The contribution of public space characteristics to the emotions of young adults while walking in urban areas

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SUMMARY

In recent years, physical activity among young adults has declined. This trend is particularly visible in walking, which is one of the easiest and most accessible forms of daily movement. The reduction in walking has a negative impact on physical health and affects mental well-being. It contributes to issues such as obesity, cardiovascular disease, and stress-related conditions. In the Netherlands, this problem is particularly visible among young adults aged 18 to 29. Many of them are aware of the importance of staying active, but still do not meet the recommended levels of exercise. To support this group, it is helpful to understand what influences their motivation to move, and in particular, what encourages them to walk more often. The design of public space plays a key role in this. When walking through an urban environment, people interact with their surroundings. The surroundings contribute to people's feelings. Positive feelings, such as relaxation and excitement, can encourage walking, while negative emotions like boredom or stress can hold people back.

This thesis examines the impact of public space characteristics on the emotions of young adults while they walk in urban areas. The aim is to find out which specific characteristics of public space contribute to emotional states during a walk. Although several studies have examined walkability in general, there is still limited knowledge about the emotional effects of specific public space characteristics during walking. Walking is often treated as a functional activity, but it is also a rich emotional experience. Especially for young adults, who are in a stage of life characterised by exploration and emotional development. Understanding which characteristics contribute to these feelings can help make cities more supportive of young people's well-being. To discover this understanding, the main research question is: *"What is the contribution of public space characteristics to the emotions of young adults while walking in urban areas?"*

The emotional reactions explored in this research are based on the Circumplex Model of Affect. This model categorises emotions along two axes: valence (pleasant to unpleasant) and arousal (active to passive). It allows emotions to be grouped in four quadrants: relaxation, excitement, boredom, and stress. Relaxation and excitement reflect positive experiences, while boredom and stress indicate more negative ones. This model helps to place the feelings people report during walks into clear categories. To explore the relationship between public space and emotions, the research uses a theoretical framework. This includes the Social Ecological Model (SEM), which explains that several layers shape emotions. These include individual, social, environmental, and external factors. Although all these layers play a role, the focus of this research is on the environmental layer, specifically the physical characteristics of public space. The literature review identifies five main categories that structure this environmental layer: natural elements, traffic, pedestrian infrastructure, street appearance, and social facilities. These categories include characteristics such as tree presence, road types, sidewalk design, architectural style, and amenities like shops and cafés. The characteristics were selected based on earlier studies that showed they can influence emotional experiences during walking.

The methodology involves an empirical study conducted in Eindhoven, the Netherlands. Participants, all young adults, walked a route through the city for about 30 minutes. Each walking route was recorded using GPS tracking devices, which collected spatial data on the participants' walking paths. After each walk, participants completed a short survey about their emotional experience during the walk. The questions were based on the Circumplex Model of Affect and helped to place their emotions on the two axes: valence and arousal. Next, the public space characteristics around the walking routes were mapped using GIS software (QGIS). This involved

combining municipal data with OpenStreetMap data to capture available characteristics. The public space characteristics that were available and used in this research are: trees, water features, flowerbeds, grass surfaces, road types, parked cars, bike lanes, crossings, sidewalk surfaces, benches, streetlights, cleanliness, public art, underpasses, shops, restaurants, playgrounds, and community centres. Each route was analysed within a 10-meter buffer, allowing a detailed understanding of what the participant experienced during the walk. Once the spatial and emotional data were gathered and combined, the analysis was carried out using SPSS. The statistical method used was multinomial logistic regression. This method is helpful when the outcome variable (in this case, the emotional state) has more than two categories. It illustrates how various spatial characteristics are associated with the likelihood of experiencing a specific emotion. The reliability of the emotional data was checked using Cronbach's alpha, confirming that the valence and arousal items worked well together.

The analysis revealed several important insights. Some public spaces were linked to emotional states. For example, fewer restaurants along a route were related to higher levels of relaxation. This might be because busy commercial areas are more stressful. On the other hand, boredom was associated with areas that had few restaurants, less public art, and fewer underpasses. A higher density of bike lanes and clinker road surfaces also contributed to boredom and stress. These areas might feel too busy or uncomfortable for walking. In contrast, benches were positively associated with reduced stress, providing opportunities to rest and observe. Low-traffic roads helped lower both stress and boredom levels, showing the importance of calm environments. The regression model performed reasonably well. It explained about 31% of the variation in emotions and was particularly good at predicting feelings of excitement and boredom. These findings help show which public space characteristics influence emotional states and can be used in practical design strategies.

However, this study also has its limitations. The study was done in only one city. To check the validity of the results in other locations, future research could be conducted in different cities or countries. It would also be helpful to study how cultural differences influence the way people respond to public spaces. Additionally, while this study used self-reported data to measure emotions, future studies could include physiological methods such as heart rate monitoring or skin conductance sensors. These methods would make the emotional data more objective and add depth to the findings. Another recommendation is to integrate the other layers from the Social Ecological Model. While this research focused on environmental characteristics, factors such as personal experiences, social context, or weather conditions also influence emotional responses. Including these layers in future research could improve understanding of how urban environments affect well-being.

Even with these limitations, this research adds new insights to the field of urban design and emotional responses. It combines environmental psychology theories with real-world spatial data and empirical research. It shows that small elements in the built environment can contribute to how people feel. These changes can increase the likelihood that young adults enjoy walking and choose to do it more frequently. Urban planners and policymakers can use these insights to improve public spaces. For example, placing benches, reducing traffic speeds, and including visually engaging elements, such as public art, can help make walking more enjoyable. Redesigning streets to include these characteristics may help make walking a more appealing activity. This is especially important for young adults, who often need environments that are both functional and emotionally engaging. If public space is designed in a way that supports positive emotional experiences, young adults may be more likely to walk regularly.

SAMENVATTING

In de afgelopen jaren is de fysieke activiteit onder jongvolwassenen afgenomen. Deze daling is vooral te zien bij wandelen, terwijl dit juist één van de meest toegankelijke vormen van dagelijkse beweging is. Minder wandelen heeft gevolgen voor zowel de lichamelijke als mentale gezondheid. Het draagt bij aan problemen zoals overgewicht, hart- en vaatziekten, en stress gerelateerde klachten. In Nederland is deze ontwikkeling vooral zichtbaar bij jongvolwassenen tussen de 18 en 29 jaar. Veel jongeren weten hoe belangrijk bewegen is, maar halen toch niet de aanbevolen hoeveelheid beweging per dag. Om deze groep beter te ondersteunen, is het belangrijk om te begrijpen wat hen motiveert om meer te bewegen. Vooral wat hen stimuleert om vaker te wandelen. De inrichting van de openbare ruimte speelt hierin een grote rol. Tijdens het lopen in een stedelijke omgeving staan mensen constant in contact met hun directe omgeving. Die omgeving heeft invloed op hoe mensen zich voelen. Positieve gevoelens zoals ontspanning en energie kunnen mensen aanmoedigen om vaker te wandelen. Negatieve gevoelens zoals stress of verveling kunnen juist het tegenovergestelde effect hebben.

Deze thesis richt zich op de vraag hoe kenmerken van de openbare ruimte de emoties van jongvolwassenen beïnvloeden tijdens het wandelen in stedelijke gebieden. Het doel is om te achterhalen welke ruimtelijke kenmerken invloed hebben op bepaalde gevoelens tijdens een wandeling. Er is al eerder onderzoek gedaan naar 'walkability', maar er is nog weinig bekend over hoe specifieke kenmerken van de openbare ruimte invloed hebben op emoties tijdens het wandelen. Wandelen wordt vaak gezien als iets functioneels, maar het is ook een emotionele ervaring. Zeker voor jongvolwassenen, die zich in een levensfase van ontwikkeling en verkenning bevinden. Begrijpen welke kenmerken bijdragen aan positieve of negatieve gevoelens kan helpen om steden beter af te stemmen op hun welzijn. Om dit te onderzoeken is de volgende hoofdvraag opgesteld: "Wat is de bijdrage van kenmerken van de openbare ruimte aan de emoties van jongvolwassenen tijdens het wandelen in stedelijke gebieden?"

De emoties die in dit onderzoek worden gemeten zijn gebaseerd op het Circumplex Model of Affect. Dit model verdeelt emoties langs twee assen: valentie (prettig tot onprettig) en activering (actief tot passief). Hiermee worden vier kwadranten gevormd: ontspanning, opwinding, verveling en stress. Ontspanning en opwinding worden gezien als positieve gevoelens, terwijl verveling en stress als negatief worden beschouwd. Dit model helpt om de gevoelens van de deelnemers op een duidelijke manier in te delen. Om de relatie tussen openbare ruimte en emoties te onderzoeken, wordt een theoretisch kader gebruikt. Daarin speelt het Social Ecological Model (SEM) een belangrijke rol. Dit model legt uit dat emoties beïnvloed worden door verschillende lagen: persoonlijke, sociale, omgevings- en externe factoren. In dit onderzoek ligt de focus op de omgevingslaag, en dan vooral op de fysieke kenmerken van de openbare ruimte. De literatuurstudie heeft vijf hoofdcategorieën van deze ruimtelijke kenmerken benoemd: natuurlijke elementen, verkeer, voetgangersinfrastructuur, straatbeeld en sociale plekken. Voorbeelden van deze kenmerken zijn bomen, soorten wegen, de kwaliteit van stoepen, architectuur en voorzieningen zoals winkels en cafés. Deze kenmerken zijn gekozen op basis van eerdere studies die laten zien dat ze invloed kunnen hebben op emoties tijdens het wandelen.

De methode bestaat uit een praktijkonderzoek in Eindhoven. Een groep jongvolwassenen liep een vaste route van ongeveer 30 minuten door de stad. Elke wandeling werd gevolgd met een GPS-tracker, zodat de exacte route en locatiegegevens werden vastgelegd. Na de wandeling vulden de deelnemers een korte vragenlijst in over hun gevoel tijdens het lopen. Deze vragen waren gebaseerd op het Circumplex Model of Affect en hielpen om hun emoties in te delen op de

valentie- en activering-schaal. Daarna werden de kenmerken van de openbare ruimte rond de gelopen routes in kaart gebracht met GIS-software (QGIS). Hiervoor is gebruik gemaakt van gemeentelijke data en informatie uit OpenStreetMap. Op deze manier werd informatie verzameld over onder andere bomen, straatverlichting, bankjes en soorten verkeer. Per route werd een buffer van 10 meter aangehouden om precies in kaart te brengen wat de deelnemer langs de route zag en ervoer. Toen alle ruimtelijke en emotionele gegevens verzameld en gecombineerd waren, is de analyse uitgevoerd in SPSS. Hiervoor is gebruik gemaakt van multinomiale logistische regressie. Deze methode is geschikt wanneer de afhankelijke variabele, in dit geval de emotionele staat, uit meerdere categorieën bestaat. De analyse laat zien hoe ruimtelijke kenmerken samenhangen met de kans op een bepaalde emotie. De betrouwbaarheid van de emotiedata is gecontroleerd met Cronbach's alpha. Dit bevestigde dat de vragen over valentie en activering goed met elkaar samenhangen.

De analyse bracht verschillende interessante uitkomsten naar voren. Sommige kenmerken van de openbare ruimte bleken duidelijk samen te hangen met bepaalde emoties. Zo bleken minder restaurants langs de route samen te hangen met meer ontspanning. Mogelijk zorgen drukke commerciële gebieden juist voor meer onrust. Verveling bleek juist vaker voor te komen in gebieden met weinig restaurants, minder kunst in de openbare ruimte en weinig tunnels. Ook een hogere dichtheid van fietspaden en klinkerwegen bleek bij te dragen aan gevoelens van verveling en stress. Deze omgevingen voelen misschien te druk of ongemakkelijk aan voor voetgangers. Bankjes bleken een positief effect te hebben: ze werden in verband gebracht met minder stress. Ook rustige wegen, met weinig verkeer, verminderden gevoelens van stress en verveling. Het regressiemodel presteerde redelijk goed. Het verklaarde ongeveer 31% van de variatie in emoties. Vooral opwinding en verveling konden goed voorspeld worden. Deze inzichten laten zien welke ruimtelijke kenmerken een rol spelen bij hoe mensen zich voelen tijdens het wandelen. Dat kan weer gebruikt worden bij het ontwerpen van prettige en stimulerende wandelomgevingen.

Natuurlijk zijn er ook beperkingen aan dit onderzoek. Het onderzoek is uitgevoerd in slechts één stad. Om te testen of de resultaten ook op andere plekken gelden, zou vervolgonderzoek in andere steden of landen nuttig zijn. Ook culturele verschillen kunnen invloed hebben op hoe mensen de openbare ruimte ervaren. Verder is er in dit onderzoek alleen gebruik gemaakt van zelf gerapporteerde emoties. In toekomstig onderzoek kunnen ook fysiologische meetmethoden, zoals hartslagmetingen of huidgeleiding, worden gebruikt om emoties objectiever vast te leggen. Een andere aanbeveling is om in toekomstig onderzoek ook andere lagen van het Social Ecological Model mee te nemen. Persoonlijke ervaringen, sociale context of weersomstandigheden kunnen ook een rol spelen in hoe iemand zich voelt tijdens het lopen. Ondanks deze beperkingen levert dit onderzoek waardevolle inzichten op. Het combineert theorieën uit de omgevingspsychologie met echte data over wandelroutes en ruimtelijke kenmerken. Het laat zien dat kleine elementen in de omgeving, zoals een bankje of een type wegdek, invloed kunnen hebben op hoe mensen zich voelen. Deze inzichten kunnen steden helpen om de openbare ruimte aangenamer te maken. Stadsplanners en beleidsmakers kunnen bijvoorbeeld meer bankjes plaatsen, verkeersdrukte verminderen of kunst aan het straatbeeld toevoegen. Dit maakt het lopen niet alleen functioneel, maar ook prettig en aantrekkelijk. Voor jongvolwassenen, die vaak behoefte hebben aan zowel praktische als inspirerende omgevingen, is dat extra belangrijk. Als de openbare ruimte zo is ingericht dat mensen er positieve emoties bij ervaren, zullen jongvolwassenen waarschijnlijk vaker gaan wandelen.

ABSTRACT

Physical activity among young adults is decreasing, particularly in the form of walking. This trend is concerning, as it affects both physical and mental health. In the Netherlands, this trend is most visible in people aged 18 to 29. To support this group, it is important to understand what can motivate them to walk more. Public space design plays a key role in this. The environment people walk through influences how they feel. Positive feelings can encourage people to walk more often, while negative feelings may discourage them. This thesis explores how public space characteristics contribute to the emotions of young adults while walking in urban areas. The goal is to identify which public space characteristics are linked to emotional experiences. Four emotions are studied: relaxation, excitement, boredom, and stress. These are based on the Circumplex Model of Affect, which uses two axes, valence and arousal, to describe emotions. The study also uses the Social-Ecological Model to frame the different layers that shape emotions. The focus is on the environmental layer. Public space characteristics were grouped into five categories: natural elements, traffic, pedestrian infrastructure, street appearance, and social spaces. Empirical research was conducted in Eindhoven. Young adults walked a 30-minute route. Their emotions were measured through a survey, and GPS devices recorded their routes. Spatial data on public space characteristics were gathered using QGIS, combining municipal data and OpenStreetMap. The data were analysed using SPSS, applying multinomial logistic regression. Cronbach's alpha confirmed the reliability of the emotional scales. The results show that several public space characteristics are associated with emotional states. Benches were associated with lower levels of stress. Low-traffic roads reduced both boredom and stress. Fewer restaurants along the route were associated with higher relaxation. In contrast, a higher density of bike lanes and clinker road surfaces increased boredom and stress. A lack of underpasses and public art was also linked to higher boredom. These findings show that the design of public space can influence how young adults feel while walking. Urban planners can use this knowledge to support walking behaviour. By incorporating characteristics that promote relaxation and reduce stress, cities can support healthy and active lifestyles among young adults.

KEYWORDS

Public space characteristics, emotions, walking behaviour, young adults, multinomial logistic regression

LIST OF ABBREVIATIONS

CBS	Centraal Bureau voor de Statistiek
CMA	Circumplex Model of Affect
MLR	Multinomial Logistic Regression
OSM	Open Street Map
QGIS	Quantum Geographical Information System
Quick OSM	Quick Open Street Map
SEM	Social-Ecological Model
SPSS	Statistical Packages for Social Sciences

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1 INTRODUCTION

1.1 PROBLEM DEFINITION AND THE OBJECTIVE

In recent years, concerns have increased about declining levels of daily physical activity, particularly among young adults. According to the physical activity guidelines of the *Gezondheidsraad* and of the *World Health Organisation*, young adults should engage in at least 2.5 hours of physical activity per week (Gezondheidsraad, 2017; World Health Organization, 2020). In the Netherlands, only 44% of the population currently meets the national physical activity guidelines (RIVM, 2023). Among young adults aged 18 to 29, this number dropped by 9.2% compared to 2019, which is far more than the national average decline of 4.7% (RIVM, 2023). For young adults, the most decline is seen in daily activities such as walking and cycling. Young adults, despite often being aware of the importance of physical activity, are walking less in their free time than before (RIVM, 2023).

A consequence of the decrease in physical activity is the rising prevalence of health issues. People who do not meet the minimum level of physical activity have an increased risk of developing chronic illnesses, such as cardiovascular diseases, diabetes, and depression (Gezondheidsraad, 2017; World Health Organization, 2020). Mental health is also a growing concern for young adults, with rising levels of stress, loneliness, and depression (Gijsbers et al., 2023). Alongside these mental and physical health concerns, rates of overweight and obesity have also increased. The situation is especially worrying among young adults. In 2022, one in four people aged 18 to 25 in the Netherlands was overweight, and 7% had obesity (CBS, 2024). This is a noticeable increase from 2014, when 21% of this age group were overweight. The combination of low activity levels and rising weight is particularly problematic because young people with overweight or obesity are less likely to meet the physical activity guidelines (RIVM, 2023). These trends suggest a concerning cycle, where low physical activity contributes to excess weight, which in turn makes regular movement less likely.

