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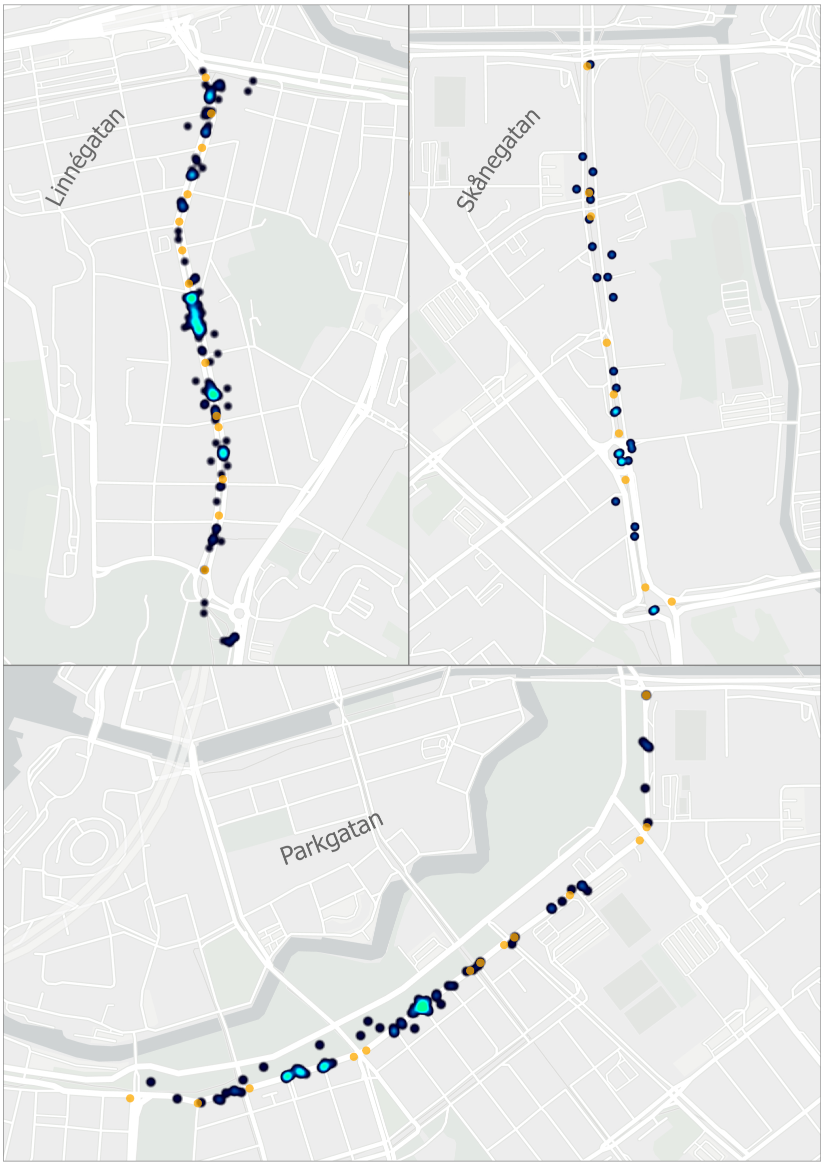

Pedestrians’ Experience in Urban Street Environments

Exploring Barrier Effects of Central Streets in Gothenburg City

Master’s thesis in Master Program Infrastructural and Environmental Engineering

ANNIE LINDFORS LJUHS
FRIDA LYSÖ

Department of Architecture and Civil Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
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Department of Architecture and Civil Engineering
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The Spatial Morphology Group [SMoG]
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Supervisors: Job van Eldijk, Department of Architecture and Civil Engineering, and David Lindelöw, WSP
Examiner: Jorge Gil, Department of Architecture and Civil Engineering

Department of Architecture and Civil Engineering
Division of Design and Urban Planning
The Spatial Morphology Group [SMOG]
Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover: Heat maps visualising the distribution of marked locations where the respondents indicate they tend to cross the streets without a pedestrian crossing present, as well as the locations of existing pedestrian crossings for each street (yellow dots).

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Abstract

While barrier effects are commonly studied on large infrastructure elements through street network analysis, perceptions of barrier effects occurring from central city streets are rarely explored. Therefore, this master's thesis adopts a methodology based on a case study, where three central, busy streets in Gothenburg city are under examination to understand the perception of barrier effects occurring from these city streets. Since volume of motorised traffic is a commonly used factor indicating barrier effects the case streets were primarily selected based on high and similar traffic flows. Furthermore, the underlying premise of this study is that if the experience of barrier effects differs between the streets, additional factors, other than traffic flow, may influence the perception of these barriers. The experiences of a selection of barrier effects and various attributes in the streetscape categorised as 'Transport features and crossing facilities' and 'Environmental features', were collected through a survey. The survey was administrated through a survey tool integrated with GIS, known as Public Participatory Geographic Information System (PPGIS), which facilitated data collection of geographic and non-geographic information. Associations between the barrier effects and attributes were examined mainly through binomial regression analyses to understand what features influence the perception of barrier effects. In addition, qualitative data such as spatial data and free-text answers were collected. For this data, methods of thematic analysis and spatial analysis were employed to enhance the depth of the study. Additionally, the impact of age and gender were analysed. The main outcome of this thesis is that barrier effects are experienced on central city streets. The results also indicate that vehicular speed, the distance between crossing facilities, the presence of obstacles, and pavement width are key factors influencing the perception of barrier effects. Regarding the impact of demographics, no conclusions could be drawn regarding age. Additionally, the regression analysis models did not show a significant difference between genders, contradicting previous assumptions in the literature about gender differences.

Keywords: barrier effects, pedestrian experience, city streets, perception, transport infrastructure, walking environment, impact of streetscape features, binomial logistic regression analysis, PPGIS

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Annie Lindfors Ljuhs & Frida Lysö, Gothenburg, June 2024

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1
Introduction

Motorways, roads, and railway lines are common features of transport infrastructure, built to facilitate efficient mobility between neighbourhoods, cities, regions, and countries. However, transport infrastructure may create barrier effects on a local scale, not only impeding accessibility and mobility but also the use of streets as a social space and have an impact on citizens' life quality, health, and well-being [Anciaes et al., 2015, Geurs et al., 2009, Handy et al., 2002]. So called barrier effects have gained attention in social and political contexts since the 1960s [Anciaes et al., 2015, James et al., 2005]. This increased relevance has grown alongside both the rapid growth of car traffic in cities [van Eldijk and Gil, 2020], but also due to a greater concern about how various demographic groups are affected differently by barriers and their effects [Anciaes et al., 2015]. Furthermore, as urban populations grow, there is an increasing demand for efficient urban development and sustainable, affordable transportation options for all citizens. In this context, promoting and facilitating walkability in cities could play an important role.

While railways and motorways through cities are the most dramatic examples of transport barriers, motorised traffic also has occupied the residential city streets and neighbourhoods [Appleyard, 1972]. Already in 1972, Appleyard demonstrated in a highly cited study that residents in streets with heavier traffic volumes had fewer social connections than in light-traffic streets. Moreover, motorised traffic impacts noise and air pollution, risking issues regarding health and well-being [Handy et al., 2002]. In contrast, designing cities that promote active travel, such as walking and cycling, supports healthier, more vibrant, and livable communities. While it is evident that the built environment, including factors such as environmental design, land use patterns, and transportation systems, influences walking and cycling, the interrelationship is less clear. Simultaneously, there is relatively little knowledge about barrier effects on pedestrians and their strategies to overcome them [Anciaes and Jones, 2016].

The most commonly used indicator for assessing barrier effects is traffic volume [Appleyard, 1972, van Eldijk et al., 2022]. Other typical parameters include traffic speed, heavy vehicle composition, the distance between crossing facilities, and number of vehicular lanes [Rabjerg and Engell Nørby, 2013, van Eldijk et al., 2022]. Additionally, geospatial measurements, such as network indicators providing information about detours and barriers positioning towards destinations, are also used [van Eldijk et al., 2022]. While these measures are commonly applied for measuring the physical transport environment, studies of users' perceptions of barrier effects are less common. Moreover, the impact of environmental features, including factors such as pavement characteristics, presence of greenery, and social activity, on the experience of barrier effects, is rarely studied [Basu et al., 2022, Fonseca et al., 2022]. To address this gap, more research on perceptions of barrier effects is called for. This could include qualitative research on citizens' perceptions in order to gain a deeper understanding of the phenomena. Most existing studies focus on the barrier effects of large infrastructure elements. While barrier effects of busy city streets – characterised by streets with high vehicular traffic volume cutting through densely populated and central parts of a city with a considerable presence of pedestrians – remain unexplored. This thesis therefore aims to examine busy city streets to understand the barrier effects of motorised traffic and its' infrastructure elements and how it affects walkability in cities. Additionally, the thesis explores the impact of transport and environmental features on the perception of barrier effects.

1.1 Aim and research questions

This thesis aims to contribute to the understanding of pedestrians' experience of barrier effects of busy streets in cities. Since traffic volume is commonly used as an indicator when assessing barrier effects, it is a central starting point of this project. If the experience of barrier effects solely depends on this indicator, streets with similar traffic volume would generate the same barrier effect. Therefore the thesis investigates the role of other factors in the streetscape, including environmental features, transport features, and crossing facilities, and how they influence pedestrians' experience of barrier effects. Such features examined are the presence of trees, aesthetic attributes, the distance between crossing facilities, and the speed of vehicular traffic. Additionally, the thesis examines how these perceptions vary across different demographic groups. To achieve the aim, the thesis will address the following questions:

- How do pedestrians experience the barrier effects of busy streets in central parts of Gothenburg?
- Which features within the streetscape impact the experience of barrier effects?
  - What is the impact of transport features and crossing facilities?
  - What is the impact of environmental features?
- How do these experiences vary between age and gender?

1.2 Scope

The thesis aims to analyse barrier effects from transport infrastructure in busy central streets. How barrier effects from transport infrastructure affect cyclists has been excluded from this project along with how barrier effects from cyclists affect pedestrians. While biking and walking are frequently studied in combination, this thesis focuses primarily on pedestrian mobility. Its widespread use and substantial influence on individuals' daily lives make it a compelling mode of transport to explore. Cyclists' experiences of barrier effects are intentionally excluded due to the significant disparities between biking and walking, including factors such as velocity, stopping effort, and travel time. Nevertheless, the topic of biking is partly addressed in the theory chapter. Furthermore, how barrier effects affect motorised vehicles has not been considered in this project. In the analysis of the impact of the environmental features on pedestrians' experience of barrier effects, the thesis focuses solely on the features surrounding the specific street. Environmental features of different surrounding streets in the neighbourhood were not considered. Similarly, the transport features included in the analysis are limited to the particular street studied.

2
Theoretical background

This section provides an overview of the theoretical background and key concepts for understanding this thesis. Initially, the phenomenon of barrier effects is described, covering terminology, a conceptual model, methods for effect estimation, and its societal significance. Following that, incentives for walking are explored, examining factors within the street network, streetscape, and demographic considerations that may impact active travel. Lastly, some theoretical background concerning how to measure perception is briefly described. Throughout the thesis, this theoretical background serves as a guiding framework for informing the project's decisions, assumptions, and interpretations.

2.1 Barrier effects

The presence of transport infrastructure can create barriers in urban areas, resulting in separation of areas and decreased local accessibility for pedestrians and cyclists [van Eldijk et al., 2022]. Depending on the features of road infrastructure, it can result in detours, reduce accessibility, or decrease social connectedness to various degrees. Barrier effects emerging from transport infrastructure can be physical or psychological [Anciaes et al., 2015]. Physical barrier effects occur due to features hindering the movement across a barrier, whereas a psychological barrier arises from transport features whose presence discourages people from crossing or travelling along a barrier [Anciaes and Jones, 2016]. Psychological barriers create an effect without forming a physical barrier, e.g., fear of traffic hazards. Physical barrier effects can occur from two categories, due to static or dynamic transport features [van Eldijk et al., 2022]. Static transport features consist of elements in the built environment, preventing a crossing movement e.g., fences, railings, road width, and noise screens. Whereas a dynamic barrier effect can arise both when travelling across and along a barrier due to, e.g., traffic flow, vehicular speed, traffic direction, and proportion of heavy vehicles.

The city of Gothenburg is characterized by the presence of a multitude of transport-related barriers [Göteborgs Stad, 2013]. The car traffic that crosses the city contributes to reduced accessibility, neighbourhood segregation, and decreased social connectedness. Streets with prioritized car traffic undermine the creation of vibrant urban environments and result in insufficient urban space utilization. Notable barriers within Gothenburg that pass through densely populated and central parts of the city include the motorways E6, E20, and E45, but also smaller roads are mentioned as Parkgatan, Nya Allén and Skånegatan. Additionally, a significant volume of public transportation and bicycles are also perceived as barriers within the city [Göteborgs Stad, 2014]. Other mentioned barriers include the river Göta älv, a railway called Hamnbanan, and a traffic route known as Dag Hammarskjöldsleden [Göteborgs Stad, 2013, 2014].

'Barrier effects' are only one of many terms used for describing the effects of transport infrastructure and motorized traffic [Anciaes et al., 2016]. Commonly used variants of the phenomena are e.g., community severance and social severance. The differences in terminology reflect how different disciplines, researching within the subject, are not collaborating. This might explain why so few actions have been developed to address the issue. The different disciplines include e.g., urban studies, public health, economics, and geography, but the issue also concerns many stakeholders, such as practitioners in different fields, road users, and local communities, with various understandings of the issue. According to Anciaes et al. [2016], researchers and practitioners are generally working separately, trying to create policy solutions, which simultaneously hinders the process of developing an assessment of the issue.

2.1.1 Emergence of barrier effects: a conceptual model

In a literature review by van Eldijk et al. [2022], a conceptual model to describe the issue of barrier effects of transport infrastructure is defined. The model, presented in Figure 2.1, illustrates factors determining the size of a barrier, outcomes of barrier effects, and the interplay within the phenomenon. Factors determining the occurrence of barrier effects consist of five determinants: *Transport features*, *Crossing facilities and Street Network*, *People's abilities*, *People's needs*, and *Land use*, and are illustrated with mathematical expressions to understand the relations between them. The first determinant, transport features, refers to any element of transportation infrastructure that affects the movement or accessibility, such as a road. The feature accounts for both static and dynamic properties, and how the characteristics influence the separation of the barrier, e.g., the ease or difficulty of crossing the barrier. Without a legitimate transport feature affecting barrier effects, the separating value is zero and no barrier effect can be detected. Moreover, separation characteristics can be mitigated by the determinant crossing facilities. This determinant includes bridges, tunnels, and pedestrian crossings and can ease the crossing of the barrier and decrease its effects. The impact of crossing facilities depends on their location within the street network and the quality of the crossing facility. However, depending on individual factors of the people that want to cross, such as age or ability, the crossing facilities' usefulness could be affected. If a user's ability to cross a barrier is limited, barrier effects increase. Moreover, the determinant of people's needs imposes the need to reach certain destinations, which is related to the determinant of land use, describing where different destinations are located compared to each other. Together, these two determinants decide the need for crossing the barrier which is important to consider since a transport feature only transfers into a barrier when it obstructs an individual's path to their destination.

Importantly, changes in the environment and urban development change the determinants, determining the barrier effects of a dynamic process. Naturally, the built environment is constantly in change, with both fast and slow changes currently going on [Handy et al., 2002]. For example, the use of a particular street could differ between day and night, while the building exterior could change over decades.

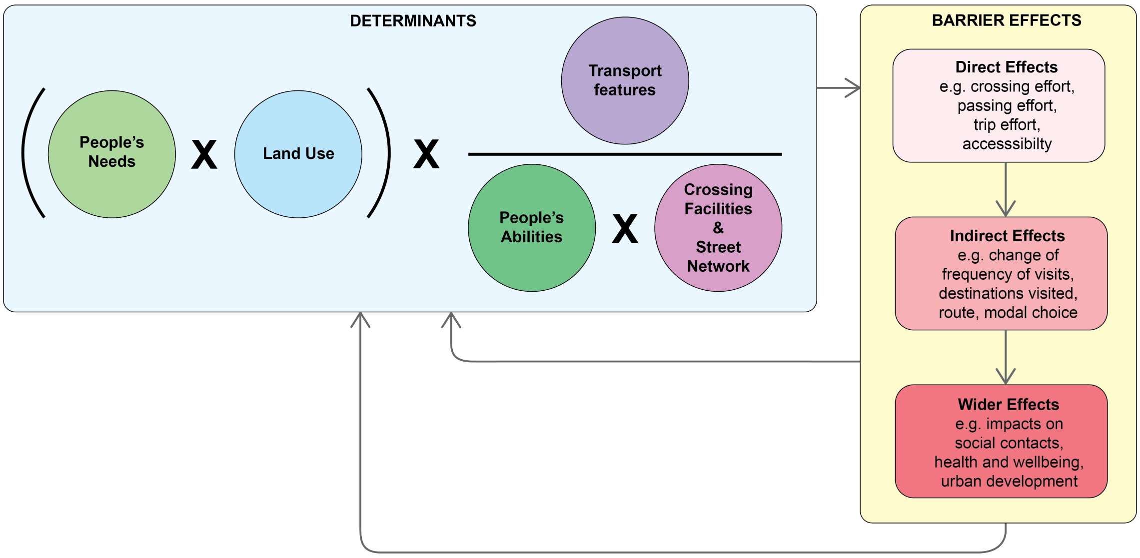

Figure 2.1: Conceptual model illustrating the emergence of barrier effects of transport infrastructure, adapted from van Eldijk et al. [2022].

In addition to the determinants, three levels of barrier effects are described in the conceptual model presented in Figure 2.1, including *Direct effects*, *Indirect effects*, and *Wider effects* [van Eldijk et al., 2022]. Direct effects are what travellers experience due to a barrier, such as an additional effort to cross or extra travel time. Direct effects are experienced but the sacrifice to cross e.g., in effort or time, is still accepted. Once the barrier effect violates a citizen's level of acceptance it results in a changed behaviour of the traveller and is defined as an indirect effect. The behavioural changes can relate to travel frequency, route choice, destination, and choice of travel mode. These changes in the travel behaviour of citizens can further result in wider effects, which are effects continuing over a long time, impacting individuals, groups, and society at large. Wider effects include social connectedness, health and well-being, urban development, and economic activity. It can also consequently concern an increased fear of crime due to a reduced number of passers-by in the vicinity of the transport infrastructure.

Fundamentally, barrier effects can generate feedback loops, implying both positive and negative consequences brought back to the origin determinant [van Eldijk et al., 2022]. One such example is if heavy traffic encourages individuals to choose driving instead of active modes of transportation. Consequently, this leads to increased vehicular traffic, making even more people opt for driving, thereby intensifying the barrier effect. Another such feedback loop is where transportation barriers increase fear of crime, resulting in avoidance of the area, consequently increasing the feeling of desolation, and making even more people avoid the area.

2.1.2 Estimating barrier effects

Despite established correlations between large traffic volumes and disadvantageous consequences on pedestrian movement and street life, the understanding of how barriers affect pedestrian behaviour and network, as well as strategies to overcome them, remains relatively limited [Anciaes and Jones, 2016]. Typical parameters to assess barriers and their effects include traffic volume, traffic speed, heavy vehicle composition, distance between crossing facilities, and number of vehicular lanes [Rabjerg and Engell Nørby, 2013]. However, a study assessing the relevance of these parameters concludes that they provide an incomplete representation. Today, methods to assess barrier effects are mostly represented by quantitative methods, such as geospatial analysis and counting observations [van Eldijk et al., 2022]. These types of methods are more compatible when measuring direct effects, implying that direct effects have been conducted to a greater extent compared to indirect and wider effects. Within this framework, a variety of measurement approaches can be conducted and analysed to comprehend barriers and their effects. Geospatial indicators, like distance between crossing facilities, can inform about the frequency of conflicts between various traffic modes and thereby shaping perceptions of urban streets [Anciaes et al., 2019]. Similarly, the ratio between network route distance and straight-line distance provides valuable insights into the detours induced by road barriers [van Eldijk et al., 2022]. Additionally, indicators such as betweenness and centrality offer insights into the relative positioning of barriers towards destinations and the surrounding network, thereby influencing barrier significance [Dhanani and Vaughan, 2016]. Although geospatial analysis, such as assessing distance to various destinations, can provide insights into pedestrian convenience, it is essential to recognize that additional factors also influence individuals' travel behaviour [Forkenbrock et al., 2001]. However, observations, site audits, and to a lesser extent, surveys and interviews have been utilized to evaluate direct effects, but their application has been comparatively limited [van Eldijk et al., 2022]. Moreover, according to Anciaes and Jones [2020], the findings in studies related to direct effects measures are rarely utilized in practice. Additionally, in another article, the authors highlight the scarcity of knowledge regarding barrier effects on pedestrians and their corresponding strategies to overcome them [Anciaes and Jones, 2018]. Also, Handy et al. [2002], emphasizes the limited available data on walking behaviour, adding complexity to research efforts. Hence, efforts should be made to develop more comprehensive datasets to facilitate thorough examinations within this field.

Measuring indirect effects requires a better understanding of the travellers' or potential travellers' behaviour, which is important since some behavioural changes, such as suppressed trips, cannot be observed directly [van Eldijk et al., 2022]. For this purpose, combining commonly used quantitative methods, such as geospatial analysis, with basis from surveys and interviews about citizens' behaviour and perceptions of barriers becomes highly relevant when assessing barrier effects. For example, interviewees can tell about changes in frequency for certain visits or routing of trips, while travel behaviour statistics can be used to assume suppressed trips.

Assessing wider effects is generally a complex issue since it includes many factors and is often changed stretching over a long time [van Eldijk et al., 2022]. Wider effects are also often related to other impacts, such as noise and pollution, and are therefore hard to assess objectively and to draw conclusions from solely based on the barrier and its effects. Consequently, there is relatively little that has been examined within this area. Though, one such methodology is to analyse changes in monetary value resulting from a barrier [Anciaes and Jones, 2020]. For example, analysing housing prices in relation to the characteristics of roads or traffic could expose one such effect. However, findings from these types of studies pose challenges in determining the influencing factors, given the simultaneous presence of both air and noise pollution as significant factors.

As previously mentioned, barrier effects are a phenomenon including numerous scientific disciplines and stakeholders, with various understandings of the issue [Anciaes et al., 2016, van Eldijk and Lundberg, 2023]. For instance, mobility is not only dependent on transport availability but also on environmental, psychological, and social factors [Anciaes et al., 2016]. Moreover, the link between transportation and public health is evident. However, despite this acknowledgement, there are relatively few tools to identify and assess the problem. The scarcity of development regarding actions on how to address barrier effects is mostly due to how the different disciplines, researching the subject, are not collaborating. In a study by Sallis et al. [2006], the authors emphasize the need for contribution from other sciences when prompting active travel in communities, e.g., measurements of physical activity, behaviour change models, and approaches to form concepts of environmental elements. These inputs can beneficially be provided by other sciences such as architecture, transport planning, urban planning, and studies of leisure [Anciaes et al., 2016]. Moreover, wider effects have been studied in other fields, e.g., social sciences, which also could be relevant for the transportation science field [van Eldijk et al., 2022]. This further highlights the potential benefits of cross-disciplinary research within the issue and a collaboration that presently is missing. Consequently, most practitioners, such as land use planners and transport planners, do not have adequate knowledge regarding the process of assessment, hindering the interaction between them [van Eldijk and Lundberg, 2023].

2.1.3 Social impacts of barrier effects

Various disciplines encompass the concept of barrier effects, reflecting the numerous social impacts. Foremost, active travel is hindered by barriers, resulting in impacts on e.g., frequency of walking and cycling [van Eldijk et al., 2022]. Active modes of transportation are known to mitigate physical inactivity [Mackett and Thoreau, 2015] and to promote health and well-being, which may be compromised in the presence of motorized traffic [Anciaes et al., 2019]. Moreover, motorized traffic contributes to emissions and causalities, further compromising public health [Mackett and Thoreau, 2015].

Transport infrastructure and high traffic volumes also impede social connectedness, physically segregating urban areas and communities [Appleyard, 1972, Hart and Parkhurst, 2011]. Especially, barriers may impact the social inclusion of people with disabilities [Baobeid et al., 2021]. Further, social relationships play an evident role in reducing mortality and influencing overall health, often surpassing the impact of traditional risk factors like smoking, high blood pressure, as well as insufficient physical activity and obesity, [Holt-Lunstad et al., 2010]. Thus, understanding and addressing the social impact of barrier effects are important for promoting public health and fostering inclusive communities.

Barriers affect active travel, leading to reduced access to essential services and opportunities. This includes limitations on activities, employment, and recreation [Crombie, 2002], as well as access to food and healthcare [Mackett and Thoreau, 2015]. In literature, barrier effects are suggested to affect genders differently. In the past women have typically had a different role in the household compared to men, resulting in higher demand for local accessibility [van Eldijk and Gil, 2020]. Additionally, the differences in car ownership between genders consequently generate an inequality in access to the road network and the accessibility it provides. Generally, accessibility to facilities and other necessities affects societal inequality, particularly for marginalized populations who already experience a greater extent of transport-related externalizes, such as causalities and emissions [Mackett and Thoreau, 2015]. Further, barriers can segregate areas from each other, resulting in social segregation [van Eldijk and Gil, 2020].

2.2 Incentives for walking

Individuals' level of physical activity, including walking, is influenced by a combination of societal and personal factors [Transportation Research Board and Institute of Medicine, 2005], in addition to factors in the urban environment [Handy et al., 2002, Baobeid et al., 2021]. While some factors are relevant for the willingness to walk, other factors influence where and for what purpose the travel is taking place. Although it is evident that the built environment influences active travelling, the interrelationship is less clear. Therefore, research delving into social and psychological factors is relevant for unravelling this connection. In urban planning, areas are often designated as 'pedestrian-oriented' when walking is a viable and attractive mode of transportation to travel by [Handy et al., 2002]. These types of streets typically meet specific criteria encompassing both network and streetscape factors, such as high connectivity and aesthetically pleasing features. How these factors, in addition to demographics of individuals and social groups, influence walking is further presented in this section.

2.2.1 Network factors

The local street network is important for pedestrian movement, making walking convenient [Anciaes and Jones, 2016, Baobeid et al., 2021]. Handy et al. [2002] presents different dimensions of the built environment and how they can be measured. The dimensions are based on the neighbourhood scale and are seen to often correlate or interrelate with each other. The first dimension is the density and intensity of urban development, which is normally described as the amount of inhabitants, work power, or buildings per unit of an area. Another dimension to measure is the mix of land use, shaped by the spatial organization of housing, stores, offices, parks, etc. This dimension could define the closeness to different land uses within a given area or the distance from one particular land use, e.g., a home, to another, e.g., a store, which could impact travel behaviour. Moreover, the connectivity of the street network can help describe the built environment by determining detours or route choices from one point to another.

Barriers are often related to these parameters, risking e.g., detours, delays, and perceived safety, for active travellers [Anciaes and Jones, 2016]. Further, it risks a reduced walking frequency, since inconvenience and time consumption are shown to be two important factors for not walking [Transportation Research Board and Institute of Medicine, 2005]. For instance, in most travel mode choice formulas, travel time is the most dominant indicator, including walking and waiting [Handy et al., 2002]. Additionally, waiting is more costly when travelling by a non-vehicle than travelling by a private car. Establishing walking distance between daily activities as well as improving the local network will decrease car use and increase walking. In many cases, the local network can be improved e.g., by interconnecting the local network of streets, pavements, and paths. However, using active travel modes also depends on the travel experience, including safety aspects, comfort, and aesthetics.

2.2.2 Streetscape factors

The local built environment is shown to influence people's walking habits whether for transportation, leisure, or exercise [Handy et al., 2002, Baobeid et al., 2021]. For example, route choice, which often is assumed to depend on the shortest or fastest route, is also influenced by the surrounding environment [Anciaes and Jones, 2016]. For instance, characteristics of the pavement, such as width, presence of steps, or crossing facilities, are impacting factors [Anciaes and Jones, 2016, Wahl et al., 2012b], as well as aesthetic attributes [Handy et al., 2002, Owen et al., 2004, Baobeid et al., 2021]. Though studies of the impact of streetscape design have resulted in varying outcomes, while most studies show the streetscapes' relevance, there are also contradictory results [Fonseca et al., 2022]. Moreover, extensive levels of motorized traffic and high traffic speeds serve as significant deterrents to walking [Owen et al., 2004]. According to Crombie [2002], one of the main reasons for reduced pedestrian movement close to streets with high traffic volumes is the perception of road danger.

