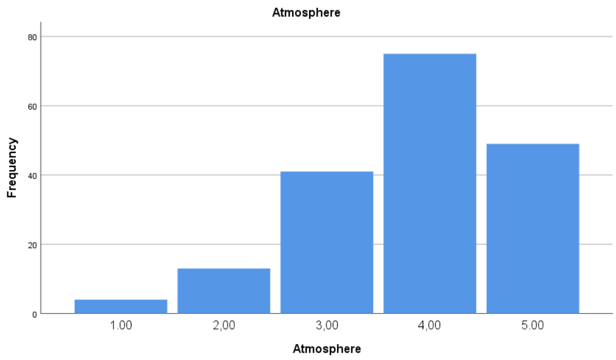
Next the histograms that summarize the answers to the perception questions are shown. As can be seen, the answers sets all have a skewed distribution, with a mode of 4 for all questions. *Crowdedness* is perceived the highest, while Experience has a median at 3, meaning the Crowdedness is perceived as neither pleasant or unpleasant.

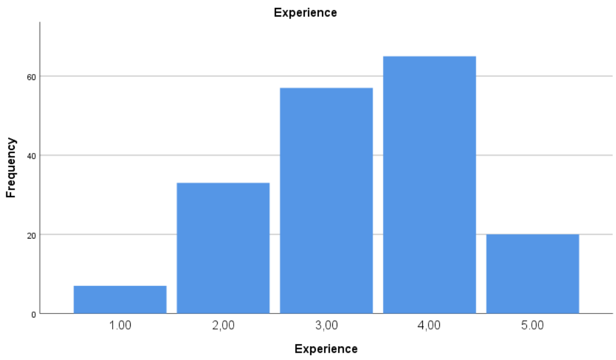












Bivariate statistics

In order to start analysing the relations in the dataset, expected relations between two variables are tested. With the variables from the survey alone, there are 22*22/2-22=220 possible relations that could be explained and tested. It is chosen to start with the relations that seem most relevant and interesting, which are the relations between the explanatory variables and the perception variables.

Perception

First the correlations within the five types of situational perception are tested. The following hypotheses were drafted for these correlations:

1. Crowdedness
    a. Safety: (non linear) In crowded places (avg. above 4) safety will be perceived as lower.
    b. Comfort: (non linear) In crowded places (avg. above 4) comfort will be perceived as lower.
    c. Attractiveness Environment: People who perceive crowdedness as higher, perceive atmosphere as higher as well.
    d. Atmosphere: People who perceive crowdedness as higher, perceive atmosphere as higher as well.
    e. Experience Crowdedness: People who perceive the crowdedness higher will experience this as unpleasant.
2. Safety
    a. Comfort: People who perceive a place as more comfortable will also perceive it as safer.
    b. Attractiveness Environment: People who perceive a place as safe will also perceive it as attractive.
    c. Atmosphere: People who perceive a place as safe will also perceive the atmosphere being higher.
    d. Experience: An unpleasant experience of Crowdedness will lead to a lower perceived Safety.
3. Comfort
    a. Attractiveness Environment: Pedestrians who rate Comfort higher will also rate the Attractiveness of the environment higher.
    b. Atmosphere: Pedestrians who rate Comfort higher will also rate the Atmosphere higher.
    c. Experience: An unpleasant experience of Crowdedness will lead to a lower perceived Comfort.
4. Attractiveness Environment
    a. Atmosphere: Pedestrians who rate the Attractiveness of the environment higher will also rate the Atmosphere higher.
    b. Experience: An unpleasant experience of Crowdedness will lead to a lower perceived Attractiveness of the environment.
5. Atmosphere
    a. Experience: An unpleasant experience of Crowdedness will lead to a lower perceived Atmosphere.

Since the data gathered on perception is ordinal, Spearman correlation and Kendall's Tau are used. The relations are tested one-tailed, since all hypotheses are directional.

Table 3: Correlations perceptions

			PC	PS	PCom	PAE	PA	EC
Kendall's tau								
	Crowdedness	Corr.	1,000	-,083	-,060	-,067	-,027	-,144*
		Sig.	.	,103	,176	,146	,340	,012
	Safety	Corr.	-,083	1,000	,499**	,203**	,254**	,245**
		Sig.	,103	.	,000	,001	,000	,000
	Comfort	Corr.	-,060	,499**	1,000	,310**	,446**	,360**
		Sig.	,176	,000	.	,000	,000	,000
	Attractiveness	Corr.	-,067	,203**	,310**	1,000	,575**	,317**
		Sig.	,146	,001	,000	.	,000	,000
	Atmosphere	Corr.	-,027	,254**	,446**	,575**	1,000	,377**
		Sig.	,340	,000	,000	,000	.	,000
	Experience	Corr.	-,144*	,245**	,360**	,317**	,377**	1,000
		Sig.	,012	,000	,000	,000	,000	.
Spearman's rho								
	Crowdedness	Corr.	1,000	-,096	-,068	-,078	-,029	-,165*
		Sig.	.	,099	,180	,148	,348	,013
	Safety	Corr.	-,096	1,000	,555**	,232**	,287**	,280**
		Sig.	,099	.	,000	,001	,000	,000
	Comfort	Corr.	-,068	,555**	1,000	,358**	,506**	,421**
		Sig.	,180	,000	.	,000	,000	,000
	Attractiveness	Corr.	-,078	,232**	,358**	1,000	,636**	,366**
		Sig.	,148	,001	,000	.	,000	,000
	Atmosphere	Corr.	-,029	,287**	,506**	,636**	1,000	,430**
		Sig.	,348	,000	,000	,000	.	,000
	Experience	Corr.	-,165*	,280**	,421**	,366**	,430**	1,000
		Sig.	,013	,000	,000	,000	,000	.

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

As can be seen in Table 3, many of the expected relations with Crowdedness are not there. The relations might become significant with a larger dataset. This is shown by doubling the dataset. With the same data doubled, the perceived safety has a significant negative correlation with perceived crowdedness. The Perceived crowdedness was also categorized as very crowded (old values: 4 and 5) and not very crowded (old values: 1,2 and 3). Testing this category with a Mann Whitney U test did not lead to other significant relations. Another reason that the expected relations are not found might be because of suppressor effects.

Other than *Crowdedness*, all perception variables are correlated positively, which is in line with the hypotheses.

Age and Gender

Age and gender are social demographic explanatory variables that are expected to affect perception in multiple ways. Based on the previous research at the TT Festival, the first hypothesis is formed. The second hypothesis is specific for the Red Light District, since there are prostitutes in the windows during the times of the survey. It is expected that young people will have a more positive overall view, because they might still find drugs and sex very new, interesting and exciting.

1. Women perceive Safety lower.
2. Men perceive the Attractiveness of the environment higher.
3. It is expected that younger people have a more positive perception.

A Mann Whitney U test is used to find differences in perception between men and women. In Appendix F, the results are reported. Hypothesis 1 is confirmed, women do indeed perceive Safety lower (z=-1,978, p=0,025 (one-tailed)). *Attractiveness* is also significant (z=-1,853, p=0,032 (one-tailed)).

Table 4: Correlation perception - age

Kendall's tau		Age
Crowdedness	Corr.	,115*
	Sig.	,038
Safety	Corr.	,043
	Sig.	,253
Comfort	Corr.	,008
	Sig.	,447
Attractiveness	Corr.	-,186**
	Sig.	,002
Atmosphere	Corr.	-,116*
	Sig.	,035
Experience	Corr.	-,067
	Sig.	,144

* one tailed

For age, it is found that *Attractiveness* and *Atmosphere* are indeed rated higher by younger people. For *Safety* and *Comfort* the original hypothesis seems unjustified. This could be explained, because while younger people might be overly confident, the experience of older people might give them better self-confidence. Although for *Crowdedness* it is found that older people rate *Crowdedness* higher, for *Experience* no correlation is found. The relation is either not that strong, or needs to be found with a larger data set.