Even though young adults have the intention to increase their movement, they often experience barriers (Diabetes Fonds, 2024). The main barrier to increasing movement is environmental discomfort (Schnell et al., 2012). This includes the way the surroundings make people feel less safe, less comfortable, or simply uninspired to go outside. Studies have shown that factors such as air quality, noise, safety, and aesthetics can negatively impact people's emotional experience of walking, making them less likely to choose walking as a daily activity (Schnell et al., 2012; Sundling & Jakobsson, 2023). While much is known about the physical health benefits of walking, less is understood about how public space contributes to the emotional experiences while walking, particularly among young adults. Positive emotions during a walk, such as relaxation or energy, can make walking feel more enjoyable and therefore more likely to be repeated. Negative emotions, such as stress or discomfort, can discourage it (Mehrabian & Russell, 1974).

Looking at the research area, there has been a growing interest in understanding how public space design affects people's emotional experiences over the past decades. This is especially relevant during walking, which is an activity where people are surrounded by their environment. Walking is, for most people, a daily activity that connects them with their surroundings. Therefore, the design and structure of the environment can significantly influence how people feel during daily movement. The idea that the built environment influences emotions is not new. It started in the 1960s and 1970s in the field of Environmental Psychology. Researchers like Roger Garlock Barker introduced concepts such as "Behaviour Settings", which emphasise the role of

environmental contexts in shaping behaviour. In 1970, the book by Proshansky called '*Man and his physical setting'* explored how people react to their surroundings (Proshansky et al., 1970). They found that people's emotions are shaped by the design of the spaces around them. Over time, more studies have supported this idea (Bronfenbrenner, 1979; Mehrabian & Russell, 1974; Russell & Lanius, 1984; Stokols, 1978; Ulrich, 1983). They all found that space is not just a background but something that actively influences how we feel. This shift acknowledged that emotional responses to environments help understand human interactions with space.

Over the last decade, more advanced methods have been used to investigate the relationship between the environment and emotions. Researchers nowadays use technology like sensors and facial expression analysis to measure how environments affect people while they are moving (Agustí & Lladós, 2022; Bower et al., 2019; Gidlow et al., 2016; Janeczko et al., 2020). For example, Bower et al. (2019) reviewed studies that used both physiological data (like nervous system activity) and self-reported feelings to measure emotional responses to building and interior environments. Other studies looked at the emotional impact of moving through space using tools like wearable sensors and facial recognition (Gidlow et al., 2016; Janeczko et al., 2020). It has been found that movement through an environment brings unique emotional reactions that differ from those experienced while standing still. As this research area continues to grow, it is important to understand how these public space characteristics relate to emotional experiences, especially while walking.

To stimulate walking, it is essential to gain a deeper understanding of how the urban environment contributes to people's emotional experiences. This research addresses this need by focusing on young adults and examining how specific public space characteristics shape the emotions they experience while walking in urban areas. While walking is often promoted for its health benefits, less is known about the role of the built environment in shaping emotional experiences during walking, especially for young adults. By combining spatial data and statistical analysis, this study aims to identify which characteristics are associated with more positive or negative emotions. The insights gained can help urban planners and policymakers design public spaces that make walking more pleasant and attractive, ultimately encouraging people to walk more often.

This research aligns with the growing awareness among governments and municipalities that the urban environment plays a significant role in addressing health issues such as obesity and inactivity. For example, the Dutch government wants to implement measures to reduce the number of obese and overweight people (Ministerie van Volksgezondheid, 2018). The focus of these measures is encouraging more daily physical activity, with walking being one of the most accessible and effective forms. Local initiatives, such as *'Eindje Om'* in Eindhoven, support this goal by offering walking routes that help residents rediscover their urban environment (Gemeente Eindhoven, 2024; Rogier van Son, 2020). By providing new insights into how public space characteristics influence emotions, this research can support local initiatives and contribute to improving public health among young adults in urban areas.

1.2 RESEARCH QUESTION(S)

To stimulate more walking among young adults, it is important to understand how the design of public space contributes to their emotional experiences while walking. Therefore, this report aims to investigate the relationship between public space characteristics and the emotions experienced by young adults while walking in urban areas. Understanding this relation can help define effective strategies to make walking more attractive and improve public health outcomes.

The aim of this study will be found by answering the following research question;

"What is the contribution of public space characteristics to the emotions of young adults while walking in urban areas?"

In order to answer this research question, the following sub-questions need to be answered. These will begin with questions that focus on identifying the emotions relevant to this study. The next question explores the broader factors that contribute to emotions. To focus specifically on the public space characteristics, the third question examines which public space characteristics are relevant to include in this research. After further research is conducted, the last sub-question can be answered to examine which specific public space characteristics have a significant effect on emotional states during walking.

Sub-questions:

1. *Which emotions of young adults are relevant to include in this research?*
2. *What personal, social, environmental and external factors contribute to the emotions of young adults?*
3. *Which public space characteristics are relevant to include in this research?*
4. *Which public space characteristics have a statistically significant effect on emotional states during walking?*

1.3 RESEARCH DESIGN

This research aims to explore the contribution of public space characteristics to the emotions of young adults while walking in urban areas. To investigate this, an empirical evaluation approach is used. This means that the research is based on real-world data. The research combines theoretical insights from environmental psychology studies with real-life spatial data and statistical analysis. This structured approach leads toward answering the sub-questions and the main objective. The research design is illustrated in Figure 1.

The research starts with a literature review to create a theoretical framework for this study. It focuses on three parts. First, the literature on emotional responses is evaluated using the Circumplex Model of Affect (CMA). Then, literature is presented on the Social Ecological Model (SEM) to understand the types of factors that contribute to emotions. The literature review ends with an evaluation of the public space characteristics that are relevant to include. This literature review helps answer the first three sub-questions. After the literature review, the selection of variables is made, which will be included in further analyses. The literature review will give insights to answer the first three sub-questions.

Next, empirical data are collected to link emotions and public space characteristics in practice. This involves tracking participants' walking routes, gathering self-reported emotional experiences, and mapping the public space characteristics present along the routes. Once the data are collected, spatial analysis and statistical modelling are conducted to examine the

relationships between public space characteristics and emotional states. A Multinomial Logistic Regression (MLR) is used to determine which public space characteristics have a significant effect on the emotions experienced during walking. This step answers the fourth sub-question.

Finally, the conclusions can be drawn based on the results. Additionally, the main research question can be answered. This research design provides a structured approach to answer the research question. By combining theory, real-world spatial data, and statistical modelling, this study presents a structured approach to understanding how public space characteristics affect the emotions of young adults. The steps of this process are shown in Figure 1.

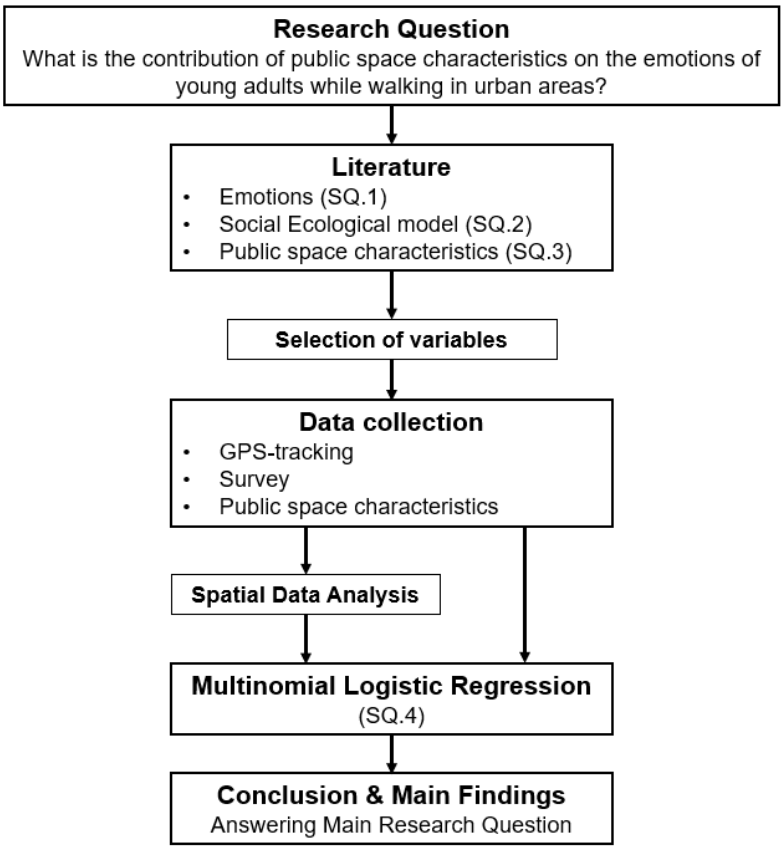

Figure 1, Research design

1.4 THE RELEVANCE OF THIS RESEARCH

This research provides new insight into how specific public space characteristics contribute to the emotional experiences of young adults while walking. This study area remains underexplored in current environmental psychology literature. While many studies have examined the functional aspects of walkability, such as safety, accessibility, and connectivity (Alfonzo, 2005; Brunner et al., 2025), only a few have explored how the physical environment contributes to emotional responses among young adults during walking. As described earlier, emotional discomfort is one of the barriers that prevent young adults from being more physically active (Gao et al., 2023). While walking is often promoted for its health benefits, less is known about the role of the built environment in shaping emotional experiences during walking, especially for young adults.

This study aims to fill that gap by identifying which public space characteristics contribute to either positive or negative emotions of young adults. As Hillnhütter states in his research, *"Understanding how urban environments can encourage more and longer walking trips is one of the most fundamental questions behind any research that focuses on walking environments."* (Hillnhütter, 2022). This thesis builds on that idea by linking specific public space characteristics to emotional responses.

Therefore, this study has practical relevance in this research area. The findings can help cities and policymakers create walking environments that support movement and feel pleasant and inviting. If young adults associate walking with more positive emotions, they may be more likely to engage in regular walking. This could support public health goals, as walking contributes to both physical and mental well-being and may help reduce obesity rates in this target group (Hart, 2009; Sallis et al., 1998).

From a scientific perspective, this research contributes to the existing literature by combining the *Socio-ecological model* (Bronfenbrenner, 1979) with the *Circumplex Model of Affect* (Russell, 1980). This research connects these theories with real data from actual walking routes. The study links GPS-tracked paths and mapped public space characteristics directly to how young adults feel. This clear link between what is around a person and how they feel is new. It gives detailed knowledge at the street level. This helps urban design and environmental psychology better understand how public space can support positive emotions while walking.

1.5 READING GUIDE

This research is structured into seven chapters that together form the basis of the study on how public space characteristics affect the emotions of young adults while walking in urban areas. The first chapter introduces the topic, the research questions, and the relevance of the study. The second chapter presents the theoretical background and reviews the existing literature. Chapter three describes the research approach and explains the methodology used. In Chapter Four, the data collection process and data preparation steps are detailed. Chapter Five presents the results of the analysis. These results are discussed in Chapter Six. This chapter presents the discussion of the findings, evaluates limitations, and provides recommendations for future research. The final chapter presents the conclusions of this research, including the scientific and societal relevance.

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2 LITERATURE REVIEW

This chapter reviews the literature related to the main topics of this research. It is divided into three main sections: emotions, the Social Ecological Model (SEM), and public space characteristics. The first section focuses on the emotions in the urban environment. Additionally, the connection between walking and emotional responses in the urban context will be examined. Section 2.2 explores the topic of emotions. It begins with an examination of how young adults experience emotions. Furthermore, the Circumplex Model of Affect (CMA) will be explained as a method to categorise emotional responses. The next part focuses on the role of the physical environment in shaping emotional experiences during walking. It begins by introducing the Social Ecological Model (SEM), which presents an overall framework illustrating how various factors influence the emotions of young adults. The physical environment factors will be further elaborated in the final part. Here, the specific public space characteristics influencing emotional responses during walking will be evaluated, based on prior studies. The literature review will end with a conclusion. In this section, the first, second, and third sub-research questions will be addressed.

2.1 EMOTIONS IN THE URBAN ENVIRONMENT

Emotions affect how people experience everyday life. They play a role in how individuals interact with their physical and social environments. Emotions are typically defined as states that involve physiological activation, subjective feeling, cognitive interpretation, and behavioural response (Brunner et al., 2025; Ortiz-Ramirez et al., 2021; Russell & Lanius, 1984; Ulrich, 1983). These emotional responses are dynamic, and they can arise in response to both internal and external stimuli.

Research in the field of environmental psychology began to pay attention to the emotional dimension of urban life in the 1970s and 1980s (Bronfenbrenner, 1979; Mehrabian & Russell, 1974; Russell & Lanius, 1984; Stokols, 1978; Ulrich, 1983). This attention marked a shift from seeing cities as functional systems to recognising them as environments that affect mental states and well-being. Environmental psychology provides the theoretical foundation for understanding this relationship. It examines the dynamic interaction between individuals and their physical surroundings. According to Stokols (1978), environmental psychology shows that environments are not only visually perceived but also emotionally experienced. The way a space feels can influence how individuals behave within it. Emotional responses help explain why specific environments are experienced as pleasant, while others may feel uncomfortable or unwelcoming.

Since then, studies have increasingly explored the impact of the built environment on people's emotions in everyday situations. Positive emotional responses such as relaxation, comfort, or interest are often associated with places that are safe, clean, and pleasant (Johansson et al., 2016). In contrast, environments with high traffic, noise, or visual disorder often cause stress, anxiety, or sensory overload (Bornioli et al., 2019). These emotional states affect how people react to their environment, whether they choose to stay, walk, avoid, or return (Ettema & Smajic, 2015). Recent studies have explored the emotional outcomes of interacting with urban environments. For instance, Bornioli et al. (2019) found that more pleasant street environments directly influence intentions to walk and stronger place attachment. Similarly, Johansson et al. (2016) demonstrated that noisy streets are associated with higher stress levels and avoidance intentions, whereas visually engaging and greener environments promote positive affect. These

findings highlight that emotional responses are not only personal. They are shaped by identifiable public space characteristics. Therefore, understanding how emotions emerge during everyday activities, such as walking, opens up opportunities to create urban environments that not only function well but also feel emotionally supportive.

2.1.1 Emotions while walking in urban environments

Outdoor walking creates continuous interaction with the physical environment. As people move through space, they are exposed to sensory stimuli, which can influence their emotional experiences. Recent urban research has increasingly recognised the emotional experiences while walking (Johansson et al., 2016; Koohsari et al., 2013; Rahman et al., 2019; Zurawik, 2014). These research focus on how feelings like calmness, excitement, or stress emerge while navigating through the city. They found that emotions often arise in response to what is seen, heard, or sensed along the way (Johansson et al., 2016).

Walking also allows for real-time evaluation of environments. It involves both mental and physical engagement. As Ettema & Smajic (2015) describe, walking can trigger affective responses that are shaped by urban environmental aspects. Their research showed that walking in lively urban environments can produce high levels of affect. At the same time, quieter, greener spaces can evoke feelings of relaxation (Ettema & Smajic, 2015). Moreover, emotional responses while walking influence how routes are remembered and judged. In a virtual walking study, Ruotolo et al. (2021) found that positive and high-arousal stimuli along a route improved participants' spatial memory and made the route seem shorter and more pleasant. This suggests that emotional stimuli do not just shape perception in the moment; they also influence how walking experiences are stored and recalled. Alfonzo (2005) contributed to the research on walking in urban areas by describing the hierarchy of walking needs. The research of Alfonzo emphasises that environments meeting the needs of safety, comfort, and pleasure to encourage pedestrian activity (Alfonzo, 2005).

Thus, emotions are central to how space is understood and evaluated while walking. These experiences help determine whether people feel safe or connected in a place. As Johansson et al. (2016) mention, public space design should support physical access and positive emotional connections, which in turn improve walkability.

2.1.2 Linking environments, emotions, and behaviour

The connection between environmental stimuli, emotional response, and behavioural outcome is formalised in the Mehrabian–Russell Model (Mehrabian & Russell, 1974). This model presents a three-step process, as illustrated in Figure 2. When individuals encounter an environment, they form an emotional impression of it. These feelings influence whether they stay and engage (approach) or leave and avoid (avoidance). This can, for example, result in a decision to keep walking through an area or to avoid it.

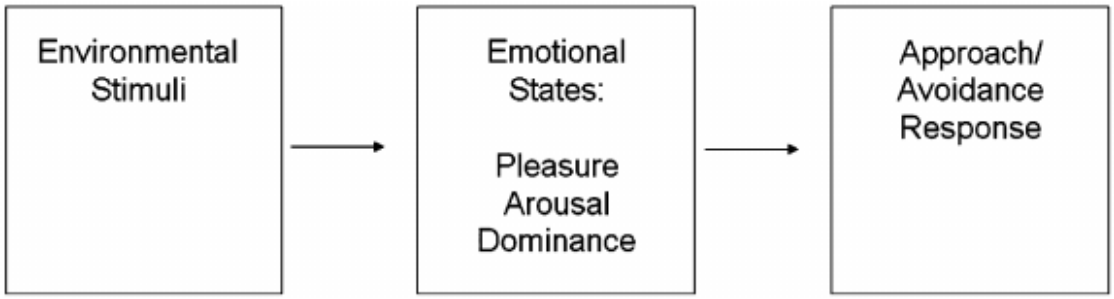

Figure 2, The Mehrabian-Russell Model ***(Mehrabian & Russell, 1974)***

This model is often used in environmental psychology to explain behaviours in different settings. Ortiz-Ramirez et al. (2021) applied the Mehrabian–Russell Model to pedestrian behaviour on sidewalks. Their study confirmed that emotional states such as pleasure and arousal, triggered by the physical design of the sidewalk, predicted whether individuals intended to approach or avoid certain areas. Johansson et al. (2016) further highlight how urban design qualities are linked to positive affective responses, which in turn increase the desire to walk. Johansson et al. (2016) asked participants to walk along three routes and rate their feelings about the environment. Participants in their study reported more positive feelings, such as relaxation and pleasure, in spaces with appealing visual qualities and greenery. These emotions correlated directly with intentions to revisit or spend more time in such environments. Their study demonstrated that emotional experience acts as a bridge between perceived design and actual walking intentions. These findings support the idea that urban design can shape behaviour through emotional cues.