It is suggested that improving the active travel environment, for enhanced safety or convenience, would increase these types of travel modes, even for those already favourably disposed to walking and cycling [Transportation Research Board and Institute of Medicine, 2005]. Generally, adding measures to the built environment is a complex issue since there is a theoretical trade-off between some parameters. For example, adding crossing facilities decreases the risk but does not decrease delay, while decreased delay and distance could be achieved with fewer lanes but then generate an increased risk. Therefore, measures might worsen the barrier effect even more [Anciaes and Jones, 2020]. One such example is crossing facilities that often have poor design or maintenance, requiring too much effort or inconvenience to use.

Barriers can also be experienced when walking along a busy road, making the characteristics of the pavement a vital aspect [Anciaes and Jones, 2016]. This could include factors such as the quality of the pavement, but also lightning on the street, and the magnitude of footstep noise from other users of the street. Other examples are greenery and parks, which in addition to being appealing to pedestrians also spread shadows, improve air quality, and reduce temperatures [Baobeid et al., 2021] One measure describing the characterization of the built environment is a scale of the street [Handy et al., 2002]. The scale of the street refers to the three-dimensional streetscape, including the surroundings of the street, e.g., buildings, and features, e.g., trees, to describe the sense of the street. For example, the ratio between building heights and street widths can say something about the dimension of the streetscape and further characterize the purpose of the street but also human-speed implying who the street is designed for in that sense [Ewing and Handy, 2009]. Additionally, another dimension of the streetscape, the aesthetic qualities of a place, emphasizes elements contributing to the attractiveness of a place [Handy et al., 2002]. These aesthetic qualities can include landscape features, the design of buildings, the size and orientation of windows, decorations, and streetscape furniture. Though, compared to other measures, qualities are more often described than measured. Simultaneously, measurements of aesthetic features are rarely made. Methodically, more qualitative research could be conducted to identify the perception of such measures in the streetscape.

2.2.3 Socio-demographics related to walking

People's physical activeness, including walking and cycling, depends on social and individual factors [Transportation Research Board and Institute of Medicine, 2005]. Demographic characteristics, such as gender, age, and ethnic background, as well as socioeconomic characteristics, such as education and income level, affect physical activeness. A study based on people from the U.S. shows that physical activity declines with age, and is lower among women, ethnic, and racial minorities, as well as among people with lower education and income levels, and disabilities. In addition, women are more dependent on active travel [van Eldijk and Gil, 2020]. Therefore, when studying barrier effects, these socio-demographic factors including age and gender, have been assumed to affect how barrier effects are perceived. For example, children and the elderly are assumed to be more sensitive to barriers. Though, while Nello-Deakin et al. [2024] concludes decreasing support for pedestrianization with advancing age, their outcomes showed almost identical results between genders. One example where gender appears to influence walking for transportation and recreational purposes is in streetscape designs, which seem to have a greater impact on women [Fonseca et al., 2022]. Moreover, it is relevant to understand that demographics are also associated with socioeconomic factors [Transportation

Research Board and Institute of Medicine, 2005]. For instance, although urban populations with lower incomes may engage less frequently in spontaneous physical activities for training or health purposes, they exhibit the highest levels of walking when commuting from one point to another.

Additionally, low-income urban populations are often associated with various socioeconomic challenges, including crime, disinvestment, and social isolation, all of which may significantly influence walking behaviour [Transportation Research Board and Institute of Medicine, 2005]. While neighbourhoods with high crime rates tend to show lower rates of walking and cycling, highlighting the importance of acknowledging the specific urban design characteristics in these areas. For example, open spaces and sufficient light on streets are less common in low-income areas, contributing to feelings of isolation and longer travel distances between destinations. Additionally, lower population densities prevalent in low-income areas result in fewer travel mode options compared to high-density urban areas, which further limits opportunities for physical activity.

Other factors influencing walking include personal conditions, such as individual health, physical disability, lack of time, motivation, energy, and self-esteem, all of which seem to reduce the level of physical activity [Transportation Research Board and Institute of Medicine, 2005]. In addition, there are individual attitudes, preferences, and skills related to the behaviour. Individual perceptions of e.g., personal disabilities or health aspects, weather conditions, equipment, or design of the built environment, are also affecting factors. Moreover, the built environment is shown to influence people's walking habits, especially some groups, e.g., less healthy, unemployed, and retired, are more dependent on the quality of the walking environment [Anciaes and Jones, 2016]. Also, the perception of the built environment is affected by to what extent the user is exposed to the studied environment [Wahl et al., 2012b]. According to the authors, the occurrence of traffic-related factors was estimated higher for participants with higher stated walking frequency at the studied street.

2.3 Studying perceptions

The dimensional structure of perception is difficult to capture since each individual has their own thoughts and interpretations based on personal experiences [Wahl et al., 2012a]. Trying to measure people's perceptions of traffic-related phenomena, such as barrier effects, thereby comes with several difficulties, e.g., choice of method, sampling of participants, and interpretation of data. Some studies use *stated preference* or *revealed preference* methods to collect data, yet it is important to acknowledge their respective limitations when utilized [Anciaes and Jones, 2020]. One advantage of revealed statement studies, which often involve quantitative components, is that the results show the actual behaviour as it is derived from observations. However, these studies are tied to the case on which the study is based, making the usefulness of the result less applicable to other aspects of the problem. Conversely, when using stated preference methods, which often involve qualitative components, such as surveys and interviews, the respondents express their preferences using hypothetical scenarios. Anciaes and Jones [2020], discusses that stated preference methods can be useful to study how barrier effects of planned improvement projects can be reduced. However, using hypothetical settings limits the usefulness of estimating real behaviour. Also, the respondent can often only choose from a limited set of pre-designed options, making the preference limited to the designs presented. The authors therefore imply that when studying barrier effects, it requires an examination of both stated and revealed preference to ensure consistency between the two outcomes. However, the authors also discuss that relying solely on stated or revealed preferences may restrict the analysis to a narrow portion of the issue, implying that it is challenging to include all relevant aspects within such studies.

3
Methodology

This chapter describes the research design adopted for this thesis, explaining the methods employed and the motivation behind their selection. Figure 3.1 illustrates the major phases of the project. The following sections describe each phase in greater detail.

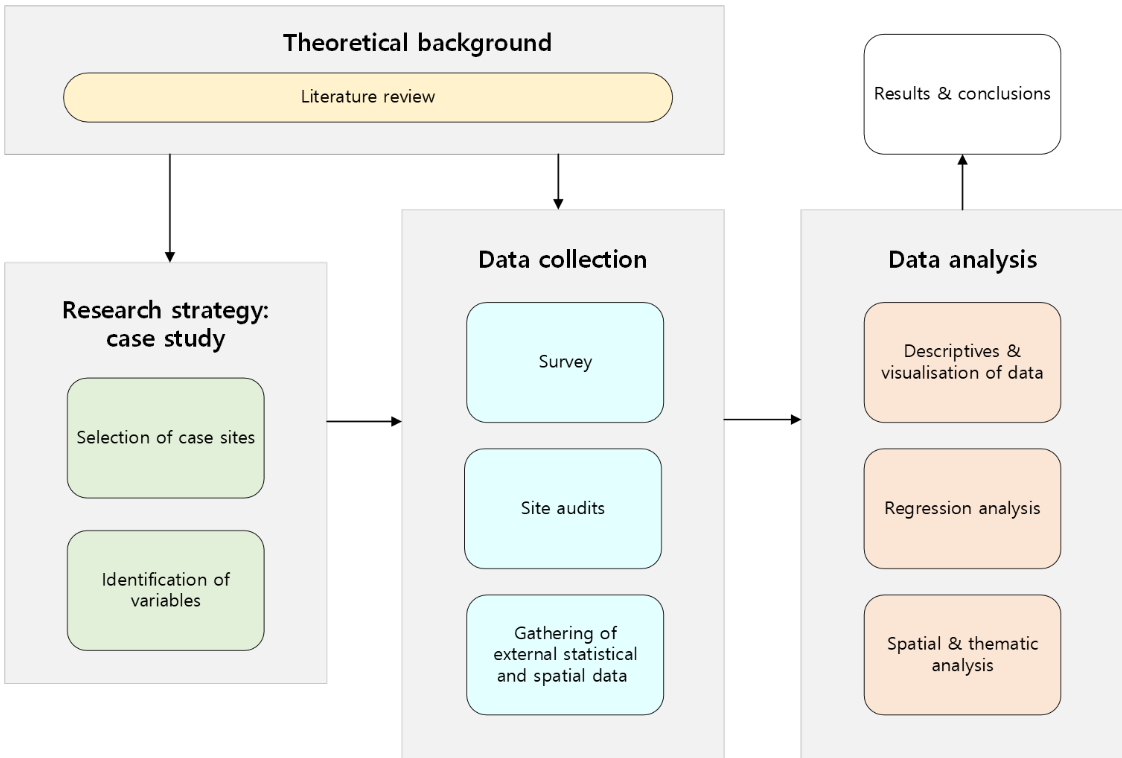

Figure 3.1: Thesis methodology, where the grey boxes illustrate the major phases of the project and the arrows show the main flow of the sequence.

3.1 Theoretical background

The understanding of the subject was informed by a literature review. The review was mainly divided into three sections: barrier effects, incentives for walking, and methods for measuring perceptions. Literature regarding barrier effects included main theories, typical methods for estimation, and their impact on different social groups. Specifically, a conceptual model examining the emergence of barrier effects by van Eldijk et al. [2022] served as the foundation of this thesis. The section on walking informed about what factors influence walking and what features within the streetscape have gained attention in previous research. The outcomes from these two sections, barrier effects and walking, supported the identification of variables to further examine within this thesis. Regarding methods for estimating peoples' perceptions, this gained knowledge was used to employ the data collection methods, understand weaknesses within these, and finally draw conclusions from the results.

The literature search utilised two primary databases, Chalmers Library's literature database and Web of Science, which encompasses research from a variety of disciplines and sources. The search strings included terms related to the thesis topic, such as 'barrier effects', 'transport infrastructure', 'pedestrians', 'walking', and 'social impacts'. In addition to the database searches, relevant literature was identified by examining references cited in other research work. The literature review incorporated both up-to-date scholarly work and older references. The earlier references were particularly valuable for describing foundational theories and influential research that has shaped the field. Given the interdisciplinary nature of the subject of barrier effects, the literature review intentionally encompassed research from various disciplinary perspectives.

3.2 Research strategy: a case study

According to [Denscombe, 2017], the selection of research strategy should be guided by its likelihood of successfully achieving the research objectives. To understand the complex relationships among factors as they operate within a specific setting or context, aligned with the objectives of this thesis, a research strategy of a case study was adopted.

3.2.1 Selection of case sites

During the case site selection process, the inclusion of multiple case sites was aimed for to enhance the reliability of the results. If there are patterns emerging across several cases, it provides greater credibility to the results. Three case sites were selected with the principal aim of having similar levels of traffic volume. In addition to this, the case sites were selected based on the following three specific criteria, where each criterion narrowed down the number of potential sites:

(1) location: Gothenburg city,
(2) traffic volume: > 8,000 vehicles per day, and
(3) similar 'Land use' and 'People's Needs'.

Firstly, the streets were geographically bounded to be located in Gothenburg city. This decision was informed by the presence of transportation barriers within the city limits [Göteborgs Stad, 2014]. Moreover, it addresses the issue of inner city consolidation in Gothenburg, providing insights into, for instance, the conflict between efficient ground-level public transport and the creation of attractive urban space. Secondly, statistical data on traffic volume sourced from Göteborgs Stad [2024b] were utilised, with Average Annual Weekday Traffic (AAWT) as an indicator. Streets with a traffic volume exceeding 8,000 vehicles per day were prioritised as studies comparable to the study by Appleyard [1972] indicate that social connectedness is impacted by traffic volume of this magnitude. The streets that passed the two first criteria were then categorised into traffic volume intervals to ensure comparability among the final selection. Finally, the streets were chosen based on a combination of land use and the presence of features that meet people's needs in the surrounding area, determinants from the conceptual model illustrated in Figure 2.1. This prioritisation was added in an attempt to ensure similar impacts of these determinants on the emergence of barrier effects on each street, allowing for analysis of the impacts of other features in the streetscape on perceived barriers. This criterion was assumed to be fulfilled by selecting centrally located streets in the city, where there are numerous destinations and high pedestrian activity.

The final streets chosen were Linnégatan, Parkgatan, and Skånegatan, all central streets in Gothenburg city that are frequently traversed by pedestrians for various activities. Notably, the traffic volumes on these streets, as presented in Table 3.1, are very similar, with a range of 9,825 to 10,880 vehicles per day.

Table 3.1: Average Annual Weekday Traffic volume at the three studied streets.

Name of street	AAWT [veh/day]
Linnégatan	9,825
Parkgatan	10,171
Skånegatan	10,880

Further, the streets have different streetscapes and street profile characteristics. There are variations between all three streets, both regarding transport features and crossing facilities, such as measured traffic speed, number of lanes and transport modes, and frequency of crossing facilities. Additionally, there are variations in environmental features, such as the amount of greenery and pavement width.

3.2.2 Identification of variables

Informing the selection of variables for this study, the conceptual model proposed by van Eldijk et al. [2022] served as the foundation, which is comprehensively described in Chapter 2.1.1. The examined barrier effects, extracted from the same paper, were selected based on their relevance to the barriers inherent in city streets along with this study's primary focus on street level. Table 3.2 presents the selected barrier effects of examination. Both direct and indirect effects are addressed. Direct effects examined include 'Crossing and Passing effort' and 'Fear of traffic accidents', while the studied indirect effects are 'Frequency of visits', 'Routing of trips', and 'Mode of transport'.

Table 3.2: Barrier effects included in the examination.

Type	Effect examined	Description
Direct effect	Crossing and passing effort	The pedestrian experiences delays, discomfort, stress, physical effort, or fear of traffic accidents when crossing or passing a transport feature.
	Fear of traffic accidents	The pedestrian experiences fear of becoming a victim of traffic accidents, often related to crossing facilities.
Indirect effect	Frequency of visits	The pedestrians' experience of the street motivates them to seek alternative routes in order to avoid it.
	Routing of trips	If the pedestrian experiences the street too difficult to cross, they consequently choose to avoid crossing the road.
	Mode of transport	People choose other types of transport modes than walking due to the experience of the barrier.

Based on the selected barrier effects, variables in the streetscape were chose for examination. The investigated variables related to the two categories of transport features and crossing facilities and street network are listed in Table 3.3.

Table 3.3: Features investigated within the determinants transport features and crossing facilities and routes.

Determinant	Variable	Description	Source of data collection
Transport features	Traffic volume	Number of vehicles per time unit	Göteborgs Stad [2024b]
	Vehicular speed	Speed of which vehicles travel	Göteborgs Stad [2024b]
	Road width	Distance to the opposite side of the road including only the traffic lanes for motorised vehicles and public transport	Site audits
	Obstacles on the road	Obstacles, such as fences or noise screens, hindering crossing at preferred locations	Site audits and Göteborg Stad [2024a]
Crossing facilities and street network	Frequency of crossing facilities	Distance between crossing facilities	Site audits
	Delay at crossing lights	Waiting time for pedestrians at crossing facilities	-

To tackle the objectives of examining environmental features' potential influence on the experience of barrier effects, additional variables were integrated in the survey. The selection process of environmental features was informed by the literature review and based on relevance to central city streets. The investigated environmental features are detailed in Table 3.4.

Table 3.4: Environmental features examined in the project.

Determinant	Variable	Description	Source of data collection
Environmental features	Benches and seating	Frequency of benches and seating at the studied streets	Site audits
	Width of pavement	Measured width of pavement	Site audits
	Facades of buildings	Attractiveness of the buildings surrounding the studied street	Site audits
	Active ground floors and welcoming entrances	Many businesses feature inviting entrances, signaling their openness to visitors	Göteborg Stad [2024a]
	Greenery	Number of trees or other greenery features	Göteborg Stad [2024a]
	Social activity	People visiting the studied street over the day	-

3.3 Data collection

Research methods can consist of either quantitative or qualitative research or a combination of both [Denscombe, 2017]. The difference between the research methods lies in the type of data they address during their analytical processes. Quantitative research essentially deals with numerical data, whereas qualitative research relies on words or visual images [Merriam and Tisdell, 2015]. Moreover, quantitative research often requires a high amount of data to be reliable, implying that this type of research is generally more suitable for large-scale research [Denscombe, 2017]. The analysis and outcome are often segregated from its' context. In contrast, qualitative research is generally associated with small-scale research, usually involving only a few people or events, due to the time needed to analyse qualitative results. The outcome is often put in its context and analysed with a holistic perspective.

The objectives of this thesis methodology include capturing pedestrians' experiences of barrier effects along with their perceptions of surrounding environmental features. To address these objectives both quantitative and qualitative methods were adopted. The integration of both types of data collection methods was chosen to facilitate a more comprehensive analysis, regardless of the scale of the data acquisition. The combination also aligns with the exploratory nature inherent in this project. The quantitative data was used to identify possible associations between the studied variables and experienced barrier effects. Whereas, the qualitative data allowed for enhanced depth and as a complement to the associations from the quantitative data. The qualitative data also provided a possibility to uncover underlying motivations and behaviours.

Given the constrained time frame of this study, a stated preference method through the administration of a survey was exclusively employed to collect data on individuals' experiences. The survey allowed for the integrated approach, combining both quantitative and qualitative components within the framework of a stated preference method. Quantitative data were gathered by allowing participants to use rating scales for specific statements, while open-ended questions facilitated the collection of qualitative insights.

3.3.1 Survey

Denscombe [2017] describes surveys as a strategy suitable for measuring some aspects of a phenomenon, and for projects with a short time constraint, making a survey a feasible method for this master's thesis. Moreover, Denscombe describes that surveys typically serve as a fundamental tool in empirical research, facilitating the gathering of data from relevant individuals and sites. Surveys are frequently employed to understand the conditions at a specific moment in time, rather than understanding changes over an extended period. Although it is possible to trace changes, it is uncommon in small-scale research projects. Furthermore, the primary intention of surveys often lies in achieving a comprehensive understanding. Therefore, surveys must have a broad scope, both regarding the questions and the diversity of respondents, to maximise the relevant information in the collected data.

The most common collection methods are questionnaires and interviews [Denscombe, 2017]. The data collection process from respondents can be executed using various survey techniques, including postal, face-to-face, telephone, internet, and social network surveys. While postal surveys are commonly employed, they usually have high costs, are time-consuming, and often generate a low response rate. Face-to-face surveys also require a lot of time and may involve travel expenses. However, this technique typically facilitates the obtainment of in-depth information candidly. Given the research objectives of this thesis to comprehensively understand pedestrians' experiences and to examine variations between demographic groups, ensuring a broad representativeness in the data collection was essential as well as managing to do so within the limited time frame. To facilitate obtaining a diversity of respondents, the survey was internet-based. Apart from enabling reaching a wider geographic spread and coverage with an internet-based survey, another advantage includes centralised data management.

Engaging with participants can take various forms, including direct e-mail communication, participation in existing online groups or social networks, and the administration of web-based questionnaires [Denscombe, 2017]. The author states that the latter method often allows for widespread distribution without entailing any costs. Specifically, social network surveys leverage platforms such as Facebook, LinkedIn, and Instagram for spreading surveys to individuals who share common interests, facilitating easy contact and interaction. For this thesis, a web-based questionnaire was therefore chosen.

It is important to carefully select the research population of a survey, making the survey collect valuable answers, and considering, not only who, but also how the contacts will be reached [Denscombe, 2017]. For this thesis, the research population was aimed to be as broad and diverse as possible, since central city streets affect most of a city's residents, but within the area of Gothenburg. Therefore, multiple techniques of distributing the survey were adopted for this project, including face-to-face interactions on the studied streets where pedestrians were given a QR code linking to the survey. Additionally, targeted e-mails were sent out to businesses, organisations, educational institutions, and residential associations in the nearby area of Linnégatan, Parkgatan and Skånegatan. The survey was also spread within relevant social media groups, Facebook groups e.g., associated with the studied streets, along with our private contacts, networks, and on social media platforms.

There are several factors that can influence the participation of potential respondents, e.g., type of occupation or their age [Denscombe, 2017]. Additionally, the design of the survey plays a vital role along with its topic and process. Other factors include the time, place, and delivery of the survey, as well as the design of the questions. It is also important to consider the ethics of surveys, both regarding the invitation of participants but also how the questions might be perceived by different individuals or social groups. To address these challenges, the survey was designed to be inclusive and without questions that might be sensitive to any participants. Additionally, no questions were obligatory and the respondents were anonymous. When face-to-face distribution on the studied streets was adopted, it was performed during less busy hours, such as during the weekend and during lunch breaks, always delivered with the message that the potential participants could engage in the survey when they had the time. The time it may take to finish the survey was also always expressed and included in the information on the first page of the survey, to facilitate complete participation. Moreover, targeted e-mails were sent out to organisations etc., during business hours to make sure they were received. According to Forkenbrock et al. [2001] the key to succeeding with a survey-based method is to limit the amount of questions and make the questions easy to administer in a short amount of time. A large effort to shorten the survey was therefore made and a majority of the questions were designed with alternatives and check-boxes.

To facilitate a promising design of the survey, engagement of diverse demographics, and the management of the collected data, the web-based questionnaire was designed utilising the Public Participatory Geographic Information System (PPGIS), accessed via the community engagement platform Maptionnaire [Maptia Oy, 2024]. The survey design enabled the incorporation of both quantitative and qualitative approaches and several different types of posed questions. Maptionnaire's functionality also allowed for the integration of a conventional questionnaire alongside map-based interactions where the respondent could pinpoint locations, draw lines, and provide both geographic and non-geographic information.

Compared to other methods, PPGIS is an efficient tool for reaching out to broader groups of participants, including on a geographical scale and to those who usually do not participate in similar processes, no matter of incentives to participate or not [Kahila-Tani et al., 2019]. Notably, PPGIS offers advantages in engaging specific demographic groups, such as children and young individuals, more effectively than traditional methods. However, it is essential to recognise that the tool may introduce barriers for elderly users, potentially leading to reduced participation among older populations. Further, Maptionnaire is developed to be compatible with both computer and mobile devices and has the feature to answer specific questions based on the respondent's earlier answers.

The questionnaire design followed a structured format, organised into sections. Initially, respondents were asked about demographic information. Subsequently, a street familiarity assessment of one specific street, Linnégatan, followed. If the respondent was not familiar with the specific street, the questionnaire seamlessly transitioned to the next street, Parkgatan. Similarly, if the respondent was unfamiliar with Parkgatan, the same process continued for the third street, Skånegatan. Implying that the respondents could choose which streets to respond to. If a respondent was familiar with a specific street, a street-specific inquiry followed with questions about their relation to the street, frequency of visits, etc. Subsequently, the questionnaire incorporated a map-based component where the respondents could provide spatial context and enhance their responses about the specific street. Finally, the questionnaire delved into experiences related to barrier effects and transport, crossing facilities, and environmental features of the same street, before transitioning to the next street. This approach aimed to systematically capture relevant information while accommodating variations in respondents' familiarity with the three different streets. The design facilitated a comprehensive exploration of various aspects of the phenomena of barrier effects and individual experiences. The map-based tool was used to identify areas of concern or appeal along the studied streets. Respondents were encouraged to provide textual explanations for their marked locations, enriching the qualitative depth of the data. Additionally, respondents could illustrate their typical routes along the streets, providing insights into their travel patterns and any avoidance behaviours. For more details about the composition of the survey, the structure of the survey is presented in Appendix A.

According to [Wahl et al., 2012b] respondents' answers may be affected by several factors when they are asked to estimate how often a traffic-related phenomenon occurs. Therefore, the authors emphasise the importance of, in addition to background variables, such as gender and age, adding inquiry addressing to what extent the respondents are exposed to the studied environments. To ensure this is considered in this thesis, the street-specific inquiry about the specific street and frequency of visits was added, facilitating the data analysis.

3.3.2 Site audits and gathering of external data

To map the three case sites, a combination of spatial measurement tools, site audit observations, and measurements were performed. Geographical data was collected from Göteborg Stad [2024a] and utilised for measurements and representation of site characteristics, including environmental and transport features. The gathering of information was conducted in ArcGIS Pro, where various features were measured, such as road width, pedestrian crossing locations and distances, tree density, fence and hedge positions, tram and bus stops, building types, and points of interest within the study area. Characteristics such as building facades, layout of the streetscape, presence of welcoming entrances, benches and seating, pavement width, and active ground floors along the streets, were collected pictorially or measured during site audits and are presented in Chapter 4 and Appendix B, C, and D.

3.4 Data analysis

This section presents the process and methods employed for the analysis of the demographic, quantitative, and qualitative data gathered from the survey. Here, the quantitative data indicates the estimations of barrier effects and features asked for in the survey, while the qualitative data is composed of the collected spatial data and accompanying free-text answers. Both types of collected data underwent subsequent sorting to ensure that the analysis was based on reliable data, thereby enhancing the accuracy and applicability of the insights obtained.

Given that the respondents only provided data about streets they were familiar with, the data were categorised into three different datasets corresponding to the streets under investigation: Linnégatan, Parkgatan, and Skånegatan. Since none of the survey questions were mandatory, response rates differed among participants. To accurately explore the relationship between various variables, it was central that the respondents addressed questions relating to several themes within a specific street. Consequently, for the quantitative data, a minimum response rate of 70 percent was instituted for each street-specific set of questions. For instance, if a respondent completed at least 70 percent of the questions related to Linnégatan, their responses were integrated into the dataset for Linnégatan. This threshold ensured that the sample used for relationship analysis was more likely to be representative of the overall population under study. Moreover, by excluding respondents who had not completed a significant portion of the survey, the potential for biases or inaccuracies in the analysis was mitigated, thereby enhancing the credibility of the research findings.

The qualitative data also underwent sorting. Regarding the spatial data, consisting of locations marked by the respondents for each street, locations that were apparent data entry errors or misunderstandings, were excluded, e.g., locations marked on other streets in Gothenburg than on the studied streets. The free-text answers related to the spatial data were also sorted. Here, comments that were not related to the subject were excluded, e.g., comments regarding travelling by car.

Both types of data that passed the sorting criteria were further described and visualised to obtain an overall impression of the collected data. Moreover, the quantitative data were assessed through regression analyses, while for the qualitative data, a spatial analysis was employed for the geographical data and a thematic analysis for the accompanying free-text comments.

3.4.1 Descriptives and visualisation of data

To provide a comprehensive understanding of the collected data and to identify the most relevant findings, the data were visualised and described. The demographic data were illustrated to understand the survey population and the risks of any biases due to the low distribution of different demographic profiles. Further, the quantitative data, i.e., estimations of various statements, were analysed. Firstly, for this type of data, estimations of how the respondents generally value different attributes in a streetscape were plotted, both in its totality but also a comparison between how the respondents included in each street-specific dataset answered. Based on the comparison, the different datasets were assumed to be compared to each other since these general estimations were similar between the datasets of all three studied streets. The street-specific estimations, both regarding the streetscape factors and the studied barrier effects, were plotted to understand how the respondents perceive and experience the streets and their components. While some visualisations were solely used to understand the collected data, some were also used for demonstration of results. The qualitative data, i.e., spatial and accompanying comments, were also analysed and are further described in Section 3.4.3.

3.4.2 Regression analysis

To analyse the quantitative survey data, binomial logistic regression analysis was employed via IBM SPSS, a statistical analysis software platform. This statistical analysis technique was determined suitable for the project because of its ability to predict the relationship between a binary dependent variable and one or more independent variables [Leard statistics, 2018]. In the statistical model, the dependent variables represent the experienced barrier effects of each street, as well as the traffic volume, as it is the reference indicator of the streets' barrier effect in this project. Whereas, the independent variables represent transport features, crossing facilities, environmental features, age, gender, and typical use of transport mode. Since both direct and indirect effects are included in the analysis, two groups were made to facilitate a more suitable analysis for each type of effect. Since indirect effects occur once the effect has reached an individual's acceptance level, and results in changed travel behaviour, e.g, experiencing discomfort while walking a street (direct effect), to a certain level that it consequently leads to avoiding the street (indirect effect), they were treated differently in the regression. Table 3.5 illustrates an overview of the dependent and independent variables and how they were stated in the survey, and included in the regression analysis.