Residence

It is expected that place of residence affects the perception of the pedestrians by culture and urbanization level. Since there are 48 different countries, it is chosen to only look at the difference between Dutch inhabitants and inhabitants of Amsterdam compared to other Dutch inhabitants. The expectation is that foreigners will have a more positive perception.

1. Foreigners will perceive the Crowdedness higher.
2. Foreigners will have a more positive perception.
3. Inhabitants of Amsterdam will have a more negative perception.

Table 5: Mann Whitey U test: Dutch vs Foreign and Amsterdammer vs Dutch

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Dutch (29) vs Foreign						
Z	-1,753	-2,787	-3,795	-2,328	-2,311	-1,542
Exact Sig. (2-tailed)	,083	,005	,000	,019	,020	,123
Exact Sig. (1-tailed)	,042	,003	,000	,010	,010	,062
Amsterdammer (13) vs Dutch (11)						
Z	-,374	-,195	-1,659	-1,336	-1,977	-2,160
Exact Sig. (2-tailed)	,771	,780	,097	,190	,051	,033
Exact Sig. (1-tailed)	,399	,387	,052	,101	,026	,016

As can be seen in from the mean rank in Appendix G, foreigners perceive Crowdedness lower, and perceive all other variables significantly higher. For Amsterdam specific, opposed to other Dutch inhabitants, Atmosphere and Experience are significantly lower. This means that inhabitants of Amsterdam have the most negative perception.

Familiarity

Familiarity will probably play a large role in the perception of the Crowdedness and other situational perceptions. In the TT research, the expectations were that people who visited the city and/or the event more often would be more positive. Based on earlier research, it is known that inhabitants of Amsterdam experience more negative aspects of the crowdedness. This can be explained as well by having a purpose, instead of looking for entertainment. Furthermore, people who are familiar with the history of the Wallen also know of the crimes and accidents in a neighbourhood.

1. People who are familiar with the Wallen will compare the crowdedness with their expectation based on previous visits. People familiar with the city will compare it with the rest of the city centre.
2. People who are familiar will perceive the situation more negatively.

Table 6: Correlation perception - visit city/event

		Visit Amsterdam	Visit Wallen
Kendall's tau_b			
Crowdedness	Corr.	-,136*	-,101

	Sig.	,019	,065
Safety	Corr.	-,128*	-,042
	Sig.	,026	,268
Comfort	Corr.	-,129*	-,027
	Sig.	,022	,341
Attractiveness	Corr.	-,152**	-,113*
	Sig.	,009	,043
Atmosphere	Corr.	-,157**	-,144*
	Sig.	,008	,015
Experience	Corr.	-,169**	-,067
	Sig.	,004	,153

As can be seen from the correlations, there are negative correlations between visiting Amsterdam and the situational perception. *Crowdedness* is also perceived lower. This could be because it was more quiet during the survey evenings and because they were conducted a little before the highest peak. Visiting of the Wallen shows the same relations as visiting Amsterdam, but they are weaker and not all significant. Only *Attractiveness* and *Atmosphere* are significant. The people who have visited the Wallen more often are slightly more negative.

Group

1. People who are part of a larger group perceive the crowdedness to be higher. Groups of men will perceive the crowdedness lower.
2. People
3. People who are part of a larger group perceive comfort to be higher.
4. Larger group feels perceives safer. Group of men perceive safer.
5. Larger groups perceive atmosphere as higher.

The results for group size can be found in Appendix A. *Comfort* has a significant negative correlation with Group size ($\tau=-0.165$, $p=0.006$). This was not expected, but is the same result as the previous research at the TT festival. The other correlations are all negative, but weak and not significant ($\tau < 0.1$, $p > 0.05$). This means these correlations are different than expected from theory, since it was expected that larger groups would have a more positive experience. However, it is not possible to draw any conclusions, because the correlations are too weak.

The group composition is tested with a Kruskal Wallis test. This yielded an unexpected result: Crowdedness is perceived higher by mixed groups opposed to single sex groups. However, in the pairwise comparisons, no significant correlations were found.

Finally, group type is tested, even though there are no specific hypotheses for this variable, it is expected that group type does have influence on a person's perception. As can be seen in Appendix K, *Crowdedness* is significantly affected. A pairwise comparison shows the following results:

Table 7: Pairwise comparison group type - Perceived crowdedness

		z	p (asym. 2-tailed) adjusted with Bonferroni corr.
Crowdedness	Colleagues – Friends	3,534	0.006
	Colleagues - Couple	3,604	0.005

From the mean ranks in the Kruskal Wallis test, it is shown that Colleagues perceive Crowdedness lower than Friends and Couples. How this is best interpreted is not fully clear. Some group types are small categories, such as combined group (n=6).

Purpose

For trip purpose, there were two hypotheses:

1. People with a trip purpose perceive the crowdedness higher and experience crowdedness more negatively.
2. People with a trip purpose perceive the atmosphere and attractiveness lower.

As can be seen in Appendix I, many tests have been performed to analyse the relation between purpose and perception. First, there were eight categories in the survey question. These were tested with a Kruskal Wallis test. However, to truly test the hypotheses, new categories have to be made. It is chosen to make three categories: No purpose, a recreational purpose and a pressing purpose. In table 8, The recategorization is shown.

Table 8: Recategorization trip purpose

New category	**Old category**
No purpose	I don't know
	Walking around in the Red light district
Recreational purpose	Another tourist attraction
	Club/bar
	Restaurant
Pressing purpose	(Train) station
	Work/school
	Home/Hotel

With these three categories, another Kruskal Wallis test is performed. From the pairwise comparisons, we find the following results:

Table 9: Pairwise comparison trip purpose - perception

		z	p (asym. 2-tailed) adjusted with Bonferroni corr.
Attractiveness	No purpose – Pressing purpose	2.777	0.016
Experience	No purpose – Pressing purpose	2.748	0.007

	Recreational purpose – Pressing purpose	3.038	0.018

From the results, it seems as if the difference between a pressing purpose and no purpose is the most important. Therefore, it is chosen to recategorise again, where the recreational purpose is changed into no purpose. Now, it is possible to perform a Mann Whitney U test. The results are very interesting. Table x shows that there are significant results now for Safety, Comfort, Attractiveness, Atmosphere and Experience (exact significance one-tailed). This confirms all hypotheses, all perceptions are negatively influenced by the variable Purpose, except perceived crowdedness. People with a purpose do experience crowdedness as less pleasant, but do not perceive the crowdedness differently.

Table 10: Mann Whitney U test purpose - perception

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	2064,000	1662,000	1743,500	1538,000	1675,500	1383,500
Z	-,380	-2,080	-1,688	-2,528	-1,977	-3,147
Asymp. Sig. (2-tailed)	,704	,038	,091	,011	,048	,002
Exact Sig. (2-tailed)	,709	,036	,091	,011	,048	,001
Exact Sig. (1-tailed)	,354	,019	,046	,006	,024	,001

Affect

Concerning Affect, the following hypotheses were drafted:

1. Deactivated and unpleasant emotions make people perceive crowdedness higher and experience crowdedness as less pleasant.
2. Pleased, activated people perceive all other perceptions higher.

Two Mann Whitney U tests are performed (Appendix J) to test for the summarized categories *Pleased* and *Active.* The summarized category *Pleased*, has a significant on all perception variables except *Crowdedness*. The perception of crowdedness is not influenced by feeling pleasant or not. All other perception variables are indeed rated higher by people who feel pleasant.

The summarized category *Activated* only has significant relations with *Attractiveness and Experience.* These are rated higher by people who experience an active emotional state. The effect (z score) is smaller than the effect of feeling pleased.