The Mehrabian–Russell Model helps to explain why certain streets feel more inviting than others. It positions emotional response as an intermediate layer that transforms physical stimuli into behavioural outcomes.

2.1.3 Young adults and their emotions while walking in urban environments

The definition of young adults in years is defined differently in several studies (Bonnie et al., 2015; Erikson, 1950; Higley, 2019). Young adults can be defined as a life stage of exploration. This phase of exploration makes their interaction with the environment emotionally rich and often more intense compared to other age groups (Erikson, 1950). This life stage is also important for developing habits that often continue into adulthood, which means that the environments young adults engage with can shape long-term behavioural patterns (Verplanken, 2006). As they engage in various forms of movement through the city, emotions play a continuous role in shaping their experience of public space. Urban environments provide a setting for young adults to participate in social life. Walking offers an accessible way to interact with these environments, making it especially relevant to this group.

Empirical studies have demonstrated that young adults respond strongly to spatial and social conditions while walking (Ettema & Smajic, 2015; Janeczko et al., 2020; Rahman et al., 2019). In a study conducted among students in Utrecht, emotional states were measured during walks using smartphone surveys (Ettema & Smajic, 2015). The findings revealed that emotional well-being was the highest in lively areas where activity and social opportunities were present (Ettema & Smajic, 2015). However, areas with natural features such as trees and water also supported positive emotions. This highlights that both stimulation and restoration are important for the well-being of this target group. Rahman et al. (2019) found that specific features of the built environment, such as street width, sidewalk quality, and lighting, were associated with increased walking among young adults. Safety and stimulation also appear to be relevant for emotional well-being during walking. The study of Ettema and Smajic also found that while perceived safety did not directly influence happiness, it did make participants feel more active and confident (Ettema & Smajic, 2015).

Given these findings, it is crucial to investigate the emotional responses of young adults in urban environments. Their emotional reactions are likely to influence future behaviour and expectations of urban life. If urban environments are designed to evoke positive emotions, young adults may be motivated to walk more often. Stimulating young adults to walk more often could lead to beneficial outcomes regarding mental and physical health (Brindis et al., 2004).

2.2 MEASURING EMOTIONS: CIRCUMPLEX MODEL OF AFFECT

To understand how people emotionally respond to environments, it is necessary to use a measuring method that captures the complexity of emotions. One of the most widely used models is the Circumplex Model of Affect (CMA), developed by Russell (1980). This model places emotions within a two-dimensional scale, using valence (pleasant to unpleasant) and arousal (high to low activation) as the main axes. In this context, the term *affect* refers to the emotional state of individuals in response to their surroundings. Each emotional state is positioned in one of the four quadrants formed in the model. For example, emotions such as relaxation are characterised by low arousal and positive valence, whereas stress is characterised by high arousal and negative valence. This structure enables researchers to categorise emotions clearly and concisely. The CMA has been widely applied across studies, including those in environmental psychology (Bornioli et al., 2019; Brunner et al., 2025; Ettema & Smajic, 2015; Johansson et al., 2016; Mouratidis & Hassan, 2020; Zhang et al., 2022). It captures the emotional reactions that come from everyday experiences. Researchers applied this model to examine how specific urban characteristics interact with emotions, such as relaxation, stress, excitement, and boredom (Brunner et al., 2025; Russell & Lanius, 1984). Figure 3 shows the Circumplex Model of Affect with the four quadrants. The CMA does not place emotions as fixed categories, but recognises them along a continuous spectrum. This is useful when studying responses to urban environments, where feelings relate to each other within a continuous system (Russell, 1980).

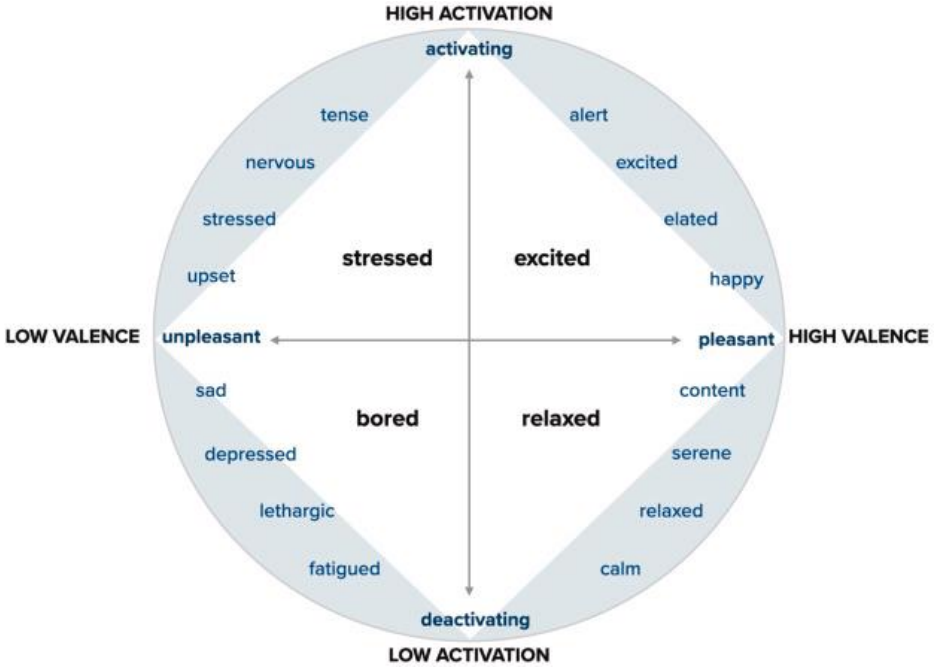

Figure 3, Circumplex Model of Affect ***(Brunner et al., 2025)***

Russell & Lanius (1984) later built on this model by connecting it to the affective appraisal of environments. According to their research, people do not only observe or evaluate an environment based on physical features. Instead, they make emotional judgments, assessing whether an environment feels calming, tense, exciting, or gloomy. These emotional evaluations are shaped by past experience. For instance, a quiet alley might feel peaceful to one person but unsafe to another, depending on their previous experiences with similar settings. In the work of Russell & Lanius (1984) it is demonstrated that these emotional appraisals can also be visualised in the same two-dimensional space as the Circumplex Model of Affect. The strength of the CMA is that it enables the quantification of emotional evaluations of environments. At the same time, it leaves room for personal interpretation.

Several studies have used the CMA to explore how urban environments affect pedestrians' emotions. Bornioli et al. (2019) used the model to measure the impact of urban design features on walking experiences. Their findings suggest that spaces with greenery, good maintenance, and low car traffic are strongly linked to positive feelings. These are based on high valence and low arousal of the Circumplex Model of Affect, suggesting calm and positive feelings. On the other hand, noisy, crowded, or visually disordered environments led to stress and discomfort, defined by low valence and high arousal. Johansson et al. (2016) similarly found that quieter, green spaces are emotionally restorative, which promotes calmness. Conversely, busy and noisy streets increase stress and discomfort, leading pedestrians to avoid these areas. Additionally, Zhang et al. (2022) found that incorporating even small green features into urban settings significantly enhances positive emotional responses. These studies confirm that specific urban features can influence how people feel during a walk.

The CMA has also been valuable in experimental research settings. Mouratidis & Hassan (2020) used virtual reality environments to compare emotional reactions with the CMA to contemporary versus traditional architecture. Their results showed that traditional designs triggered feelings of comfort and pleasure. While the contemporary designs led to increased stress or anxiety due to specific designs and a lack of human-scale features. Additionally, Ettema & Smajic (2015) explored the emotional dimension of walking, also with the CMA. The focus of their study was more on how dynamic urban environments with active street life and diverse sensory experiences increase emotional arousal. They found, on the contrary, that quieter and greener spaces evoke lower levels of arousal.

Advancements in emotional mapping have further reinforced the applicability of the CMA. Zhu et al. (2023) combined physiological measures, including heart rate and skin conductance, with real-time walking experiences. They identified specific urban characteristics associated with stress, including high traffic and poor pedestrian infrastructure. Conversely, open spaces, greenery, and human-scale designs correlated with positive emotions. Hillnhütter (2022) also noted that combining self-reported emotional states with physiological measures provides more accurate emotional mappings.

There are various ways to measure emotions, ranging from self-report surveys to physiological sensors. With this inconsistency in methodology, the Circumplex Model of Affect provides an overall framework that can be applied to indicate emotions in environmental psychology studies. The CMA's structured approach facilitates the identification of urban characteristics associated with emotional states, enabling detailed comparisons across diverse urban environments.

2.3 A FRAMEWORK FOR ENVIRONMENTAL INFLUENCE: THE SOCIO-ECOLOGICAL MODEL

From the previous literature review, it is found that the built environment shapes human emotional experiences. This subchapter examines the potential environmental factors that may influence the emotional experiences of young adults while walking in urban environments. It starts by introducing the Socio-Ecological Model (SEM) as a theoretical framework. This framework illustrates the interactions between the individual, social, environmental, and external layers that shape emotional experiences. Furthermore, this subchapter examines the specific layers of the SEM that influence individuals' emotional responses. By framing these insights, this section provides an understanding of the relationship between environmental influences and the emotional experiences of young adults.

2.3.1 The Socio-Ecological Model (SEM)

Understanding how public space characteristics influence human emotions and behaviour requires a framework that captures the interactions between individuals and their surrounding environments. The Socio-Ecological Model (SEM) suggests that behaviour does not solely come from individual factors, but results from interactions across multiple levels of influence. The most used framework is Bronfenbrenner's Ecological Systems Theory, which can be seen in Figure 4 (Bronfenbrenner, 1979). In his model, he describes five systems that each contribute to individual experiences: the microsystem, mesosystem, exosystem, macrosystem, and chronosystem. Based on Bronfenbrenner's (1979) Ecological Systems Theory, the SEM has evolved into a widely applied model in several fields, including public health, urban planning, and behavioural science.

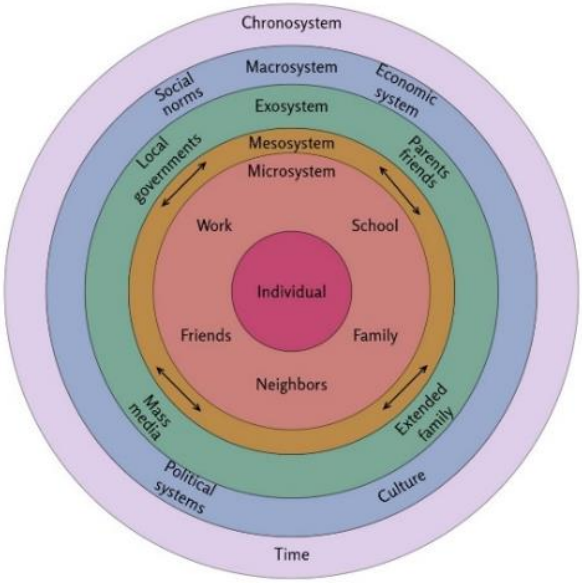

Figure 4, Bronfenbrenner's Ecological Systems Theory ***(Bronfenbrenner, 1979)***

The model has been used, among others, to investigate physical activity behaviour (Hu et al., 2021; Sallis et al., 1998; Zurawik, 2014). It highlights that multiple layers, including personal attributes, social relationships, environmental factors, and external factors, influence human behaviour. According to Hu et al. (2021), the SEM is especially suitable for studying behaviours like walking, as these relate to physical and social environments. Additionally, Sallis et al. (1998) found that physical activity change is more likely when interventions address multiple levels of the ecological model at the same time. Zurawik (2014) further elaborates on walking behaviour by categorising it into the level of individual perceptions, social interactions, environmental aesthetics, and urban governance. Her research suggests that walking is not only a physical activity but also a cultural experience, shaped by societal norms. According to Zurawik, walking behaviours are connected within networks of social groups and local environmental contexts, which together shape individual experiences.

To identify the factors that influence the emotions of young adults while walking, the SEM will be divided into the following parts. First, the focus will be on the individual layer to look at which personal factors influence emotional responses. Second, the social factors will be determined to see how social interactions influence young adults. The third part will explore which environmental factors influence emotions. This includes the physical surroundings through which individuals walk, which is the focus of this research. Finally, some external factors will be evaluated. This is the outer layer of the SEM, which includes external factors that cannot be controlled.

2.3.2 Individual factors

Individual characteristics influence emotional responses while walking in urban environments. As part of the socio-ecological model, individual-level factors include sociodemographic characteristics, health, and well-being, as well as personal attitudes (Alfonzo, 2005; Ettema & Smajic, 2015; Kent et al., 2017).

Sociodemographic variables such as age, gender, education level, and household income contribute to the emotional experiences during walking (Koohsari et al., 2013; Rodrigue et al., 2024). Although different studies use different age ranges, this research defines young adults as people between 17 and 28 years old, based on Erikson's developmental stages (Erikson, 1950). Erikson's theory of psychosocial development outlines the life stages based on behavioural changes. Additionally, according to Levinson's research, young adults can be categorised into varying life stages as well. Young adults within the age categories of 17–22 and 23–28 may differ in their emotional experiences due to varying life stages (Levinson et al., 1978). According to Levinson et al. (1978) The early adult transition (age group 17-22) primarily involves leaving home, leaving family, and making initial choices about career and education. The second age group (22-28) is called entering the adult world and deals with committing to an occupation, defining goals, and finding intimate relationships (Levinson et al., 1978).

Gender also influences emotional experiences. As Rodrigue et al. (2024) mentions, women often place higher importance on safety and security compared to men. This is also found in the research of Hu et al. (2021), who focused on the physical activity participation of adolescents. Emotional reactions are not only determined by physical characteristics of space, but also by who is experiencing them. For instance, Agustí & Lladós (2022) found that emotional responses differed between men and women even within the same public locations. This is found with heart rate variability, indicating stronger emotional reactions in women under certain spatial conditions. Features such as poor lighting, enclosed layouts, and lack of visual orderliness seemed to evoke more negative emotions in women than in men. These findings suggest that urban design must be sensitive to gender-specific needs, especially when aiming to create emotionally supportive public environments.

Education level and household income also influence the emotional experience while walking (Rodrigue et al., 2024). These reflect the socioeconomic status, which affects expectations and needs regarding the walking environment (Adkins et al., 2017). Research indicates that the impact of walkable environments is often weaker for lower-income and less educated groups. For instance, Adkins et al. (2017) found that although supportive built environments generally encourage walking, these benefits are twice as strong for individuals with higher incomes and higher levels of education.

Health and well-being factors also contribute to an individual's walking behaviour. Physical health status, such as mobility constraints, can directly impact walking experiences. Individuals who report a good mobility experience have fewer constraints and thus may experience more positive emotions while walking, compared to those with reduced mobility who may encounter frustration or negative emotions due to barriers (Frank et al., 2008). Mental health status is also important. Individuals rating their mental health from poor to excellent are likely to experience different emotional responses to similar environmental stimuli (Pae & Akar, 2020). Individuals with better mental health tend to be more resilient to environmental stressors.

Lastly, attitudes and behaviours, like walking purposes, also determine the emotional outcomes (Pae & Akar, 2020). Utilitarian walkers, focused on reaching destinations efficiently, may

prioritise functionality and safety. In contrast, recreational walkers often seek aesthetic enjoyment and relaxation from their environment, experiencing more positive emotions in aesthetically pleasing environments (Alfonzo, 2005; Ettema & Smajic, 2015). Those with a mixed walking purpose may balance between functionality and recreational enjoyment.

2.3.3 Social factors

It is found that human interactions form a part of the overall walking experience of individuals (Ayala-Azcárraga et al., 2019; Ettema & Smajic, 2015). Within the SEM, social interactions and cultural attitudes towards walking contribute to emotional outcomes (Zurawik, 2014). Factors included in the social environment that contribute to emotions while walking will be elaborated on in this section. Social cohesion refers to how connected people in the same environment feel toward each other. When social cohesion is strong, people often feel safer and more at ease in public spaces, which directly affects emotional comfort during walks. Areas with high social cohesion encourage feelings of comfort and security, thus evoke positive emotional responses among pedestrians (Kent et al., 2017). On the other hand, places with low perceived social cohesion might lead to feelings of isolation or discomfort, thereby triggering negative emotions (Brindis et al., 2004).

Social safety is another factor of the social layer. Young adults' perceptions of safety influence their emotional states. It is found that safer environments promote overall positivity, while unsafe settings can create stress or anxiety (Adkins et al., 2017). Walking companionship also contributes to emotional responses. Walking alone versus with friends, family, peers, or others can contribute to the emotional experience (Ettema & Smajic, 2015). Walking companionship offers opportunities for social interactions. This might evoke positive feelings while reducing feelings of loneliness. Furthermore, pedestrian density plays a role in the social interactions category. According to Brunner et al. (2025) high pedestrian density is associated with stressful walking experiences. High pedestrian density results in a sensory overload, which creates stress (Bornioli et al., 2018, 2019). According to Hu et al. (2021) cultural attitudes towards walking are indicators reflecting the broader societal norms and values of physical activity. Positive local attitudes toward walking foster feelings of motivation and social acceptance. Neutral or negative local attitudes might discourage walking or diminish the quality of emotional experiences by instilling feelings of judgment (Hu et al., 2021).

2.3.4 Environmental factors

Since public space characteristics are the main focus of this research, they will be elaborated on more specifically in Subchapter 2.4. In this section, the overall connection between individuals and their physical environment will be evaluated in light of previous studies. The way people emotionally respond to public spaces is not only shaped by public space characteristics, but also by how they perceive and connect with these places. According to Bornioli & Subiza-Pérez (2023), restorative experiences in urban environments depend on two types of features. One of the objective features of the environment is aesthetics, greenery, and safety. The other factors are subjective, including personal memories and symbolic meanings. These perceptions are well connected to place attachment (Bornioli & Subiza-Pérez, 2023). Place attachment refers to the emotional bond people form with a location. Johansson et al. (2016) evaluate that emotional experiences during walking are influenced by more than just what is physically present. They are shaped by an individual’s relationship with the space, including past experiences, familiarity, and emotional associations. It has also been found that well-being outcomes in parks are strongly connected to how much users feel they belong there (Ayala-Azcárraga et al., 2019). This is in line with the place attachment concept.