	Dependent variables	Statement/question
Reference indicator	Traffic volume	'There is too much car, bus, and tram traffic'
Direct effects	Fear of traffic accidents	'I feel unsafe here based on road safety (risk of accident)'
	Crossing & Passing effort	'I find it difficult to get around here on foot'
Indirect effects	Frequency of visits	'I avoid the street when moving on foot'
	Routing of trips	'I avoid crossing the street when moving on foot'
	Mode of transport	'I choose other modes of transport than walking on this street'
	Independent variables	**Statement/question**
Transport features and crossing facilities	Traffic volume	'There is too much car, bus, and tram traffic'
	Traffic speed	'Cars, buses, and trams drive too fast'
	Number of pedestrian crossings	'There are too few pedestrian crossings'
	Obstacles	'There are obstacles bothering me where I want to cross'
Environmental features	Greenery	'There is a lack of trees and other greenery'
	Width of pavement	'pavements are too narrow'
	Facades of buildings	'The facades of the buildings are not aesthetically pleasing'
	Active ground floors and inviting entrances	'There is a lack of active ground floors and inviting entrances'
Demographics	Age	'How old are you?'
	Gender	'Gender'
	Typical transport mode at the specific street	'How do you usually travel on Linnégatan/-Parkgatan/Skånegatan?'
	Frequency of visits at the specific street	'How often do you cross or walk along Linnégatan/Parkgatan/Skånegatan (on foot)?'

Table 3.5: Dependent and independent variables were included in the regression analysis.

To employ binomial logistic regression analysis, four assumptions need to be fulfilled for the validity of the statistical analysis. Assumption number one is that the dependent variable should be measured on a dichotomous scale, meaning it can take on only two possible outcomes, e.g., "yes" and "no" [Leard statistics, 2018]. In this case, the dependent variables were measured on a different scale. In the survey, the respondents were allowed to describe how often they experience a specific statement about barrier effects, e.g., 'I avoid this street when moving on foot', where they could answer ’Always’, ’Often’, ’Occasionally’, ’Never’, or ’No opinion’. Therefore, the answers had to be adjusted to the dichotomous scale. For the direct barrier effects, the alternatives ’Always’ and ’Often’ were grouped into group ’1’, while ’Occasionally’, and ’Never’ were grouped into group ’0’. Regarding the indirect effects, ’Always’, ’Often’, and ’Occasionally’, were grouped together into group ’1’, and ’Never’ was set to group ’0’, see Table 3.6. The reasoning behind this categorisation was to capture indirect effects as they can be seen as more severe than direct effects, if an individual avoids a street occasionally it weighs heavier than an individual experiencing discomfort occasionally. For an individual to avoid a street occasionally, they most likely experience e.g., discomfort to a higher level and more frequently than occasionally.

	Input	Dichotomous variable
Direct effects	’Always’ or ’Often’	1
	’Occasionally’ or ’Never’	0
	’Fully agree’ or ’Partially agree’	1
	’Partially disagree’ or ’Disagree’	0
	’No opinion’	Null
Indirect effects	’Always’ or ’Often’ or ’Occasionally’	1
	’Never’	0
	’No opinion’	Null

Table 3.6: Included variables for direct and indirect effects adjusted to a dichotomous scale to be able to employ binary logistic regression analysis.

Assumption number two indicates that there are one or more independent variables, which can be measured on different scales, meaning that a combination of e.g., continuous or categorical variables can be included in the model [Leard statistics, 2018]. Since the survey data consists of different variables, including interval variables, ordinal variables, and nominal variables, this assumption was fulfilled without adjustments. Simultaneously the ability to analyse data consisting of different variables on different scales was also a reason for selecting binary logistic regression analysis. The third assumption insists on the independence of observations and the dependent variable should have mutually exhaustive and exclusive categories. The independence of observations refers to each data point in the dataset being independent of the others. The collected survey data fulfils this since no data point influences or depends on any other data point, no respondents had access to other respondent’s answers. A mutually exclusive category refers to that the categories of the dependent variable should not overlap, the answer should only fall into one category. This was fulfilled since the respondents were not allowed to select more than one alternative, e.g., ’Often’ or ’Never’. An exhaustive category means that all possible categories are covered by the response alternatives. Since the alternative ’No opinion’ was present, this assumption was also fulfilled. Assumption four indicates the need for a linear relationship between the logit transformation of the dependent variable and any continuous independent variables and was considered fulfilled. However, one variable that risked not fulfilling this assumption was age, as children and the elderly are often seen as the most sensitive to barriers. Therefore, this variable was evaluated by another analysing technique as well.

While there are several advantages to binomial logistic regression analysis, such as interpretability, and efficiency, and it suits this project's dataset characteristics, there are some disadvantages that should be taken into account. As mentioned, in analysing individual perceptions of a phenomenon where personal preferences and behavioural patterns are involved, the degree of complexity of the relationships involved is high. It may be difficult for a model to capture complex relationships. With this model linearity was assumed, meaning that if the relationship instead is non-linear, the technique might not be as suitable. Another disadvantage is the limitation of predicting discrete outcomes, e.g., 0 or 1. In the survey, the respondents could choose between several alternatives, meaning that continuous outcomes would have been more ideal and less simplified.

When the binomial logistic regression analysis was carried out, SPSS Statistics also generated several tables that are required to understand the results [Leard statistics, 2018]. One of these tables is called 'Model Summary' and explains the variation in the dependent variable, which is represented by the Nagelkerke, R^2 value. The value ranges from 0 to 1, with a higher value indicating a better fit of the model to the data and suggesting that the independent variables explain a large proportion of the variability in the binary outcome. Additionally, a 'Classification Table' is generated providing information about the model's accuracy, indicating the proportion of correct predictions out of all predictions made by the model. Regarding interpreting the outcome, the model generates odds ratios (OR) by exponentiating the regression coefficients. OR that are greater than 1 indicate that the event is more likely to occur as the predictor (independent variable) increases. OR that are less than 1 indicate that the event is less likely to occur as the predictor increases. In addition, it generates p-values, testing the null hypothesis that a coefficient is equal to zero. If the p-value is small (<0.05), it indicates that the predictor variable is significantly associated with the outcome variable, meaning it has an impact on the dependent variable according to the model.

3.4.3 Spatial and thematic analysis

The spatial data collected from the survey refers to pin-pointed locations on the streets marked by the respondents. The questions concerned where the respondents experience 'the highest amount of traffic', where the street is 'complex or hindering', or 'pleasant', as well as where they tend to 'cross the street without a pedestrian crossing present'. This data was exported as shape files, which are geographical information data layers consisting of e.g., points. This data was then analysed spatially with the software ArcGIS Pro, where the distribution of points could be analysed and compared by creating heat maps visualising the density of marked locations for each category and street. Since the same respondent could mark more than one point per question, the number of unique respondents per question was also counted in ArcGIS Pro.

Regarding the two questions about where the respondents experience a street segment as 'complex or hindering' or as 'a pleasant place to be or walk', they were allowed to accompany the pin-pointed location with a free-text comment motivating their choice. These free-text answers are previously referred to as part of the qualitative data but are hereby referred to as comments related to the spatial data. These comments were analysed by adopting a technique of thematic analysis. This included listing every comment, sorted by location of the street, as well as categorising them by content. This facilitated the process of finding patterns and themes among the comments that could be compared to the regression analysis results.

4
Case sites

This chapter presents an overview of the case sites, Linnégatan, Parkgatan, and Skånegatan. Presented are road characteristics, geographical profiles, as well as photographs visualising the streetscapes' layouts and nuances.

4.1 Overview of the case sites

An overview of the locations of the studied streets in Gothenburg is presented in Figure 4.1. All three streets are centrally located in the city. At each end of Linnégatan, there are two large combined bus and tram stops, called Järntorget and Linnéplatsen. Southwest of Linnégatan lies a popular park, Slottsskogen. Similarly, there are park areas around Parkgatan, such as Hagaparken, Kungsparken and Trädgårdsföreningen, along the city's moat. Noteworthy for Parkgatan is the street parallel to Parkgatan called Nya Allén, where the traffic drives in the opposite direction of Parkgatan, only separated by a green area. There is a prominent and popular avenue street that intersects with Parkgatan, known as Kungsportsavenyn, with a lot of social activity. East of Kungsportsavenyn, lies a sports centre area known as Heden, serving as a central hub for various activities and events. Noteworthy locations surrounding Skånegatan are: Ullevi, a large multipurpose arena on the northeastern side; Korsvägen, a major bus and tram stop to the south; and Liseberg, a large amusement park also to the south. Worth noting are also some features of Gothenburg delineating the central area of the city, where the case sites are located. The figure also illustrates the motorway E6, which serves as an eastern boundary, with a limited amount of non-motorised street network connections to and from the eastern side. Additionally, the Central Train Station along with the river Göta Älv in the north, further defines the central parts of Gothenburg. Further, to the east and south, significant variations in altitude contribute to framing the central city. Additionally, at the eastern end of Parkgatan and the southern end of Skånegatan, are two ongoing large construction sites creating barriers as they cordon off a substantial space from the public.

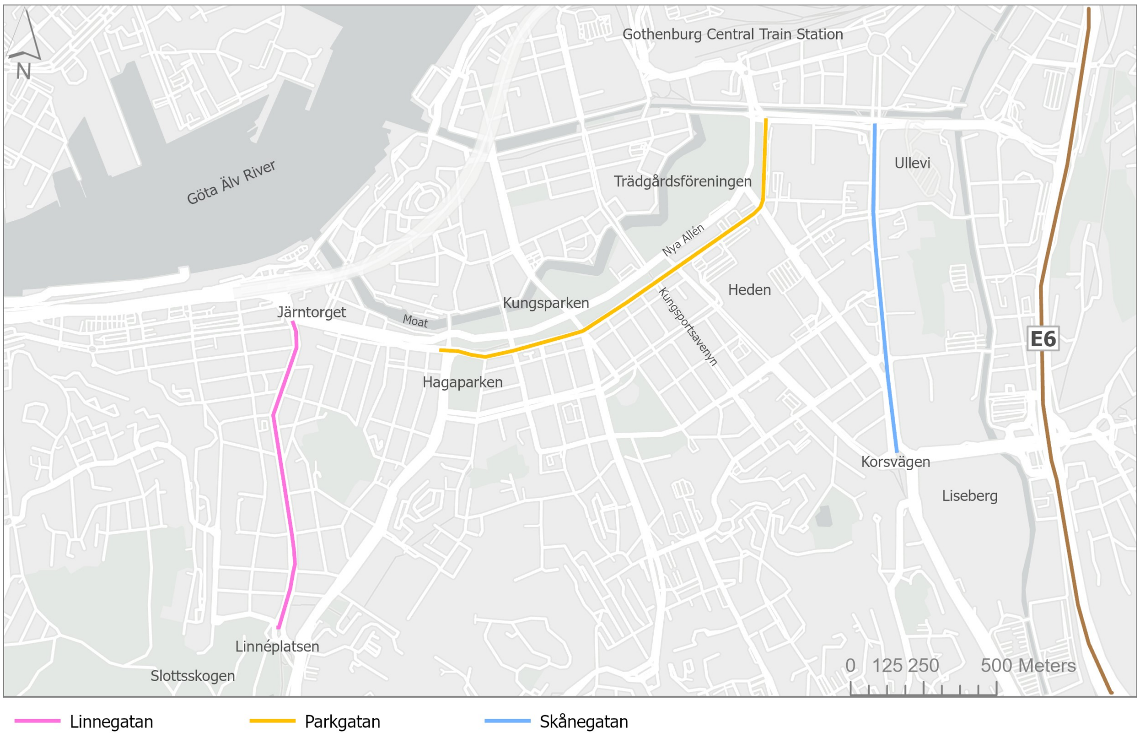

Figure 4.1: Overview of Gothenburg, including the case sites' locations and labels of noteworthy locations.

4.2 Road characteristics

Presented in Table 4.1 are measurements of road characteristics for each street including road width, number of traffic lanes, car traffic speed limit and measured speed, traffic volume, road length, and number of crossing facilities along with the spacing between them. Linnégatan, with a total road width of approximately 18 meters, features one car traffic lane and one tram traffic lane in each direction. The speed limit is 50 kilometres per hour, but measured vehicle speed on Linnégatan indicates a lower speed, the lowest of all three streets. Linnégatan's 1.0 kilometer road length makes it the shortest street, with a total of 13 pedestrian crossings. The spacing between the crosswalks on Linnégatan is the lowest compared to the other streets. Parkgatan has three car traffic lanes in the same direction, the highest measured vehicle speed, and lacks tram traffic except for the initial 250 meters from the west, where the tram line turns towards the moat and the inner city. Parkgatan has the same number of pedestrian crossings as Linnégatan, but they are distributed along a road length of 1.5 kilometres, with a maximum spacing of 275 meters and a median spacing of 121 meters which is the largest of the three streets. Skånegatan, with a road width of 30 meters, accommodates, in each direction, two to three car traffic lanes and one tram lane. Skånegatan's road length is 1.1 kilometres, hosting a total of nine pedestrian crossings with the largest average spacing of 140 meters.

	Linnégatan	Parkgatan	Skånegatan
Road width [m]	18	10	30
Car lanes [n]	2	3	4-6
Tram lanes [n]	2	-	2
Speed limit [km/h]	50	50	50
Median speed* [km/h (year)]	22-29 (2017/2013)	44-47 (2018/2004)	38 (2013)
85-percentile* [km/h (year)]	25-38 (2017/2013)	46-56 (2018/2004)	48 (2013)
AAWT [veh/day]	9,825	10,171	10,880
Road length [km]	1.0	1.5	1.1
Crossing facilities [n]	13	13	9
Spacing of crossing facilities [m]			
Maximum	166	275	265
Minimum	27	23	32
Average	87	126	140
Median	74	121	98
Pavement width [m]	1.4-3.7	1.8-2.9	1.0-4.4

*Interval of highest speeds measured across various segments of the street. The data is sourced from Göteborgs Stad [2024b], with measurements conducted in multiple years. The earliest data dates back to 2004, while the most recent data is from 2018.

Table 4.1: Road characteristics for each case site.

Despite these differences, all three streets share similar traffic volume, with a difference within a span of 1.000 vehicles per day Göteborgs Stad [2024b]. The highest speed levels are measured at Parkgatan, followed by Skånegatan, and lastly Linnégatan, detailed in Table 4.1. Regarding the measured pavement widths, they differ on and between the streets. On Linnégatan, the difference in width is relatively low, where the widest measured width of 3.7 is for a segment dedicated to both pedestrians and cyclists. At Parkgatan, the pavements are relatively narrow and do not vary too much, while for Skånegatan it differs a lot, especially on the west side of the street.

4.3 Geographical profile

To provide an overview of each site's functions and land use, Figure 4.2 presents the main types of buildings in the area around the case sites, i.e., housing, economy buildings, industries, societal function buildings, and businesses. The buildings surrounding Linnégatan are mostly represented by housing as well as businesses in the north. On the north side of Parkgatan and the moat, there are mostly businesses and societal function buildings, whereas, on the southern side of Parkgatan, there is a mixture of housing, businesses, and societal function buildings, including schools, churches, a football stadium, and a culture facility for theatre. Moreover, Skånegatan is mainly surrounded by societal function buildings and its eastern side can be recognised as an event hub, consisting of a multi-purpose stadium, a sports centre, and a fair, in combination of school facilities. East of the event hub buildings lies a mixture of industry buildings and businesses. On the western side of Skånegatan, many buildings are predominantly residential.

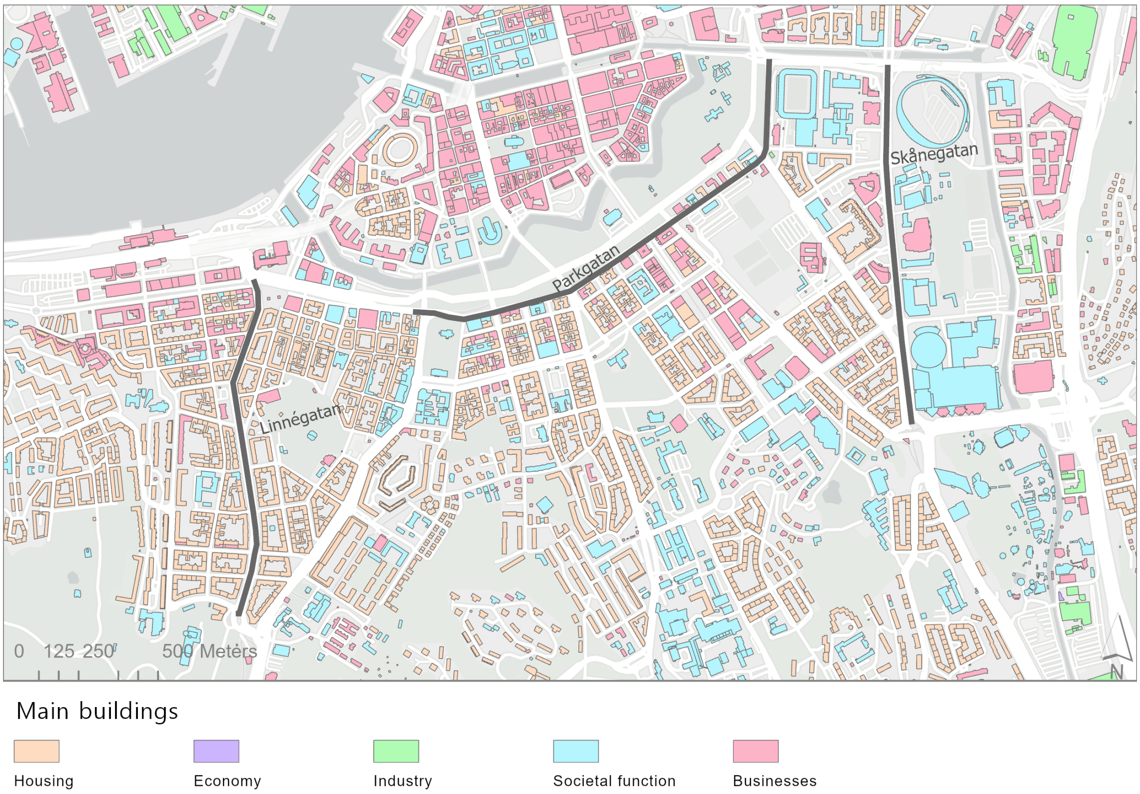

Figure 4.2: Map illustrating main building types in the areas surrounding all case streets. [Göteborg Stad, 2024a]

Figure 4.3 illustrates the distribution of destination points across the area around the case sites, including cultural and educational facilities, shops, restaurants, health centres, and services. Notably, a higher density of points can be seen north of Parkgatan, within the moat where the inner city is located. Here, a high concentration of points representing restaurants, shops and services can be found. Southward from Parkgatan, the density of points remains high, stretching to the southern part of Skånegatan and towards the area surrounding Linnégatan. The vicinity of Linnégatan especially hosts target points such as restaurants and services as well as some shops in the north. The overall distribution shows a slightly lower density around Skånegatan, which could partly be related to the extensive space occupied by the large event hub buildings, including arenas and sports centres, and the closeness to the motorway E6, visible in Figure 4.1.

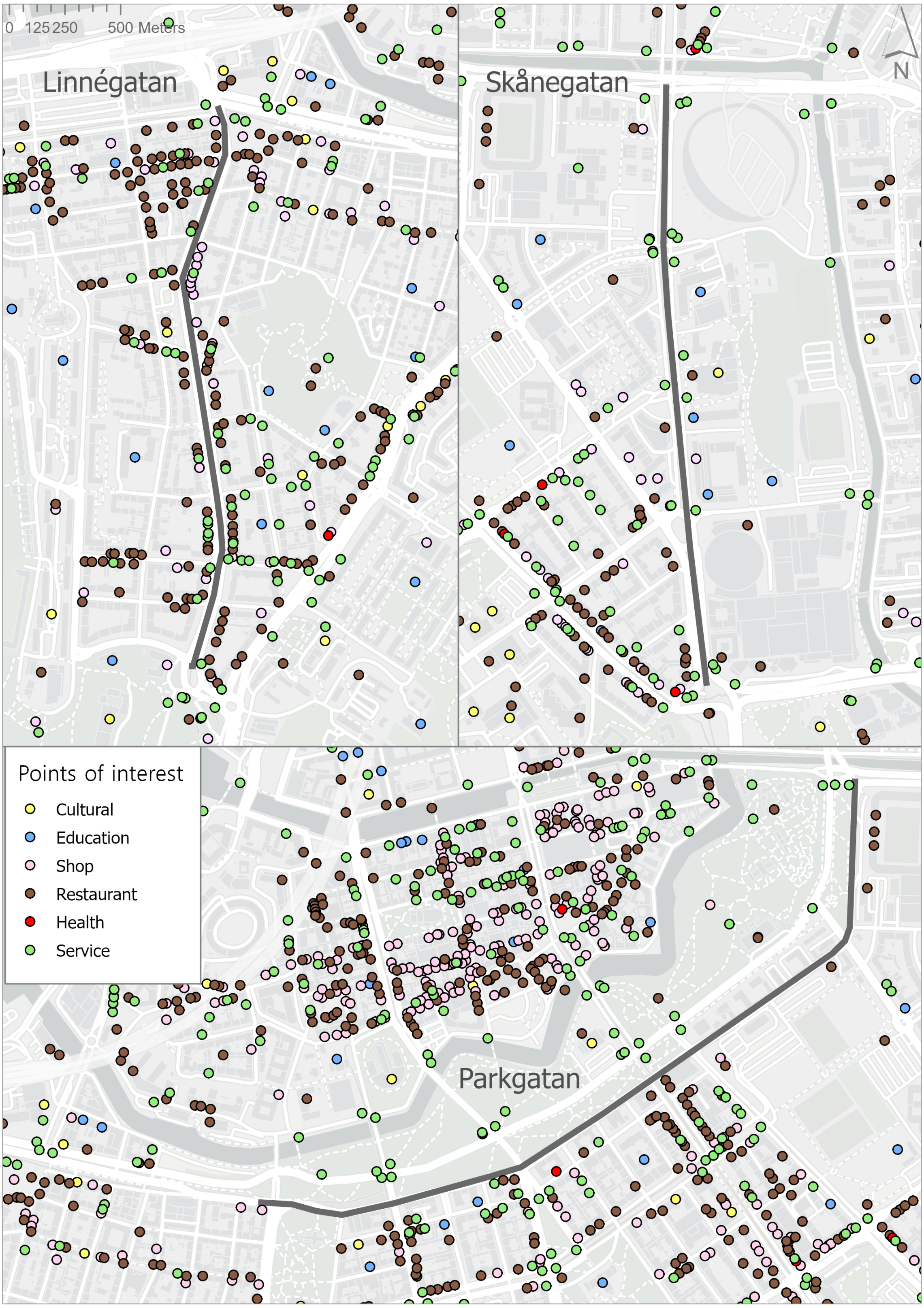

Figure 4.3: Map of different destinations in Gothenburg surrounding each case site [Göteborg Stad, 2024a].

Figure 4.4 illustrates the amount and density of planted trees within the streetscapes of Linnégatan, Parkgatan, and Skånegatan. Notably, the surronding of Parkgatan has the highest amount of trees. Linnégatan and Skånegatan have much fewer trees than Parkgatan, but they both have planted tree avenues along the pavements, mostly covering both sides of the streets.

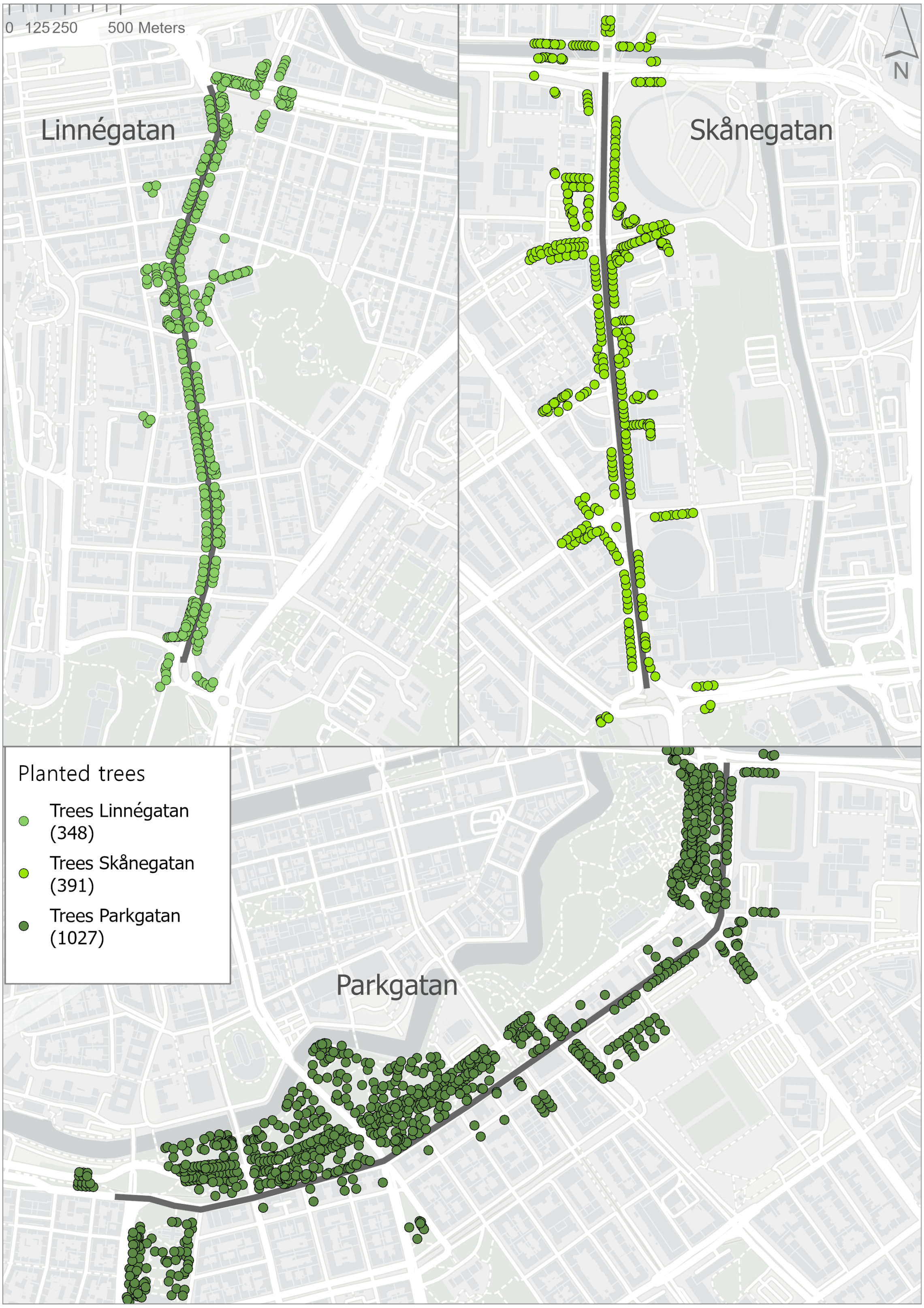

Figure 4.4: Density and number of planted trees surrounding each case site [Göteborg Stad, 2024a].

Locations and labels of tram and bus stops of the case sites are presented in 4.5.

Linnégatan has two large combined tram and bus stops at its ends, Järntorget in the north and Linnéplatsen in the south. Along the street, there are two other stops called Prinsgatan and Olivedalsgatan. On Skånegatan, there is a bus stop called Ullevi Norra in the north, and moving southward from there follows two tram stops called Ullevi Södra and Scandinavium. In the southern end, Korsvägen, serving as a large combined bus and tram stop with many transfers. On Parkgatan, there are fewer stops. In the west, there is a tram stop called Hagakyrkan, and further east there is a large bus stop called Heden.