Substances

For substances, it was expected that people that have drunk are less inhibited, so would estimate crowdedness lower, and all other perception variables higher. Furthermore, it is expected that people under influence of marihuana are more relaxed, but also dislike crowdedness more. A Mann Whitney U test was performed to test this, see Appendix M. A significant z-score is found for Safety, Comfort, Attractiveness and Atmosphere. In all cases, marihuana users have a more positive perception.

Metadata

Time of day/week

The variable time is expected to have a major influence on the perception of the visitors of the event. However, this is not because of time itself, but because other circumstances change over time, such as actual crowdedness, music type and other activity related variables. The hypotheses concerning time will be tested two-tailed, because most of them are not directional.

1. Crowdedness: There are certain peaks in densities on certain times during the day, depending on the attractions (artists), start/end time event
2. Safety: At later hours, safety may be perceived as lower.
3. Comfort: People who are present longer perceive comfort to be lower.
4. Attractiveness may vary in time, due to location characteristics
5. Atmosphere may vary in time, later at night better atmosphere

Table 11: correlation perception - time of day

Kendall's tau		Time of day
Crowdedness	Corr.	,174**
	Sig.	,007
Safety	Corr.	-,005
	Sig.	,937
Comfort	Corr.	-,077
	Sig.	,227
Attractiveness	Corr.	-,026
	Sig.	,688
Atmosphere	Corr.	-,038
	Sig.	,557
Experience	Corr.	-,063
	Sig.	,321

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

As can be seen in Table 11, *Crowdedness* is positively correlated with time of day, which makes sense looking at actual crowdedness on a normal evening. Other correlations are not found. This can be explained by the fact that indeed not many other circumstances change and the time window of the survey is not very broad (19:00-22:00). It is expected that the Atmosphere is perceived very different during the day.

Next, the three different evenings are tested against each other. It is expected that the evenings are perceived differently in *Crowdedness,* because the actual Crowdedness was also different. Other than that, it is expected that the bad weather on the 26th of October will affect the perceived Atmosphere and Attractiveness of the Environment.

Ranks

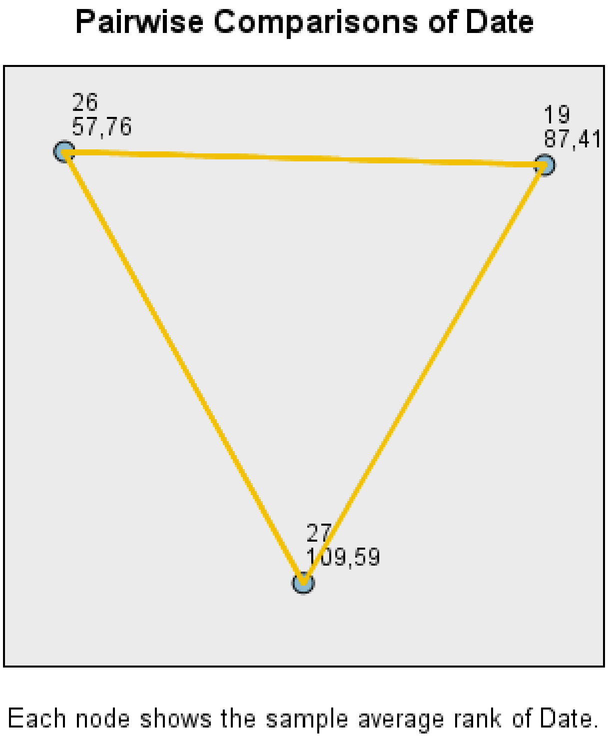
	Date	N	Mean Rank
Crowdedness	19	69	87,41
	26	34	57,76
	27	79	109,59
	Total	182	
Safety	19	69	87,00
	26	34	96,32
	27	79	93,35
	Total	182	
Comfort	19	69	89,08
	26	34	89,50
	27	79	94,47
	Total	182	
Attractiveness	19	69	90,48
	26	34	99,18
	27	79	89,09
	Total	182	
Atmosphere	19	69	92,20
	26	34	89,44
	27	79	91,78
	Total	182	
Experience	19	69	90,86
	26	34	102,40
	27	79	87,37
	Total	182	

Test Statistics[a,b]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H	26,580	1,033	,491	1,005	,074	2,128
df	2	2	2	2	2	2
Asymp. Sig.	,000	,597	,782	,605	,964	,345

a. Kruskal Wallis Test

b. Grouping Variable: Date



Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
26-19	29,641	10,419	2,845	,004	,013
26-27	-51,830	10,199	-5,082	,000	,000
19-27	-22,189	8,193	-2,708	,007	,020

Figure 8: Pairwise comparison time of week

As can be seen in Figure 8, *Crowdedness* is indeed perceived different on every day. The mean ranks seem to fit the actual Crowdedness as perceived by the survey takers. Other correlations are not found.

Weather type

Ranks

	Weather_type	N	Mean Rank	Sum of Ranks
Crowdedness	3,00	34	57,76	1964,00
	6,00	148	99,25	14689,00
	Total	182		
Safety	3,00	34	96,32	3275,00
	6,00	148	90,39	13378,00
	Total	182		
Comfort	3,00	34	89,50	3043,00
	6,00	148	91,96	13610,00
	Total	182		
Attractiveness	3,00	34	99,18	3372,00
	6,00	148	89,74	13281,00
	Total	182		
Atmosphere	3,00	34	89,44	3041,00
	6,00	148	91,97	13612,00
	Total	182		
Experience	3,00	34	102,40	3481,50
	6,00	148	89,00	13171,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	1369,000	2352,000	2448,000	2255,000	2446,000	2145,500
Wilcoxon W	1964,000	13378,000	3043,000	13281,000	3041,000	13171,500
Z	-4,387	-,639	-,258	-,988	-,267	-1,397
Asymp. Sig. (2-tailed)	,000	,523	,797	,323	,790	,162

a. Grouping Variable: Weather_type

Appendix

A. General descriptives

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Crowdedness	182	-,433	,180	-,713	,358
Safety	182	-,625	,180	-,150	,358
Comfort	182	-,747	,180	,101	,358
Attractiveness	182	-,706	,180	,126	,358
Atmosphere	182	-,703	,180	,174	,358
Experience	182	-,260	,180	-,515	,358
Valid N (listwise)	182				

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Crowdedness	182	2,00	5,00	4,0330	,85979	-,433	,180	-,713	,358
Safety	182	2,00	5,00	4,1538	,78555	-,625	,180	-,150	,358
Comfort	182	1,00	5,00	3,7637	1,05338	-,747	,180	,101	,358
Attractiveness	182	1,00	5,00	3,7857	1,02629	-,706	,180	,126	,358
Atmosphere	182	1,00	5,00	3,8352	,97781	-,703	,180	,174	,358
Experience	182	1,00	5,00	3,3187	1,01784	-,260	,180	-,515	,358
Age	182	1,00	5,00	2,0769	,98867	,885	,180	,277	,358
Visit_Amsterdam	182	1,00	4,00	1,8846	,95355	1,007	,180	,168	,358
Visit_Wallen	182	1,00	4,00	1,6264	,73052	1,143	,180	1,296	,358
Group_size	182	1,00	4,00	2,1319	,60766	,825	,180	1,871	,358
Wific1ma15	182	28,20	80,93	56,0905	14,30978	-,142	,180	-1,411	,358
camc15	182	24,13	88,53	50,8736	16,70087	,648	,180	-,541	,358
Valid N (listwise)	182								