2.3.5 External factors

External factors include policy and governance, weather conditions, and the temporal context, which have been found in previous studies to contribute to the emotional experience of pedestrians (Ettema & Smajic, 2015; Gao et al., 2023; Zhu et al., 2023). Walkability policies are implemented to create structured, safe, and accessible walking environments. Creating these structured and safe walking environments enhances the perception of security and comfort. This will positively impact the emotional experience while walking (Ettema & Smajic, 2015). On the other hand, areas with limited walkability policies perceive a lack of support and infrastructure for walking activities. This is comparable to the cultural attitudes towards walking norms.

Weather conditions, including rain, temperature, and wind, directly affect walking experiences. Research consistently shows that heavy rain and strong winds negatively impact pedestrians' willingness to walk, and people are more likely to switch to another transit mode (Gao et al., 2023). According to Gao et al. (2023), pedestrians experience decreased emotional comfort in such weather conditions. Similarly, he found that extreme temperatures, both cold and hot, can lead to discomfort and negative emotional states, reducing the overall pleasantness of walking. Thus, moderate weather conditions (such as dry, moderately warm temperatures with minimal wind) are associated with more positive emotional experiences.

Temporal contexts include the time of day, day of the week, and season of the year. Research indicates that walking experiences in the morning and afternoon are typically perceived as safer and more enjoyable compared to evening and nighttime, because these often evoke feelings of insecurity (Zhu et al., 2023). Furthermore, the day of the week has a significant influence on emotional experiences. According to Gao et al. (2023), weekend walks tend to be more relaxing due to their often leisure-oriented walking purpose, compared to weekday walks. Seasonal variations also contribute to emotions while walking. Walking in spring and summer generally evokes more positive emotional experiences due to better weather, more daylight, and pleasant environmental conditions. Whereas winter, characterised by cold temperatures and limited daylight, often evokes negative emotional responses among pedestrians (Gao et al., 2023; Zhu et al., 2023).

2.4 PUBLIC SPACE CHARACTERISTICS AND THEIR EMOTIONAL IMPACT

Several studies have investigated the impact of physical environments on people’s emotions. From these studies, public space characteristics can be derived that may contribute to the emotions of young adults while they walk. The five categories are based on the environment matrix from Hillnhütter (2022). Within each category, specific public space characteristics are evaluated. At the end, a recap will be provided in the form of a table.

2.4.1 Natural elements

It is found that natural elements contribute to the emotional experiences of young adults in urban walking environments. The presence of urban greenery can evoke a range of emotions, including relaxation, excitement, stress, and overall emotional well-being (Agustí & Lladós, 2022; Brunner et al., 2025; Ulrich, 1983, 1986; Zhang et al., 2022). Physiological evidence also supports the beneficial influence of natural elements. Walking in natural environments has been associated with decreased physiological stress markers, such as cortisol levels, and improved concentration (Gidlow et al., 2016). Within natural elements, not only is greenery mentioned in literature, but also water features. In the research of Gidlow et al. (2016), the water features are included as blue environments. Gidlow found that water features are also significant in influencing emotions while walking in both natural and urban areas.

Trees, shrubs, grass surfaces, and vertical greenery are different forms of green elements that influence individuals' emotions (Zhao et al., 2022). Especially the presence of trees, since they provide shade and give visual aesthetic pleasure. Trees thus contribute to feelings of calmness and relaxation (Zhao et al., 2022). Additionally, Ulrich (1986) emphasizes that visual interactions with trees and vegetation can notably reduce stress and anxiety levels. This also came forward in the research of Bornioli & Subiza-Pérez (2023). They found that exposure to greenery can evoke calming feelings, leading to stress reduction. Vertical greening, such as green façades, can be an alternative for urban contexts with limited horizontal space. The effect of this form of greenery may vary slightly from traditional green elements such as grass and trees. According to Zhao et al. (2022), vertical green on façades enhances emotional experiences by increasing aesthetic satisfaction and lowering perceived urban density and stress.

Moreover, variations in the type and scale of green spaces further affect emotional responses. Larger green spaces recall stronger emotional benefits. This enhances a positive mood and reduces negative affect, such as stress or anxiety (Ayala-Azcárraga et al., 2019). Nevertheless, small-scale urban greenery can evoke positive emotional responses. As (Ulrich, 1986) According to his research, even smaller vegetation, such as flowering plants, has an aesthetic effect on pedestrians. Therefore, it can be concluded that the presence of any greenery positively contributes to the emotional experiences compared to purely built urban environments (Ulrich, 1986). Furthermore, urban streets enhanced with substantial green vegetation generate more positive emotional experiences compared to streets with limited or no greenery (Zhang et al., 2022). The quality and design of greenery are also important to indicate in this research. Public spaces with diverse, well-maintained vegetation tend to foster more positive emotional experiences than those with poorly maintained or monotonous greenery. Spaces that integrate green elements with pedestrian infrastructure create engaging environments, increasing emotional well-being, and reducing boredom and stress (Brunner et al., 2025). Since greenery has a positive effect on the emotional experience while walking, the following green public space characteristics are relevant to include: trees, water, shrubs, flowers, green facades, and grass surfaces.

2.4.2 Traffic

The second group to investigate are traffic aspects that contribute to emotional experiences while walking in urban environments. These traffic aspects are shaped by how the environment is designed and managed. The presence of motorised traffic is generally associated with negative emotional outcomes, such as increased stress and reduced pleasantness (Bornioli et al., 2018, 2019). Research by Schnell et al. (2012) identifies traffic-related noise and air pollution as the main sources of environmental discomfort. Heavy motor traffic not only elevates noise and air pollution levels but also negatively impacts pedestrian safety perceptions, generating feelings of insecurity and stress (Bornioli et al., 2018; Brunner et al., 2025). Environments dominated by vehicles often result in sensory overload due to high noise levels. This leads to increased head movements or looking down, behaviours that suggest discomfort and disengagement from their surroundings (Hillnhütter, 2022). Besides motorised traffic, cycling is also found to be disturbing to the walkability. (Ortiz-Ramirez et al., 2021) found that passing bicyclists are correlated with negative emotional experiences while walking. Therefore, the presence of bike lanes with high bike flow can annoy pedestrians (Ortiz-Ramirez et al., 2021).

Moreover, traffic density and speed affect people's emotional well-being. Urban areas characterised by high traffic intensity are linked to heightened arousal in terms of stress (Bornioli et al., 2018, 2019). Contrarily, pedestrianised areas, with less exposure to traffic, are found to

promote relaxation. These areas improve the walking experience, suggesting that reducing or eliminating motorised traffic can improve emotional outcomes for pedestrians (Brunner et al., 2025). Even parked cars and bicycles are found to impact pedestrians' emotions (Brunner et al., 2025; Sundling & Jakobsson, 2023). Parked cars and bicycles can be obstacles to the footpath, creating a stressful situation. Also, the look of parked cars can create feelings of boredom, since streets can look monotonous (Brunner et al., 2025). The design of pedestrian crossings and intersections is also important for pedestrians. Poorly designed pedestrian crossings, lacking clear visibility or sufficient time to cross, evoke feelings of insecurity and anxiety (Bornioli et al., 2019). Well-designed crossings with good visibility and proper signage mitigate stress by ensuring pedestrians feel secure in urban spaces (Hillnhütter, 2022).

From these studies, it can be concluded that traffic factors influence emotions. The identified factors include: traffic volume, traffic speeds, noise pollution, bike lanes, parked cars and bicycles, and pedestrian crossings.

2.4.3 Pedestrian infrastructure and street furniture

According to previous studies, pedestrian infrastructure in urban environments has a significant influence on emotional experiences during walking. First, the quality and width of sidewalks have an impact on pedestrian comfort (Sundling & Jakobsson, 2023; Zhao et al., 2022). Narrow sidewalks or poorly maintained pathways increase perceived risks, which create stress and discomfort among pedestrians (Bornioli et al., 2019; Hillnhütter, 2022). In contrast, wide and well-maintained sidewalks facilitate pedestrian flow and enhance perceptions of safety, which promotes positive emotions (Sundling & Jakobsson, 2023). This also includes the surface of the sidewalks. Poor surface conditions or a lack of continuity in footpaths could lead to frustration (Sundling & Jakobsson, 2023). Street configuration and connectivity also influence pedestrian emotional experiences. While integrated street configurations can sometimes reduce the perception of convenience, leading to less use of certain routes (Koohsari et al., 2013). Limited pedestrian routes and options can negatively impact pedestrian emotions, causing frustration due to detours and unclear routing (Brunner et al., 2025).

Furthermore, the presence and quality of street furniture such as benches, adequate lighting, and resting areas play significant roles. Comfortable and well-positioned seating areas, sufficient street lighting, and pedestrian-oriented amenities enhance feelings of safety and enjoyment among pedestrians (Li et al., 2016). Additionally, elements such as cleanliness shape pedestrian emotional states, impacting their overall perception of street appearance (Brunner et al., 2025). This can also be linked to the presence of street furniture, such as waste baskets.

Another aspect to include is public art. Public art can evoke both pleasant and unpleasant feelings (Motoyama & Hanyu, 2014). According to the study of Motoyama & Hanyu (2014) about public art and the affective appraisals, the emotional impact of public art depends on its quality. For example, well-maintained and visually attractive art gives more pleasantness than poorly maintained and deteriorated art (Motoyama & Hanyu, 2014). This applies to public art, such as statues, art furniture, and graffiti. Additionally, the presence of underpasses or tunnels are found to be very unattractive in urban walk environments (Hillnhütter, 2022). According to Brunner et al. (2025), these underpasses can cause stressful experiences while walking.

This literature review reveals that the following pedestrian infrastructure features and street furniture elements contribute to the emotional experience of pedestrians: sidewalk width, sidewalk surface, street connectivity, benches, street lighting, cleanliness, public art, and underpasses.

2.4.4 Street appearance

Streetscapes can be defined as the physical and visual features of street environments that influence the emotional experience of pedestrians. Architectural diversity contributes to positive emotional experiences. Architectural diversity refers to environments characterised by mixed-use streets and varied building facades. This variety often leads to feelings of engagement (Bornioli et al., 2019; Brunner et al., 2025). However, overly complex visual environments with excessive stimulation will create stress and overwhelm pedestrians (Brunner et al., 2025). Streetscapes, including modern residential buildings and natural elements, have been shown to enhance relaxation (Bornioli et al., 2019; Brunner et al., 2025). Conversely, monotonous or neglected street appearances, including repetitive building designs, closed façades, and signs of deterioration or litter, are strongly associated with negative emotional states like boredom and dissatisfaction (Bornioli et al., 2019; Brunner et al., 2025). These factors reduce pedestrians' intentions to engage in urban walking activities. Additionally, the perceived aesthetics of a street play a role in promoting emotional well-being and happiness (Kent et al., 2017). Urban environments perceived as aesthetically pleasing not only enhance positive emotions but also encourage social interaction and community cohesion (Kent et al., 2017).

Additionally, the integration of urban design qualities such as openness, enclosure, and transparency significantly affects pedestrians' emotional responses. Street designs that give a positive emotional experience are visual openness, clear sightlines, and balanced enclosure, which enhance feelings of safety, comfort, and perceived control (Li et al., 2016). These also stimulate pedestrian activities.

Besides the street designs, the buildings also influence the street appearance. Building aesthetics include various elements such as architectural style, facade quality, building materials and maintenance condition. These aspects shape pedestrians' emotional experience by providing visual stimulation (Batty, 2001; Bornioli et al., 2019). In contrast, visual monotony or neglected buildings create negative emotional states. Varied building facades with differentiated architectural elements evoke excitement, whereas monotonous, closed facades typically lead to feelings of boredom (Brunner et al., 2025). Diverse facade designs encourage sensory engagement, increasing the likelihood of positive emotions, such as excitement and interest, during urban walking experiences (Batty, 2001). Furthermore, building aesthetics have a direct impact on environmental perceptions and walking intentions. Attractive building aesthetics promote positive walking intentions among young adults (Adkins et al., 2012). In contrast, negative visual attributes of buildings, including poor design or neglect, diminish walking enjoyment (Bornioli et al., 2019).

The maintenance of building facades also plays a role in shaping pedestrian emotions. Poor maintenance, such as visible deterioration or lack of cleanliness, can increase stress and discomfort among pedestrians, reducing the enjoyment of walking in urban areas (Agustí & Lladós, 2022). Conversely, well-maintained facades enhance perceived safety and comfort, contributing positively to pedestrians' psychological well-being. The architectural age is a central aspect that influences positive emotional states (Batty, 2001). Historical architectural elements have been found to promote relaxation and positive affective states (Bornioli et al., 2018). Building height also contributes to emotional experiences. Environments characterised by appropriately scaled buildings support feelings of comfort and security. High buildings may cause negative emotions, such as stress or discomfort, due to feelings of being enclosed (Adkins et al., 2012).

2.4.5 Social facilities

The presence of social facilities, such as shops, restaurants, cafes, and other public spaces, in urban walking environments contributes to the emotional experiences of pedestrians, as they provide opportunities for social interaction. As part of the broader street-level experience, social facilities shape how pedestrians emotionally respond to public spaces.

One important factor is the presence of shops. Higher concentrations of commercial activity along the street have been associated with increased feelings of engagement. Streets with more shops are typically perceived as more lively, which contributes to a more positive emotional experience (Bornioli et al., 2019). The liveliness that comes from shops is a positive stimulus that boosts people's mood (Ettema & Smajic, 2015). Besides the quantity of shops, the diversity of shop types also plays a role. The diversity of shops refers to the range of functions that shops offer. A greater diversity has been linked to higher psychological satisfaction, as it supports walking purposes (Sundling & Jakobsson, 2023). For young adults, who often value multifunctional and flexible environments, the presence of diverse types of shops can create a sense of engagement (Weijs-Perrée et al., 2020). Monotony in shop functions, in contrast, has been associated with lower emotional stimulation and even boredom. The attractiveness of shop windows is another component influencing affective responses (Hillnhütter, 2022). High ratings of shop window attractiveness have been positively associated with pedestrian enjoyment, attention, and willingness to linger (Bornioli et al., 2019; Sundling & Jakobsson, 2023). A well-designed and maintained shopping window can evoke positive emotions such as curiosity and pleasure, while poorly maintained or visually cluttered windows may contribute to feelings of annoyance or even insecurity (Hillnhütter, 2022).

In addition to shops, cafés, and restaurants also contribute to pedestrians' emotional experiences by creating opportunities for social interaction. Like retail environments, restaurants and cafes attract people and create lively street atmospheres. Their presence increases social engagement, which is positively correlated with feelings of inclusion and happiness (Ettema & Smajic, 2015). These social spaces serve not only as destinations but also as emotional stimulators that enhance the perceived vitality and friendliness of the walking environment.

Playgrounds are another element of the social environment that influences emotional responses, particularly through their role in encouraging social activity and community presence. The presence of playgrounds has been linked to improved well-being and reduced psychological distress among pedestrians (Ayala-Azcárraga et al., 2019; Sundling & Jakobsson, 2023). For pedestrians, especially those with children, playgrounds contribute to feelings of relaxation and social connection.

Community centres also contribute to shaping emotional responses within walking environments. These facilities often act as social meeting places, strengthening place attachment and fostering a sense of belonging. Research indicates that the presence of community-oriented features enhances perceived walkability and increases emotional satisfaction during walks (De Vos et al., 2023). Environments that evoke a stronger sense of community have been associated with increased reports of happiness and comfort while walking in public spaces (Kent et al., 2017).

Examining social environments, the following facilities are found to have an influence on the emotions of pedestrians: shops, restaurants and cafes, playgrounds, and community centres.

2.5 CONCLUSION

The main objective of this literature review was to identify the relevant emotions and public space characteristics that influence young adults' emotional experiences while walking in urban environments. It reviewed theories and findings from existing studies. Based on these findings, three sub-questions can be answered.

Sub-question 1: Which emotions of young adults walking in urban environments are relevant to include in this research?

The Circumplex Model of Affect is used to map how young adults experience emotions while navigating different urban environments. This research uses the CMA to define four emotions: relaxation, stress, excitement, and boredom. These emotions have been frequently used in previous studies to assess the emotional experiences associated with urban environments. The model helps to place these emotions on a scale of valence and arousal. These emotions reflect both positive and negative experiences and can occur in different walking environments. Additionally, the relationship between emotions and public space characteristics can be explained using the Mehrabian-Russell model. This model states that environmental stimuli contribute to the emotional responses, which eventually lead to an approach or avoidance reaction.

Sub-question 2: What individual, social, environmental and external factors contribute to the emotions of young adults?

The literature indicates that various factors influence how young adults perceive their experiences while walking. The Social Ecological Model illustrates that emotions are influenced by multiple layers. These include the individual factors, social factors, environmental factors and external factors. The model helps to understand which aspects of the environment should be considered when conducting studies about emotional responses.

Individual factors include who someone is and their personal feelings. Table 1 below gives an overview of the individual factors that contribute to emotions while walking according to the literature.

Table 1, Individual factors that contribute to emotional experiences

Category	Characteristic	Measurement Levels
Sociodemographic	Age	17–22, 23–28
	Gender	Female, Male, Prefer not to say
	Education level	High school, Bachelor, Master, PhD
	Household income	< €1000, €1000–€2000, > €2000
Health & Well-being	Physical health status	Mobility constraint, Prefer not to say
	Mental health status	1 (Poor) – 5 (Excellent)
Attitude & Behaviour	Walking purpose	Utilitarian, Recreational, Mixed

Social factors focus on interactions with other people and how safe or connected someone feels. Table 2 gives an overview of these. Factors such as social safety, companionship, and a sense of social cohesion all influence emotions.

Table 2, Social factors that contribute to emotional experiences

Category	Characteristic	Measurement Levels
Social interactions	Social cohesion	1 (Very low) – 5 (Very high)
	Social safety	1 (Unsafe) – 5 (Very safe)
	Walking companionship	Alone, Friends, Family, Peers
	pedestrian density	1 (Very low) – 5 (Very high)
Cultural attitudes	Local attitudes towards walking	Positive, Neutral, Negative

External factors are outside conditions that can change every walk. Table 3 shows these factors. This includes weather, time of day, and policies which contribute to the emotional experience of each walk.