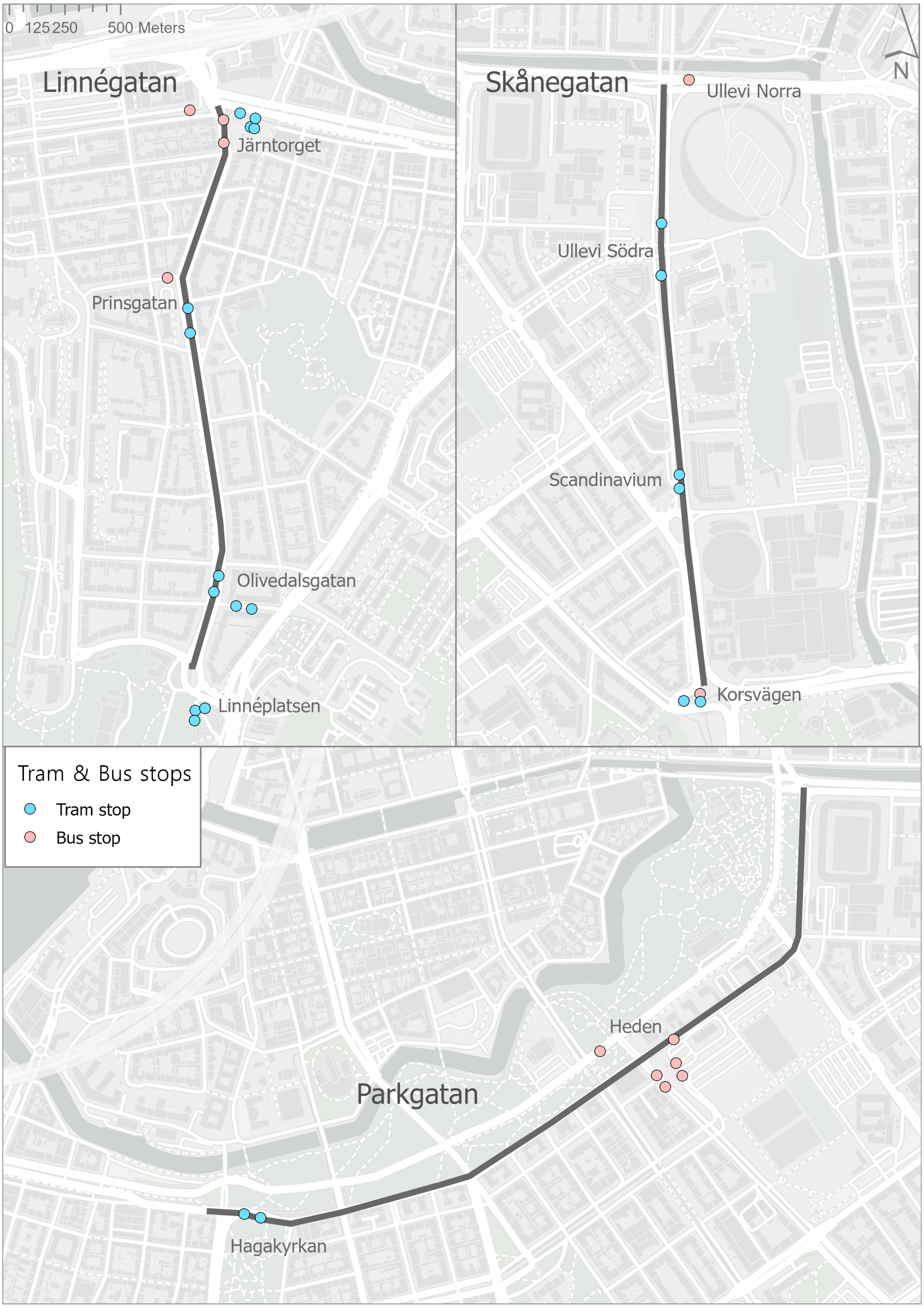

Figure 4.5: Locations and labels of all tram and bus stops on each case site [Göteborg Stad, 2024a].

Figure 4.6 illustrate locations of physical hinders within each case site's streetscape, such as fences and hedges. Fences are mainly located around tram and bus stops which are presented in 4.5. On Linnégatan, there is a fence stretching approximately 200 meters by the stop Prinsgatan, otherwise, most of the fences are located by the stop Järntorget. On Skånegatan, tram fences can be found along the entire street, except for a few openings at intersections. On Parkgatan, there are multiple fences in the western part, by the tram stop Hagakyrkan. A lot of these fences cordon off the temporary, but long-term, construction site at this location. Further along the street to the east, hedges are separating the park area from the road, with a few openings. North of Heden there are multiple fences on the northern side of the street, surrounding buildings as well as a long fence encircling Trädgårdsföreningen.

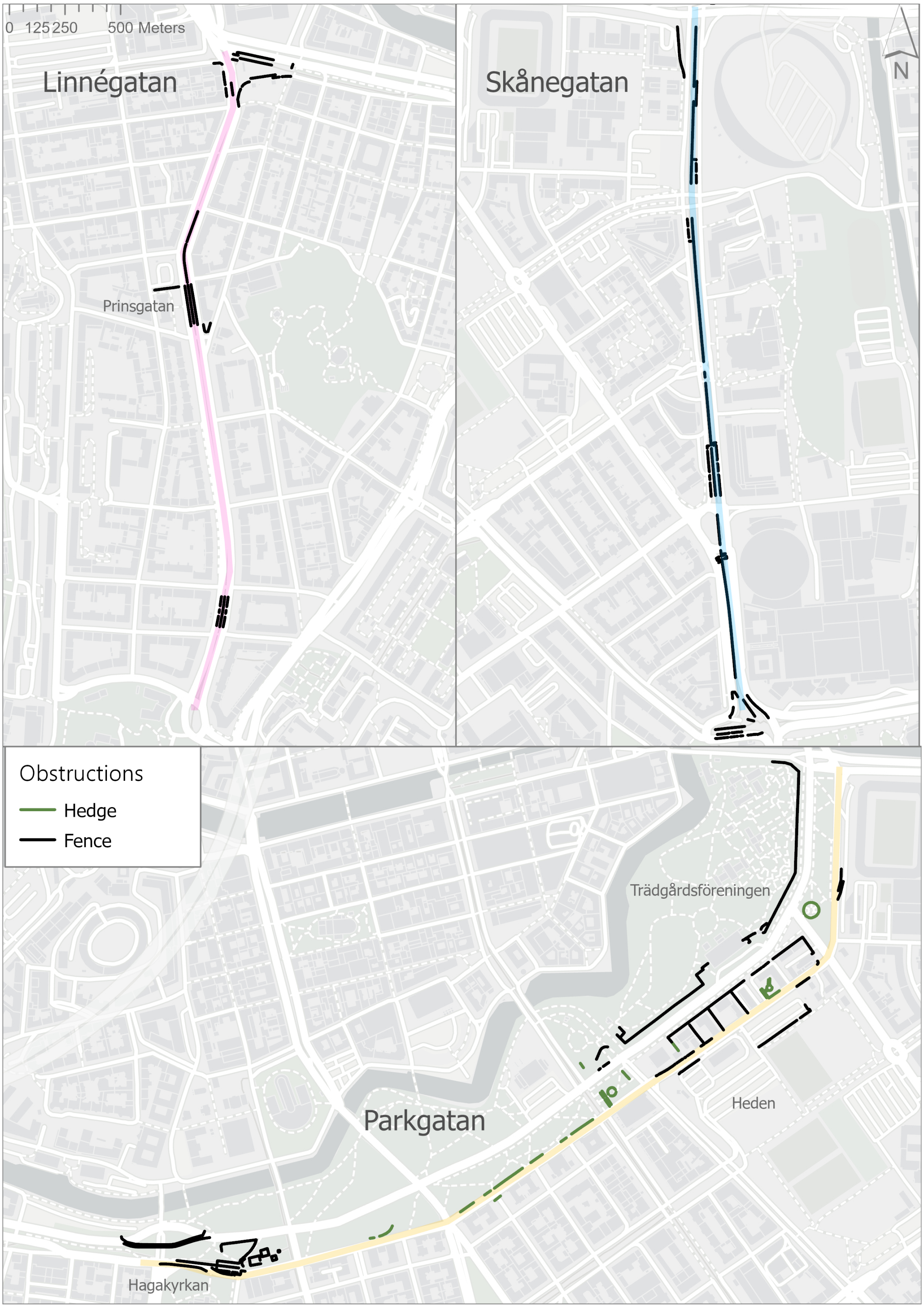

Figure 4.6: Locations of obstructions such as fences and hedges on each case site [Göteborg Stad, 2024a].

4.4 Streetscape layout and nuances

The following photographs, Figure 4.7, 4.8, and 4.9 depict streetscape layouts and views from the case sites' pavements, which are more effectively revealed through visual representation. One essential aspect is spaciousness, the perception of spatial arrangement within the streets, which encompasses characteristics such as the width of pavements, roadways, and public places. More photographs can be found in Appendix B, C and D, for Linnégatan, Parkgatan, respective Skånegatan, as well as a map for each street illustrating the sections where the photographs were taken, where letters (A-J) indicate which photo is taken in which section. The photographs also show the architectural character and overall aesthetics of buildings lining the streets. In addition, this visual documentation provides an overview of ground-level activity, e.g., commercial spaces impacting the vibrancy and functionality of the streetscape, as well as the presence or absence of inviting entrances along the street that can enhance accessibility and create a welcoming and positive impression for pedestrians.

Figure 4.7: Photograph (location F in Appendix B) of Linnégatan, giving an understanding of the space dedicated to pedestrians and cyclists and the distance to the vehicular lane. On the left side of the picture is one of the tram stops, Olivedalsgatan. On the right of the picture are restaurants and shops located.

Figure 4.8: Photograph (location E in Appendix C) of Parkgatan showing the pavement and the distance to the vehicular lanes. In the right side of the photograph details of the building facades can also be seen.

Figure 4.9: Photograph (location E in Appendix D of Skånegatan showing one of the wider pavements, dedicated to pedestrians and cyclists. On the left is the fence separating the tram lanes, whereas the vehicular lanes are located between the tram lane and the pavement.

5

Results

This chapter presents the visualisation and description of the survey population and results. Results obtained from the regression analysis of the quantitative data and spatial and thematic analysis of the qualitative data are also presented.

5.1 Survey population results

In this section, the data concerning the respondents participating in the survey are presented. This data includes demographic characteristics and the respondents' connection to the studied streets. Among the 702 initial survey participants, a total of 367 respondents' data were analysed, where the remaining was eliminated due to not answering enough questions about any specific street. Out of these analysed respondents, 356 successfully completed at least 70 percent of the questions pertaining to Linnégatan, constituting the threshold for inclusion in the analysis, and was therefore included in the analysis of this specific street. Similarly, the analysis of Parkgatan included data from 236 respondents, and for Skånegatan, data from 224 respondents were included.

The demographic profile of the survey respondents regarding age, gender, and occupation are detailed for respective street in Table 5.1. As can be seen, all age groups except 0-9 years are represented. Compared to the typical age distribution in Gothenburg, there is an overrepresentation of individuals aged 20-29, 30-39, and 50-59, while people under the age of 20 and over 70 are underrepresented [SCB, 2023]. Moreover, there were more women than men participating, contrary to the approximately equal amount of women and men living in Gothenburg [Göteborg Stad, 2023]. Regarding occupation, there are fewer unemployed as well as more people working to align with accurate numbers. In addition to these demographic categories, respondents were asked regarding any disabilities that may impede their mobility in street environments. Out of the 367 studied participants, none reported a requirement for a wheelchair, while only two people indicated a need for a walker or any other balance support, and five people reported 'Other' disabilities affecting their street navigation.

Question	Options	**Linnégatan**	**Parkgatan**	**Skånegatan**
Age	Total responses [n]	**356**	**236**	**224**
	0-9 years [%]	0	0	0
	10-19 years [%]	6	4	5
	20-29 years [%]	20	23	25
	30-39 years [%]	21	21	22
	40-49 years [%]	13	13	13
	50-59 years [%]	21	20	20
	60-69 years [%]	12	12	8
	70 years or more [%]	7	7	5
Gender	Total responses [n]	**319**	**21**	**204**
	Woman [%]	60	58	58
	Man [%]	39	41	41
	No identity in terms of woman or man [%]	1	1	1
Occupation	Total responses [n]	**313**	**210**	**203**
	Working [%]	74	73	74
	Studying [%]	17	17	18
	Parental leave [%]	1	2	1
	Unemployed [%]	0	1	1
	Retired [%]	6	6	5
	Other [%]	2	1	1

Table 5.1: Characteristics of respondents regarding age, gender, and occupation presented separately for each street.

To understand how people utilise and travel on the streets, the survey asked about travel frequency, typical transport mode, and typical activity when traversing the streets. The results are detailed in Table 5.2 disaggregated for Linnégatan, Parkgatan, and Skånegatan. As can be seen in the table, there is a varied distribution of walking frequency. At Linnégatan, the stated frequency is relatively even distributed between the given alternatives, while Parkgatan and Skånegatan are stated to be visited more rarely. Regarding typical transport modes on the studied streets, walking is the highest stated option at Linnégatan with 66 percent of the answers, followed by public transport which is stated by 17 percent of the respondents included in the analysis of Linnégatan. At Parkgatan, walking is also the highest stated option with 47 percent of the answers, but here followed by car use, consisting 22 percent. At Skånegatan, the most frequent mode of transport is public transport, followed by walking, consisting of 35 and 31 percent respectively of the total answers to this particular question. Additionally, the respondents were asked what type of activity they usually engage in when traversing the streets. However, for this question, the respondent could choose up to two options, which explains the higher number of total responses for this question. When comparing the use of the streets among the respondents, it can be seen that Linnégatan is where most people live, Parkgatan is where most people walk, and Skånegatan is where people typically work or study. It can also be seen that at Linnégatan and Parkgatan, the majority of responses indicate that the street is used for shorter visits, including visits to businesses and walking on the street or in the neighbourhood. Visiting businesses is also the most selected answer at Skånegatan but followed by the option of working or studying. Despite differences in street usage, all activities are represented for all streets, indicating broad land use with various destination points.

Question	Options	**Linnégatan**	**Parkgatan**	**Skånegatan**
Travel frequency at the specific street	Total responses [n]	**342**	**220**	**207**
	Daily [%]	19	5	11
	A few times a week [%]	22	15	15
	A few times a month [%]	32	32	30
	More rarely [%]	27	48	43
Typical transport mode at the specific street	Total responses [n]	**349**	**233**	**218**
	Walking [%]	66	47	31
	Cycling [%]	10	17	17
	Public transport [%]	17	12	35
	Car [%]	6	22	16
	Other [%]	1	1	1
Typical activity when traversing the street	Total responses [n]	**581**	**341**	**323**
	Living [%]	20	7	5
	Working or studying [%]	14	15	25
	Leisure activities [%]	5	6	12
	Visits businesses [%]	36	27	32
	Walking [%]	23	34	16
	Other [%]	2	11	10

Table 5.2: Characteristics of respondents' relation to the studied streets, presented separately for each street.

Illustrated in Figure 5.1 is an overview of the general impact of various street factors as assessed by the survey respondents included in the analysis of any street. Notably, when considering only the respondents who contributed with data for a specific street, the composition remains very similar. This implies that the respondents have similar initial perceptions about the streetscape. Based on this, the results are suggested to be valid for comparison between the streets without introducing biased results. Not included in the figure are the participants not answering this particular question, which are between 70-77 respondents per statement, thus the total number of respondents answering each statement is presented. The data presented in the figure indicate that participants are most influenced by greenery, followed by traffic speed, traffic volume, and facades of buildings. The features the participants generally are least affected by are benches and seating along a street.

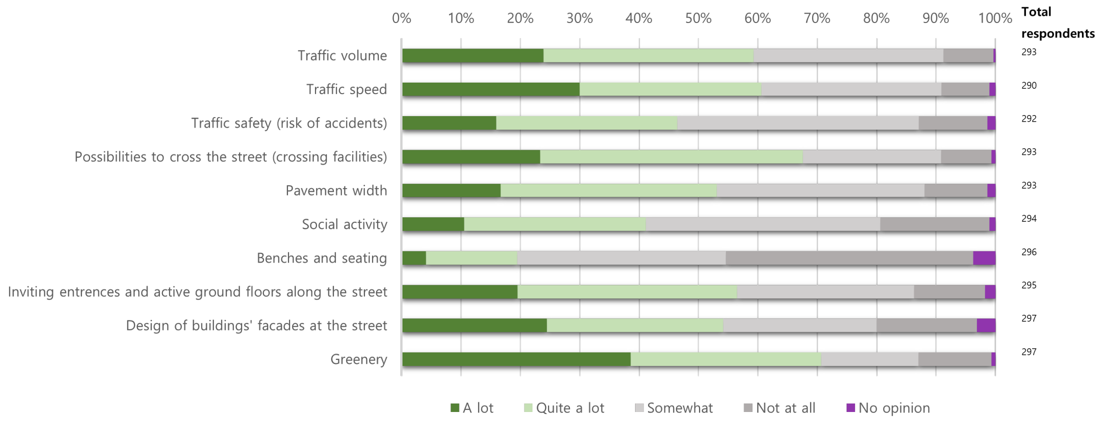

Figure 5.1: Estimations of how much the respondents included in the data analysis are affected by various street factors.

Using the estimations provided in Figure 5.1, the selection of statements for inclusion in the regression analysis was determined. The highest-ranking three statements regarding transport features and crossing facilities, i.e., traffic volume, traffic speed, and crossing facilities, were included in further analyses, in addition to the presence of obstacles hindering crossing which was added. Additionally, the top four statements regarding environmental features, i.e., the width of the pavement, inviting entrances and active ground floors, design of buildings' facades, and greenery were also further analysed.

5.2 Estimations of barrier effects and features within the streetscape

In this section, the responses regarding respondents' experiences are examined. Firstly, the results of experienced barrier effects are visualised and described, followed by the perception of various features including the categories of transport features and crossing facilities, and environmental features. Lastly, it is demonstrated how different age groups and genders have stated perceived barrier effects.

Figure 5.2 illustrate the estimations of how people experience the studied barrier effects, presented separately for each of the studied streets. The results represent how much the respondents agree with the statements associated with barrier effects. For all the studied streets, the statement 'I feel unsafe here based on road safety', had the highest percentage of respondents agreeing out of all statements. However, while experiences of traffic safety were estimated based on a scale from 'Fully agree' to 'Disagree', the other statements had a scale from 'Always' to 'Never', implying that these results may not be accurate to compare. Though, looking at the other statements they are also represented to be experienced. According to the results, the rating of the statement 'I find it difficult to get around here on foot', is relatively low on Linnégatan, but higher stated at Parkgatan and Skånegatan. For these two streets, about 30 percent of the respondents either 'Always' or 'Often' find it difficult to move on foot here. The statement of experiencing fear of traffic accidents and difficulties when moving on foot represents the studied direct effects while the other are related to indirect effects.

Examining the indirect effects, as illustrated in Figure 5.2, these effects are also experienced on the studied streets. For the statement 'I avoid the street when moving on foot', 21 percent of the respondents at Linnégatan either 'Always', 'Often', or 'Occasionally' state that they avoid the street, while up to 59 and 51 percent state the same settings at Parkgatan respectively Skånegatan. Particularly, 15 percent of the participants answering this statement at Parkgatan state that they 'Always' avoid this specific street. Further, the statement 'I avoid crossing the street when moving on foot' is stated slightly higher at Linnégatan and slightly lower at Parkgatan and Skånegatan compared to the estimations of the previous statement. Lastly, regarding the statement of 'I choose other modes of transport than walking on this street', it is relatively highly estimated compared to the other statements with the same scaling. Particularly, this statement is high at Skånegatan, where 75 percent of the participants either 'Always', 'Often', or' Occasionally' choose other modes of transport on this street. However, while these estimations could indicate significant indirect effects at Skånegatan, they could also be attributed to the lower prevalence of walking as a predominant mode of transport on this street compared to Linnégatan and Parkgatan. Additionally, it is more common to work or study on this particular street, suggesting an alternative travel pattern on this street among the respondents.

As touched upon previously, the estimations do not only vary between the studied effects but also how the barrier effects are experienced between the studied streets. The estimations follow a pattern where Linnégatan has the lowest stated barrier effects, while Parkgatan generally has the highest, closely followed by Skånegatan, as shown in Figure 5.2. Given that the traffic volume is approximately the same on all three streets, other features within the streetscape are ensured to influence the perception of barrier effects.

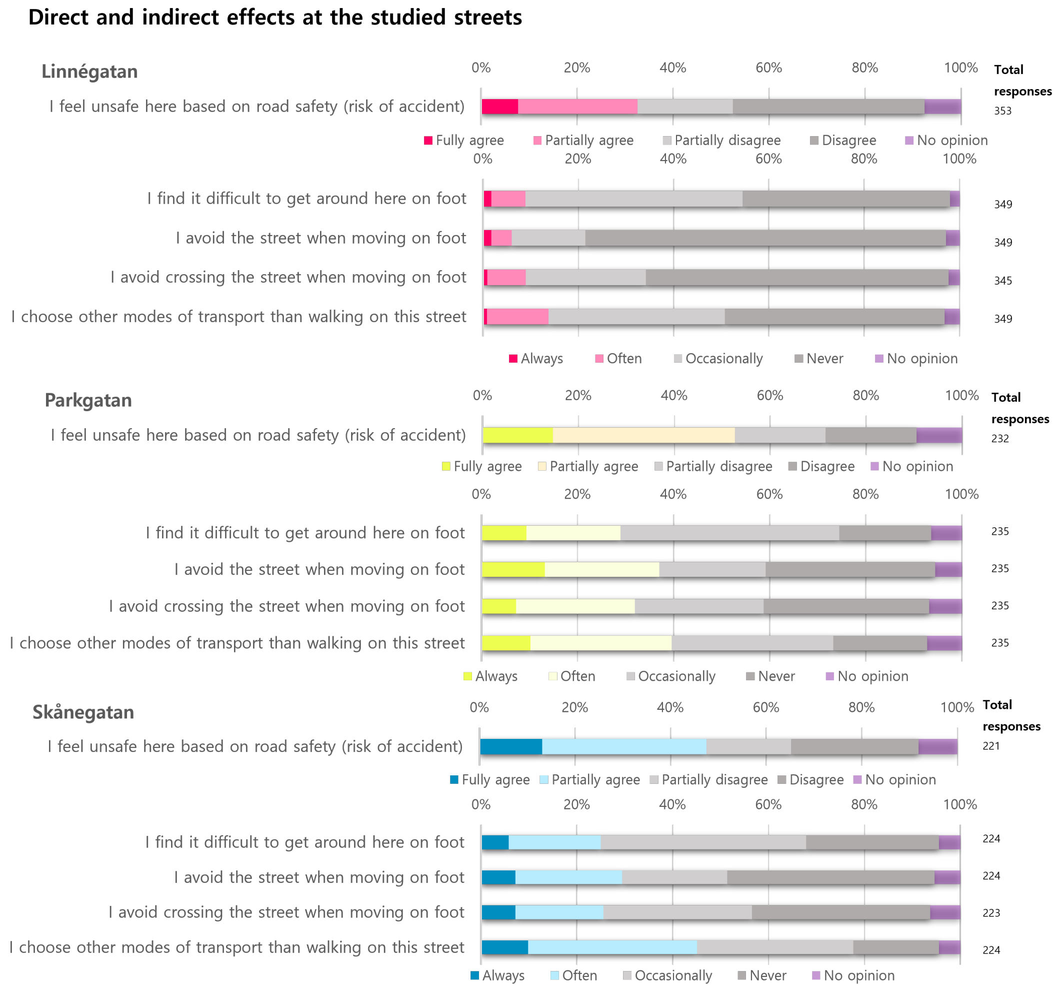

Figure 5.2: Estimations of how the respondents experience the studied barrier effects, presented for each case street.

In the survey, respondents provided estimations regarding the perceived quality of transport features, crossing facilities, and environmental features. Starting with results of features associated with transport and crossing facilities, presented in Figure 5.3. Included in transport features is traffic volume, being the most apparent factor according to the respondents. 61 percent of the respondents at Linnégatan either 'Fully agree' or 'Partially agree' that the traffic volume is excessive. These numbers are even higher at Parkgatan and Skånegatan where 74 respectively 72 percent either fully or partially agree that 'There is too much car, bus, and tram traffic'. Following traffic volume, the highest estimations are regarding traffic speed which is slightly higher than the lack of pedestrians crossing, at least for Linnégatan and Parkgatan. Regarding Skånegatan, the estimations of traffic speed, lack of pedestrian crossings, and the waiting time at crossing facilities are similarly rated. The lowest estimations are the experience of too broad road width at Linnégatan, while the statement concerning obstacles hindering crossing has the lowest rating at Parkgatan and Skånegatan. Overall, the assessments of transport features and crossing facilities reveal a consistent pattern for where traffic volume received the highest rating at each street, followed by progressively lower ratings for each subsequent feature, ending with the perception of road width or obstacles.

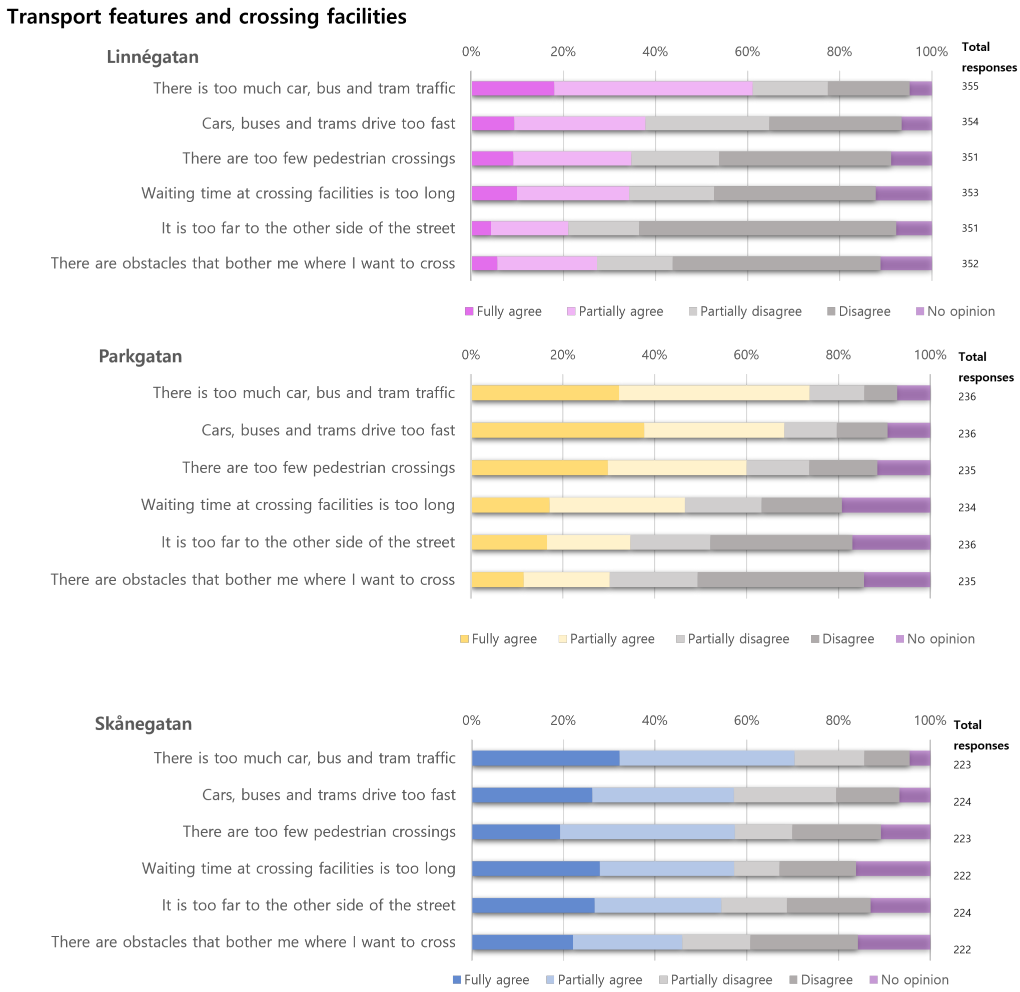

Figure 5.3: Estimations of how respondents perceive features of transport and crossing facilities at the case streets.