B. Correlations

	Age	Visit Amsterdam	Visit Wallen	Group_size
Kendall's tau_b				

	Crowdedness	Corr.	,115*	-,136*	-,101	,010
		Sig.	,038	,019	,065	,438
	Safety	Corr.	,043	-,128*	-,042	-,099
		Sig.	,253	,026	,268	,072
	Comfort	Corr.	,008	-,129*	-,027	-,165**
		Sig.	,447	,022	,341	,006
	Attractiveness	Corr.	-,186**	-,152**	-,113*	-,022
		Sig.	,002	,009	,043	,367
	Atmosphere	Corr.	-,116*	-,157**	-,144*	-,076
		Sig.	,035	,008	,015	,125
	Experience	Corr.	-,067	-,169**	-,067	-,093
		Sig.	,144	,004	,153	,078
	Age	Corr.	1,000	,069	,106	-,054
		Sig.	.	,146	,056	,208
	Visit_Amsterdam	Corr.	,069	1,000	,768**	-,126*
		Sig.	,146	.	,000	,031
	Visit_Wallen	Corr.	,106	,768**	1,000	-,191**
		Sig.	,056	,000	.	,003
	Group_size	Corr.	-,054	-,126*	-,191**	1,000
		Sig.	,208	,031	,003	.
Spearman's rho						
	Crowdedness	Corr.	,129*	-,152*	-,112	,012
		Sig.	,042	,020	,067	,436
	Safety	Corr.	,049	-,142*	-,046	-,108
		Sig.	,254	,028	,270	,073
	Comfort	Corr.	,011	-,149*	-,031	-,184**
		Sig.	,442	,022	,341	,006
	Attractiveness	Corr.	-,217**	-,175**	-,129*	-,026
		Sig.	,002	,009	,041	,364
	Atmosphere	Corr.	-,135*	-,180**	-,163*	-,086
		Sig.	,035	,007	,014	,125
	Experience	Corr.	-,079	-,196**	-,079	-,105
		Sig.	,145	,004	,146	,078
	Age	Corr.	1,000	,080	,118	-,060
		Sig.	.	,142	,056	,211
	Visit_Amsterdam	Corr.	,080	1,000	,804**	-,139*
		Sig.	,142	.	,000	,031
	Visit_Wallen	Corr.	,118	,804**	1,000	-,207**
		Sig.	,056	,000	.	,003
	Group_size	Corr.	-,060	-,139*	-,207**	1,000

	Sig.	,211	,031	,003	.

		Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Wific1ma15	Correlation Coefficient	,215**	0,023	0,003	-0,012	0,022	-0,073
	Sig. (1-tailed)	0,000	0,345	0,481	0,416	0,345	0,095
Wific1MA3	Correlation Coefficient	,205**	0,002	-0,046	-0,025	0,010	-0,066
	Sig. (1-tailed)	0,000	0,488	0,207	0,328	0,427	0,118
Wific15ma15	Correlation Coefficient	,195**	-0,005	-0,018	-0,028	0,009	-0,084
	Sig. (1-tailed)	0,000	0,466	0,376	0,306	0,434	0,067
Wific3ma3	Correlation Coefficient	,179**	0,007	-0,048	-0,041	0,004	-0,072
	Sig. (1-tailed)	0,001	0,453	0,196	0,233	0,473	0,098
Wific1ma30	Correlation Coefficient	,224**	0,008	-0,017	-0,034	-0,002	-0,070
	Sig. (1-tailed)	0,000	0,442	0,383	0,271	0,486	0,105
Wific1ma60	Correlation Coefficient	,226**	0,000	-0,019	-0,046	-0,024	-0,055
	Sig. (1-tailed)	0,000	0,497	0,369	0,204	0,333	0,161
Allwifi60	Correlation Coefficient	,292**	-0,011	0,008	-0,025	0,002	-0,053
	Sig. (1-tailed)	0,000	0,422	0,445	0,328	0,487	0,171
volc15	Correlation Coefficient	,265**	-0,039	-0,054	-0,053	-0,010	-,118*
	Sig. (1-tailed)	0,000	0,248	0,167	0,171	0,431	0,017
volc3	Correlation Coefficient	,224**	-0,024	-0,063	-0,039	0,006	-0,081
	Sig. (1-tailed)	0,000	0,341	0,130	0,246	0,461	0,074
camc15	Correlation Coefficient	,162**	0,041	0,066	0,009	0,036	-0,015
	Sig. (1-tailed)	0,002	0,239	0,120	0,437	0,264	0,398
camc3	Correlation Coefficient	,140**	0,039	0,036	-0,041	-0,036	-0,013
	Sig. (1-tailed)	0,007	0,252	0,261	0,236	0,261	0,409
camf15	Correlation Coefficient	,127*	0,062	0,050	0,010	-0,008	0,000
	Sig. (1-tailed)	0,013	0,139	0,185	0,430	0,442	0,500
camf3	Correlation Coefficient	,097*	0,044	0,055	-0,032	-0,034	-0,018
	Sig. (1-tailed)	0,045	0,225	0,163	0,286	0,276	0,375

C. Time of day/week

D. Location

E. Ranks

	Location	N	Mean Rank
Crowdedness	GAWW 02 Oud kennissteeg	69	90,33
	GAWW 06 Oud. AB Wal	65	90,75
	GAWW 07 Stormsteeg	48	94,19
	Total	182	
Safety	GAWW 02 Oud kennissteeg	69	98,19
	GAWW 06 Oud. AB Wal	65	86,54
	GAWW 07 Stormsteeg	48	88,60
	Total	182	
Comfort	GAWW 02 Oud kennissteeg	69	94,46
	GAWW 06 Oud. AB Wal	65	92,74
	GAWW 07 Stormsteeg	48	85,56
	Total	182	
Attractiveness	GAWW 02 Oud kennissteeg	69	90,93
	GAWW 06 Oud. AB Wal	65	94,55
	GAWW 07 Stormsteeg	48	88,19
	Total	182	
Atmosphere	GAWW 02 Oud kennissteeg	69	90,75
	GAWW 06 Oud. AB Wal	65	96,39
	GAWW 07 Stormsteeg	48	85,95
	Total	182	
Experience	GAWW 02 Oud kennissteeg	69	95,21
	GAWW 06 Oud. AB Wal	65	88,83
	GAWW 07 Stormsteeg	48	89,78
	Total	182	

Test Statistics[a,b]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H	,193	2,137	,951	,458	1,232	,611
df	2	2	2	2	2	2
Asymp. Sig.	,908	,343	,622	,795	,540	,737

a. Kruskal Wallis Test

b. Grouping Variable: Location

		Temperature
Crowdedness	Pearson Correlation	-,300**
	Sig. (2-tailed)	,000
	N	182

Safety	Pearson Correlation	-,060
	Sig. (2-tailed)	,421
	N	182
Comfort	Pearson Correlation	-,061
	Sig. (2-tailed)	,414
	N	182
Attractiveness	Pearson Correlation	,011
	Sig. (2-tailed)	,881
	N	182
Atmosphere	Pearson Correlation	-,010
	Sig. (2-tailed)	,895
	N	182
Experience	Pearson Correlation	,042
	Sig. (2-tailed)	,574
	N	182

F. Familiarity

Visit_Wallen

		Frequency	Percent
Valid	Never before	90	49,5
	A few times	75	41,2
	Regularly	12	6,6
	Daily	5	2,7
	Total	182	100,0

Visit_Amsterdam

		Frequency	Percent
Valid	Never before	74	40,7
	A few times	75	41,2
	Regularly	13	7,1
	Daily	20	11,0
	Total	182	100,0

G. Residence

Foreign

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	,00	29	15,9	15,9	15,9
	1,00	153	84,1	84,1	100,0
	Total	182	100,0	100,0	

Amsterdammer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	,00	171	94,0	94,0	94,0
	1,00	11	6,0	6,0	100,0
	Total	182	100,0	100,0	