Table 3, External factors that contribute to emotional experiences

Category	Characteristic	Measurement Levels
Policy & governance	Walkability policies	Extensive, Moderate, Limited, None
Weather conditions	Rain	Dry, Light rain, Heavy rain
	Temperature	Cold, Moderate, Warm, Hot
	Wind	No wind, Light wind, Heavy wind
Temporal context	Time of walk	Morning, Afternoon, Evening, Night
	Day of the week	Weekday (Mon–Fri), Weekend (Sat–Sun)
	Season	Winter, Spring, Summer, Autumn

Looking at the SEM, these factors create the emotional context for each walk. By understanding each layer, this research identifies the factors that should be considered when examining how public space affects emotions.

Sub-question 3: Which public space characteristics are relevant to include in this research?
Based on the literature and the environmental matrix of Hillnhütter, 2022), the public space characteristics were grouped into five categories: natural elements, traffic, pedestrian infrastructure and street furniture, street appearance, and social facilities. These categories are characterised by specific characteristics, as shown in Table 4.

Table 4, Overview of the five categories and the public space characteristics

Category	Characteristics
Natural elements	Tree density, water features, shrubs, flowers, green façades, grass surfaces
Traffic	Traffic volume, traffic speed, noise pollution, parked cars, bike lanes, parked bikes, pedestrian crossings
Pedestrian infrastructure and street furniture	Sidewalk width, sidewalk surface, street connectivity, benches, street lighting, cleanliness, public art, underpasses
Street appearance	Architectural diversity, façade transparency, architectural age, building height
Social facilities	Shops, diversity of shops, restaurants and cafés, playgrounds, community centres

Previous studies have shown that certain public space characteristics are linked to specific emotional responses. High traffic volumes, noise, and high buildings are often associated with stress, while a high diversity of shops, clean surroundings, and unique architecture tend to evoke excitement. In contrast, green elements, good pedestrian infrastructure, and historic buildings are linked to feelings of relaxation. Lastly, monotonous façades, underpasses, and abandoned spaces are often associated with feelings of boredom. These findings support the idea that the physical environment can contribute to emotional responses.

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3 METHODOLOGY

3.1 INTRODUCTION

As seen in the literature review, many studies have explored how public spaces shape people's emotions and walking behaviours. However, relatively little attention has been paid to how specific public space characteristics contribute to the overall emotional experiences of young adults while walking. As discussed in Chapter 2, young adults are in a life phase where emotional engagement with the environment is especially relevant. At the same time, walking is promoted as a healthy mode of urban mobility. To better support walking among young adults, more knowledge is needed of which environmental factors affect their emotions in urban environments. This study, therefore, investigates the emotional impact of public space characteristics during walking. It focuses on young adults and applies a spatial-emotional framework. The aim is to determine which public space characteristics contribute to the following emotions: relaxation, stress, excitement, or boredom.

This chapter describes the methodological steps that are needed to find the aim of this research. First, the research approach is introduced. Next, the chosen data collection methods are explained. This section primarily explains why these methods were suitable for this research. The data collection methods are categorised into three approaches for gathering data in this research: GPS tracking, a survey, and spatial data. After collecting the data, the datasets are cleaned and checked for further analyses. Finally, the statistical methods are determined.

3.2 RESEARCH APPROACH

This research follows an empirical evaluation research approach. It is empirical because the emotional data and the spatial data are collected in an experiment. This is done with GPS-tracks of the walking routes and with self-reported survey responses. It is also considered evaluation-based research, as it examines the relationship between real-world public space characteristics and emotional experiences during walking. The empirical cycle is followed throughout the literature review, where operationalisation is conducted through public space characteristics and emotional categories, and the analysis is performed using descriptive statistics and multinomial logistic regression. This approach uses direct observations of emotional responses, since young adults report their feelings after walking through real urban environments. Existing theories are used to translate emotional concepts into practical and measurable elements. Although the sample is limited to students in Eindhoven, the method can be applied to other groups and settings. Therefore, this methodology offers a broader relevance for environmental psychology.

3.2.1 Theoretical and conceptual framework

The theoretical framework of this research is shown in Figure 5 on the next page. It integrates Bronfenbrenner's Socio-Ecological Model (1979) and the Mehrabian-Russell model (1974). With these theories, a layered framework is made to understand how different types of environmental influences affect emotional responses. The framework visualises four layers of influence on young adults' emotions while walking: individual, social, environmental, and external factors. Each layer contains factors supported by literature as relevant to emotional outcomes. As the Mehrabian-Russell model introduces, the contribution of the spatial environment to emotions eventually leads to an approach or avoidance reaction (Mehrabian & Russell, 1974). Therefore, it is formulated in this framework that the outcome of emotions could contribute to the walking stimulation of young adults.

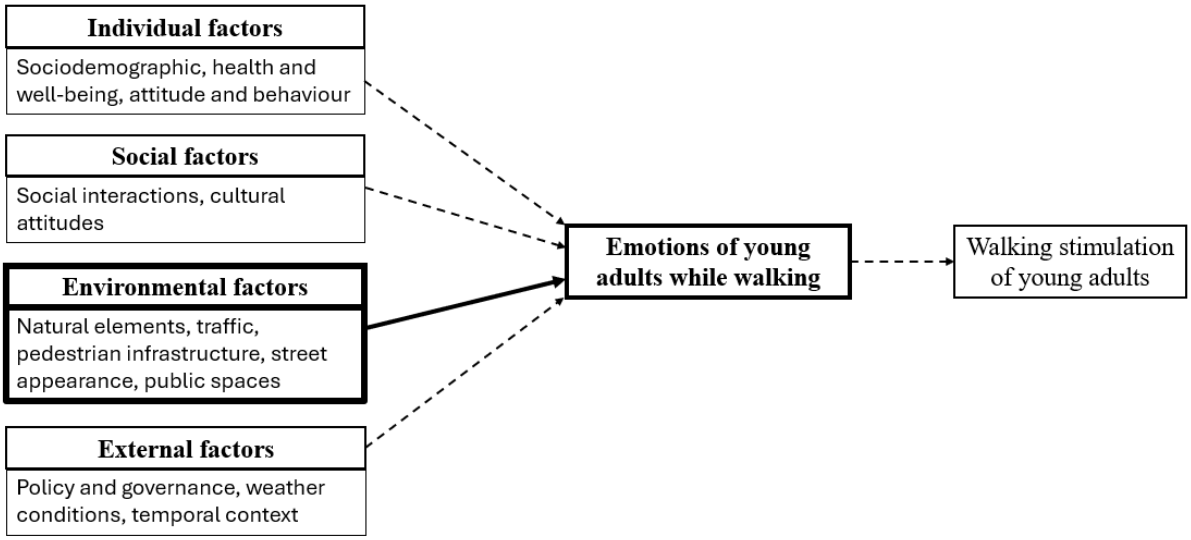

Figure 5, Theoretical framework

While all four layers are considered in the framework, this research focuses on the environmental factors. This focus is chosen because of the literature gap identified in Chapter 2. There is still a limited understanding of how public space characteristics specifically impact the emotional states of young adults during walks. This framework visualises that emotional reactions do not come from a single factor, but are created within a broader context of personal and environmental influences, using the SEM.

The focus of this research is on determining the relationship between the public space characteristics and the emotions experienced by young adults while walking. In Figure 6, the conceptual model of this research is visualised. On the left, the independent variables are listed. These are the public space characteristics identified in the literature review as influencing emotions. The dependent variable of this research is emotions. This variable can be categorised based on the Circumplex Model of Affect.

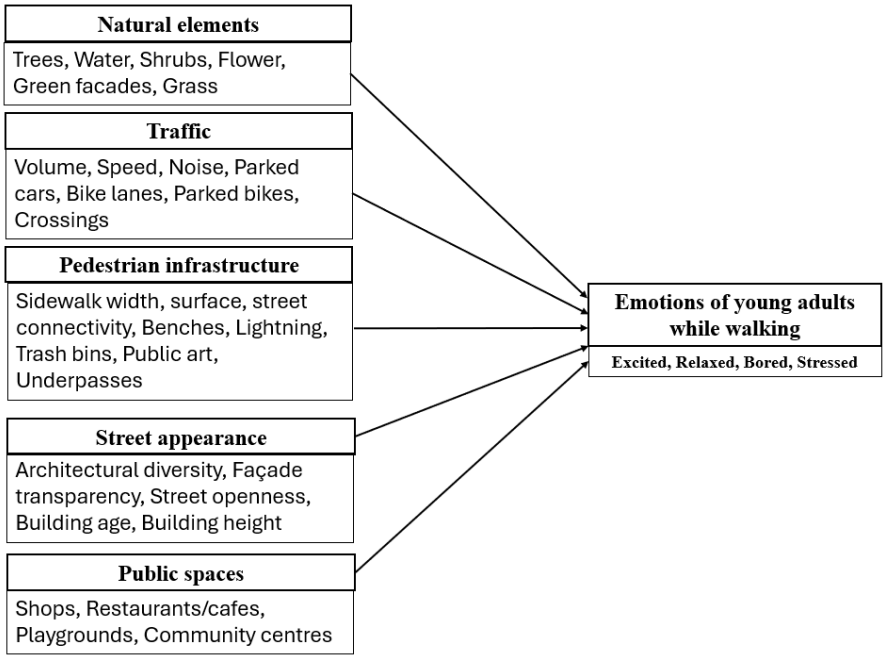

Figure 6, Conceptual model

The physical environment is divided into five categories of public space characteristics, based on Hillnhütter (2022) environmental matrix: natural elements, traffic, pedestrian infrastructure and street furniture, street appearance, and social facilities. These categories include several public space characteristics based on the literature review. Figure 6 illustrates the conceptual model, which includes the five categories and their relationship to the emotions of young adults while walking. These public space characteristics will be empirically tested for their influence on emotional outcomes.

By using the Circumplex Model of Affect (Russell, 1980), these emotional responses are translated into four measurable categories: excitement (high valence, high arousal), relaxation (high valence, low arousal), boredom (low valence, low arousal), and stress (low valence, high arousal). The combination of framework and conceptual model provides a clear overview of the relationships between the spatial environment and emotions, ultimately leading to walking stimulation.

3.2.2 Hypothesis

Based on the literature review and conceptual frameworks discussed in the previous section, this research expects that specific public space characteristics are associated with distinct emotional responses during walking. This study builds on previous research in environmental psychology and urban design, which has demonstrated how physical and social features shape people's emotions. These expectations are visualised in Figure 7, which links public space characteristics to emotional states in the Circumplex Model of Affect.

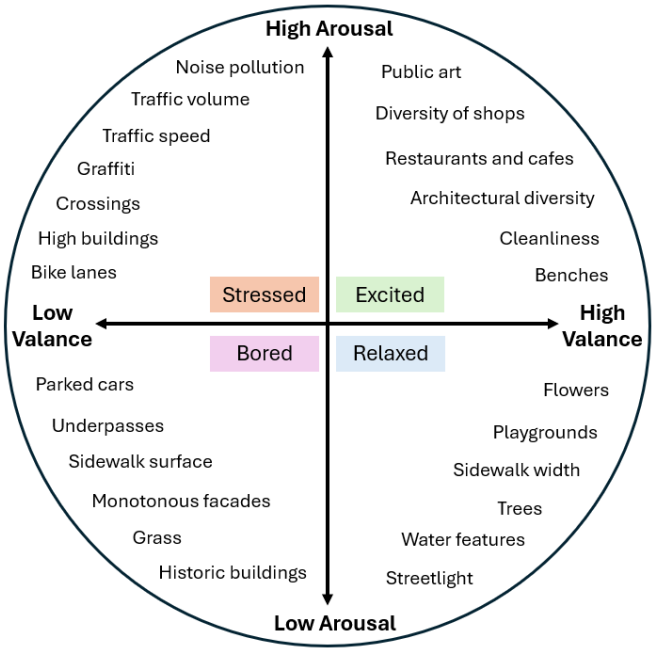

Figure 7, Pubic space characteristics positioned within the Circumplex Model of Affect

This figure combines insights from environmental psychology and urban design studies. It illustrates how different public space characteristics are associated with the scale of valence (pleasant–unpleasant) and arousal (active–passive). By doing so, this research extends earlier findings by specifically mapping these characteristics in the context of young adults' emotional experiences while walking. For example, greenery, historic buildings, and pedestrian-friendly infrastructure are generally associated with a higher valence, such as feelings of relaxation or excitement. In contrast, environments with high traffic volume, parked cars, or abandoned buildings are associated with a lower valence, such as feelings of boredom or stress.

3.3 DATA COLLECTION METHODS

To execute the research, the data needs to be collected. This is done with three instruments. Each participant walked for 30 minutes, tracking their routes with GPS data. This is collected with GPX files for implementation for further analysis. After the walk, the emotions will be measured. The participants evaluated their walking route using a survey, which included questions about demographics and their emotional experiences. To link the data of the participants (GPS and survey) to the physical environment, the public space characteristics need to be evaluated. The steps of these three types of data collection will be explained in the following sections. Each data source is described in detail in Chapter 4, including the precise cleaning, preparation, and visualisation of the data.

3.3.1 Tracking routes (GPS Data)

The first step in collecting the data is route tracking. Participants walk for 30 minutes in urban areas, where they will observe and interact with the spatial environments. The reason that participants walk for 30 minutes is based on the research of Gidlow et al., (2016). It is found that 30 minutes is needed to let the environment have a significant influence on the emotional experience, physiological and psychological (Gidlow et al., 2016).

Each route was tracked using a smartphone app, such as OsmAnd or Strava. All participants used their smartphones as tracking devices to collect the GPS points. These GPS points will be exported to GPX files, which contain geographic coordinates and timestamps for every point along the route. The routes need to be visually checked to ensure the reliability of the GPS points. Outliers should be removed to avoid incorrect results. After the visual inspection and cleaning of the GPS points, the remaining valid points can be converted into continuous walking paths. This step of data preparation makes the data more manageable by simplifying all GPS points to a line vector. With these lines, the data can be used for further analysis.

To analyse how the environment around the participant might influence the emotional experience, a visibility-based boundary will be used. This is done based on the term isovists. An isovist represents the area that is visible from a specific point in space (Benedikt, 1979). This helps to understand what parts of the environment a person might have perceived during their walk (Batty, 2001). For this research, a visibility radius of ten meters is chosen. This means that for each GPS point, the surrounding environment within ten meters is considered. This threshold is based on the study by Li et al. (2016), and is considered a realistic distance for what pedestrians can see and process while walking.

3.3.2 Measuring emotions (Survey)

Measuring the emotions of the participants during their walk can be done in multiple ways. As mentioned in the literature review, some studies have measured emotions through physiological methods, such as measuring heart rate, blood pressure and cortisol with sensors. This could provide real-time observations of the emotions and the direct environment in which they are situated. However, this method is challenging to execute, as the sensors and measurements must be highly secure (Brunner et al., 2025).

Another option is the post-walk evaluation method of emotions. This can be conducted using a survey, in which participants can evaluate their emotional experience of the walk afterwards. Emotions are often closely tied to perception and interpretation, making them challenging to measure objectively. A survey allows participants to describe their emotions using a Likert scale immediately after the experience. This makes the data more reflective of how participants truly

felt overall during their walk in urban environments. The only risk of this method is that participants can lose or change their emotional experience over time. Therefore, it is important that participant fill in the survey immediately after finishing their walk.

For this research method, the emotions will be measured with a post-walk survey. This evaluation method is chosen because it is simple to use, not too time-consuming for the participants, and fits well with this type of research (empirical evaluation research). The focus of this study is on capturing the subjective emotional experience along the entire walking route, rather than relying on objective sensor measurements. Therefore, a survey is more appropriate and makes it easier to include a larger number of participants.

The survey includes basic information about the participant. The survey questions are included in Appendix A. The question about gender is used to validate the sample. To check whether the sample group aligns with the young adult population of Eindhoven, a Chi-square goodness-of-fit test is conducted. This statistical test compares the observed sample group with the population distribution to determine whether any significant differences exist between them. A significance level of $\alpha = .05$ is used.

Furthermore, it is essential that the survey includes questions about the emotional experiences of the participants. These questions are based on the Circumplex Model of Affect (Russell, 1980), as the literature review found that this model effectively captures emotions related to spatial environments. The CMA makes it possible to quantify the emotional experiences of the participants. The survey questions should be continuous, measurable, and related to valence and arousal. A way to measure emotions continuously is by using a seven-point Likert scale. The survey questions regarding emotions are presented in Figure 8.