For estimations of perception of environmental features at the studied streets, the results do not follow patterns, as for the estimations of barrier effects and transport features, but are more varied which can be seen in Figure 5.4. At Linnégatan, the respondents seem to mostly agree with the statement regarding the width of pavements followed by lack of greenery, while a lack of active ground floors and social activity are the two highest estimated statements at Parkgatan. Regarding Skånegatan, a lack of greenery and active ground floors seem to be the most agreeable statements. Furthermore, even though about 35-40 percent either fully or partially agree with the statement 'There are too few benches and seats along the street', this statement consistently has the highest portion of answers of 'No opinion'. This suggest a general lack of interest in this issue among the respondents, while those who do express an opinion demonstrate relatively strong concerns.

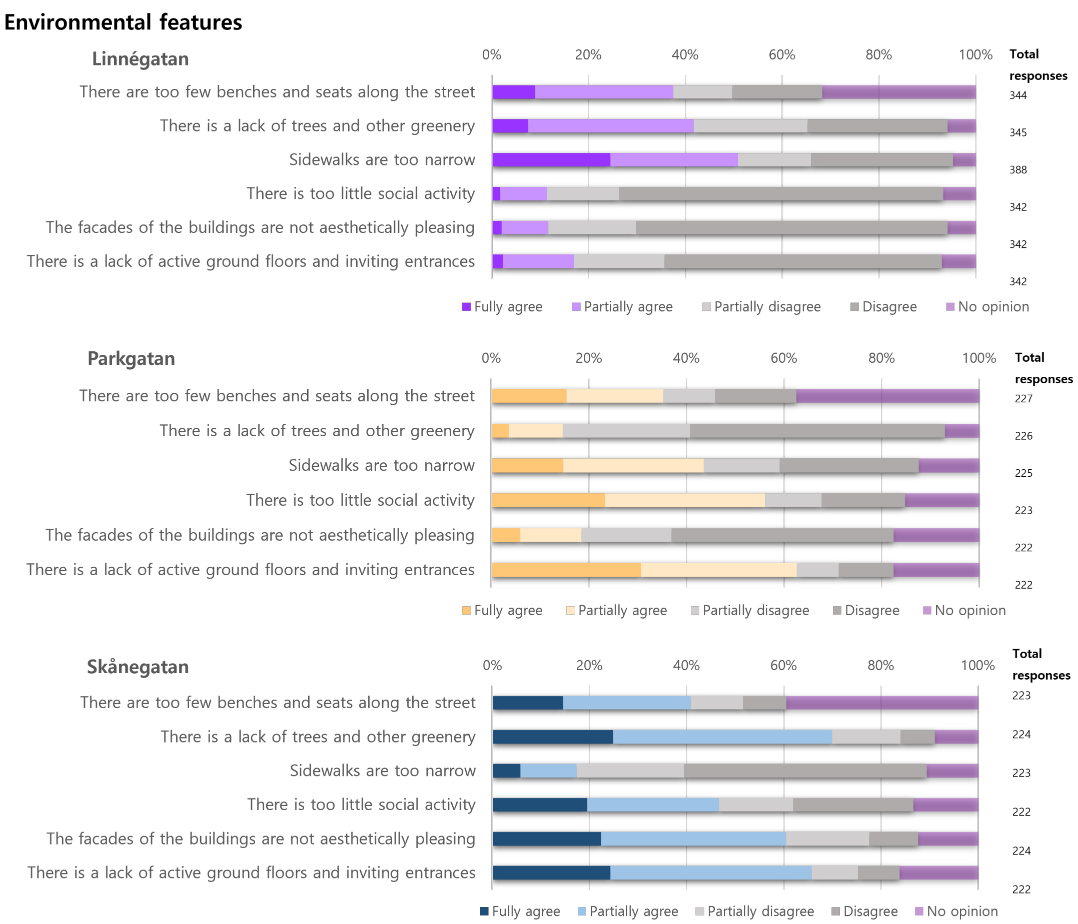

Figure 5.4: Estimations of how respondents perceive environmental features at the case streets.

The final charts presented in this section demonstrate how different age groups and genders have stated their perceptions of barrier effects. Presented are estimations of two barrier effects, given as examples of variations. Examples presented are the statements 'I feel unsafe here based on traffic safety' and 'I avoid crossing the street when moving on foot' illustrated in Figure 5.5 for the different age groups and Figure 5.6 for gender. The total answers are reported above each bar to understand the differences in total respondents within a group of age or gender. When studying the variations of all studied barrier effects considering age, no typical patterns could be identified, meaning that the graphs are different from each other. As can be seen in Figure 5.5, the youngest participating age group, i.e., 10-19 years, has the lowest estimations of barrier effect on almost all streets. Notable though, no participants were in the age group of 0-9 years. Regarding the oldest age group, here 70 years or more, the outcomes are more varying. While this age group has relatively low estimations for e.g., the street at Linnégatan and Skånegatan, the same group has relatively high estimations for e.g., avoiding the street at Parkgatan and feeling unsafe at Linnégatan and Parkgatan. Moreover, the intermediate age groups are also showing varying results. Again, it is important to note that the outcomes from the other statements differ significantly from those discussed here, indicating there is no clear pattern to identify.

Figure 5.5: Graphs showing the variation between different age groups' estimations of the statements 'I feel unsafe here based on traffic safety' and 'I avoid crossing the street when moving on foot'. The number over each bar refers to the number of respondents within each age group.

The variation between genders for the two examples generally follows a pattern. As can be seen in Figure 5.6, women and men have estimated the statements similarly. Looking in more detail, the estimations of women are a bit higher than the men group, implying that women experience the studied barrier effects a bit more than men. Although there is a pattern, the differences are very small.

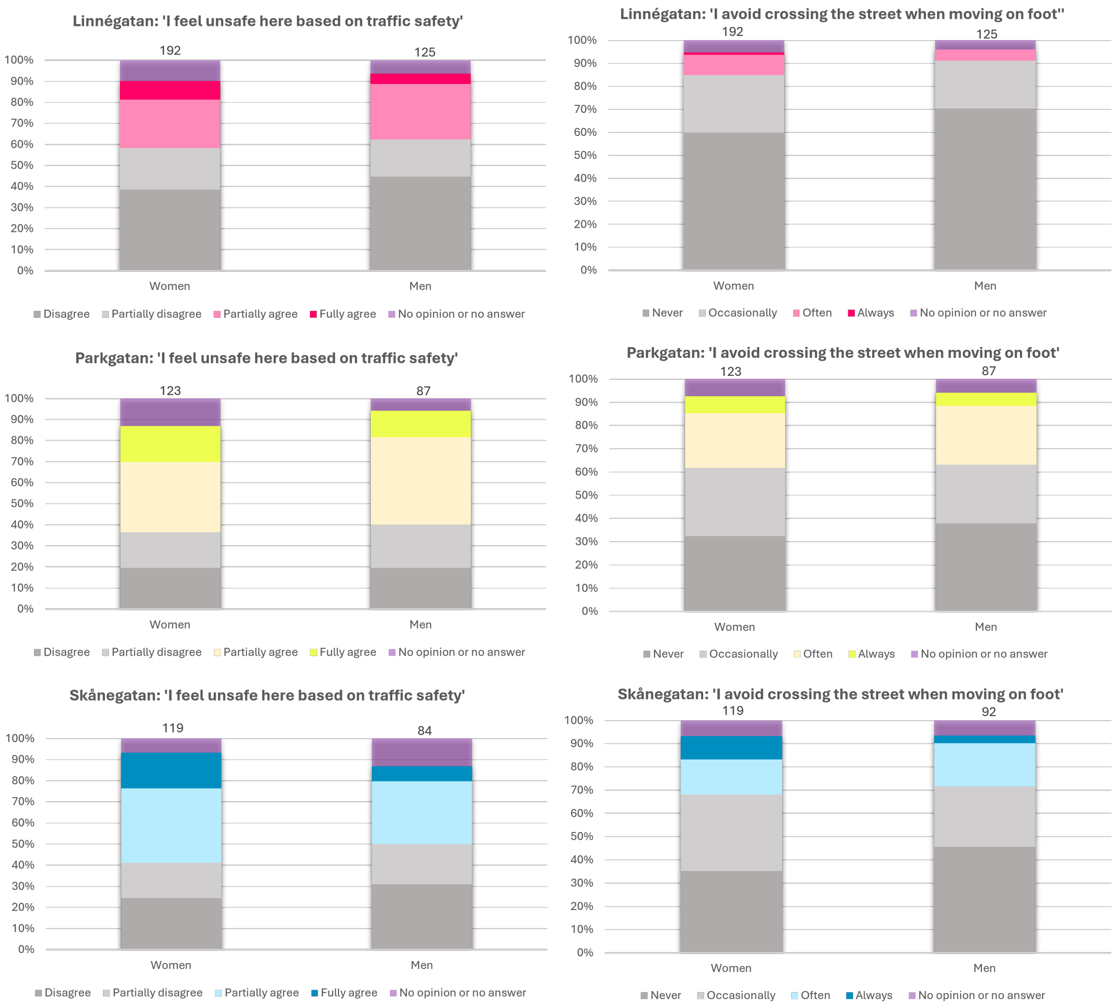

Figure 5.6: Graphs showing the variation between women's and men's estimations of the statements 'I feel unsafe here based on traffic safety' and 'I avoid crossing the street when moving on foot'. The number above each bar refers to the number of respondents within the gender group.

5.3 Regression analysis

In this section, the outcomes of the regression analyses are presented. Here, only a summary of the significant results is presented. The outcomes of the 18 regression analyses are further detailed in E. In general, the overall percentages and Nagelkerke values were relatively high for all conducted regression analyses, implying that the models rather well capture the phenomena. In Figure 5.7 and 5.8, the significant outcomes of the regression analyses are presented together with a specification of the overall percentage of accuracy and the Nagelkerke value. In these figures, the numbers represent the OR values, where the green results indicate significant and positive associations, i.e., OR values greater than one, and the red boxes indicate significant and negative associations, i.e., OR values less than one. For the interpretation process of the results and variables, it is important to note that the statements are biased, e.g., 'there is too much car, bus and tram traffic', implying that it concerns the experience of 'too much', not simply stating that there is traffic present at the site. Furthermore, not agreeing with the statement does not indicate the opposite, that the situation is ideal, but could simply indicate that the conditions are 'not poor'.

In Figure 5.7, the significant results of the regression analyses regarding traffic volume and the studied direct effects, i.e., fear of traffic accidents and passing and crossing effort, are presented for the three studied streets. For the dependent variables of traffic volume and direct effects, outcome 1 was used if the respondent 'Fully agree' or 'Partially agree' and outcome 0 was used if the respondent 'Partially disagree' or 'Disagree' with the statement. The same procedure was for the options including 'Always' or 'Often', which was set to 1, and 'Occasionally' or 'Never', which was set to 0. As can be seen, the experience of traffic volume only has one significant association which is with fear of traffic accidents at Skånegatan, implying that if the experience of excessive traffic volume increases, so do the odds that the participants feel unsafe based on traffic accidents. Regarding traffic speed, it seems to be an important factor, influencing the perception of traffic volume on all three streets, in addition to fear of traffic accidents at Parkgatan and Skånegatan. The perception of too few pedestrian crossings is also significant for the same dependent variables, where it is significant and positive for the perception of traffic volume at Linnégatan and Parkgatan and fear of traffic accidents at Parkgatan and Skånegatan. However, this variable is also significant but negative for fear of traffic accidents at Linnégatan, implying that if the experience of 'There are too few pedestrian crossings' increases, the odds of the outcomes of 'Partially disagree' and 'Disagree' increases for the statement 'I feel unsafe here based on traffic safety'. Noteworthy regarding the same outcome, fear of traffic accidents, is that the Nagelkerke value is relatively low, indicating that the model's ability to predict this phenomenon is limited to only 8.3 percent. Regarding the last independent variable included in the category transport features and crossing facilities, no significant associations were identified.

For the environmental features, there were no significant outcomes for the perception of traffic volume or fear of traffic accidents, but several significant and positive associations for passing and crossing effort, which can be seen in Figure 5.7. While a lack of greenery and active ground floors is associated with this barrier effect at Parkgatan, the perception of too narrow pavements is significant at both Linnégatan and Skånegatan. These significant and positive associations imply that if the participants state that they agree with the statements for the independent variables, the model predicts that the outcomes of 'Fully agree' or 'Partially agree' with the statement concerning passing and crossing effort increases. Lastly, no associations were found for the impact of buildings' facades on the three streets for traffic volume and the studied direct effects. Lastly, regarding the associations for the independent variables related to the category of demographics, only two significant results were found – for the independent variable of age. While the association between age and perception of traffic volume at Parkgatan was positive, the association with crossing and passing effort at Parkgatan was negative. This implies that the older a respondent was, the higher the odds of perceiving excessive traffic volume, and the younger a participant was the higher the odds of estimating difficulties when moving on foot at Parkgatan. No identified outcomes suggested that typical transport mode at the street, frequency of visits at the street, or gender affect the results.

		Traffic volume 'There is too much car, bus and tram traffic'			Fear of traffic accidents 'I feel unsafe here based on traffic safety'			Passing & crossing effort 'I find it difficult moving around here'		
		L	P	S	L	P	S	L	P	S
	Overall percentage	75,0	86.4	81.4	63.3	75.6	74.2	94,0	82.3	85.4
	Nagelkerke	0.327	0.569	0.345	0.083	0.441	0.429	0.373	0.441	0.4
Transport features & crossing facilities	'There is too much car, bus and tram traffic'	-	-	-			2.225			
	'Cars, buses and trams drive too fast'	2.550	3.904	2.630		2.190	1.580			
	'There are too few pedestrian crossings'	1.581	3.171		0.660	2.217	1.658			
	There are obstacles that bother me where I want to cross'									
Environmental features	'There is a lack of trees and other greenery'								1.987	
	'Sidewalks are too narrow'							3.175		1.648
	'The facades of the buildings are not aesthetically pleasing'									
	'There is a lack of active ground floors and inviting entrances'								1.893	
Demographics	Typical transport mode at the specific street									
	Frequency of visits at the specific street									
	Gender									
	Age		1.780						0.729	

L = Linnégatan, P = Parkgatan, S = Skånegatan

Figure 5.7: A summary of the significant outcomes from the regression analyses related to traffic volume and the studied direct effects. The values refer to the OR values, where the green values indicate positive associations and the red negative associations.

Proceeding to the results from the regression analyses of the studied indirect effects; they are presented in Figure 5.8. Different from the direct effects, the option of 'Occasionally' is included in outcome 1 for the indirect effects, together with 'Always' and 'Often'. Only 'Never' is set to be outcome 0. For the independent variables related to the category of transport features and crossing facilities, the perception of excessive traffic volume is significant and positively associated with all three indirect effects at Parkgatan, implying that if the respondents included in the analysis of Parkgatan estimate the perception of excessive traffic volume higher, the odds of either 'Always', 'Often', or 'Occasionally' avoiding the street, avoiding to cross the street, and choosing other types of transport modes than walking increases. Further, no significant associations could be identified for traffic speed, and only one for lack of pedestrian crossings which influence the odds of the outcome of avoiding crossing the street on Linnégatan. However, the variable related to obstacles is positively associated with the frequency of visits at Skånegatan, while for two of three streets regarding the indirect effects of routing of trips. In Figure 4.6 in Chapter 4 it can be seen that fences stretch over a majority of the street on Skånegatan. In this case, the main barrier may be assumed to be the fences impacting the pedestrians' accessibility.

Regarding the environmental features, it can be seen in Figure 5.8 that there are several significant associations. Particularly, there are five significant and positive associations for the statement 'pavements are too narrow'. These significant results are associated with all three streets for the statement of avoiding the streets and two

		Frequency of visits 'I avoid the street when moving on foot'			Routing of trips 'I avoid crossing the street when moving on foot'			Mode of transport 'I choose other modes of transport than walking on this street'		
		L	P	S	L	P	S	L	P	S
	Overall percentage	76.8	76,0	69.8	69.6	80.8	73.1	68.7	80.3	84.6
	Nagelkerke	0.151	0.516	0.322	0.194	0.519	0.316	0.186	0.279	0.279
Transport features & crossing facilities	'There is too much car, bus and tram traffic'		2.481			2.908			2.408	
	'Cars, buses and trams drive too fast'									
	'There are too few pedestrian crossings'				1.674					
	There are obstacles that bother me where I want to cross'			1.416		2,000	1.472			
Environmental features	'There is a lack of trees and other greenery'		2.215							
	'Sidewalks are too narrow'	1.559	2.013	1.557		2.029	1.665			
	'The facades of the buildings are not aesthetically pleasing'		0.531	1.591						
	'There is a lack of active ground floors and inviting entrances'		2.194							
Demographics	Typical transport mode at the specific street							0.342		0.148
	Frequency of visits at the specific street		0.331	0.309			0.390			
	Gender									
	Age									

L = Linnégatan, P = Parkgatan, S = Skånegatan

Figure 5.8: A summary of the significant outcomes from the regression analyses related to the studied indirect effects. The values refer to the OR values, where the green values indicate positive associations and the red negative associations.

out of three for avoiding crossing the streets. According to the model, this implies that the more the respondents agree with the statement of pavements being too narrow, the higher the odds are for the outcomes of 'Always', 'Often', or 'Occasionally' avoiding the streets or avoiding crossing the streets. Additionally, there are positive and significant results for the lack of greenery and active ground floors which are positively associated with avoiding the street, but only significant at Parkgatan. Lastly, regarding the environmental features, the aesthetics of buildings' facades are significantly associated with avoiding the streets at Parkgatan and Skånegatan. The association is positive at Skånegatan, implying that the higher estimations of 'The facades of the building are not aesthetically pleasing', the higher the odds for the outcome of avoiding the street at least 'Occasionally'. However, the association at Parkgatan is negative, which indicates, according to the model, that the higher the estimations of perceiving the buildings' facades as not aesthetically pleasing, the lower the outcomes of avoiding the street. Though, when examining the estimations of the statement in Figure 5.4 not many respondents experience the aesthetics of the building facades as unpleasant on Parkgatan, and according to Figure 5.2 many respondents avoid the street. This implies that more respondents than those experiencing the buildings' facades as unpleasant also avoid the street. Therefore, this negative significant association seems somewhat puzzling.

For the category of demographics, negative associations could only be found among the significant outcomes for indirect effects, as demonstrated in Figure 5.8. The variable 'Typical transport mode at the specific street' implies whether the respondent walks or not and is significantly associated with the choice of transport mode at both Linnégatan and Skånegatan. These associations are reasonable since this explains that if the respondent typically does not walk on the studied street, it is more likely of the odds that they choose other modes of transport on the same street. Likewise, if the respondent typically walks more often on the studied street, it generates higher odds of not avoiding the street. This association is negatively significant at Parkgatan and Skånegatan. The final significant finding, a negative association between the frequency of respondents' visits to the street and their avoidance of crossing Skånegatan implies that more frequent visits to the street reduce the likelihood of avoiding street crossings. Similar to the significant results of the direct effects, no associations were identified for gender for the indirect effects, but also not for age.

5.4 Spatial and thematic results

This section presents the results from the spatial analysis of the spatial data and the thematic analysis of the accompanying comments. First, the locations marked where the respondents experience the street as 'complicated or an obstruction', for each street are presented along with a summary of the comments and identified themes among them. Then, locations, where the respondents experience 'the highest amount of traffic' on each street, are presented, followed by marked points where the respondents state they tend to cross the street without a pedestrian crossing present. Lastly, locations marked as 'pleasant places to be or walk' are presented along with the associated comments for this category. For each category, there are heat maps illustrating the results. Noteworthy is that the number of points and respondents differ among the streets, which is described further in each category section.

5.4.1 Street segments experienced complicated

Figure 5.9 illustrates heat maps of the distribution of pin-pointed locations for each street. The number of places marked on Linnégatan is 294, of which there are 214 unique respondents who answered. At Skånegatan, the number of places marked is 153, of which there are 114 unique respondents. Regarding Parkgatan, the number of places marked is 122, of which there are 91 unique respondents.

Figure 5.9: Heat maps visualising the distribution of locations where the respondents experience the street as 'complicated or an obstruction'.

There were 244 comments associated with the complicated locations on Linnégatan.

Overall, many comments highlight the narrow pavements and cycle lanes as well as the short distance between them, leading to conflicts between cyclists and pedestrians. At the designated crossings respondents expressed difficulties navigating through the many various transport modes along with excessive waiting time. Many participants have marked the shared tram and bus stations Järntorget and Linnéplatsen, at each end of the street along with the crossings close to them, as complex. Both the stations are described as chaotic with a congested traffic situation with high amounts of traffic, including various modes, coming from several different directions resulting in challenges of navigation. The respondents also expressed difficulties in crossing due to the abundance of traffic lights, cyclists, and pedestrians, as well as the presence of heavy vehicles. By the crossings close to Järntorget, the northern bus and tram station, concerns were raised about dangerous conditions due to high traffic volumes. The respondents also highlight the challenge of navigating through busy and stressful intersections with multiple modes of transportation including cars, trams, busses, and bicycles. Additionally, respondents expressed concern about unclear crossings and conflicts between pedestrians and vehicles. The high amount of traffic leads to stress and uncertainty for pedestrians, especially during rush hours or bad weather conditions. Comprehensively, the northern section of Linnégatan is described as chaotic and the respondents experience difficulties in traversing safely.

North of the middle of Linnégatan, where the points are very dense, see Figure 5.9, there is another tram and bus station, Prinsgatan. Here a lot of comments concern the presence of several transport modes, sharing a small area as well as the presence of fences along the tram stop which are seen as obstructive, impeding pedestrian flow around the stop. South of Prinsgatan there is a cycle crossing where many respondents expressed the absence of a designated crosswalk for pedestrians, compelling them to take detours, wait, or having to cross other streets before being able to traverse Linnégatan. Markings, where respondents stated they cross the street without a crosswalk present, can further be seen in Figure 5.11 in the section about crosswalks. The expressed absence of crossing facilities on Linnégatan is recurring when moving southward. In the southern part, closer to Linnéplatsen, the intersections are described as very complicated and congested as they accommodate various transport modes from different directions, similar to Järntorget. Navigating through requires detours. Comments here highlight the concern of cyclists tending to speed through the area, adding to the complexity. Additionally, there is a lack of clarity regarding pedestrian pathways and designated bike lanes.

On Skånegatan, 112 of the marked locations are accompanied by comments. Many respondents marked the northernmost crossing of the street, by Ullevigatan, and the most common motivation is dense traffic from various directions, including cars, trams, buses, and bicycles, leading to long waiting times for pedestrians at traffic lights. Participants mentioned excessively long red light intervals and the signals not being synchronised in this intersection. Along the street, some described the tram track and the belonging fence as a barrier hindering respondents from crossing the street where they want to cross. They also expressed limited crossing options and far distances between the existing pedestrian crossings. Recurrent along the street are comments about complex intersections, where the distribution of points is very dense. This can be seen in Figure 5.9 where the four large crossings of Skånegatan are marked to a greater extent. Here, the comments mention high levels of traffic and that the combination of various traffic modes increase navigation difficulties. In the southern part of the street, comments describe a disorderly and stressful environment with various traffic modes making it difficult for pedestrians to navigate safely, particularly when crossing or interacting with other traffic modes. Respondents also mentioned the ongoing construction related to the construction site by Korsvägen. Further, comments mention an environment dominated by cars despite the street being a hub for events and gatherings with a lot of pedestrians.

On Parkgatan there are 95 of the marked locations that are accompanied by comments. In the western part of the street, the respondents frequently expressed that the area is trafficked and impacted by the ongoing construction related to the construction site, resulting in poor visibility, barriers, and disrupted pedestrian and cycling lanes. Frequently mentioned is that crossing Parkgatan is challenging due to the absence of crossing facilities and the presence of multiple lanes for cars, trams, and bicycles. Because of the lack of crosswalks, a lot of respondents mentioned that they tend to run over the street where there are no designated pedestrian crossings, which was also observed multiple times during the site audits. The lack of pedestrian crossings was significantly mentioned and marked on the route from Hagaparken to Kungsportsavenyn. Further, the high vehicle speed and unclear traffic patterns were mentioned, increasing the challenges of navigating the area, leading to safety concerns and long waiting times.

The identified themes that are recurring among the comments, and that cause the experienced complications are presented in Table 5.3.

Theme	Description
Amount of traffic and traffic lights	The traffic density is perceived as high and traffic comes from various directions including numerous types of vehicles, such as cars, trams, buses, and bicycles. Additionally, waiting times at traffic lights are very long and the signals are not synchronised well for pedestrians, interrupting the walking flow.
High complexity at intersections	Large intersections are complicated due to the various traffic modes as well as the multiple lanes and tram tracks to cross, leading to uncertainties of who has the way and difficulties in navigation.
Pedestrian crossings	The lack of crosswalks increases difficulties in crossing the street and their design and level of complexity result in insecurity for pedestrians. Respondents mention they cross the street even if it is a red light, or where there is no pedestrian crossing.
Conflicts between different traffic modes	Various traffic modes share the same space which leads to conflicts, especially at pedestrian crossings and intersections. Conflicts between cyclists and pedestrians occur due to the unclear and narrow paths.
Stress and insecurity	Discomfort and fear are experienced due to speeding vehicles, complex intersections with long waiting times, and high traffic intensity resulting in situations experienced as chaotic.
Poorly designed infrastructure	Pedestrian and bicycle paths are frequently expressed as narrow and unclear, creating conflicts between them. Further, the infrastructure is designed with a car-oriented approach, creating difficulties in navigation for active travellers.

Table 5.3: Identified themes among the comments that are found common on all three streets.

5.4.2 Street segments with highest experienced traffic volume

The distribution of points marked where the respondents experience 'the highest amount of traffic' on each street, is illustrated as heat maps in Figure 5.10. A total of 330 points were marked on Linnégatan, by a total of 238 respondents. At Skånegatan, a total of 177 points were marked by a total of 133 unique respondents, whereas at Parkgatan the total number was 142, by 106 unique respondents.

The results show that the participants experience the highest amount of traffic to a greater extent in some specific sections of the street, especially at intersections. Marked locations for this category seem to reflect the marked locations in the previous category, locations experienced complicated. Similarities between the heat maps can be seen when comparing Figure 5.9 and 5.10.