Mann Whitney: Foreign vs Dutch

Ranks

	Foreign	N	Mean Rank	Sum of Ranks
Crowdedness	,00	29	106,34	3084,00
	1,00	153	88,69	13569,00
	Total	182		
Safety	,00	29	68,34	1982,00
	1,00	153	95,89	14671,00
	Total	182		
Comfort	,00	29	59,05	1712,50
	1,00	153	97,65	14940,50
	Total	182		
Attractiveness	,00	29	71,59	2076,00
	1,00	153	95,27	14577,00
	Total	182		
Atmosphere	,00	29	71,84	2083,50
	1,00	153	95,23	14569,50
	Total	182		
Experience	,00	29	78,26	2269,50
	1,00	153	94,01	14383,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	1788,000	1547,000	1277,500	1641,000	1648,500	1834,500
Wilcoxon W	13569,000	1982,000	1712,500	2076,000	2083,500	2269,500
Z	-1,753	-2,787	-3,795	-2,328	-2,311	-1,542
Asymp. Sig. (2-tailed)	,080	,005	,000	,020	,021	,123
Exact Sig. (2-tailed)	,083	,005	,000	,019	,020	,123
Exact Sig. (1-tailed)	,042	,003	,000	,010	,010	,062
Point Probability	,003	,000	,000	,000	,000	,001

a. Grouping Variable: Foreign

Mann Whitney: Inhabitants Amsterdam vs Other

Ranks

	Amsterdammer	N	Mean Rank	Sum of Ranks
Crowdedness	,00	171	91,12	15581,00
	1,00	11	97,45	1072,00
	Total	182		
Safety	,00	171	92,53	15822,00
	1,00	11	75,55	831,00
	Total	182		
Comfort	,00	171	94,15	16099,50
	1,00	11	50,32	553,50
	Total	182		
Attractiveness	,00	171	93,80	16039,50
	1,00	11	55,77	613,50
	Total	182		
Atmosphere	,00	171	93,91	16058,00
	1,00	11	54,09	595,00
	Total	182		
Experience	,00	171	93,89	16055,50
	1,00	11	54,32	597,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	875,000	765,000	487,500	547,500	529,000	531,500
Wilcoxon W	15581,000	831,000	553,500	613,500	595,000	597,500
Z	-,410	-1,119	-2,806	-2,434	-2,563	-2,523

Asymp. Sig. (2-tailed)	,682	,263	,005	,015	,010	,012
Exact Sig. (2-tailed)	,710	,283	,004	,012	,010	,011
Exact Sig. (1-tailed)	,369	,142	,002	,007	,005	,006
Point Probability	,017	,000	,000	,000	,000	,000

a. Grouping Variable: Amsterdammer

Mann Whitney: Inhabitant Amsterdam vs Dutch

Ranks

	AMSordutch	N	Mean Rank	Sum of Ranks
Crowdedness	,00	13	12,96	168,50
	1,00	11	11,95	131,50
	Total	24		
Safety	,00	13	12,73	165,50
	1,00	11	12,23	134,50
	Total	24		
Comfort	,00	13	14,58	189,50
	1,00	11	10,05	110,50
	Total	24		
Attractiveness	,00	13	14,23	185,00
	1,00	11	10,45	115,00
	Total	24		
Atmosphere	,00	13	15,04	195,50
	1,00	11	9,50	104,50
	Total	24		
Experience	,00	13	15,27	198,50
	1,00	11	9,23	101,50
	Total	24		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	65,500	68,500	44,500	49,000	38,500	35,500
Wilcoxon W	131,500	134,500	110,500	115,000	104,500	101,500
Z	-,374	-,195	-1,659	-1,336	-1,977	-2,160
Asymp. Sig. (2-tailed)	,708	,845	,097	,182	,048	,031
Exact Sig. [2*(1-tailed Sig.)]	,733[b]	,865[b]	,119[b]	,207[b]	,055[b]	,035[b]
Exact Sig. (2-tailed)	,771	,780	,097	,190	,051	,033
Exact Sig. (1-tailed)	,399	,387	,052	,101	,026	,016
Point Probability	,062	,008	,004	,018	,006	,001

a. Grouping Variable: AMSordutch

b. Not corrected for ties.

H. Age and gender

Age

		Frequency	Percent
Valid	18-24	55	30,2
	25-34	82	45,1
	35-44	24	13,2
	45-64	18	9,9
	65-74	3	1,6
	Total	182	100,0

Gender

		Frequency	Percent
Valid	Male	98	53,8
	Female	84	46,2
	Total	182	100,0

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Crowdedness	Male	98	88,23	8647,00
	Female	84	95,31	8006,00
	Total	182		
Safety	Male	98	98,12	9616,00
	Female	84	83,77	7037,00
	Total	182		
Comfort	Male	98	92,30	9045,50
	Female	84	90,57	7607,50
	Total	182		
Attractiveness	Male	98	97,89	9593,00
	Female	84	84,05	7060,00
	Total	182		
Atmosphere	Male	98	91,89	9005,50
	Female	84	91,04	7647,50
	Total	182		
Experience	Male	98	93,00	9114,00

	Female	84	89,75	7539,00
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	3796,000	3467,000	4037,500	3490,000	4077,500	3969,000
Wilcoxon W	8647,000	7037,000	7607,500	7060,000	7647,500	7539,000
Z	-,957	-1,978	-,232	-1,853	-,115	-,433
Asymp. Sig. (2-tailed)	,339	,048	,816	,064	,909	,665
Exact Sig. (2-tailed)	,342	,049	,817	,064	,909	,667
Exact Sig. (1-tailed)	,171	,025	,409	,032	,454	,334
Point Probability	,002	,001	,000	,000	,001	,002

a. Grouping Variable: Gender

I. Purpose

Purpose

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't know	25	13,7	13,7	13,7
	Walk around RLD	76	41,8	41,8	55,5
	Another tourist attraction	5	2,7	2,7	58,2
	Club/bar	29	15,9	15,9	74,2
	Restaurant	19	10,4	10,4	84,6
	(Train) station	3	1,6	1,6	86,3
	Work/school	2	1,1	1,1	87,4
	Home/hotel	23	12,6	12,6	100,0
	Total	182	100,0	100,0	

Ranks

	Purpose	N	Mean Rank
Crowdedness	Don't know	25	73,36
	Walk around RLD	76	94,87
	Another tourist attraction	5	77,80
	Club/bar	29	82,86
	Restaurant	19	113,84
	(Train) station	3	129,00
	Work/school	2	85,00

	Home/hotel	23	91,17
	Total	182	
Safety	Don't know	25	112,04
	Walk around RLD	76	91,68
	Another tourist attraction	5	93,60
	Club/bar	29	94,90
	Restaurant	19	84,00
	(Train) station	3	56,67
	Work/school	2	84,50
	Home/hotel	23	75,17
	Total	182	
Comfort	Don't know	25	104,62
	Walk around RLD	76	91,52
	Another tourist attraction	5	134,50
	Club/bar	29	92,52
	Restaurant	19	83,00
	(Train) station	3	61,17
	Work/school	2	81,25
	Home/hotel	23	78,41
	Total	182	
Attractiveness	Don't know	25	98,36
	Walk around RLD	76	99,51
	Another tourist attraction	5	122,30
	Club/bar	29	85,59
	Restaurant	19	83,89
	(Train) station	3	118,33
	Work/school	2	51,00
	Home/hotel	23	64,65
	Total	182	
Atmosphere	Don't know	25	104,88
	Walk around RLD	76	96,55
	Another tourist attraction	5	120,80
	Club/bar	29	85,19
	Restaurant	19	80,92
	(Train) station	3	118,00
	Work/school	2	24,50
	Home/hotel	23	72,98
	Total	182	
Experience	Don't know	25	115,54
	Walk around RLD	76	90,41

	Another tourist attraction	5	138,50
	Club/bar	29	89,78
	Restaurant	19	95,13
	(Train) station	3	103,50
	Work/school	2	99,50
	Home/hotel	23	55,65
	Total	182	