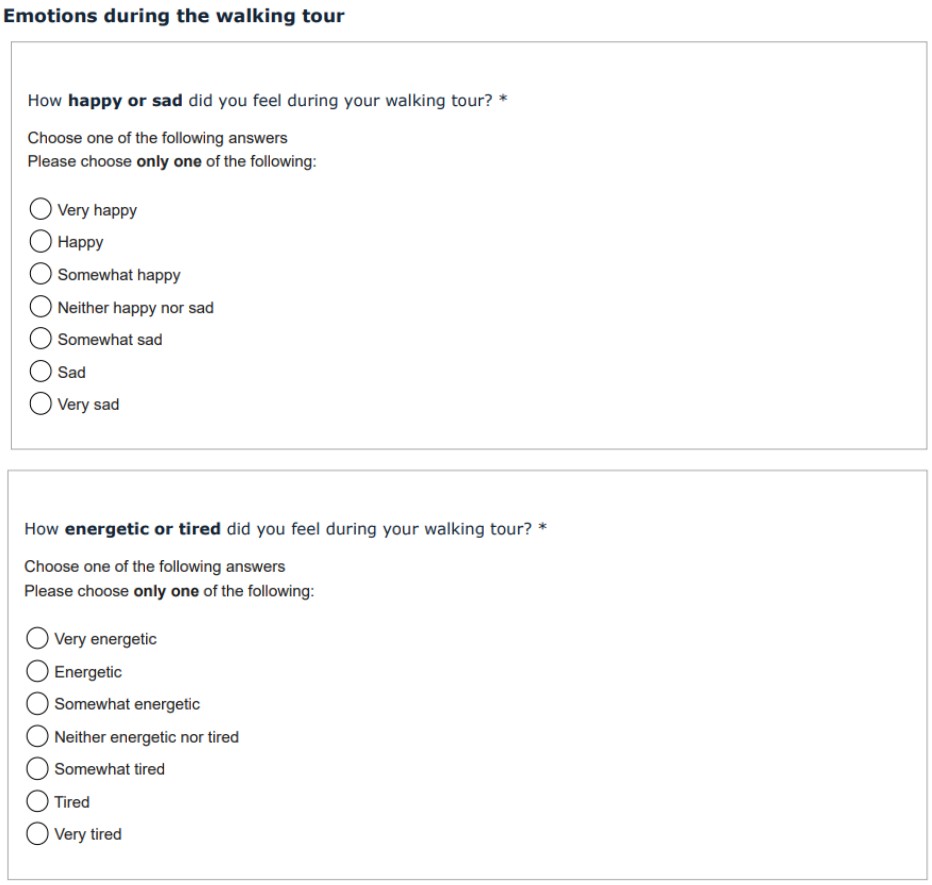

Figure 8, Survey questions about emotions experienced during the walking tour

To create a clear Circumplex Model of Affect (CMA) from the survey results, the emotional data should be standardised. Although both valence and arousal are measured on the same 7-point Likert scale, standardising is still useful. It ensures that both dimensions have the same mean (zero) and the same spread (standard deviation of one). This prevents small differences in how people use the scale from giving one dimension more influence than the other. For example, if participants tend to score valence higher on average than arousal, standardising removes this bias. With these standardised scores for valence and arousal, a CMA can be made in the form of a scatterplot. Valence is shown on the y-axis and arousal on the x-axis. Each participant's position in this plot indicates the emotions they experienced during their walk. The emotions are divided into four categories, based on the literature about the CMA:

- Excited: Valence > 0, Arousal > 0
- Relaxed: Valence > 0, Arousal < 0
- Bored: Valence < 0, Arousal < 0
- Stressed: Valence < 0, Arousal > 0

The participants can be divided according to these categories. In this way, the emotional experience of each participant can be measured based on their valence and arousal. This categorical variable will be added to the dataset for later use as the dependent variable.

After the data have been cleaned and prepared, the descriptive statistics of the survey can be evaluated. The purpose of these descriptives is divided into three parts: to characterise the sample, to secure data quality, and to prepare each variable in the form required for the statistical models. A descriptive analysis will also be executed for the emotion categorisation.

3.3.3 Selection and implementation of public space characteristics

To discover the relation between the physical environment and the emotions of young adults, the public space characteristics need to be specified. This is categorised into five main areas, based on the literature review: natural elements, traffic, pedestrian infrastructure and street furniture, street appearance, and social facilities. These categories will cover multiple aspects of the physical environment. Within each category are several characteristics that might influence young adults' emotions. Based on the literature review, the following public space characteristics are relevant to include, as shown in Table 5.

Table 5, Relevant public space characteristics

Category	Characteristics
Natural elements	Tree density, water features, shrubs, flowers, green façades, grass surfaces
Traffic	Traffic volume, traffic speed, noise pollution, parked cars, bike lanes, parked bikes, pedestrian crossings
Pedestrian infrastructure and street furniture	Sidewalk width, sidewalk surface, street connectivity, benches, street lighting, cleanliness, public art, underpasses
Street appearance	Architectural diversity, façade transparency, architectural age, building height
Social facilities	Shops, diversity of shops, restaurants and cafés, playgrounds, community centres

The public space characteristics can be implemented and discovered in many ways. The characteristics can be determined and implemented using OpenStreetMap (OSM) data and Municipal data. The data from these sources needs to be checked for outliers or missing values. Also, the reliability of the data needs to be checked. This can be done manually, with real-life observations of the physical environment, or with the use of Google Maps Street View. Another way to check the reliability of the data sources is to work with multiple datasets. This could give additional information about the actual public space characteristics. In addition to data cleaning, some of the public space characteristics need to be recoded into categories. For example, the sidewalk surface is a categorical variable, classified into specific types such as unpaved, semi-paved, clinkers, and asphalt. This categorisation ensures that the data can be analysed. By mapping the public space characteristics, they can be linked to the routes of the participants. By using the buffer around each route, the overlap of public space characteristics within the sight field of the participants can be identified.

In order to use the data of the public space characteristics for further analyses, these characteristics need to be quantified per route. This can be achieved by considering the number of characteristics per 100 meters or by calculating the percentage of surfaces that overlap with the buffer. First, counting the public space characteristics will give a number of each characteristic for each route. Some public space characteristics on the list are not countable, as they are represented by a line or polygonal data type. Therefore, these need to be measured differently. The buffer of the participant will overlap with the polygon surface of the characteristic. To determine the influence of water in this context, the percentage of the overlap between the sight field and the polygon will be calculated. This will provide a result indicating how long a participant has walked with visual sight on water.

To link public space characteristics to the routes of young adults, the public space characteristics need to be quantified per route. This operationalisation is done in three ways, for points, lines, and polygon vectors. For point vectors, the method of counting each point in the buffer is used. Second, the line vectors are quantified with the percentage of overlapping lines with the buffer. This is also done for the polygons. The specific operationalisation of this step for this research is elaborated in more detail in section 4.4.3. After conducting these quantifications, the dataset is complete for executing the statistical analyses, which aim to identify relations and correlations between public space characteristics and emotions.

Once the spatial data is implemented in a statistical analysis software program, some checks need to be performed. Starting with missing values and outliers. This is important to prevent the influence of incorrect values. Additionally, normal distribution checks are necessary to ensure the analytical validity of the results. Normality can be checked with histograms and statistics. Variables with skewness values greater than one require transformation. To handle a high amount of zero values, a log(x+1) transformation needs to be applied. This transformation improved normality and linearity of relationships for variables that initially showed significant skewness. Following these data cleaning steps, the data will be used for further analyses.

3.4 STATISTICAL ANALYSIS METHODS

With the cleaned data sets of the survey and the public space characteristics, the statistical analyses can be conducted. Through these analyses, the relationships between public space characteristics and emotions can be identified. The methods to discover these relations are evaluated below.

3.4.1 Cronbach's alpha

The reliability analysis will be done with Cronbach's alpha. This will test if the valence arousal scale is reliable for measuring emotions. For Cronbach's alpha, values of 0.7 or 0.8 are generally considered acceptable (Taber, 2018). However, Kline (1999) explains that for psychological concepts, Cronbach's alpha values below .7 can be expected, since these types of constructs often involve much variation. The value of alpha also depends on the number of items. A larger number of items is most likely to get a higher alpha (Taber, 2018). When alpha turns out negative, the scales are likely to be the opposite of each other. Then the variable needs to be transformed the opposite way, so the items get reversed.

Cronbach's alpha will be conducted for the emotional measurement. The scale items used for this reliability analysis are the survey questions that relate to the respondents' emotions. These are the questions;

- How happy/sad do you feel? (1=very sad, 7=very happy)
- How tired/energetic do you feel? (1=very tired, 7=very energetic)
- How relaxed/stressed do you feel? (1=very stressed, 7=very relaxed)

For the Circumplex Model of Affect, only the happy/sad question and the tired/energetic questions are included. For this reliability test, it is interesting to see if the stress-related question can provide a higher alpha for reliability. If so, the third question related to stress could be included in the CMA for better consistency.

3.4.2 Multinomial Logistic Regression

Multinomial Logistic Regression (MLR) is used to understand relationships between a nominal dependent variable and multiple independent variables (Field, 2012). Logistic regression is a specialised version of multiple regression. With a logistic regression, the outcome is a categorical variable. It is called multinomial logistic regression when the outcome has more than two categories (Field, 2012). In this research, the dependent variable has four non-ordered categories (Excited, Relaxed, Bored, and Stressed). Therefore, the multinomial logistic regression is suitable for this research.

Before conducting the multinomial logistic regression, the following assumptions need to be checked. These assumptions are defined by (Laerd statistics, 2018).

1. The dependent variable should be measured at the nominal level.

The analysis requires that the dependent variable be measured on a nominal scale. This means that the variable must consist of categories without any natural order.

2. The independent variables are continuous, ordinal, or nominal (including dichotomous variables)

3. There should be independence of observations and mutually exclusive categories.

Another important assumption is that the observations must be independent from each other, and the categories of the dependent variable must be mutually exclusive. This means that each observation can only belong to one category and that all possible categories are covered.

4. There should be no multicollinearity.

Multicollinearity occurs when two or more independent variables are highly correlated with each other. Multicollinearity among the independent variables should be avoided, as it can affect the reliability of the coefficient estimates (Senaviratna & A. Cooray, 2019). To check this, correlations between variables were assessed first through Pearson correlations, where |r| values above 0.7-

0.8 suggest the presence of multicollinearity. Next, Variance Inflation Factor (VIF) and Tolerance values were examined via linear regression. The model itself is not to be examined; only the collinearity statistics of the independent variables are to be considered. Tolerance values below 0.1 or VIF above 10 indicate multicollinearity (Senaviratna & A. Cooray, 2019). If multicollinearity is found, variables should be merged or deleted. After merging or deleting the collinear pair, the same steps described earlier need to be repeated to check if the multicollinearity has improved and is now corrected.

5. Continuous independent variables must have a linear relationship with the logit of the dependent variable.

This assumption needs to be checked by testing the interaction between each continuous predictor and its log-transformed value. To check this assumption, a Box-Tidwell test can be conducted. This test checks the interaction between each continuous predictor and its log-transformed value. For each continuous spatial attribute, a log transformation was created, and an interaction term was computed. These interaction terms were then included in a multinomial logistic regression (comparing 'Excited' versus another category) along with the public space characteristic predictors. If this interaction is not significant ($p > .05$), the assumption of linearity is met (Roni et al., 2019). If the interaction is significant, the variable does not have a linear relationship with the logit and therefore violates the assumption (Roni et al., 2019). Variables that did not meet this assumption were either transformed or excluded from further analysis. This test was performed for the continuous spatial variable used in the final multinomial logistic regression model. However, the Box–Tidwell test was not conducted for continuous predictors that were already log-transformed, as the transformation itself was applied to improve normality.

6. There should be no outliers or influential points.

Lastly, the data should be checked for outliers and influential cases. These can distort the regression results. This check can be done by inspecting standardised residuals and leverage values. Cases with extreme values are then reviewed or excluded.

With the checks of the assumptions, it can be ensured that the results are correctly interpretable (Laerd statistics, 2018). After checking these assumptions, a multinomial logistic regression can be performed. MLR calculates the probability that a case falls into a specific outcome category compared to a reference category. In this case, the model compares the chances of a participant reporting one of the three emotional states (Relaxed, Bored, or Stressed) relative to the reference category (Excited). The model calculates these probabilities using a formula based on the observed values of the predictors (the public space characteristics). This is done with the following equations:

Equation 1, Multinomial Logistic Regression equation

$$P(i|A_q) = \frac{\exp(V_i)}{\sum_{i'} \exp(V_{i'})} \quad i, i' \in A_q$$

Equation 2, Structural Utility equation

$$V_{iq} = \sum_n ß_n \cdot X_{inq}$$

Here, *P(i)* is the probability of choosing emotion category *i*, and *Vi* is the observed utility of category *i*. This utility is calculated using the values of the spatial characteristics and the estimated coefficients from the regression. The model compares the utility of each emotion category. The higher the utility of a category compared to the others, the higher the chance that this emotion is the one experienced. This regression is used because the dependent variable (emotion) is nominal and has four categories: Excited, Relaxed, Bored, and Stressed. A set of public space characteristics (X_1, X_2, X_3, ...) was included as independent variables in the model. These predictors were used to examine which physical characteristics are related to the emotions experienced during a walk. Although the multinomial logistic regression model assumes the Independence of Irrelevant Alternatives (IIA), this limitation is less critical in the context of this study (Kemperman, 2000). Since the emotional categories are not exclusive choices but self-reported states, the risk of IIA violations affecting the results is limited.

To understand the model's outcomes, several statistics were selected. A Classification Table was used to evaluate how well the model predicts group membership for each emotion category. To evaluate the model's overall quality, the Model Fitting Information and Goodness-of-Fit tests were reviewed. These tests help determine if the final model improves predictions compared to a model without predictors. Furthermore, the Nagelkerke pseudo-R-squared statistic was reviewed. This statistic indicates the proportion of variation in emotional states that the model can explain. Higher values generally reflect a better model fit. Additionally, odds ratios and their corresponding 95% confidence intervals were computed. The odds ratios help interpret the direction and strength of effects. An odds ratio above 1 means higher odds of being in a specific emotion category compared to the reference category (Excited), while an odds ratio below 1 means lower odds. Finally, the Likelihood Ratio Tests were used to determine whether the inclusion of each predictor significantly improves the model. A significant outcome indicates that the variable contributes to explaining differences between emotional states. By interpreting these selected statistics, the multinomial logistic regression provides insights into how public space characteristics relate to emotional experiences during walking.

3.5 CONCLUSION

In conclusion, this research aims to answer the research question: "What is the contribution of public space characteristics to the emotions of young adults while walking in urban areas?". To arrive at the answer, the steps are evaluated within this methodology. First, the GPS data collection was used to track the exact routes of participants. Second, the participants' emotions were measured through a survey directly after their walk, using questions based on Russell's Circumplex Model of Affect. This ensured a precise categorisation of emotional experiences into excitement, relaxation, boredom, or stress.

To connect these emotions with specific public space characteristics, relevant characteristics identified from the literature were selected and analysed. The characteristics were mapped and quantified within each participant's visual field. Cronbach's alpha was calculated to check the reliability of the emotional measurement scales. Before proceeding with further analysis, the assumptions were checked, including multicollinearity, linearity, and potential outliers. Finally, multinomial logistic regression was conducted to evaluate how different public space characteristics influenced emotional experiences statistically. Overall, this methodology gives the steps to answer the main research question. At the end, the relationship between public space characteristics and the emotions of young adults during urban walks can be determined.

4 DATA

In this chapter, the three data instruments will be elaborated on with the specifications of this research. It builds on the methods introduced in Chapter 3 by providing a detailed description to arrive at the final datasets. The focus of this chapter is on what the data looks like and how it is structured. First, the study area and the participants of this research will be elaborated. The following sections are divided into three main data instruments: GPS data, survey data, and public space characteristics data. These three main topics will each be subdivided into data cleaning and preparation, as well as data visualisation. With the data visualisations, the outcome of the data will be shown. The visualisations help to show what the data looks like and how it is organised. This makes it easier to understand how the data can be used in the analysis and helps with interpreting the results in Chapter 5.

4.1 SAMPLE DESCRIPTION

The research is conducted in the urban environment of Eindhoven, a city in the Netherlands. Participants in this research are students from Eindhoven University of Technology (TU/e), both bachelor's and master's students. The students were mostly between 17 and 28 years old, fitting the definition of "young adults" for this research. Master's students participated for the first time in November. Bachelor students joined the study in March to balance the data across different times of the year. This approach ensured that the study captured a broad range of weather and seasonal differences that could affect how people feel during their walks.

A total of 331 participants completed the survey. However, 11 participants did not give consent for their data to be used. These 11 survey answers were removed for this research, which gave 320 participants. Looking at the collected GPS data, some responses had to be removed to keep the dataset accurate and reliable. There were practical problems that led to some missing data: 8 participants completed the survey but did not include the GPS data, 5 routes were unusable because participants walked outside the planned study area, and 6 files were not functioning correctly. In the end, 301 complete sets of survey answers and corresponding GPS routes were available for analysis. For a multinomial logistic regression, the sample size needs to be a minimum of participants. According to the statistical book of Field (2012) the minimum to conduct an MLR is that there should be at least ten cases per independent variable for each category of the outcome. There will be 23 independent variables included in the MLR, so the sample size needs to be at least 230. Therefore, the sample size of 301 is sufficiently large to conduct further analyses.

4.2 GPS DATA

The GPS data has been collected using smartphone apps, as described in Chapter 3. In this section, the data cleaning procedure and the visualisation of the GPS data will be elaborated.

4.2.1 Cleaning and preparation

Preparing and cleaning spatial data ensures accuracy for the analyses. Initially, all GPX route files were imported into the QGIS software. These files used the geographic coordinate reference system (CRS) WGS84 (EPSG: 4326), which is the standard for GPS data. Each GPX file first appeared as multiple separate points on a map, indicating the locations participants visited during their walks.

An essential step in the cleaning process involved visually inspecting every individual route. Routes often contained inconsistent GPS points. Such inaccuracies can occur due to multipath effects, signal blockage by buildings, atmospheric interference or temporary signal, which are common GPS problems in cities (Kaplan & Hegarty, 2006). These outlier points, which appeared far from logical walking paths, needed to be carefully identified and manually removed. Keeping these inaccurate points could significantly affect the accuracy of the analysis later, when identifying the characteristics of the urban environment. An example of such outlier points is shown in Figure 9 below. By plotting the GPS points, it becomes clear that the route does not align with the actual route walked by the participant. After deleting the outliers, a more reliable route is formed, as shown in Figure 10, where the blue line is more accurate.