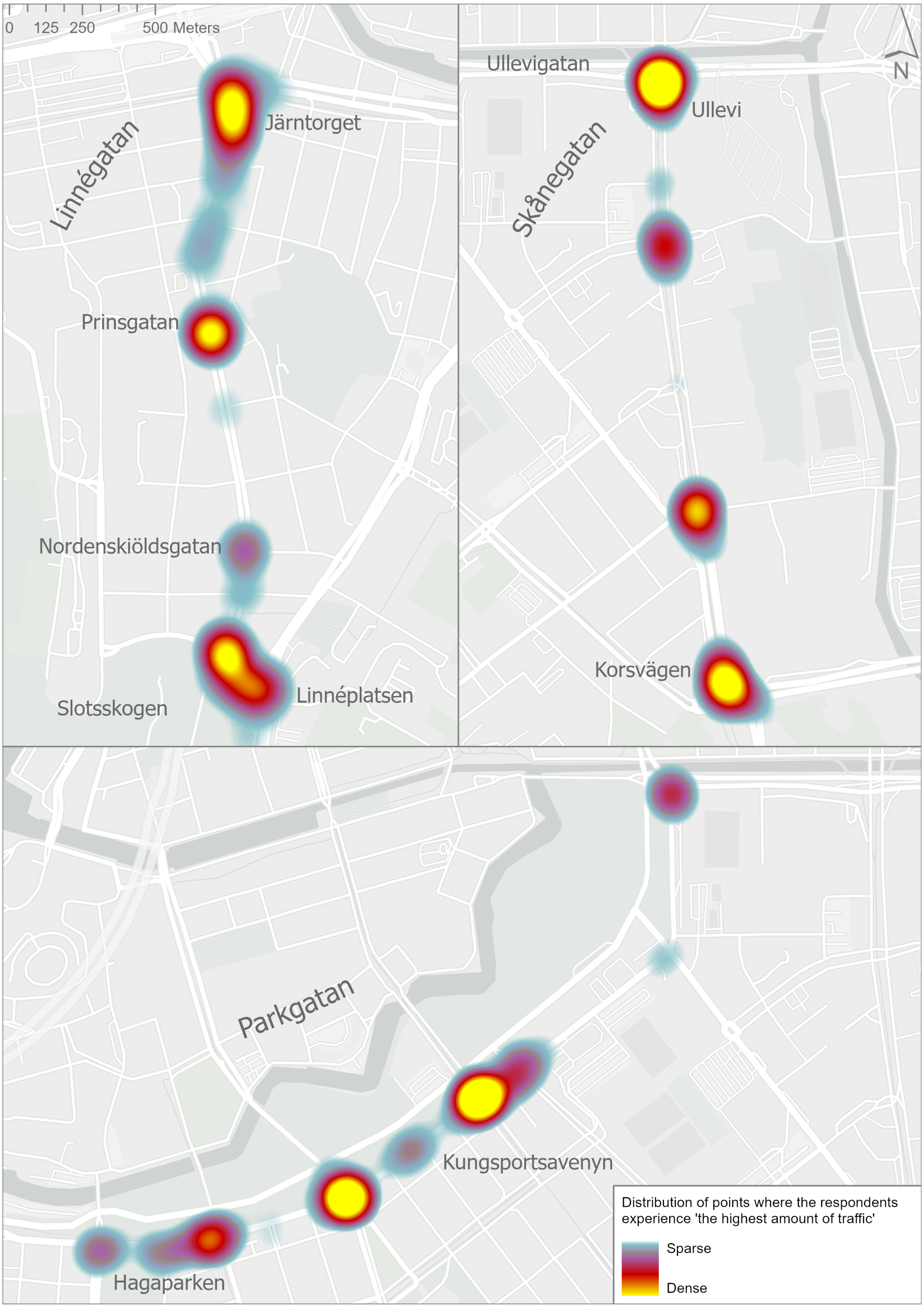

Figure 5.10: Heat maps visualising the locations where the respondents experience 'the highest amount of traffic' on each street.

5.4.3 Locations where the respondents cross without pedestrian crossings

Illustrated in Figure 5.11 are heat maps visualising the distributions of marked points on each street, where the respondents tend to cross the street despite no crosswalk being present, along with locations of existing crosswalks. On Linnégatan, there were a total of 169 marked points by 127 unique respondents. Regarding Skånegatan, there were 28 marked points by 27 unique respondents, and lastly, on Parkgatan there were 91 marked points, by 69 unique respondents. The markings are placed along the streets but to a lesser extent at Skånegatan, where the lowest number of points are marked. Since 133 participants answered the previous question about Skånegatan and only 27 answered this question, this may indicate that fewer people cross Skånegatan without a crosswalk present. The significant drop in the number of respondents is not as clear on the other streets. This might be because there are tram racks hindering crossing along the entire street at Skånegatan, apart from the intersections. Still, there are some marked locations on Skånegatan, which might indicate that people jump over the fences to cross the street. By examining Figure 5.11, the many marked points may indicate that there is a higher demand for crossing the streets than the supply of existing pedestrian crossings provides.

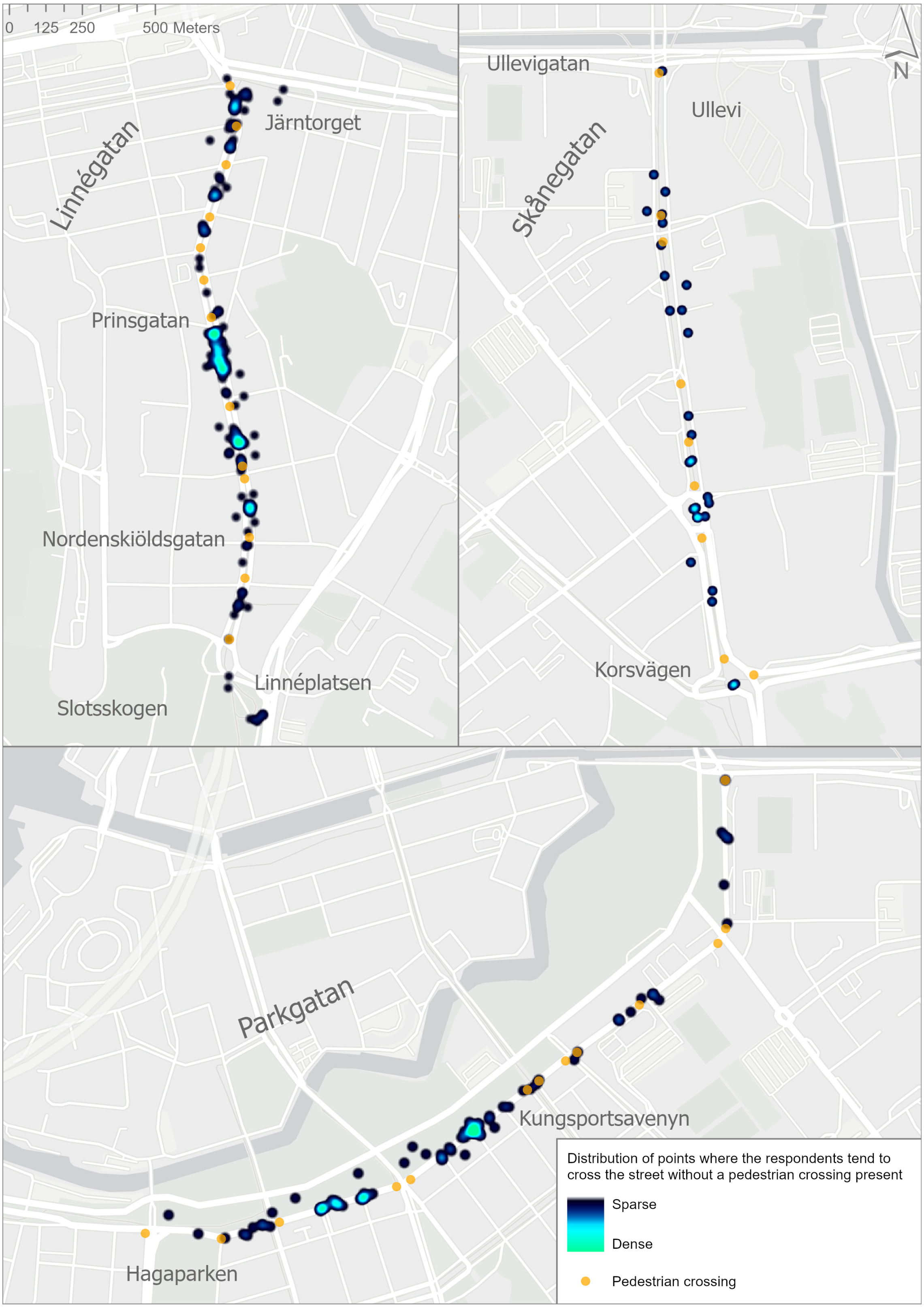

Figure 5.11: Heat maps visualising the distribution of marked locations where the respondents indicate they tend to cross the streets without a pedestrian crossing present, as well as the locations of existing pedestrian crossings for each street.

5.4.4 Designated pleasant locations

Heat maps visualising the distribution of locations marked as 'pleasant places to be or walk' on each street are presented in Figure 5.12. The number of points marked on Linnégatan was 236 by 204 unique respondents, 63 points were marked on Skånegatan by 63 unique respondents, and 64 points were marked at Parkgatan by 40 unique respondents. There are generally more respondents for Linnégatan than the other streets in the survey, but this large drop in responses compared to the previous questions in the survey for Parkgatan and Skånegatan may indicate that these streets are perceived as less pleasant compared to Linnégatan.

The number of accompanying comments to the places marked as pleasant on Linnégatan was 162. Overall, along the entire street, many comments praise the elegant architecture and intricate details of the building facades. Notably, some parts of the street, such as where the points are the densest in the middle of Linnégatan where there is a popular cinema and restaurant with outdoor seating, are particularly appreciated for their spaciousness, creating an open and social atmosphere. In the northern part, where Järntorget and the streets on the west side, meet Linnégatan many comments appreciate the abundance of restaurants and shops, along with a presence of city pulse. South of the middle section of the street, from approximately Prinsgatan to Nordenskiöldsgatan, respondents frequently mention the appeal of restaurants with outdoor seating and forecourts with gardens, especially on the eastern side because of the sunlight. Additionally, comments from this section highlight wider pavements contributing to a more pleasant walking experience. Overall, the southern part is perceived as a slightly calmer environment. Many respondents also mention the presence of trees and greenery as motivation, more frequently in the southern part closer to the large park, Slottsskogen.

On Parkgatan there were 40 marked locations with comments. Where the points are the densest is where Parkgatan meets and intersects with a very popular avenue street of Gothenburg, Kungsportsavenyn. The marking of these points is motivated by a lot of social activity, restaurants and bars, and appealing building facades in the comments. Overall, the most common theme mentioned in the comments is the presence of greenery and parks along the street. The respondents appreciated the open and park-like environment. A few comments mention that there are no pleasant places on this street.

On Skånegatan there were 43 marked locations with comments and they are denser in some street segments. In the north comments highlight a bit of greenery and a more open area. In the middle section, where the densest distribution of points is located, respondents appreciated the area outside of a cinema, with wider pedestrian lanes, open space, and outdoor seating. In the south respondents find the buildings on the west side pleasant as well as the presence of restaurants and cafes.

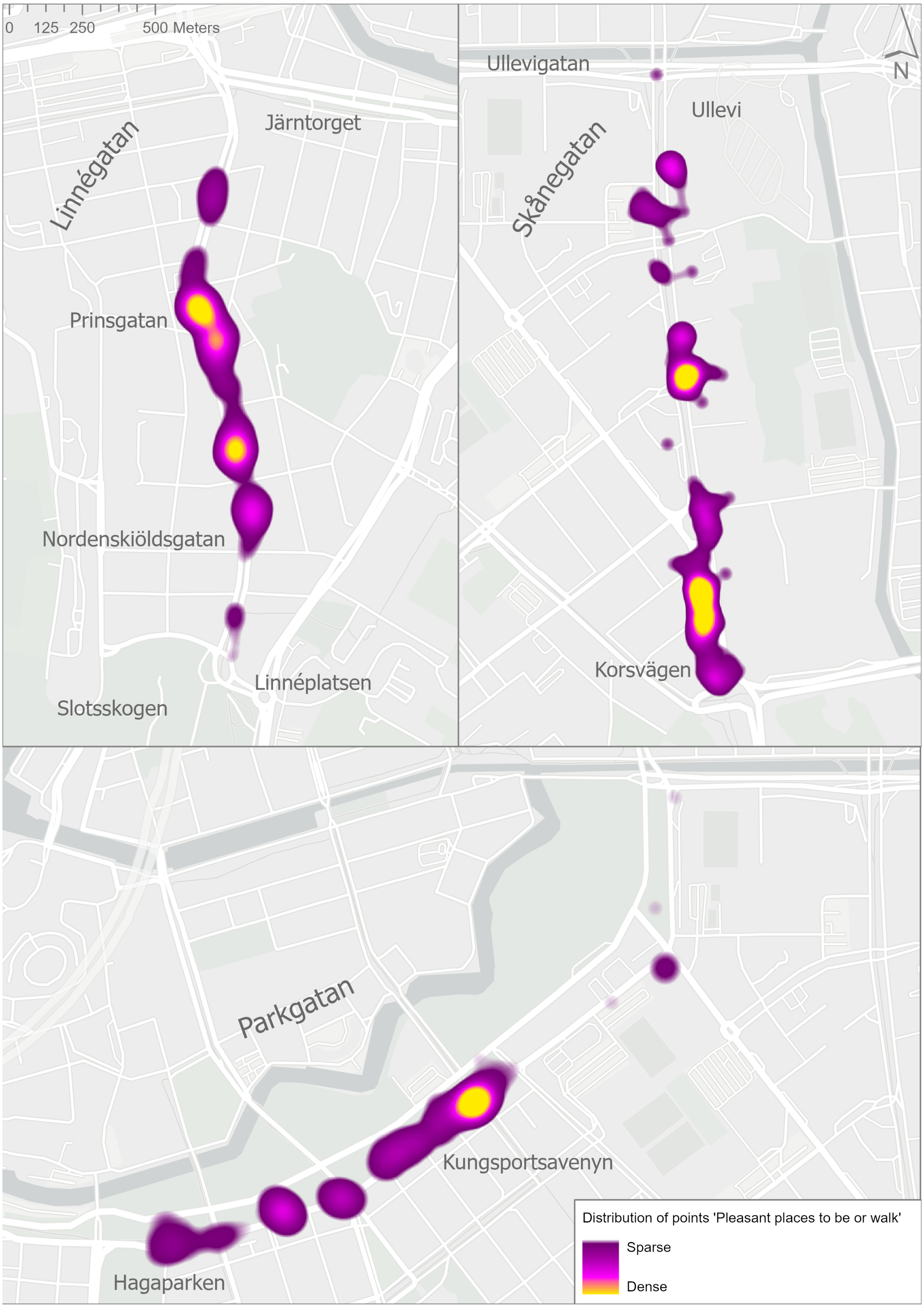

Figure 5.12: Heat maps visualising the distribution of locations marked as 'pleasant places to be or walk' on each street.

Several recurring themes emerged as common reasons why the marked locations are perceived as pleasant. The themes are presented in Table 5.4.

Theme	**Description**
Greenery and nature	The presence of vegetation and green areas is highlighted as contributing to a pleasant atmosphere. Trees along the pavements are appreciated.
Open spaces	Bright and spacious places are highlighted as well as wide streets and pavements, contributing to good visibility. Specific areas are noted for having broader pavements and more space, enhancing the pedestrian experience.
Social and cultural places	Restaurants, cafes, and shops are appreciated and contribute to a lively atmosphere with pleasant surroundings and social activity.
Aesthetics and architecture	Detailed and beautiful building facades are appreciated on all three streets.

Table 5.4: Identified recurring themes among the comments for all three streets.

6 Discussion

This chapter presents a discussion of the obtained results and is organised according to the research questions. Additionally, the limitations of the study are discussed along with further research suggestions. When discussing the consequences of this study's outcome, the obtained results reflect the importance of just and sustainable transport planning in cities. For the development of sustainable cities, walking plays a significant role. Some outcomes regarding factors impacting the experience of traffic and transportation elements in cities are crucial for design and planning processes. For instance, this thesis highlights the importance of the design of vehicular speed, crossing facilities, and obstacles, and suggests that these, to an extent, may be more important than traffic volume. Additionally, this thesis proposes that transport features are important for organising and mitigating conflicts between pedestrians and vehicular traffic. Environmental features, especially the width of pavements, are more important for the overall impression of the street space and could influence indirect effects to a greater extent. These insights might influence what attributes to prioritise in the streetscape and the importance of comprehensive planning, including convenience and comfort for pedestrians. Facilitating walkability could generate healthier and more economically just transport situations in cities. Gained knowledge regarding barrier effects may thereby influence the implementation of policies aiming to decrease barrier effects in cities and promote active travel. While previous research mainly is based on large infrastructure elements such as railways and motorways, barrier effects are in this study applied on central city streets with a mixture of land use purposes, where people are daily traversing. The outcomes of the study support the hypothesis of pedestrians experiencing barrier effects emerging also from central city streets.

6.1 How do pedestrians experience the barrier effects of busy streets in central parts of Gothenburg?

The central aim of this master's thesis was to investigate how pedestrians experience barrier effects of central streets in cities. According to the results, barrier effects are concluded to be experienced on these types of streets. Also, the studied indirect effects are experienced on the case streets. For instance, the respondents state that they avoid the streets, see Figure 5.2. These types of effects are rather severe in themselves, but can also lead to wider effects [van Eldijk et al., 2022]. Such wider effects applicable to these central city streets could be impacts on economic activity and social interactions, as well as a decline in the number of passers-by which may magnify the direct and indirect effects even more. However, considering the central location of these streets, these barriers may not be possible to avoid completely but can impact travel mode and frequency of visits. Indeed, some wider effects might already be noticeable at Parkgatan, where the indirect effects of avoiding the street are stated the highest. For instance, closed businesses are observed complemented by high estimations regarding lack of social activity and active ground floors among the obtained data of environmental features at Parkgatan as illustrated in Figure 5.4.

When comparing the estimations of barrier effects, it was evident that the streets generated different levels of barrier effects. Linnégatan demonstrated relatively low estimated effects. In addition, the literature suggests that respondents who state a higher walking frequency tend to estimate the occurrence of traffic related factors higher [Wahl et al., 2012b]. In the conducted survey, the respondents stated a higher walking frequency at Linnégatan compared to Parkgatan and Skånegatan, which may indicate even lower estimations of barrier effects at Linnégatan to be more representative to compare with the others. However, the variable 'Frequency of visits at the specific street' was added to the statistical model as an independent variable to detect any impact on the outcomes of experienced barrier effects. Three significant associations were detected for this variable where two out of these, on Parkgatan and Skånegatan, were negatively associated with avoiding the street. These negative associations imply that the more often the respondent visits the street, the odds of avoiding it decrease. Since there is only one significant and positive variable, the frequency of visits is assumed to not influence the outcomes of the regression analysis, and thereby opposes that the results at Linnégatan are higher estimated due to the higher frequency of visits. In addition, the variable 'Typical transport mode at the specific street' was also included in the regression analysis which only resulted in a few significant outcomes. The only significant associations are negative, but in this case with 'I choose other transport modes than walking on this street'. These associations are fundamental since this implies that people typically not walking on the street also choose other transport modes than walking on the street. This again strengthens the assumption that the estimations of barrier effects at Linnégatan is not estimated too high, and are thereby comparable to the other streets.

6.2 What is the impact of transport features and crossing facilities?

As there is a distinct difference in experienced barrier effects between the studied streets, despite all streets having approximately the same traffic volume, it can be concluded that other variables in the streetscape influence the perception of barrier effects. This is particularly interesting since traffic volume symbolises a dominant indicator when assessing barriers [Appleyard, 1972, Anciaes and Jones, 2016]. Indeed, only a few of the studied barrier effects are impacted by the experience of traffic volume according to the regression analysis. This suggests that other road and streetscape attributes should be included in the assessment of traffic barriers and the perception of infrastructural components, as it is in the conceptual model by van Eldijk et al. [2022]. As summarised in Figure 5.7 and 5.8, the regression analysis results indicate that traffic volume does not impact any barrier effect outcomes at Linnégatan and only one at Skånegatan. Though, for Parkgatan, traffic volume is significant and positively associated with all three indirect effects, i.e., avoiding the street, avoiding crossing the street, and choosing other transport modes than walking. Evaluating the estimations with the measured attributes within the streets, the respondents generally estimated the variables well, e.g., the street with the highest estimations of vehicular speed also has the highest measured vehicular speed. However, for traffic volume, this is not the case. While Skånegatan has the highest measured traffic volume, Parkgatan shows the highest estimations of traffic volumes, though only slightly higher than Skånegatan. However, the regression analysis models indicate that the experience of traffic speed impacts the experience of too high traffic volume, as this association is positive and significant for all three studied streets. In addition, Figure 5.3 shows that a higher portion of the respondents have estimated the speed to be too high at Parkgatan compared to Skånegatan, which, contrary to traffic volume, aligns with the measured speed at these streets. Overall, the statements concerning barrier effects, Figure 5.2, are also highest estimated at Parkgatan, where the measured traffic speed is highest but not traffic volume. Additionally, in the comments, respondents express that there are high traffic volumes, especially on Parkgatan. This suggests that vehicular speed, rather than volume, might be the primary factor influencing the perception of traffic.

Further, the discussed variables of transport features and crossing facilities involve variables positively significant at more than one street for one specific dependent variable. This suggests that these variables influence multiple cases, leading to a more reliable result. In addition to traffic speed, one such variable is the experience of too few crossing facilities. This impact on barrier effects aligns with the determinant of 'crossing facilities and street network' which is included in the conceptual model by van Eldijk et al. [2022] explaining the occurrence of barrier effects. In the regression analyses, this variable shows positive and significant associations for Linnégatan and Parkgatan regarding the perception of traffic volume and Parkgatan and Skånegatan for fear of traffic accidents. According to the estimations of transport features and crossing facilities in Figure 5.3, Parkgatan has the highest estimations of experiencing a lack of pedestrian crossings, followed by Skånegatan, while Linnégatan has the lowest estimations of this variable. Again, this corresponds to the measured spacing between crossing facilities. The absence of pedestrian crossings is also repeatedly expressed in the qualitative data of hindrance points for all three case streets. The last variable showing significant results at more than one street is the presence of obstacles which, according to the regression models, seem to influence the barrier effects of avoiding crossing the street for Parkgatan and Skånegatan, presented in Figure 5.8. This association is intuitive since if there are hindrances in the way of crossing, it affects the possibility of crossing the road. That it is particularly Parkgatan and Skånegatan that are affected by this variable can be explained by that these streets have obstacles, especially Skånegatan where fences stretch over large parts of the street, see Figure **??** in Chapter 4.

In general, comparing the distribution of significant results in Figure 5.7 and 5.8 for transport features and crossing facilities, it is evident that these types of variables are more frequently occurring for traffic volume and fear of traffic accidents, and to some extent for routing of trips, than for the other barrier effects. In a way, this is reasonable, since traffic volumes are dependent on transport features to exist and crossing facilities to be managed. In addition, fear of traffic accidents is commonly experienced at crossing facilities according to [van Eldijk et al., 2022].

6.3 What is the impact of environmental features?

The results from the regression analysis regarding environmental features are very different between the various statements of experienced barrier effects. Among all environmental features, the variable referring to too narrow pavements is most frequently positive and significant. It is also the only studied environmental feature having significant results at more than one street for one specific barrier effect. It is positively significant at two out of three case streets regarding finding the streets difficult and avoiding crossing the street, while at all three streets for avoiding the street. This implies a relatively high influence of this variable on the studied barrier effects according to the conducted regression analyses, where this indicates that narrow pavements increase the experienced barrier effect. This is further strengthened by the qualitative outcomes in the thematic analysis. The feature is mentioned frequently among the comments on complicated street segments, but there are also comments appraising the wider pavements in the comments on the markings of pleasant places to be or walk.

One of the significant variables of the environmental features is negative, that is 'the facades of the buildings are not aesthetically pleasing', which is negatively associated with 'I avoid the street when moving on foot' for Parkgatan. This indicates that a decrease in the experience of not aesthetically pleasing building facades increases the odds for the outcome of avoiding the street. According to the statistical model, this implies that more enjoyable building facades increase the effect of avoiding the street, which might seem counter-intuitive. At Parkgatan, many comments highlight the facades, and according to results illustrated in Table 5.4, most of the participants disagree with that the facades are unpleasant. Furthermore, Parkgatan is the most avoided street, but it could be argued that it most likely is not due to the facades. The results from the regression analysis that impact the increase of avoidance of Parkgatan are many. For instance, the independent variables representing too much traffic, lack of greenery, narrow pavements, and the absence of active ground floors, all impact the odds of the outcome of avoiding Parkgatan according to the model. Furthermore, the comments motivating the locations of enjoyable places to be or walk highlight the facades, especially aesthetically appealing facades, on all three streets, visible in Table 5.4. It is most frequently mentioned on Linnégatan, while the comments regarding Skånegatan are fewer and more located to a certain spot on the street, where there is an architectural character more similar to the buildings on Linnégatan and Parkgatan. While the association between facades and avoidance of the street is significant and negative at Parkgatan, it is significant and positive at Skånegatan and not significant at Linnégatan. Otherwise are there no other significant associations regarding the facades, clarifying the insignificance of this variable on barrier effects even more. Despite this, since the appealing building facades are highlighted extensively in the comments, it is suggested to have an impact on the walking experience, which is confirmed by literature [Handy et al., 2002].

Another environmental feature that is frequently appreciated among the comments is greenery, see Table 5.4. The presence of vegetation is consistently highlighted on all three streets at the segments where trees are present. Interestingly, the only street where a lack of trees was significant with barrier effects is Parkgatan, where there are far more trees than on the other streets, evident in Figure 4.4. However, the trees present are mostly located in the park areas along Parkgatan, in comparison to Linnégatan and Skånegatan where there are tree alleys along the entire pavement, separating the pavement from the car traffic. Hence, this could imply that the presence of tree alleys along pavements has a different impact on the perception of the surrounding greenery compared to the number of trees close to the road. In any case, the results of the regression analyses in this study indicate that a lack of trees and other greenery does not have an impact on the experienced barrier effects. However, as with building facades, according to the comments, it can be concluded that it is a feature that is much appreciated but may be affecting the walking experience rather than the experienced barrier effect.

The significant outcomes of the regression analyses regarding environmental features are more aggregated at the effects of passing and crossing effort and frequency of visits, shown in Figure 5.7 and 5.8. Both of these effects, require a more comprehensive perspective to be assessed to understand if there are potential risks of these effects and to what degree. Crossing and passing effort can be impacted by several different attributes such as delay, physical effort, stress, and fear of traffic-related accidents [van Eldijk et al., 2022]. Similarly, indirect effects are hard to assess since it is based on to what extent the barrier impacts e.g., effort, accessibility, and travel time, but also depend on the tolerance of the travellers. This, in addition to the environmental features being particularly commented on concerning pleasant places on the streets, may indicate that environmental features may be suggested, to a greater extent, to have an impact on the walking experience rather than specifically the barrier effects. However, the presence of environmental features, such as greenery, buildings' facades, and active ground floors and welcoming entrances, may positively influence and mitigate barrier effects, somehow serving as a resistance against the impact of them on pedestrians' everyday lives.

6.4 How do these experiences vary between age and gender?

Overall, the regression analysis statistical models did not find significant relationships between the demographic variables, age or gender, related to the outcomes of perceived traffic volume or experienced barrier effects. In contrast with this, previous studies suggest the importance of these factors when analysing the social impacts of barrier effects [van Eldijk et al., 2022]. Regarding the age variable, children and the elderly are suggested to face more challenges and limitations in trafficked environments due to sensorial, cognitive, and practical constraints. This implies a non-linear relationship, not fulfilling the demand of linearity which is required within binomial regression analysis. Though, since children under the age of ten were absent in the survey population, this could generate this linear relationship, but can not be confirmed. In addition to the regression analyses, plots showing the distribution of how different age groups estimated the studied barrier effects were analysed to see if there were any other forms of patterns to identify, where Figure 5.5 provides such examples. Nonetheless, no clear patterns were identified in these plots either. However, for this method of analysis, the low representation of children and elderly might have impacted the outcomes.

Moreover, the correspondent literature indicates that different gender groups are likely to experience barrier effects differently, where women tend to experience barrier effects more severely than men [van Eldijk and Gil, 2020]. Despite this, the gender variable gives only a few and solely nearly significant outcomes in the regression model. In addition, one of these outcomes is a negative association, implying that men experience this barrier effect more severely. Again, the low variation in age may implicate these few outfalls from the regression analysis, since most people answering are in a non-sensitive age to experiencing barrier effects. However, to analyse the potential difference between genders further, plots were also analysed for this demographic group. In the plots showing the variation of how men and women answered the different statements in Figure 5.6, only small differences could be hinted at, where women estimated the statements slightly higher. However, this impact could not be statistically confirmed in the regression analyses, indicating minimal differences. While previous research suggests differences in perception between genders, it is rarely examined comprehensively. One study, investigating the support of pedestrianisation concluded almost identical results between genders [Nello-Deakin et al., 2024]. This suggests that the findings of this thesis regarding gender, i.e., that there is no or a very small relation between gender and experienced barrier effects, may be accurate. This result could be significant, as it challenges previous assumptions about gender variations, or at least suggests a similarity regarding perceptions of barriers in urban environments.

6.5 Limitations

While the studied effects address some direct and indirect effects, some were not included. For instance, the direct effects of trip effort and accessibility, and indirect effects of visited destinations and organisations of trips are not addressed [van Eldijk et al., 2022]. Additionally, the studied effects are only focusing on one indicator each. For example, discomfort is used to describe crossing and passing effort, while other indicators, such as delay, fear of traffic accidents, and stress, also indicate this barrier effect. Thereby, the addressed barrier effects are only partially described and do not answer for the full phenomena. Regarding studied indirect barrier effects, these effects are studied as stated behaviours for a present barrier, not change in behaviour after implementing a barrier. Therefore, it is not certain that there has been a change in travel behaviour, indicating indirect barrier effects.