Test Statistics[a,b]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H	10,508	9,174	8,669	13,841	13,213	22,031
df	7	7	7	7	7	7
Asymp. Sig.	,162	,240	,277	,054	,067	,003

a. Kruskal Wallis Test

b. Grouping Variable: Purpose

Ranks

	Purpose	N	Mean Rank
Crowdedness	Don't know	25	73,36
	Walk around RLD	76	94,87
	Another tourist attraction	5	77,80
	Club/bar	29	82,86
	Restaurant	19	113,84
	(Train) station	3	129,00
	Work/school	2	85,00
	Home/hotel	23	91,17
	Total	182	
Safety	Don't know	25	112,04
	Walk around RLD	76	91,68
	Another tourist attraction	5	93,60
	Club/bar	29	94,90
	Restaurant	19	84,00
	(Train) station	3	56,67
	Work/school	2	84,50
	Home/hotel	23	75,17
	Total	182	
Comfort	Don't know	25	104,62
	Walk around RLD	76	91,52
	Another tourist attraction	5	134,50
	Club/bar	29	92,52

	Restaurant	19	83,00
	(Train) station	3	61,17
	Work/school	2	81,25
	Home/hotel	23	78,41
	Total	182	
Attractiveness	Don't know	25	98,36
	Walk around RLD	76	99,51
	Another tourist attraction	5	122,30
	Club/bar	29	85,59
	Restaurant	19	83,89
	(Train) station	3	118,33
	Work/school	2	51,00
	Home/hotel	23	64,65
	Total	182	
Atmosphere	Don't know	25	104,88
	Walk around RLD	76	96,55
	Another tourist attraction	5	120,80
	Club/bar	29	85,19
	Restaurant	19	80,92
	(Train) station	3	118,00
	Work/school	2	24,50
	Home/hotel	23	72,98
	Total	182	
Experience	Don't know	25	115,54
	Walk around RLD	76	90,41
	Another tourist attraction	5	138,50
	Club/bar	29	89,78
	Restaurant	19	95,13
	(Train) station	3	103,50
	Work/school	2	99,50
	Home/hotel	23	55,65
	Total	182	

Test Statistics[a,b]

		Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H		10,508	9,174	8,669	13,841	13,213	22,031
df		7	7	7	7	7	7
Asymp. Sig.		,162	,240	,277	,054	,067	,003
Monte Carlo Sig.	Sig.	,145[c]	,234[c]	,281[c]	,043[c]	,056[c]	,001[c]

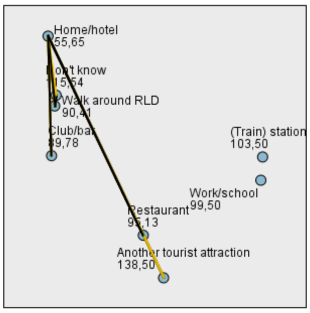
99% C.I.	lb	,136	,223	,269	,038	,050	,000
	ub	,154	,245	,293	,049	,062	,002

a. Kruskal Wallis Test

b. Grouping Variable: Purpose

c. Based on 10000 sampled tables with starting seed 2000000.

Pairwise Comparisons of Purpose

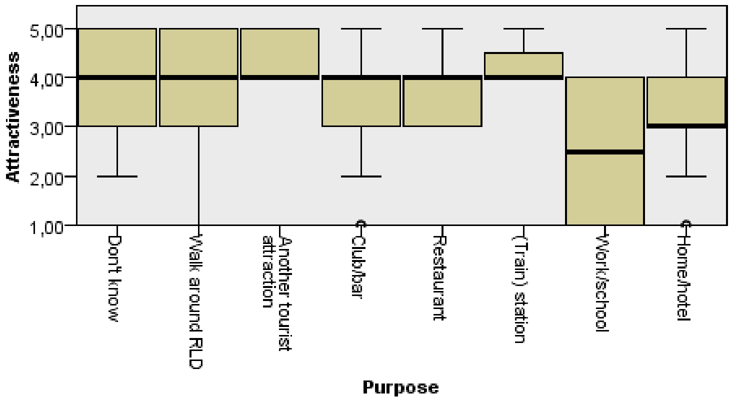


Each node shows the sample average rank of Purpose.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Home/hotel-Don't know	59,888	14,571	4,110	,000	,001
Home/hotel-Another tourist attraction	82,848	24,885	3,329	,001	,024
Home/hotel-Walk around RLD	34,762	12,002	2,896	,004	,106
Home/hotel-Restaurant	39,479	15,635	2,525	,012	,324
Home/hotel-Club/bar	34,124	14,082	2,423	,015	,431
Walk around RLD-Don't know	25,126	11,628	2,161	,031	,860
Don't know-Another tourist attraction	-22,960	24,707	-,929	,353	1,000
Club/bar-Don't know	25,764	13,764	1,872	,061	1,000
Walk around RLD-Another tourist attraction	-48,086	23,284	-2,065	,039	1,000
Club/bar-Walk around RLD	,639	11,008	,058	,954	1,000
Restaurant-Don't know	20,408	15,350	1,330	,184	1,000
Club/bar-Another tourist attraction	48,724	24,421	1,995	,046	1,000
Walk around RLD-Restaurant	-4,717	12,936	-,365	,715	1,000
(Train) station-Don't know	12,040	30,815	,391	,696	1,000
Walk around RLD-(Train) station	-13,086	29,687	-,441	,659	1,000
Restaurant-Another tourist attraction	43,368	25,349	1,711	,087	1,000
Work/school-Don't know	16,040	37,061	,433	,665	1,000
Club/bar-Restaurant	-5,356	14,885	-,360	,719	1,000
Walk around RLD-Work/school	-9,086	36,128	-,251	,801	1,000
(Train) station-Another tourist attraction	35,000	36,831	,950	,342	1,000
Club/bar-(Train) station	-13,724	30,587	-,449	,654	1,000
Work/school-Another tourist attraction	39,000	42,195	,924	,355	1,000
Club/bar-Work/school	-9,724	36,871	-,264	,792	1,000
Restaurant-(Train) station	-8,368	31,332	-,267	,789	1,000
Restaurant-Work/school	-4,368	37,492	-,117	,907	1,000
Work/school-(Train) station	4,000	46,039	,087	,931	1,000
Home/hotel-(Train) station	47,848	30,958	1,546	,122	1,000
Home/hotel-Work/school	43,848	37,180	1,179	,238	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

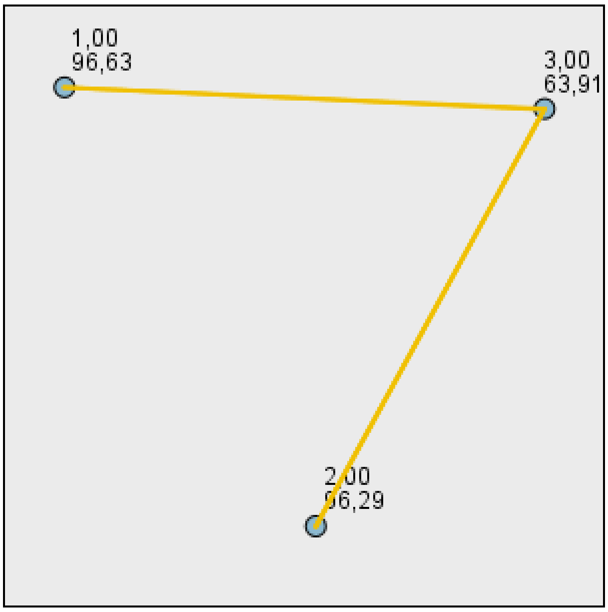
Independent-Samples Kruskal-Wallis Test



Total N	182
Test Statistic	13,841
Degrees of Freedom	7
Asymptotic Sig. (2-sided test)	,054

1. The test statistic is adjusted for ties.
2. Multiple comparisons are not performed because the overall test does not show significant differences across samples.