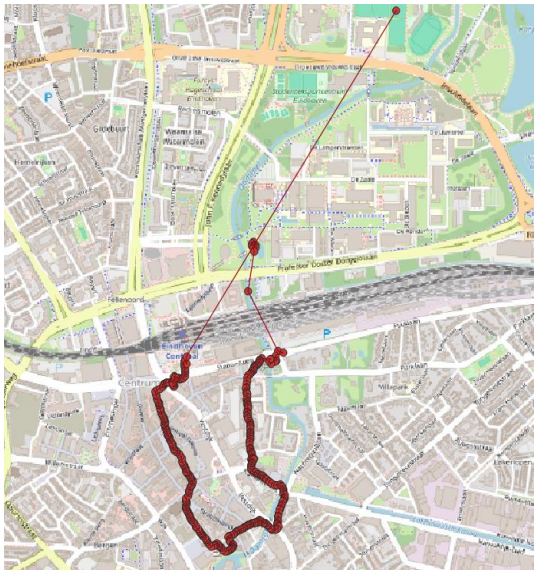

Figure 9, Example route with outliers

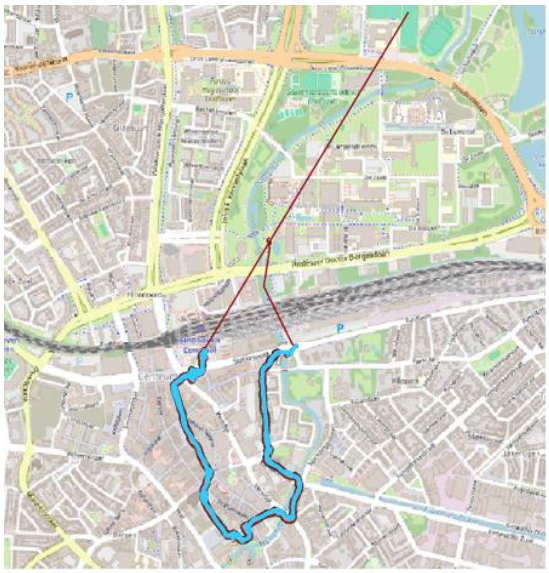

Figure 10, Example route without outliers

After the visual inspection and cleaning of the GPS points, the remaining valid points were converted into continuous walking paths. This step was completed using QGIS's 'Point to Path' feature, which turns multiple points into a single, coherent line vector for each route. This makes the data easier to work with and more comprehensible. Using lines instead of many separate points keeps the routes clear and preserves useful information, such as the starting and ending points of each route.

To connect the two datasets, each processed GPX route was linked to the corresponding participant survey responses through unique identifiers. By linking the two datasets using identifiers, integration between the spatial and survey data can be implemented at a later stage. Once all GPX files are linked to the correct identity number, all routes are merged into one layer. This new combined layer included the unique identifiers for each route in the attribute table. These unique ID numbers facilitate easy identification during analysis.

Next, the coordinate reference system needs to be changed to achieve precise spatial measurements. To comply with Dutch national spatial analysis standards, the data were reprojected to the Amersfoort coordinate system (EPSG:28992). Using this projected CRS ensures that distance and area calculations are accurate, which is important for creating realistic buffer zones around the walking paths for detailed analysis (QGIS User Guide, 2025). With the correct CRS projection, buffer zones were then created around each walking route using the 'Buffer' geoprocessing tool in QGIS. The size of these buffer zones was chosen based on previous research findings about the buffer, which is set at 10m, as described in Section 3.3.1.

4.2.2 Visualisation

The collection of GPX files from the participants has given 301 routes, which were collected in QGIS. An overview of the collected GPS data routes is shown in Figure 11.

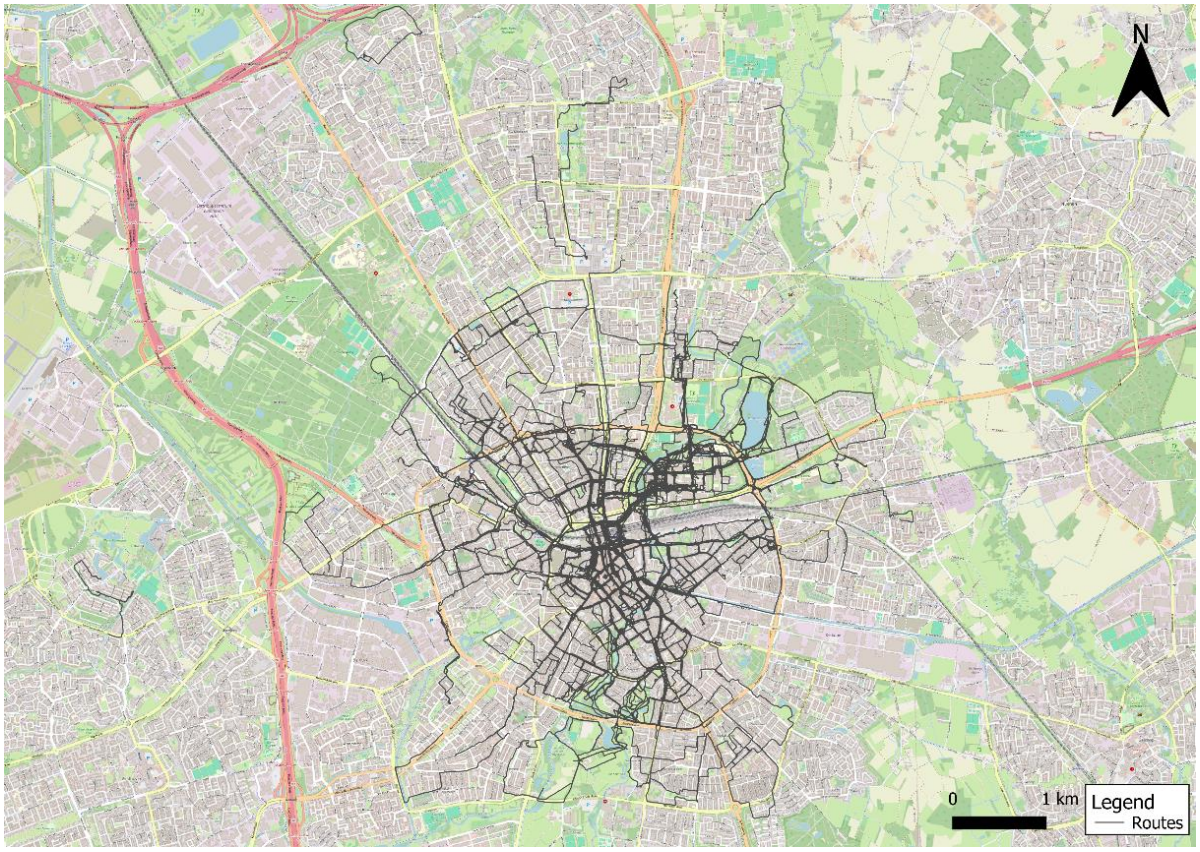

Figure 11, Routes of the participants

About one-third of the routes are located in the city centre of Eindhoven. Another one-third are situated around the TU/e campus area. The remaining one-third is spread across other parts of Eindhoven. Only a few routes are entirely separate from the main clusters, which makes them easy to spot in the figure, as they are located outside the dense city centre and campus area.

Looking at the routes more closely, there has been a shift in the overall environment that young adults have encountered. Many participants have walked in green areas, such as the Karpendonkse Plas or the Anne Frank Plantsoen, but others have chosen different environments, like the city centre shopping streets. Other participants have walked a block around the neighbourhood.

Another thing to notice is that some participants have walked in a straight line, from one starting point to another destination point. In contrast, others walked for 30 minutes and ended at the same point where they had started. This can indicate that some individuals have walked with a different purpose in mind than others, which could have an impact on their emotions while walking. Additionally, not all young adults walked the timeline of 30 minutes. Around 20 young adults have walked for more than 60 minutes. This could also have an effect on the emotional experience of the urban environment.

A buffer of 10m is created around each route. An example of the buffer around a route is shown in Figure 12.

Figure 12, Example route with buffer zone of 10m

4.3 SURVEY DATA

The survey data has been collected after the 30-minute walk of the young adults. The survey consisted of 15 questions and is available in Appendix A. Of these 15 questions, four were relevant to this research. The relevant survey questions included basic personal demographics and emotional evaluation. The emotional questions followed the Circumplex Model of Affect, allowing participants to indicate how they felt during their walks. The CMA allowed the study to quantify the emotional experiences of the participants. The emotions are based on the question about valence and arousal, asked in a 7-point Likert scale, as explained in Chapter 3.

4.3.1 Cleaning and preparation

The survey answers are used in the program SPSS. After implementation, the survey values are implemented as string variables. To make the data usable for analyses, the survey answers need to be transformed into numeric values. This way, SPSS can recognise the variables as ordinal or scale measurements. The transformation is performed using an automatic recode for all survey answers. With the use of value labels, the data view is displayed in numbers, and the output shows the corresponding labels. This helps to present the results.

The focus of the survey is on questions about emotions. The values of valence and arousal questions need to be transformed in the opposite direction. This is for a logical order for the CMA later. A higher valence number should indicate happier feelings, so 1 = very sad, 7 = very happy. The transformation is achieved by computing a new variable in reverse order of the emotions. After transforming the sequence of the variables, the data needs to be standardised. As mentioned in the methodology, this prevents one variable from having a disproportionate weight. With the SPSS function *descriptives*, the values can be saved as standardised values.

4.3.2 Visualisation

The emotions will be measured with the Circumplex Model of Affect. The CMA will be constructed using valence data and arousal data, as explained in Section 3.3.2. Valence is based on the responses to the survey, which included happy and sad answers. Arousal is based on the answers to the energetic/tired question. The CMA is represented by a scatterplot, where the valence scale is plotted on the x-axis and the arousal scale on the y-axis. The respondents will then be implemented in this scatterplot to see in which category they belong. The scatterplot of the emotion classifications is shown in Figure 13 below.

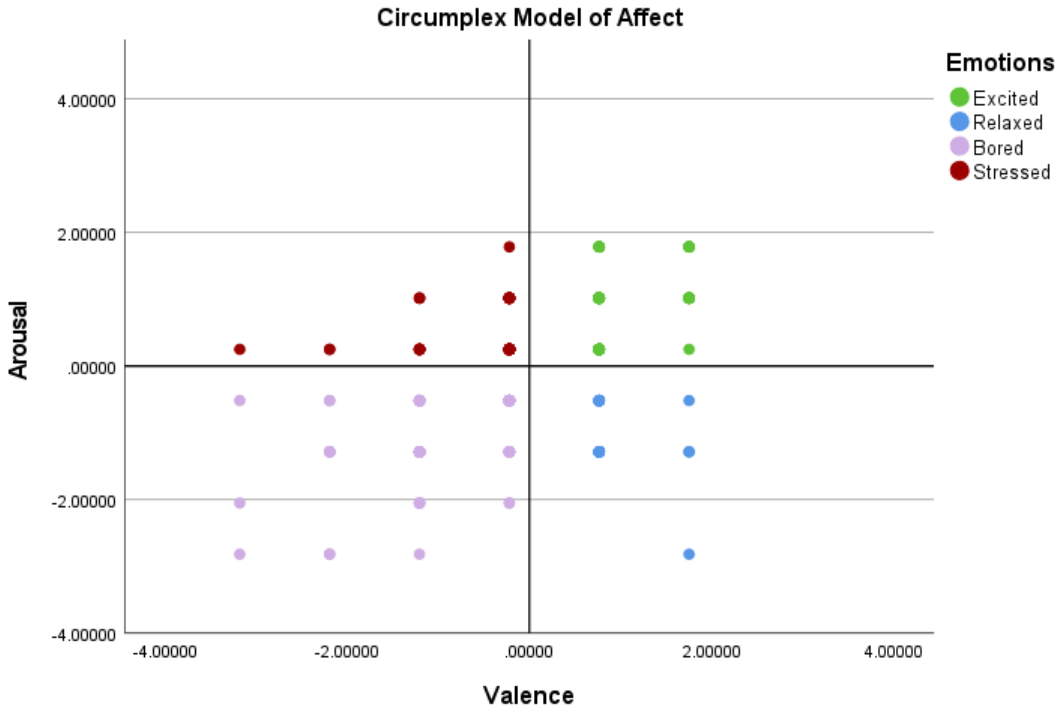

Figure 13, Circumplex Model of Affect with the participants

The values of the respondents are divided in the scatterplot in one of the quadrants. For further analysis of these emotions, the respondents are linked to each category within a new variable. The new variable will be named *Emotions*. To select the corresponding quadrant for the right emotions, the *IF conditions* need to be filled in. With the *IF conditions*, the following quadrants can be made: *Quadrant 1 - Valence >= 0 AND Arousal >= 0; Quadrant 2 - Valence >= 0 AND Arousal < 0; Quadrant 3 - Valence < 0 AND Arousal < 0; Quadrant 4 - Valence < 0 AND Arousal >= 0*. The quadrants will be linked to the emotions: 1 = Excited, 2 = Relaxed, 3 = Bored, 4 = Stressed. This new variable can be used for descriptive analysis of the participants' emotions. This categorical variable will be written to the dataset for later use as the dependent variable in the Multinomial logistic regression.

Figure 13 illustrates the spatial distribution of emotion scores across the two axes. The coloured dots make the categorisation visually clear, with each emotion group occupying a specific section of the model. The four colours correspond to the emotion categories: excited (green), relaxed (blue), bored (purple), and stressed (red). This provides a quick impression of the variation in responses and shows that all four emotional states are represented.

4.4 PUBLIC SPACE CHARACTERISTICS DATA

The public space characteristics are collected from publicly available datasets provided by the municipality of Eindhoven or OpenStreetMap. In Section 3.3.3, the general data cleaning steps are described. This section will elaborate on the implementation of public space characteristics in QGIS, with a specific focus on the city of Eindhoven.

4.4.1 QGIS implementation

The collection of public space characteristics is conducted using the QGIS program. The main tools used to gather the spatial data were QuickOSM for OpenStreetMap (OSM) data and municipal datasets provided by the Eindhoven Municipality. QuickOSM is a plugin within QGIS that simplifies retrieving spatial data from OpenStreetMap (OSM) by using specific tags. These tags enable the quick addition of detailed map layers, such as benches, pedestrian crossings, and streetlights, directly into QGIS. OSM data was a helpful resource because it provided consistent and accessible geographic information on various public space characteristics across the city. However, the OSM data did not cover every detail perfectly. Sometimes it lacked completeness or accuracy. To overcome this limitation, detailed municipal datasets from Eindhoven were also used (Municipality Eindhoven, 2025). The municipality's datasets provided more accurate local data that OSM did not fully capture. The Eindhoven Open Data portal provided numerous datasets categorised under infrastructure, nature, and traffic. The municipal datasets included detailed records of street furniture, trees, parked cars, and bike lanes, offering more reliable data points than OSM for these particular characteristics. In Table 6, the datasets used for each implemented public space characteristic are listed.

While the conceptual model includes a wide range of public space characteristics identified in the literature, not all of these could be implemented in this research. Several characteristics were not included because reliable spatial data were not publicly available. Therefore, the following characteristics were excluded from this research: shrubs, green facades, traffic speed, noise pollution, parked bikes, sidewalk width, street connectivity, diversity of shops and all street appearance characteristics. In some cases, specific datasets were either incomplete or outdated, making them unsuitable for consistent analysis. As a result, the analysis of this research includes only those characteristics for which both theoretical relevance and spatial data were available. The variables included are listed in Table 6. These will be used in QGIS for the subsequent analyses.

Table 6, The public space characteristics included for analysis

Category	Characteristic	Measurement Approach	Geometry	Data Source	OSM Tags / Ehv datasets
Natural elements	Tree density	Number of trees per 100m	Points	OSM & Municipality Eindhoven data	OSM: natural=tree Ehv: Dataset bomen
	Water features	Percentage water per route	Polygons	OSM	OSM: natural=water, waterway=riverbank, landuse=reservoir
	Flowerbeds	Percentage of flowerbeds per route	Polygons	Municipality Eindhoven data	Ehv: Dataset bloembollen
	Grass surface	Percentage grass per route	Polygons	OSM	OSM: landuse=grass, natural=grassland
Traffic	Road type	Percentage of each road classification	Lines	OSM	OSM: highway=* motorway, primary OSM: highway=* secondary, tertiary OSM: highway=* residential, living_street, unclassified
	Parked cars	Percentage of parked cars per route	Polygons	OSM & Municipality Eindhoven data	OSM: amenity = parking Ehv: Dataset parkeerplaatsen
	Bikelanes	Percentage bikelanes per route	Lines	OSM & Municipality Eindhoven data	OSM: highway = cycleway, path, track ; bicycle = designated, yes Ehv : Dataset bestrating; fietspad, fietsstrook
	Pedestrian crossings	Number of crossings per 100m	Points	OSM	OSM: highway=crossing
Pedestrian infrastructure and street furniture	Sidewalk surface	Percentage of each pavement material	Polygons	Municipality Eindhoven data	Ehv: Dataset bestrating; voetpad
	Benches	Number of benches per 100m	Points	OSM	OSM: amenity=bench
	Street lighting	Number of Streetlamps per 100m	Points	Municipality Eindhoven data	Ehv: Dataset verlichting option osm: highway=street_lamp
	Cleanliness	Number of waste baskets per 100m	Points	OSM	OSM: amenity=waste_basket, amenity=waste_disposal
	Public art	Number of artworks per 100m	Points	OSM	OSM: tourism=artwork
	Underpasses	Number of underpasses per 100m	Points	Municipality Eindhoven data	Ehv: Dataset tunnelvisie
Social facilities	Shops	Number of shops per 100m	Points	OSM	OSM: shop=* with different values
	Cafés / restaurants	Number of cafés / restaurants per 100m	Points	OSM	OSM: amenity=restaurant/café
	Playgrounds	Percentage of playgrounds per route	Polygons	OSM	OSM: Leisure = playground
	Community centers	Number of community centers per 100m	Points	OSM	OSM: Amenity = community centre

Some characteristics needed to be categorised because of the level of detail. This is done for road classification and sidewalk surfaces. The categories are listed below in Tables 7 and 8.

Table 7, Categories for road classification

Traffic Level	OSM Tags	Characteristics
Low traffic	Living street, residential, unclassified	Residential streets and small roads, low speed, few cars
Medium traffic	Tertiary, secondary	Local streets and connector roads, moderate speed, and traffic volume
High traffic	primary, motorway	Main roads and highways, high speed, and heavy traffic

Table 8, Categories for sidewalk surfaces

Surface Type	Characteristics
Unpaved	Sand, grass, soil; natural feel
Semi-paved	Fine gravel, crushed shells, wood chips
Clinkers	Bricks, cobblestones, tiles
Asphalt & Concrete	Smooth, even, urban

4.4.2 Visualisation of public space characteristics

This subsection presents maps that illustrate the distribution of public space characteristics listed in Table 6 throughout the study area. These characteristics were implemented in QGIS and adjusted to represent each characteristic at a realistic scale, as different urban features naturally vary in size. For example, shops cover more space than trees or benches, so each point was scaled to match its real-world dimensions better. This makes the maps more realistic and supports accurate spatial analysis. Figures 14 to 17 illustrate the distribution of each category across the city of Eindhoven. Together, these visualisations help better understand the spatial context of the walking routes.