Furthermore, when conducting a case study, it is important to make sure that the case is representative, otherwise one can not generalise from it. There are always uncertainties regarding the possibility that even though the outcome is interesting, it is unique to the particular circumstances of the case. For this study, conducting three case sites reduced the risk of this problem. However, conducting additional case studies would have reduced the risk further. Additionally, using more similar and comparable case streets could lead to more solid conclusions. Furthermore, all three case sites are located in Gothenburg, which makes a generalisation less valid if applied to any other location. Further, for the obtained results, it may complement and strengthen previous research regarding indicators impacting barrier effects, while it is difficult to state whether these results solely apply to city streets with this magnitude of traffic volume, composition of streetscape, or location. Though, it is likely that some variables have an impact on barrier effects, but are probably not the only influencing factors. For example, even though literature highlights the impact of traffic volume [Appleyard, 1972, Anciaes and Jones, 2020], it is not deemed critical in the obtained results.

It is important to highlight that the study is based on participants' individual perceptions, shaped by their personal preferences and experiences. Additionally, the data relies on their interpretation of the survey questions, adding another layer of uncertainty. What "too much traffic" means for one respondent, might not be rated likewise by another. According to Wahl et al. [2012b], minor variations in the phrasing of questions can bias the respondents' answers. On top of this, the survey is based on stated preference, which relies on the respondent's memory and observation. To reduce the uncertainty among the answers, the alternative 'No Opinion' was included in the rating scales. However, revealed preference, such as observed behaviour, is generally more reliable. On the other hand, when estimating people's perceptions and experiences, it might not be as easily revealed as stated. Another aspect to consider is the opportunity given to the respondents to complain about occurrences related to traffic through the survey, implying they might rate statements higher than they actually experience the effects. In a study by Wahl et al. [2012a] this was however, not the outcome when people's estimation of an occurrence related to traffic was examined with their level of annoyance with it.

Another important part of the study to discuss is the regression analysis and the statistical model. Even though the significant values from the regression analysis are relatively many, indicating that the independent variables correctly do impact the odds of the outcome according to the model, it is also important to consider that all influencing variables are not included in the analysis. The variables included in this study do not explain the full phenomena, and other variables could have a larger impact. Further, some of the associations between the dependent and independent variables could be merely due to correlation. While the theoretical mode suggests a causal relationship, all statistical outcomes do not necessarily reflect this notion. The model does, however, generate relatively high Nagelkerke values for most cases, which increases the reliability of the results. The findings also align with the literature on features impacting barrier effects and walking [Handy et al., 2002, Anciaes and Jones, 2016, Wahl et al., 2012b].

Furthermore, to claim the reliability of the results, the population of respondents participating in the survey is of high importance whether it is representative or not. Overall, the age distribution is not entirely representative, lacking respondents in the age groups that are, according to the literature, more sensitive to barriers [van Eldijk et al., 2022]. Other disadvantages of the survey as a data collection method are lack of depth and detail, especially when using quantitative data, low response rates, and the difficulty to reach contact with some research populations [Denscombe, 2017]. Having low response rates implies less data, which might result in data from only a certain type of people or views. Consequently, there can be a potential for bias, arising when patterns emerge in the responses, potentially reflecting the perspectives of those who chose not to participate. For instance, the respondents might be participating because of interest in the topic, and thereby the population might not be reflecting all social groups. Another consideration regarding the data is that it is essential to recognise the inherent limitations of the technique applied to sharing the survey on private social media platforms and among our social networks. While social network surveys offer convenience, they tend to homogenise the participant population [Denscombe, 2017]. By relying on "friends" or "followers", researchers unintentionally exclude individuals with diverse demographics and opinions. Consequently, the data may not fully represent the broader population. Moreover, the respondents might be influenced by their familiarity with the creators of the survey, potentially comprising the honesty of their responses. To avoid or reduce this matter, the participants and their responses were anonymous.

As for the survey tool, PPGIS, some participants had problems with the process of data input in the survey. When sorting the data this was notable not only by patterns not matching what was asked for, but also by respondents leaving comments unsure about the precision. Additionally, when answering the survey, the respondents were able to have different zoom settings, which could affect the accuracy. Therefore, this was taken into account when deciding which data to include and exclude. Additionally, according to the literature of previous PPGIS analyses, they often include inquiries regarding participants' experiences and preferences [Kahila-Tani et al., 2019]. However, the responses do not always represent well-defined geographical objects, which complicates the evaluation. The same study mentions that similar surveys to this project, have been found to alter in representing the wider population. Some studies are assumed to be representative of all social groups, while others have had over-representations in specific socioeconomic or geographical groups.

6.6 Further research

According to the obtained results, demographic groups of age and gender did not influence the experience of barrier effects in this study. However, further research is necessary on this topic before assuming this as the correct assumption for central city barriers. While the analysis of age could be influenced by various errors regarding data and methods, the result on gender is more reliable. Therefore, further research is essential to clarify the role of gender in this context. Otherwise, urban planning may restrict accessibility and mobility for limited demographic groups rather than enhancing it. Additionally, it is important to recognise that the tolerance for specific streetscape attributes differs among individuals, and is often related to various demographic groups, as noted in literature. Consequently, while some of the results of the studied variables aligned with previous findings, others did not. However, this does not imply that they do not impact the experience or perception of barrier effects and traffic in cities, but that these may need further reviewing and confirmation to be more credible. Conducting more studies analysing the influence of transport and environmental variables on barrier effects, including both the variables studied in this thesis but also other variables not included, would be a suitable approach for further research. Additionally, conducting similar comparisons of street attributes at more similar streets, only differing with a few attributes, would be preferred to facilitate the generalisation and ensure the outcomes of the studied variables.

Further research is suggested to include the influence of cyclists and bicycle infrastructure when assessing barrier effects from the pedestrians' perspective. In accordance with the knowledge gained from the qualitative data, the cyclists and bicycle lanes are also perceived as barriers. Also, this potential conflict between various sustainable transport modes, such as walking, cycling, and public transport, is worth exploring since these modes are central to the development of sustainable cities. The issue of barrier effects in its essence includes multiple fields of sciences, such as transport and urban planning, psychology, economics, and health, which indeed would benefit of further transfer between the various sciences. Accordingly, with van Eldijk et al. [2022], this is a direction of further research, complementing already existing theories and methods. In summary, all further research on barrier effects in cities contributes to the understanding of this phenomenon, given the limited previous research within this particular field.

7

Conclusion

This master's thesis aimed to contribute to the understanding of the barrier effects of busy streets in cities. To undertake this, the thesis investigated how pedestrians experience barrier effects by adopting a methodology of a case study of three busy central streets in Gothenburg city. In addition, the thesis investigated which factors in the streetscape may influence how barrier effects are perceived. The experiences of direct and indirect barrier effects and various attributes in the streetscape categorised as 'Transport features and crossing facilities' and 'Environmental features', as well as demographic information, were collected through a survey. The results were obtained from analysing visualised data, regression analysis, spatial analysis, and thematic analysis.

This project is the first comprehensive investigation of the barrier effects of central city streets. The most obvious finding to emerge from this study is that barrier effects are experienced also on these streets, highlighting the importance of assessing barrier effects on central city streets. Also, several severe statements of barrier effects, such as avoiding a street, are shown to be experienced to a relatively large extent on the studied streets. Since all three case streets in this project endure approximately the same traffic volume, around 10,000 vehicles per day (AAWT), but generate different levels of experienced barrier effects, it can be concluded that additional factors are of importance when assessing barrier effects. In this study, the results from the regression analyses of transport features showed that vehicular speed is an important factor, suggested to influence the perception of the studied streets more than the traffic volume. Additionally, the spacing of crossing facilities and the presence of obstacles hindering crossings of the streets are important attributes influencing experienced barrier effects.

The relevance of environmental features is also supported by the findings of the regression analyses as the pavement width was shown to influence several of the studied barrier effects. None of the other environmental features, i.e., the presence of greenery, the presence of active ground floors and inviting entrances, and the aesthetics of building facades showed a consistent association with barrier effects across multiple case sites. Therefore, no conclusions can be drawn about the influence of these features on barrier effects based on the regression analysis. However, the importance of these features in shaping the walking experience was highlighted in the thematic analysis. Further research on how environmental features can influence barrier effects is therefore suggested.

Another finding from this thesis is that the results showed no differences between genders in the experience of barrier effects, which is assumed in previous literature, questioning this assumption's certainty. Regarding the other studied demographic variable, age, no conclusions can be drawn. This variable did not show any significant results in the regression analyses in addition to no identified patterns when visualising the data. Whether this is due to the sampling and uneven age distribution in the population, flaws in the statistical model assuming linearity, or if these differences do not exist for the studied case sites can not be verified.

Regarding the studied demographic variable, age, no conclusions can be drawn. This variable did not show any significant results in the regression analyses in addition to no identified patterns when visualising the data. Whether this is due to the sampling and uneven age distribution in the population, flaws in the statistical model assuming linearity, or if these differences do not exist for the studied case sites can not be verified. Interestingly, another notable finding from this thesis is that the results revealed no significant differences between genders in their experience of barrier effects. This challenges the previous assumptions in the literature, prompting a reconsideration of the assumption's reliability. Therefore, further research is essential to clarify the role of gender in this context. Generally, further research on city barrier effects is recommended due to the limited previous literature. Lastly, including bicycle infrastructure as a barrier to experienced barrier effects of pedestrians is valuable to explore the full perspective. This could also support the knowledge of conflicts between sustainable transportation modes in cities, including cycling and public transport in addition to walking.

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A

Design of survey

Overview of the survey questions. For the street-specific questions, Linnégatan is presented as an example since the questions for the other two streets are identical.

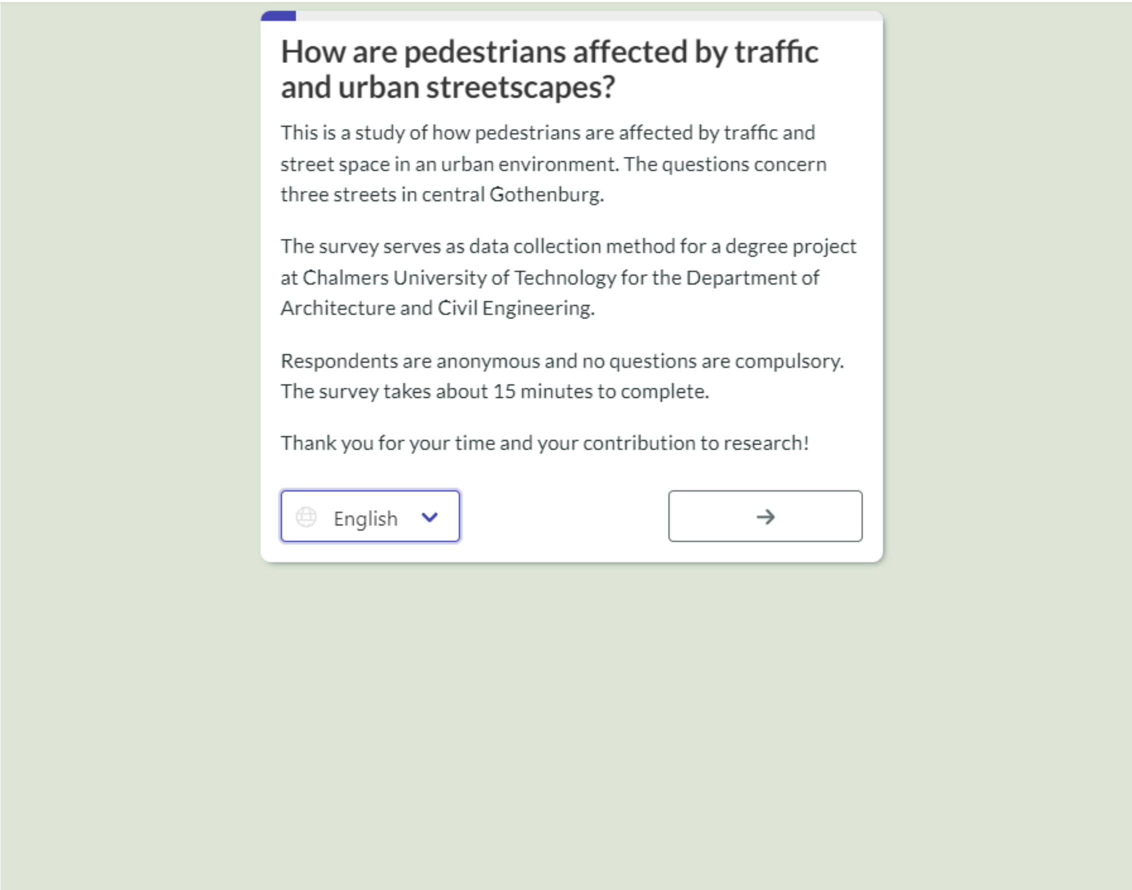


Figure A.1: Page 1 of the survey.

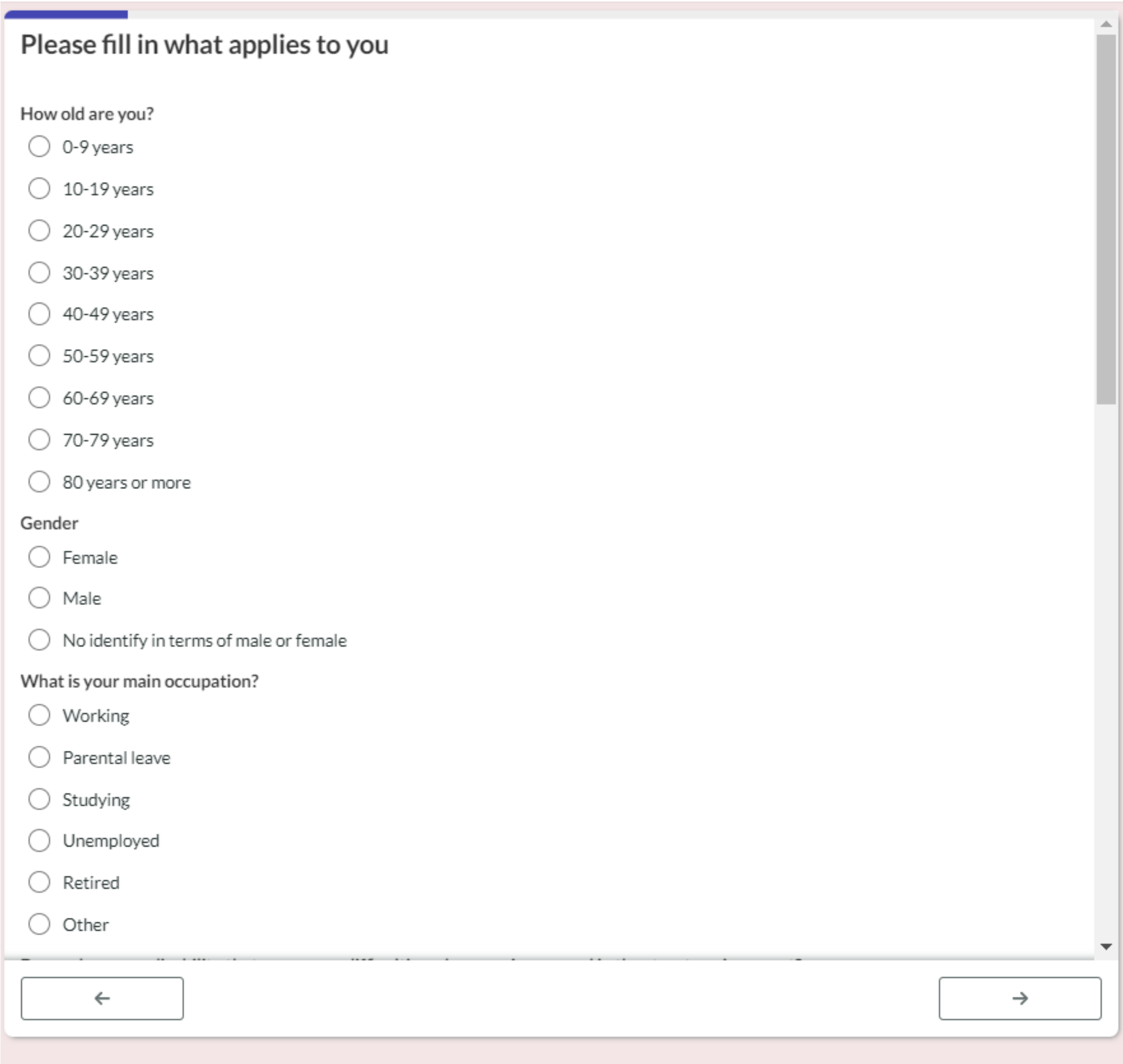
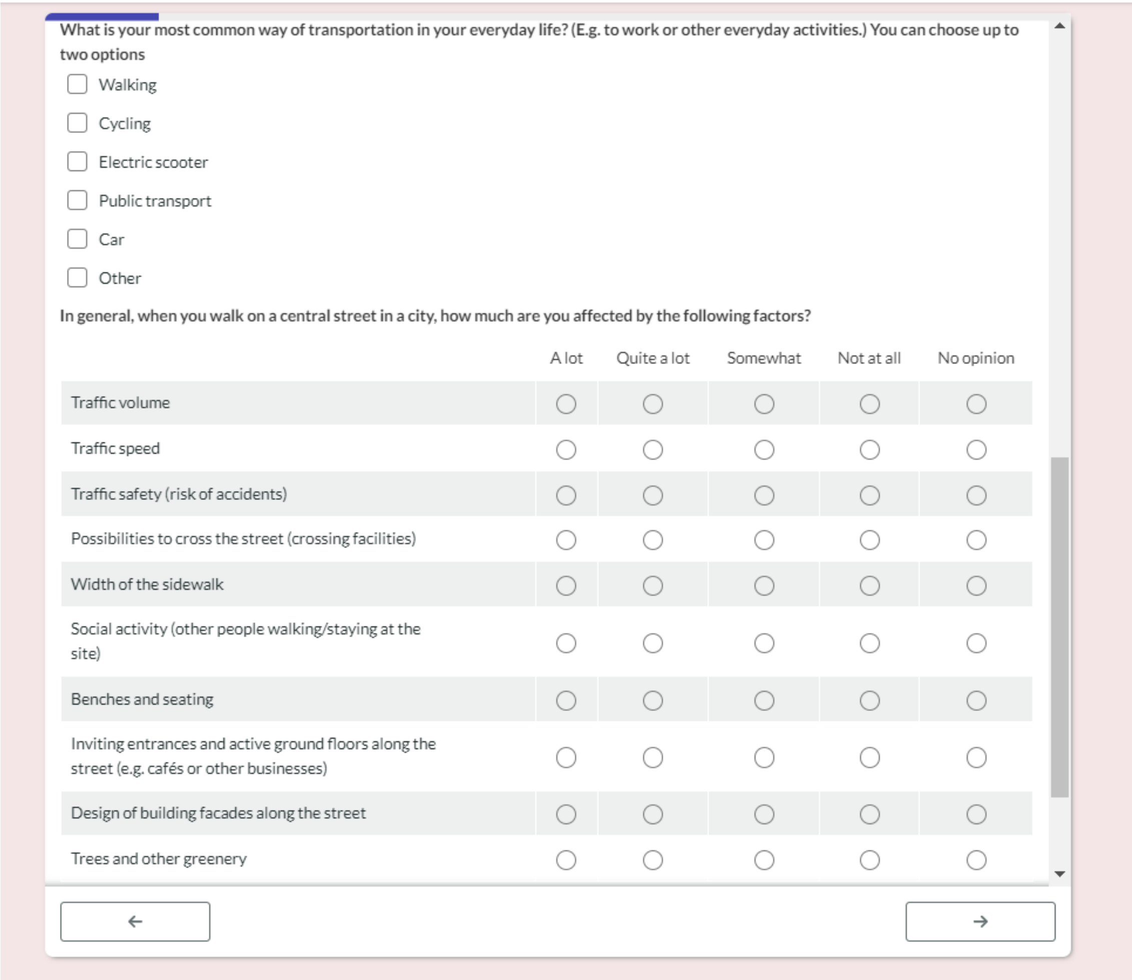


Figure A.2: Part 1 of Page 2 of the Survey, demographics.



What is your most common way of transportation in your everyday life? (E.g. to work or other everyday activities.) You can choose up to two options

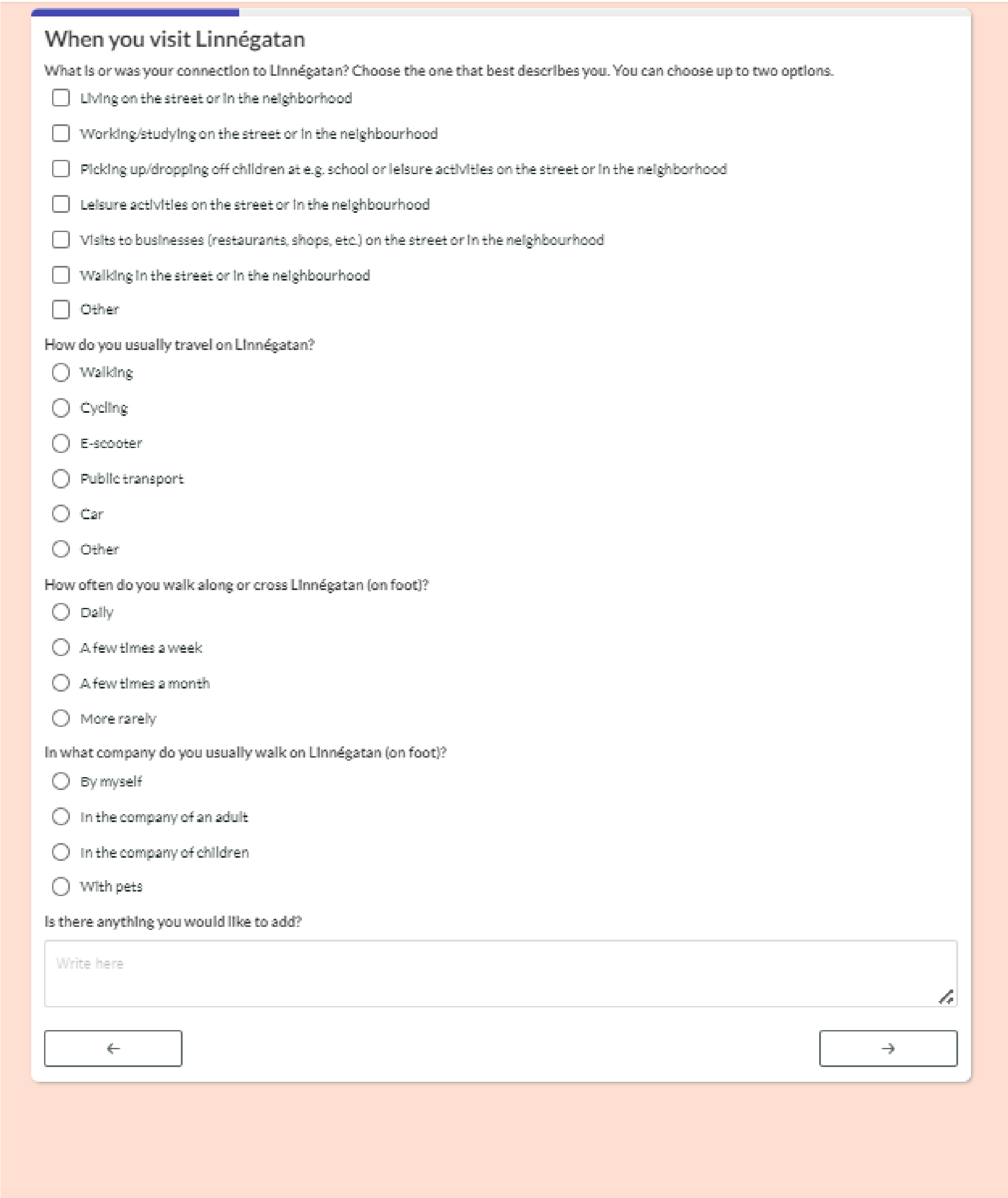
- Walking
- Cycling
- Electric scooter
- Public transport
- Car
- Other

In general, when you walk on a central street in a city, how much are you affected by the following factors?

	A lot	Quite a lot	Somewhat	Not at all	No opinion
Traffic volume					
Traffic speed					
Traffic safety (risk of accidents)					
Possibilities to cross the street (crossing facilities)					
Width of the sidewalk					
Social activity (other people walking/staying at the site)					
Benches and seating					
Inviting entrances and active ground floors along the street (e.g. cafés or other businesses)					
Design of building facades along the street					
Trees and other greenery					

Figure A.3: Part 2 of Page 2 of the survey, demographics.

Figure A.4: Page 3 of the survey.



When you visit Linnégatan

What is or was your connection to Linnégatan? Choose the one that best describes you. You can choose up to two options.

- ☐ Living on the street or in the neighborhood
- ☐ Working/studying on the street or in the neighbourhood
- ☐ Picking up/dropping off children at e.g. school or leisure activities on the street or in the neighborhood
- ☐ Leisure activities on the street or in the neighbourhood
- ☐ Visits to businesses (restaurants, shops, etc.) on the street or in the neighbourhood
- ☐ Walking in the street or in the neighbourhood
- ☐ Other

How do you usually travel on Linnégatan?

- ◯ Walking
- ◯ Cycling
- ◯ E-scooter
- ◯ Public transport
- ◯ Car
- ◯ Other

How often do you walk along or cross Linnégatan (on foot)?

- ◯ Daily
- ◯ A few times a week
- ◯ A few times a month
- ◯ More rarely

In what company do you usually walk on Linnégatan (on foot)?

- ◯ By myself
- ◯ In the company of an adult
- ◯ In the company of children
- ◯ With pets

Is there anything you would like to add?

Write here

← →

Figure A.5: Page 4 of the survey.