Pairwise Comparisons of Purpose_short



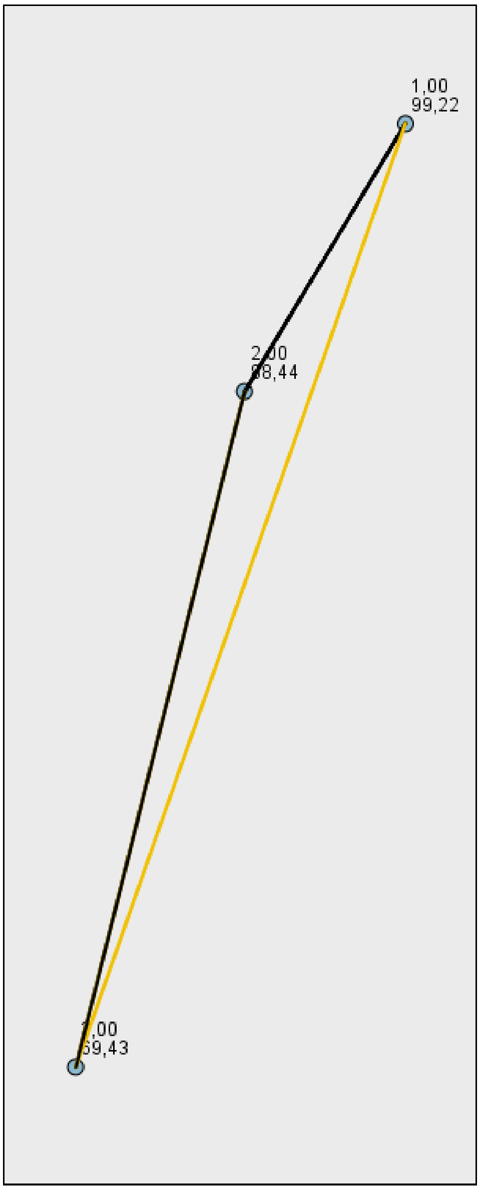
Each node shows the sample average rank of Purpose_short.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
3,00-2,00	32,382	11,783	2,748	,006	,018
3,00-1,00	32,723	10,771	3,038	,002	,007
2,00-1,00	,341	8,554	,040	,968	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Attractiveness

Pairwise Comparisons of Purpose_short



Each node shows the sample average rank of Purpose_short.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
3,00-2,00	19,015	11,735	1,620	,105	,316
3,00-1,00	29,794	10,728	2,777	,005	,016
2,00-1,00	10,779	8,520	1,265	,206	,617

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Mann Whitney: Pressing purpose vs no purpose

Ranks

	Purpose_shorter	N	Mean Rank	Sum of Ranks
Crowdedness	1,00	154	90,90	13999,00
	3,00	28	94,79	2654,00
	Total	182		
Safety	1,00	154	94,71	14585,00
	3,00	28	73,86	2068,00
	Total	182		
Comfort	1,00	154	94,18	14503,50
	3,00	28	76,77	2149,50
	Total	182		
Attractiveness	1,00	154	95,51	14709,00
	3,00	28	69,43	1944,00
	Total	182		
Atmosphere	1,00	154	94,62	14571,50
	3,00	28	74,34	2081,50
	Total	182		
Experience	1,00	154	96,52	14863,50
	3,00	28	63,91	1789,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	2064,000	1662,000	1743,500	1538,000	1675,500	1383,500
Wilcoxon W	13999,000	2068,000	2149,500	1944,000	2081,500	1789,500
Z	-,380	-2,080	-1,688	-2,528	-1,977	-3,147
Asymp. Sig. (2-tailed)	,704	,038	,091	,011	,048	,002
Exact Sig. (2-tailed)	,709	,036	,091	,011	,048	,001
Exact Sig. (1-tailed)	,354	,019	,046	,006	,024	,001
Point Probability	,004	,001	,000	,000	,000	,000

a. Grouping Variable: Purpose_shorter

J. Affect

Affect

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	27	14,8	14,8	14,8
	Aroused	2	1,1	1,1	15,9
	Excited	18	9,9	9,9	25,8
	Delighted	15	8,2	8,2	34,1
	Happy	58	31,9	31,9	65,9
	Glad	6	3,3	3,3	69,2
	Serene	3	1,6	1,6	70,9
	Relaxed	37	20,3	20,3	91,2
	Sleepy	1	,5	,5	91,8
	Tired	5	2,7	2,7	94,5
	Bored	2	1,1	1,1	95,6
	Sad	2	1,1	1,1	96,7
	Frustrated	1	,5	,5	97,3
	Annoyed	2	1,1	1,1	98,4
	Angry	1	,5	,5	98,9
	Alarmed	2	1,1	1,1	100,0
	Total	182	100,0	100,0	

Ranks

	Pleased	N	Mean Rank	Sum of Ranks
Crowdedness	,00	42	90,76	3812,00
	1,00	140	91,72	12841,00
	Total	182		
Safety	,00	42	75,14	3156,00
	1,00	140	96,41	13497,00
	Total	182		
Comfort	,00	42	68,20	2864,50
	1,00	140	98,49	13788,50
	Total	182		
Attractiveness	,00	42	74,71	3138,00
	1,00	140	96,54	13515,00

	Total	182		
Atmosphere	,00	42	71,50	3003,00
	1,00	140	97,50	13650,00
	Total	182		
Experience	,00	42	79,32	3331,50
	1,00	140	95,15	13321,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	2909,000	2253,000	1961,500	2235,000	2100,000	2428,500
Wilcoxon W	3812,000	3156,000	2864,500	3138,000	3003,000	3331,500
Z	-,110	-2,477	-3,428	-2,469	-2,959	-1,784
Asymp. Sig. (2-tailed)	,913	,013	,001	,014	,003	,074

a. Grouping Variable: Pleased

Ranks

	Activated	N	Mean Rank	Sum of Ranks
Crowdedness	,00	83	89,55	7433,00
	1,00	99	93,13	9220,00
	Total	182		
Safety	,00	83	86,30	7163,00
	1,00	99	95,86	9490,00
	Total	182		
Comfort	,00	83	85,17	7069,00
	1,00	99	96,81	9584,00
	Total	182		
Attractiveness	,00	83	83,02	6890,50
	1,00	99	98,61	9762,50
	Total	182		
Atmosphere	,00	83	89,21	7404,50
	1,00	99	93,42	9248,50
	Total	182		
Experience	,00	83	83,96	6968,50
	1,00	99	97,82	9684,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	3947,000	3677,000	3583,000	3404,500	3918,500	3482,500
Wilcoxon W	7433,000	7163,000	7069,000	6890,500	7404,500	6968,500
Z	-,483	-1,316	-1,557	-2,086	-,566	-1,847
Asymp. Sig. (2-tailed)	,629	,188	,119	,037	,571	,065

a. Grouping Variable: Activated

K. Group

L. Group_type

		Frequency	Percent
Valid	,00	17	9,3
	Couple	55	30,2
	Family	23	12,6
	Friends	65	35,7
	Colleagues/Peer students	16	8,8
	Combined group	6	3,3
	Total	182	100,0

Group_comp

		Frequency	Percent
Valid	,00	17	9,3
	Only men	37	20,3
	Only women	29	15,9
	Mixed group	99	54,4
	Total	182	100,0

Group_size

		Frequency	Percent
Valid	Alone	17	9,3
	Small group (2-3)	130	71,4
	Medium sized group (4-6)	29	15,9
	Large group (7+)	6	3,3
	Total	182	100,0

Ranks

	Group_comp	N	Mean Rank
Crowdedness	Only men	37	72,50
	Only women	29	72,45
	Mixed group	99	90,02
	Total	165	
Safety	Only men	37	89,01
	Only women	29	75,90

	Mixed group	99	82,83
	Total	165	
Comfort	Only men	37	89,00
	Only women	29	86,12
	Mixed group	99	79,84
	Total	165	
Attractiveness	Only men	37	81,72
	Only women	29	77,60
	Mixed group	99	85,06
	Total	165	
Atmosphere	Only men	37	85,05
	Only women	29	78,95
	Mixed group	99	83,42
	Total	165	
Experience	Only men	37	83,35
	Only women	29	77,24
	Mixed group	99	84,56
	Total	165	