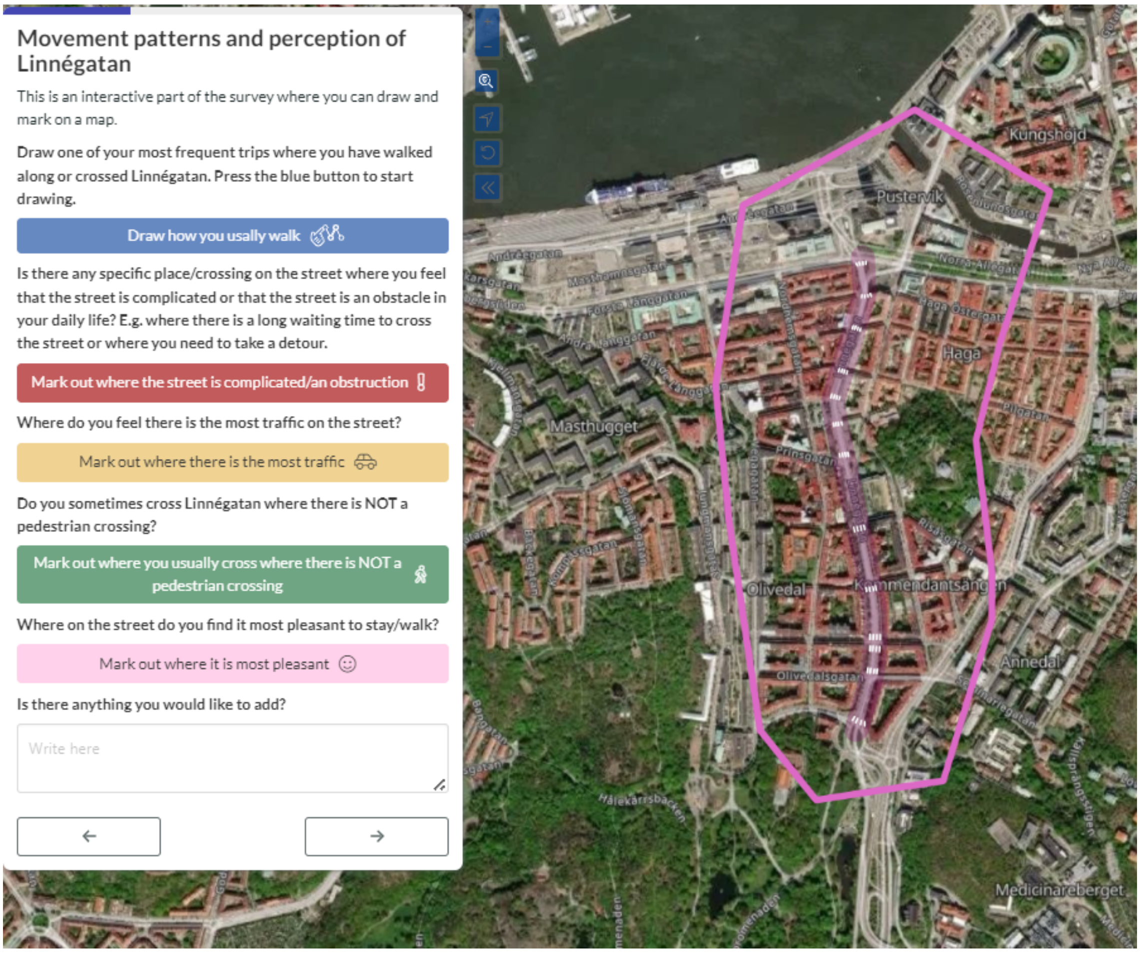
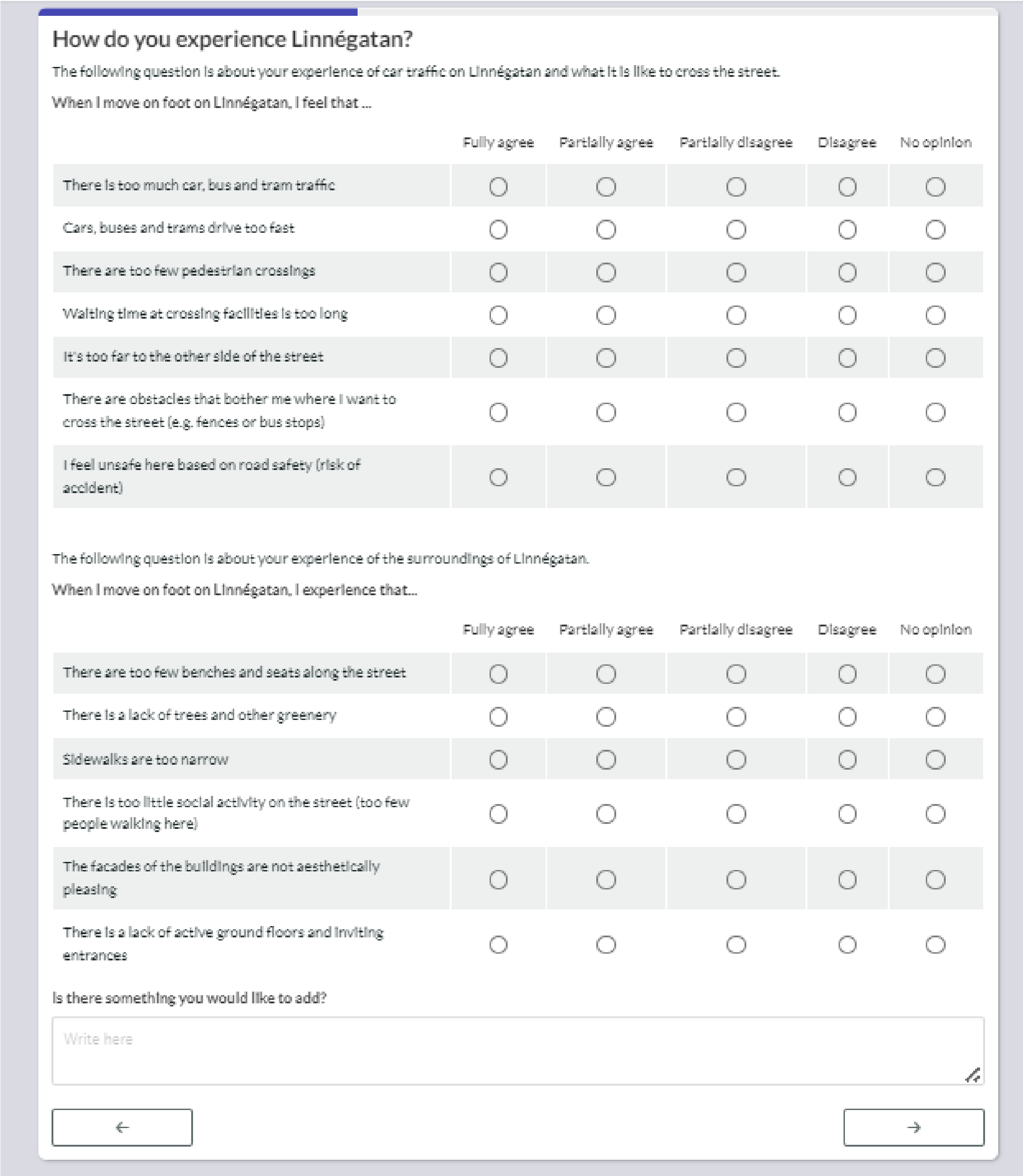


Figure A.6: Page 5 of the survey, interactive part.



How do you experience Linnégatan?

The following question is about your experience of car traffic on Linnégatan and what it is like to cross the street.

When I move on foot on Linnégatan, I feel that ...

	Fully agree	Partially agree	Partially disagree	Disagree	No opinion
There is too much car, bus and tram traffic	○	○	○	○	○
Cars, buses and trams drive too fast	○	○	○	○	○
There are too few pedestrian crossings	○	○	○	○	○
Waiting time at crossing facilities is too long	○	○	○	○	○
It's too far to the other side of the street	○	○	○	○	○
There are obstacles that bother me where I want to cross the street (e.g. fences or bus stops)	○	○	○	○	○
I feel unsafe here based on road safety (risk of accident)	○	○	○	○	○

The following question is about your experience of the surroundings of Linnégatan.

When I move on foot on Linnégatan, I experience that...

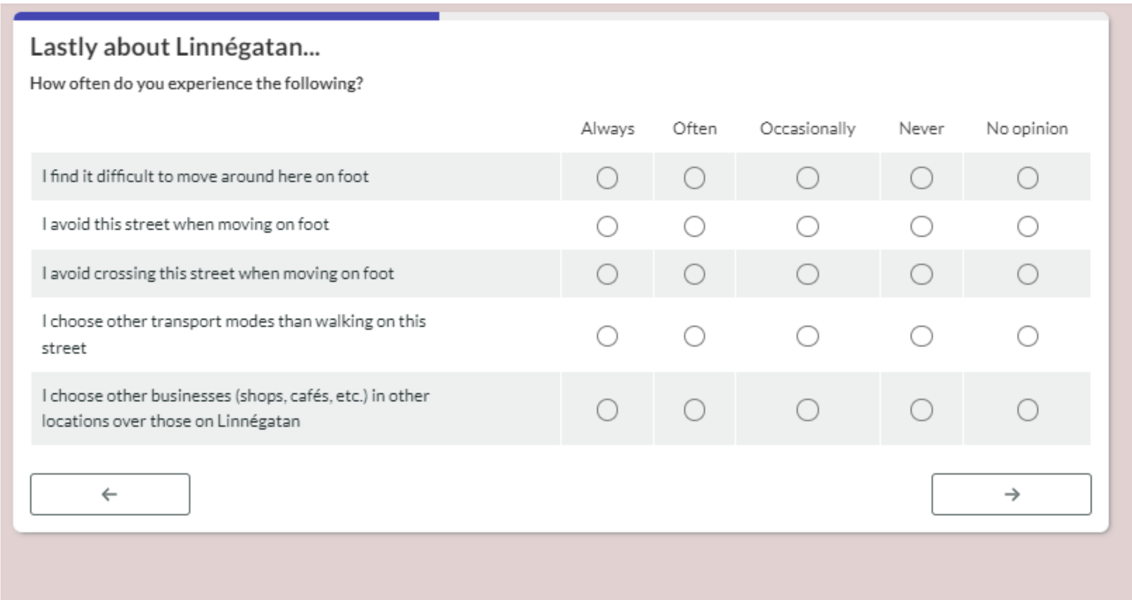
	Fully agree	Partially agree	Partially disagree	Disagree	No opinion
There are too few benches and seats along the street	○	○	○	○	○
There is a lack of trees and other greenery	○	○	○	○	○
Sidewalks are too narrow	○	○	○	○	○
There is too little social activity on the street (too few people walking here)	○	○	○	○	○
The facades of the buildings are not aesthetically pleasing	○	○	○	○	○
There is a lack of active ground floors and inviting entrances	○	○	○	○	○

Is there something you would like to add?

Write here

← →

Figure A.7: Page 6 of the survey, streetscape features.



Lastly about Linnégatan...

How often do you experience the following?

	Always	Often	Occasionally	Never	No opinion
I find it difficult to move around here on foot	○	○	○	○	○
I avoid this street when moving on foot	○	○	○	○	○
I avoid crossing this street when moving on foot	○	○	○	○	○
I choose other transport modes than walking on this street	○	○	○	○	○
I choose other businesses (shops, cafés, etc.) in other locations over those on Linnégatan	○	○	○	○	○

← →

Figure A.8: Page 7 of the survey, barrier effects.

B
Photographs of Linnégatan

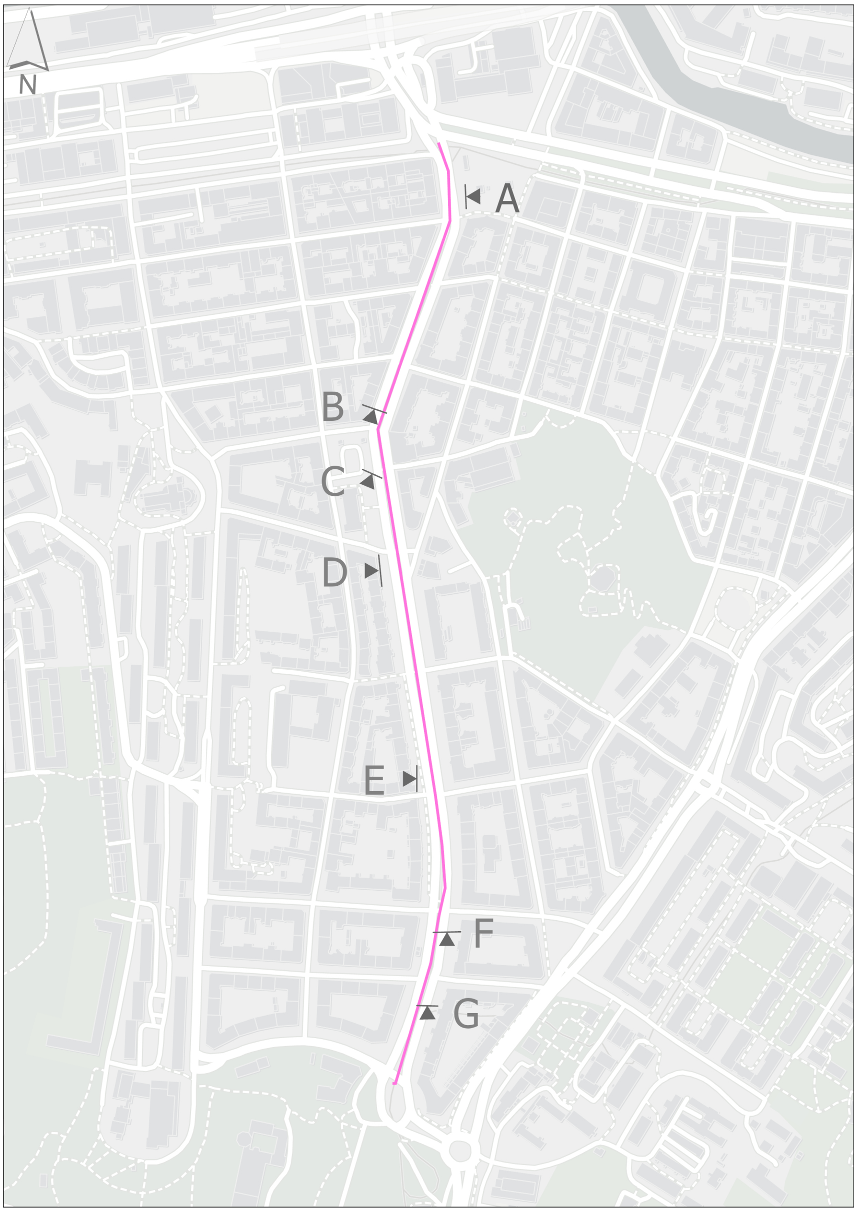


Figure B.1: Map illustrating locations where photographs (A-G) were taken at Linnégatan,

Figure B.2: Photograph (A) of Linnégatan. Showing the streetscape's layout near Järntorget, where fences, bus and tram stops, cafes and shops are located.

Figure B.3: Photograph (B) of Linnégatan showing the space divided for pedestrians, cyclists and vehicles, tree alleys and a few shops on the street.

Figure B.4: Photograph (C) of Linnégatan showing the streetscape's layout, where fences are present.

Figure B.5: Photograph (D) of Linnégatan showing a bicycle crossing, a location where a lot of respondents mention the lack of a pedestrian crossing.

Figure B.6: Photograph (E) of Linnégatan presenting the architectural character of the street.

Figure B.7: Photograph (G) of Linnégatan showing the vehicle lanes as well as the building design, tree alleys, and forecourt gardens.

C
Photographs of Parkgatan

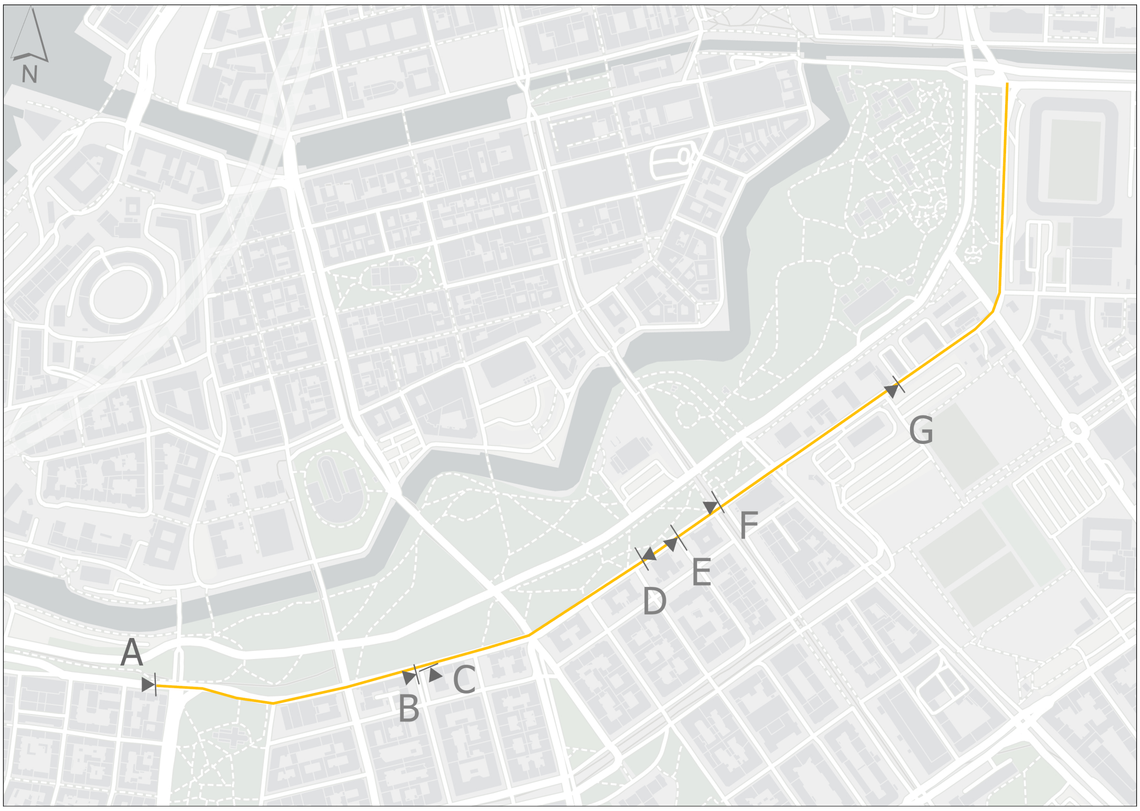


Figure C.1: Map illustrating the locations where the photographs (A-G) of Parkgatan were taken.

Figure C.2: Photograph (A) of Parkgatan showing a part of the ongoing construction project.

Figure C.3: Photograph (B) of Parkgatan illustrating the pavement, the vehicular lanes, the building facades on the right and the park area on the left.

Figure C.4: Photograph (C) of Parkgatan where a walking path has been made in the grass area in the park, where pedestrians cross the street.

Figure C.5: Photograph (D) of Parkgatan illustrating the pavements, the vehicular lanes, the park area, and a location where many respondents expressed they lack a pedestrian crossing.

Figure C.6: Photograph (F) of Parkgatan showing the architectural character of the buildings on the right, the vehicular lanes, and the park area on the left side.

Figure C.7: Photograph (G) of Parkgatan illustrating the pavements, the vehicular lanes and vegetation by Heden.

D
Photographs of Skånegatan

Figure D.1: Map illustrating the locations where the photographs (A-J) were taken of Skånegatan.

Figure D.2: Photograph (A) of Skånegatan showing an overview of the the large crossing in the north of the street, near the arena, Ullevi, on the right side. The width of the road as well as the tram rails and fences can also be seen in this photograph.

Figure D.3: Photograph (B) of Skånegatan illustrating the layout of the streetscape, including the pavement and bicycle path.

Figure D.4: Photograph (C) of Skånegatan illustrating the width of the pavement and vegetation near Ullevi.

Figure D.5: Photograph (D) of Skånegatan showing one of the larger intersections on the street.

Figure D.6: Photograph (F) of Skånegatan showing the pavement and tree alleys.

Figure D.7: Photograph (G) of Skånegatan illustrating the width of the pavement, tree alleys and a tram stop, where fences are present.

Figure D.8: Photograph (H) of Skånegatan showing a pedestrian crossing.

Figure D.9: Photograph (I) of Skånegatan showing the width of the pavement, a tree alley, building facades, and forecourt gardens.

Figure D.10: Photograph (J) of Skånegatan showing the large combined bus and tram stop, where fences are present. In the background lies Liseberg, an amusement park.

E

Results from regression analyses

	Traffic volume		**Fear of crime**		**Passing & crossing effort**	
Statement	'There is too much car, bus, and tram traffic here'		'I feel unsafe here based on traffic safety'		'I find it difficult moving around here'	
Overall percentage [%]	75.0		63.3		94.0	
Nagelkerke R^2	0.327		0.083		0.373	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	-	-	1.273	0.206	1.674	0.241
'Cars, buses and trams drive too fast'	2.550	**<0.001**	0.963	0.850	0.996	0.993
'There are too few pedestrian crossings'	1.581	**0.012**	0.660	**0.018**	1.949	0.051
'There are obstacles that bother me where I want to cross'	1.063	0.747	1.140	0.456	1.113	0.746
'There is a lack of trees and other greenery'	1.330	0.145	1.053	0.786	1.179	0.673
'Sidewalks are too narrow'	0.938	0.664	1.100	0.496	3.175	**0.015**
'The facades of the buildings are not aesthetically pleasing'	0.865	0.569	1.050	0.830	0.966	0.938
'There is a lack of active ground floors and inviting entrances'	1.022	0.921	0.749	0.171	0.484	0.105
Typical transport mode at the specific street	1.658	0.153	0.798	0.503	4.011	0.211
Frequency of visits at the specific street	0.819	0.611	0.660	0.255	2.118	0.419
Gender	1.552	0.201	1.217	0.560	0.624	0.488
Age	1.003	0.973	0.956	0.641	0.964	0.853
Constant	0.047	<0.001	0.932	0.933	0.000	<0.001

Table E.1: The output from the regression analysis of direct barrier effects experienced at Linnégatan, presenting the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.

	Frequency of visits		Routing of trips		Mode of transport	
Statement	'I avoid the street when moving on foot'		'I avoid crossing the street when moving on foot'		'I choose other modes of transport than walking on this street'	
Overall percentage [%]	76.8		69.6		68.7	
Nagelkerke R^2	0.151		0.194		0.186	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	1.422	0.110	1.204	0.342	0.999	0.997
'Cars, buses and trams drive too fast'	1.015	0.944	1.082	0.690	0.860	0.432
'There are too few pedestrian crossings'	1.026	0.888	1.674	**0.002**	1.350	0.069
'There are obstacles that bother me where I want to cross'	1.159	0.428	1.250	0.188	1.357	0.070
'There is a lack of trees and other greenery'	1.131	0.550	1.149	0.462	1.302	0.135
'Sidewalks are too narrow'	1.559	**0.008**	1.055	0.711	1.012	0.930
'The facades of the buildings are not aesthetically pleasing'	0.765	0.318	0.753	0.230	0.789	0.278
'There is a lack of active ground floors and inviting entrances'	0.646	0.087	0.959	0.839	0.988	0.951
Typical transport mode at the specific street	0.958	0.912	1.379	0.361	0.342	**0.001**
Frequency of visits at the specific street	1.012	0.977	1.203	0.626	0.878	0.721
Gender	1.311	0.472	1.520	0.213	1.742	0.078
Age	1.025	0.823	0.837	0.078	0.903	0.278
Constant	0.041	<0.001	0.065	0.001	0.892	0.886

Table E.2: The output from the regression analysis of indirect barrier effects experienced at Linnégatan, presenting the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.

	Traffic volume		Fear of crime		Passing & crossing effort	
Statement	'There is too much car, bus, and tram traffic here'		'I feel unsafe here based on traffic safety'		'I find it difficult moving around here'	
Overall percentage [%]	86.4		75.6		82.3	
Nagelkerke R^2	0.569		0.441		0.522	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	-	-	1.469	0.329	2.133	0.123
'Cars, buses and trams drive too fast'	3.904	**<0.001**	2.190	**0.004**	1.053	0.885
'There are too few pedestrian crossings'	3.171	**0.008**	2.217	**0.009**	1.576	0.216
'There are obstacles that bother me where I want to cross'	0.695	0.355	1.250	0.401	1.650	0.069
'There is a lack of trees and other greenery'	0.886	0.788	1.432	0.264	1.987	**0.047**
'Sidewalks are too narrow'	1.149	0.742	0.919	0.751	1.551	0.138
'The facades of the buildings are not aesthetically pleasing'	1.052	0.910	0.827	0.480	0.572	0.099
'There is a lack of active ground floors and inviting entrances'	1.389	0.365	1.048	0.866	1.893	**0.049**
Typical transport mode at the specific street	0.479	0.260	0.638	0.349	0.434	0.129
Frequency of visits at the specific street	0.382	0.207	1.817	0.240	0.455	0.141
Gender	1.098	0.891	0.567	0.260	1.353	0.584
Age	1.780	**0.037**	0.947	0.709	0.729	**0.045**
Constant	0.001	0.004	0.004	<0.001	0.001	<0.001

Table E.3: The output from the regression analysis of direct barrier effects experienced at Parkgatan, presents the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.

	Frequency of visits		Routing of trips		Mode of transport	
Statement	'I avoid the street when moving on foot'		'I avoid crossing the street when moving on foot'		'I choose other modes of transport than walking on this street'	
Overall percentage [%]	76.0		80.8		80.3	
Nagelkerke R^2	0.516		0.519		0.279	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	2.481	**0.027**	2.908	**0.012**	2.408	**0.049**
'Cars, buses and trams drive too fast'	1.148	0.642	1.167	0.589	0.891	0.714
'There are too few pedestrian crossings'	1.030	0.923	1.239	0.471	0.952	0.888
'There are obstacles that bother me where I want to cross'	1.433	0.209	2.000	**0.015**	1.112	0.729
'There is a lack of trees and other greenery'	2.215	**0.041**	1.504	0.263	1.781	0.138
'Sidewalks are too narrow'	2.013	**0.018**	2.029	**0.011**	0.659	0.183
'The facades of the buildings are not aesthetically pleasing'	0.531	**0.044**	1.660	0.089	1.242	0.504
'There is a lack of active ground floors and inviting entrances'	2.194	**0.008**	0.739	0.311	1.251	0.420
Typical transport mode at the specific street	0.407	0.080	0.901	0.833	0.359	0.059
Frequency of visits at the specific street	0.331	**0.046**	0.686	0.477	0.550	0.288
Gender	2.397	0.111	0.855	0.772	1.821	0.281
Age	0.943	0.712	0.925	0.614	0.768	0.104
Constant	0.001	<0.001	0.001	<0.001	0.878	0.928

Table E.4: The output from the regression analysis of indirect barrier effects experienced at Parkgatan, presenting the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.

	Traffic volume		**Fear of crime**		**Passing & crossing effort**	
Statement	'There is too much car, bus, and tram traffic here'		'I feel unsafe here based on traffic safety'		'I find it difficult moving around here'	
Overall percentage [%]	81.1		74.2		85.4	
Nagelkerke R^2	0.345		0.429		0.400	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	-	-	2.225	**0.004**	1.912	0.057
'Cars, buses and trams drive too fast'	2.630	**<0.001**	1.580	**0.046**	1.761	0.054
'There are too few pedestrian crossings'	0.859	0.479	1.658	**0.008**	1.202	0.422
'There are obstacles that bother me where I want to cross'	1.421	0.061	1.317	0.102	1.341	0.119
'There is a lack of trees and other greenery'	0.936	0.777	0.660	0.061	0.737	0.224
'Sidewalks are too narrow'	1.189	0.555	1.156	0.548	1.648	**0.041**
'The facades of the buildings are not aesthetically pleasing'	1.538	0.064	1.412	0.149	1.312	0.316
'There is a lack of active ground floors and inviting entrances'	0.677	0.099	0.734	0.163	0.993	0.978
Typical transport mode at the specific street	2.269	0.099	0.934	0.876	0.587	0.325
Frequency of visits at the specific street	0.861	0.748	1.217	0.642	0.501	0.147
Gender	2.417	0.060	1.990	0.135	1.042	0.936
Age	0.781	0.090	0.987	0.919	1.009	0.952
Constant	0.220	0.139	0.006	<0.001	0.002	<0.001

Table E.5: The output from the regression analysis of direct barrier effects experienced at Skånegatan, presenting the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.

	Frequency of visits		Routing of trips		Mode of transport	
Statement	'I avoid the street when moving on foot'		'I avoid crossing the street when moving on foot'		'I choose other modes of transport than walking on this street'	
Overall percentage [%]	69.8		73.1		84.6	
Nagelkerke R^2	0.322		0.316		0.279	
Statements	**OR**	**Sig.**	**OR**	**Sig.**	**OR**	**Sig.**
'There is too much car, bus and tram traffic'	0.790	0.297	1.218	0.382	1.233	0.438
'Cars, buses and trams drive too fast'	1.445	0.096	0.926	0.721	1.483	0.146
'There are too few pedestrian crossings'	1.039	0.830	1.361	0.087	0.737	0.184
'There are obstacles that bother me where I want to cross'	1.416	**0.029**	1.472	**0.019**	1.240	0.271
'There is a lack of trees and other greenery'	0.724	0.107	0.913	0.653	0.605	0.053
'Sidewalks are too narrow'	1.557	**0.045**	1.665	**0.030**	1.307	0.320
'The facades of the buildings are not aesthetically pleasing'	1.591	**0.028**	1.014	0.945	1.050	0.841
'There is a lack of active ground floors and inviting entrances'	1.233	0.281	1.293	0.183	1.114	0.648
Typical transport mode at the specific street	0.518	0.116	0.502	0.100	0.148	**>0.001**
Frequency of visits at the specific street	0.309	**0.003**	0.390	**0.021**	1.025	0.957
Gender	1.862	0.128	1.637	0.249	1.410	0.494
Age	1.060	0.633	0.829	0.141	1.020	0.896
Constant	0.106	0.021	0.209	0.127	3.655	0.290

Table E.6: The output from the regression analysis of indirect barrier effects experienced at Skånegatan, presenting the odds-ratio (OR), significance (Sig.), Nagelkerke value, and overall percentage of the model's correct predictions.