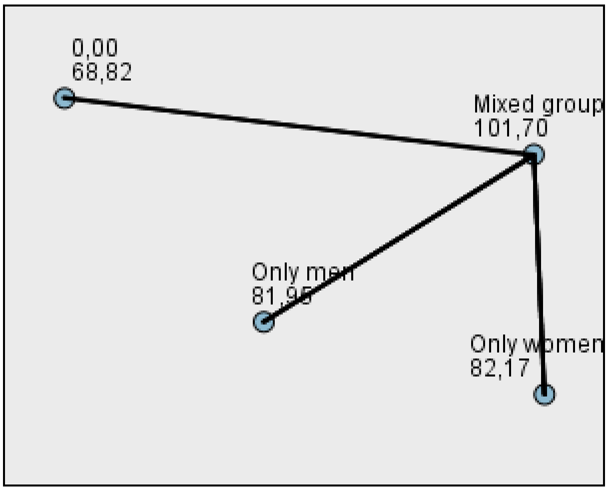
Test Statistics[a,b]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H	6,024	1,425	1,259	,644	,319	,575
df	2	2	2	2	2	2
Asymp. Sig.	,049	,490	,533	,725	,853	,750

a. Kruskal Wallis Test

b. Grouping Variable: Group_comp

Pairwise Comparisons of Group_comp



Each node shows the sample average rank of Group_comp.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
0,00-Only men	-13,122	14,569	-,901	,368	1,000
0,00-Only women	-13,349	15,189	-,879	,379	1,000
0,00-Mixed group	-32,873	13,054	-2,518	,012	,071
Only men-Only women	-,226	12,332	-,018	,985	1,000
Only men-Mixed group	-19,751	9,581	-2,061	,039	,236
Only women-Mixed group	-19,525	10,499	-1,860	,063	,378

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

Ranks

	Group_type	N	Mean Rank
Crowdedness	Couple	55	89,30
	Family	23	75,50
	Friends	65	87,80
	Colleagues/Peer students	16	43,72
	Combined group	6	106,75
	Total	165	

Safety	Couple	55	84,70
	Family	23	65,89
	Friends	65	84,45
	Colleagues/Peer students	16	87,44
	Combined group	6	105,50
	Total	165	
Comfort	Couple	55	83,81
	Family	23	79,72
	Friends	65	79,31
	Colleagues/Peer students	16	92,91
	Combined group	6	101,75
	Total	165	
Attractiveness	Couple	55	81,70
	Family	23	81,28
	Friends	65	80,28
	Colleagues/Peer students	16	91,25
	Combined group	6	108,92
	Total	165	
Atmosphere	Couple	55	87,68
	Family	23	81,07
	Friends	65	75,88
	Colleagues/Peer students	16	92,78
	Combined group	6	98,58
	Total	165	
Experience	Couple	55	87,22
	Family	23	84,80
	Friends	65	79,83
	Colleagues/Peer students	16	83,78
	Combined group	6	69,67
	Total	165	

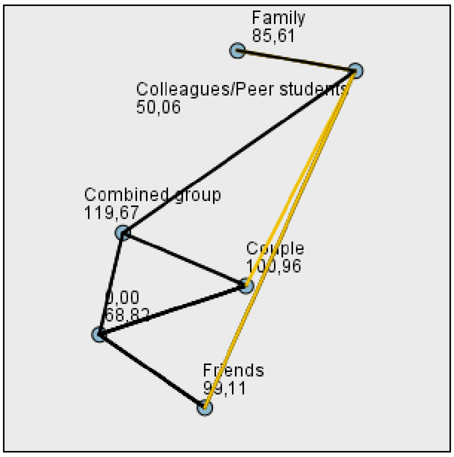
Test Statistics[a,b]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Kruskal-Wallis H	16,344	5,274	2,347	2,797	3,720	1,327
df	4	4	4	4	4	4
Asymp. Sig.	,003	,260	,672	,592	,445	,857

a. Kruskal Wallis Test

b. Grouping Variable: Group_type

Pairwise comparison Group type - Crowdedness



Each node shows the sample average rank of Group_type.

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Colleagues/Peer students-0,00	18,761	17,320	1,083	,279	1,000
Colleagues/Peer students-Family	35,546	16,187	2,196	,028	,421
Colleagues/Peer students-Friends	49,045	13,877	3,534	,000	,006
Colleagues/Peer students-Couple	50,901	14,124	3,604	,000	,005
Colleagues/Peer students-Combined group	-69,604	23,803	-2,924	,003	,052
0,00-Family	-16,785	15,904	-1,055	,291	1,000
0,00-Friends	-30,284	13,545	-2,236	,025	,381
0,00-Couple	-32,140	13,798	-2,329	,020	,298
0,00-Combined group	-50,843	23,612	-2,153	,031	,469
Family-Friends	-13,499	12,064	-1,119	,263	1,000
Family-Couple	15,355	12,347	1,244	,214	1,000
Family-Combined group	-34,058	22,794	-1,494	,135	1,000
Friends-Couple	1,856	9,110	,204	,839	1,000
Friends-Combined group	-20,559	21,216	-,969	,333	1,000
Couple-Combined group	-18,703	21,378	-,875	,382	1,000

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is ,05.
Significance values have been adjusted by the Bonferroni correction for multiple tests.

M. Substances

Ranks

	Alcohol	N	Mean Rank	Sum of Ranks
Crowdedness	,00	106	89,61	9499,00
	1,00	76	94,13	7154,00
	Total	182		
Safety	,00	106	88,93	9427,00
	1,00	76	95,08	7226,00
	Total	182		
Comfort	,00	106	90,25	9567,00
	1,00	76	93,24	7086,00
	Total	182		
Attractiveness	,00	106	90,83	9627,50
	1,00	76	92,44	7025,50
	Total	182		
Atmosphere	,00	106	91,27	9675,00
	1,00	76	91,82	6978,00
	Total	182		
Experience	,00	106	95,84	10159,50
	1,00	76	85,44	6493,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	3828,000	3756,000	3896,000	3956,500	4004,000	3567,500
Wilcoxon W	9499,000	9427,000	9567,000	9627,500	9675,000	6493,500
Z	-,605	-,838	-,395	-,214	-,072	-1,372
Asymp. Sig. (2-tailed)	,545	,402	,693	,831	,942	,170

a. Grouping Variable: Alcohol

Ranks

	Marihuana	N	Mean Rank	Sum of Ranks
Crowdedness	,00	136	94,30	12825,00
	1,00	46	83,22	3828,00
	Total	182		
Safety	,00	136	86,57	11774,00
	1,00	46	106,07	4879,00
	Total	182		

Comfort	,00	136	86,23	11727,00
	1,00	46	107,09	4926,00
	Total	182		
Attractiveness	,00	136	83,94	11416,50
	1,00	46	113,84	5236,50
	Total	182		
Atmosphere	,00	136	85,13	11577,00
	1,00	46	110,35	5076,00
	Total	182		
Experience	,00	136	89,76	12207,50
	1,00	46	96,64	4445,50
	Total	182		

Test Statistics[a]

	Crowdedness	Safety	Comfort	Attractiveness	Atmosphere	Experience
Mann-Whitney U	2747,000	2458,000	2411,000	2100,500	2261,000	2891,500
Wilcoxon W	3828,000	11774,000	11727,000	11416,500	11577,000	12207,500
Z	-1,307	-2,342	-2,435	-3,489	-2,961	-,800
Asymp. Sig. (2-tailed)	,191	,019	,015	,000	,003	,424
Exact Sig. (2-tailed)	,192	,019	,015	,000	,003	,428
Exact Sig. (1-tailed)	,097	,009	,007	,000	,001	,214
Point Probability	,001	,001	,000	,000	,000	,001

a. Grouping Variable: Marihuana