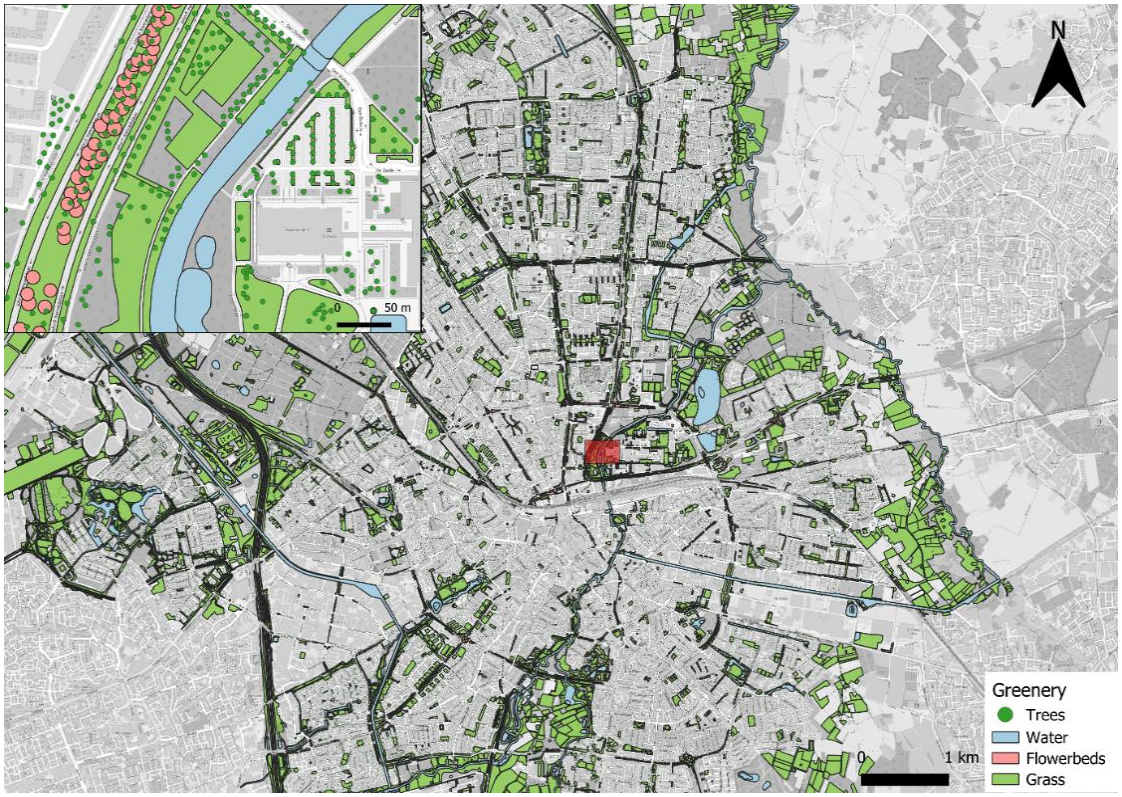

Figure 14, Map including the natural element characteristics

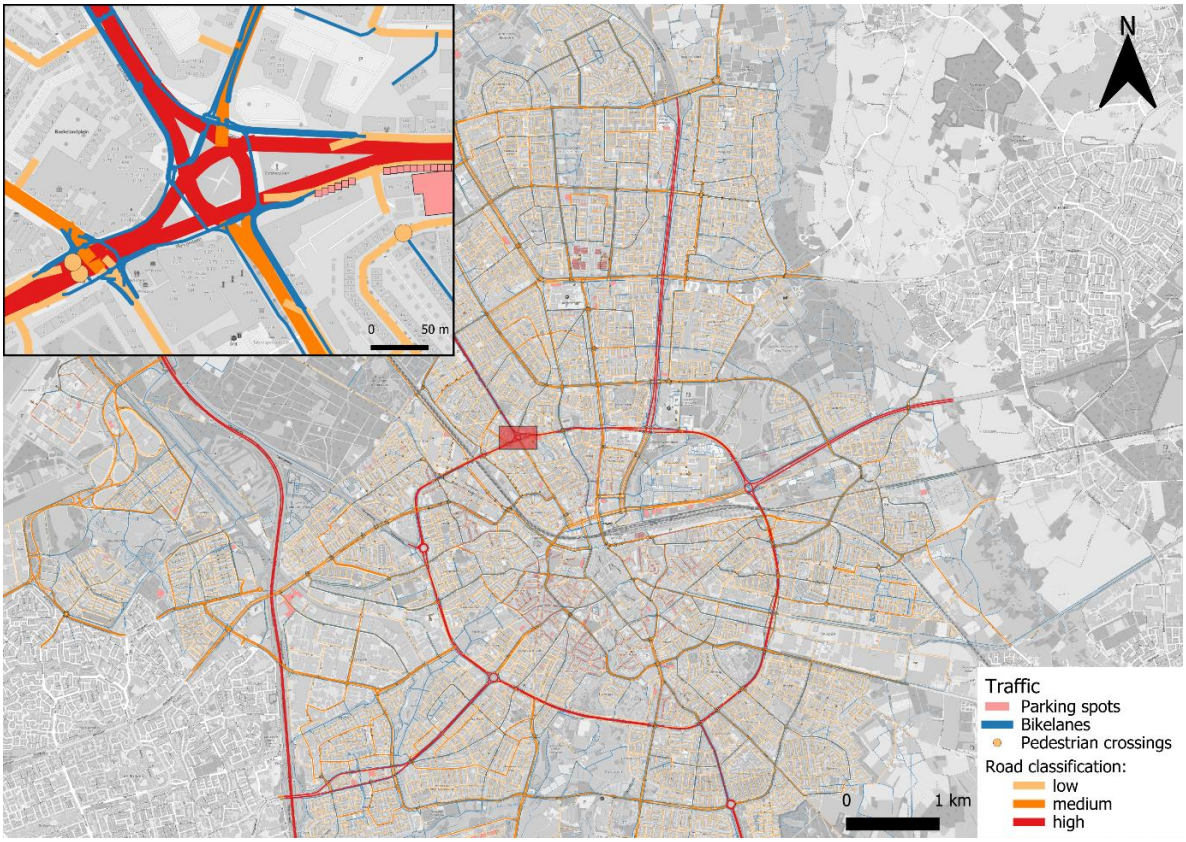

Figure 15, Map including the traffic characteristics

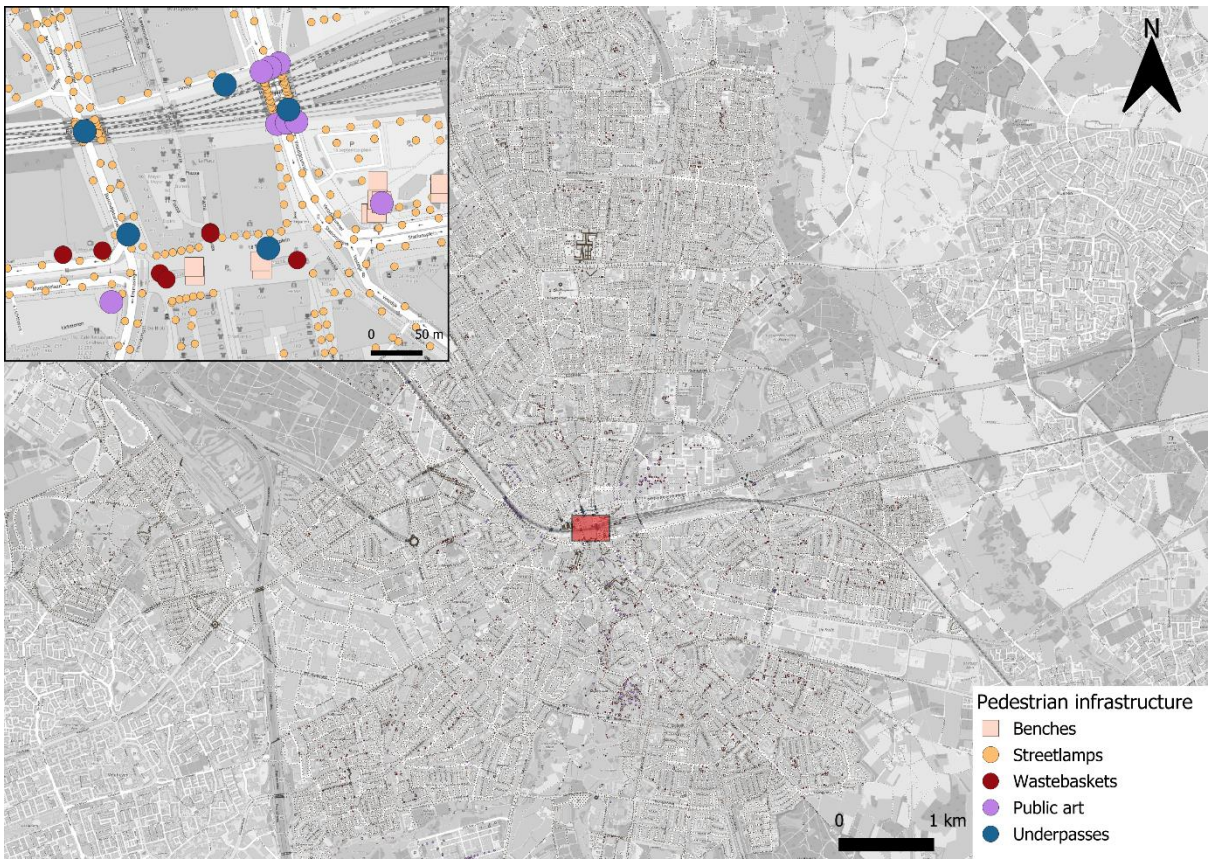

Figure 16, Map including the pedestrian infrastructure characteristics

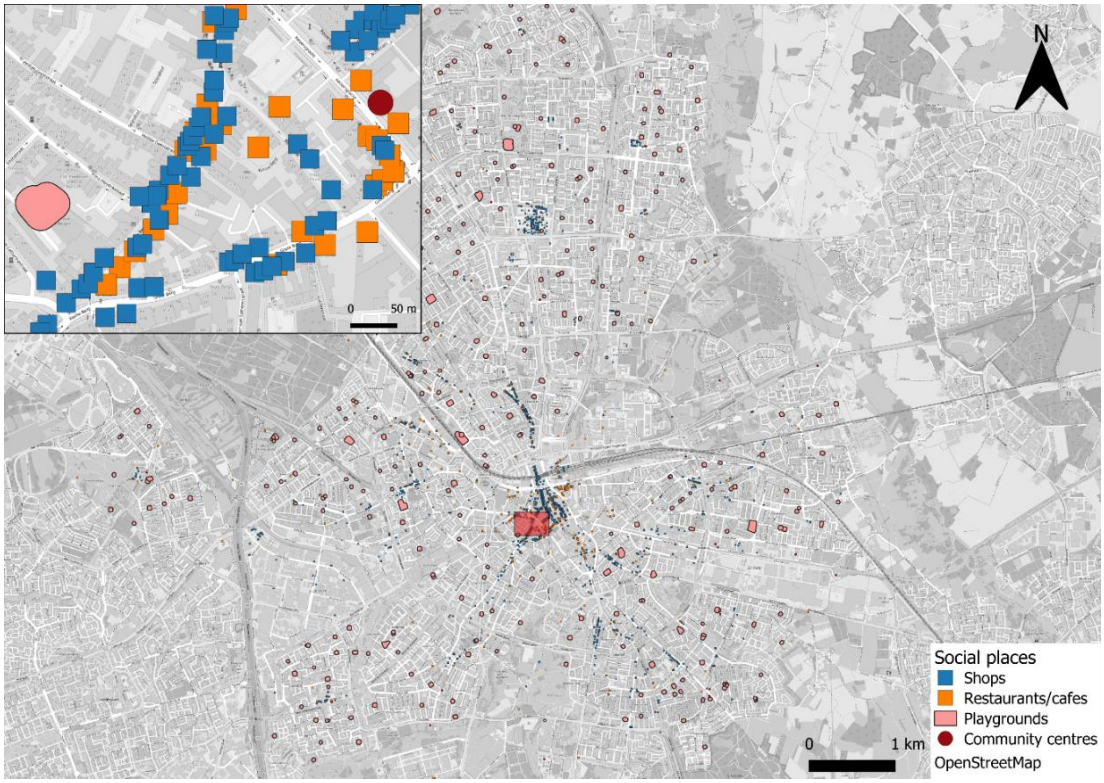

Figure 17, Map including the social facilities characteristics

4.4.3 Quantifying public space characteristics

As explained in Chapter 3, the public space characteristics need to be quantified per route. This section elaborates on the three methods for handling point, line, and polygon vectors.

For the point characteristics, the counting of public space characteristics was done using QGIS's 'count points in polygon' analysis. For each walking route, buffer zones were created, and within these buffer zones, occurrences of each public space characteristic were counted. The results of this analysis were created in several new layers. These layers were eventually combined into a final attribute table. This method ensured no data was lost and all counts were accurately preserved for further analysis.

After counting, the public space characteristics were standardised per 100 meters. This step allowed for fair comparisons across routes of differing lengths. For instance, someone who walked 3 km and passed 40 trees could be fairly compared to someone who walked 2 km and passed 80 trees. This standardisation was executed for all counted variables in the attribute table using the field calculator tool. A new field named *attribute_per_100m* (Decimal Float) was created with the calculation: *("Attribute" / "Length_route") * 100*. This step was repeated for each variable in the attribute table that was counted.

For polygon characteristics such as grass surfaces and water surfaces, the method was more complex. Instead of simple counts, the percentage of each walking route overlapping with the polygon of the characteristics needs to be calculated.

To calculate the percentage of each public space characteristic per walking route, a spatial join was performed between the attribute layers and the route buffers. Overlapping layers needed to contain a common identifier, *route_id*. Using spatial processing tools, attribute data was joined to the corresponding route areas based on spatial overlap. After this process, each attribute segment was correctly linked to the walking route.

Next, the buffer layer per route summed all attribute areas. Within the attribute table of the buffers, the field calculator was used again. A new field named *Sum_area_attribute* (Decimal Float) was created. The following steps could be executed in one combined step using this field calculator expression, summing surfaces, calculating percentages, and rounding results to one decimal place by using the following expression:

```
round(
 (
  aggregate(
   layer:='Name of intersection-layer',
   aggregate:='sum',
   expression:="area_attribute"
  )
 / "area_buffer") * 100
, 1)
```

Certain polygon attributes were categorised, specifically road classification and pedestrian surface materials. These characteristics underwent an additional step in the quantification process. For categorisation, the percentage of each route (line) crossing each polygon material type was calculated. Initially, routes were intersected with the surface material polygons using *the Processing toolbox → intersection, producing a new layer named 'route_segments_by_category'*. Each segment in this layer was associated with a specific category.

Segment lengths were calculated next. In the *route_segments_by_category* layer, a new field, seg_length, was created with the expression *$length*. Similarly, the total route length *(total_length*) was calculated in the original routes layer using the same expression. Percentages per category were calculated using the aggregate function in the routes layer. To calculate the percentage for a category, the following expression was used:

```
round(
 (
  aggregate(
    layer:='route_segments_by_category',
    aggregate:='sum',
    expression:="seg_length",
    filter:= "layer" = attribute(@parent,'layer')
          AND "category" = 'the_specific_category'
  )
 / "Route_len"
 ) * 100
,1)
```

This then needs to be repeated for the other categories as well. These steps were executed for the road classifications (low traffic, medium traffic, high traffic) and the sidewalk surfaces (unpaved, semi-paved, clinkers, asphalt).

Finally, the public space characteristics were combined into a single attribute table using join attributes by field value, ensuring both layers shared the common field *route_id*. After running this join, all values were integrated into one comprehensive attribute table. This table can then be exported as a CSV file for further analysis in SPSS.

4.4.4 SPSS implementation and preparation

The resulting attribute table from QGIS was imported into SPSS. Here, the data preparation can be done to provide the correct data for statistical analyses. Before entering the public space characteristics into the statistical analyses, the distribution of each characteristic was checked to assess the need for transformation. This is achieved through the use of histograms and the calculation of the skewness values. The histograms can be found in Appendix B. Most of the public space characteristics showed positive skewness, which can affect the assumptions of multinomial logistic regression. As explained in the methodology, a log transformation was considered the most appropriate technique to reduce this skewness.

According to the statistical guidelines in the book of Field (2012), the logarithmic transformation compresses the right tail of a skewed distribution, making the data more normally distributed and variances more equal. However, because logarithms cannot be computed for zero or negative values, a constant was added to all values before transformation. In this study, log(x + 1) was used, since several variables contained zero values. This transformation reduces the influence of extreme values while maintaining interpretability. The decision to apply transformation was based on skewness values. A general rule of thumb is that variables with skewness within the range of -1 to +1 can be considered approximately symmetric and do not require transformation (Field, 2012). Based on the skewness values (see Table 9), the following variables were left untransformed:

Table 9, Skewness values of the public space characteristics

Untransformed		**Transformed with Log(x+1)**	
Trees	skew = 0.526	Crossings	skew = 1.25
Lamps	skew = 0.186	Benches	skew = 1.33
Wastebaskets	skew = 1.000	Public art	skew = 6.31
Surface Clinkers	skew = 0.537	Underpasses	skew = 2.25
Road type Low	skew = 0.544	Shops	skew = 2.15
Road type Medium	skew = 0.950	Restaurants	skew = 1.44
Bike lanes	skew = 0.217	Community centres	skew = 12.21
		Water	skew = 2.57
		Grass	skew = 1.72
		Flowers	skew = 4.94
		Playgrounds	skew = 4.13
		Surface semi-paved	skew = 5.45
		Surface asphalt	skew = 2.15
		Surface unpaved	skew = 15.51
		Road type high	skew = 4.14

The remaining variables exceeded the threshold and were log-transformed using the formula log(x + 1). These included: crossings, benches, public art, underpasses, shops, restaurants, community centres, water, grass, flowers, playgrounds, surface types: semi-paved, asphalt, unpaved, and road types: high. After transformation, distributions were reassessed (see Appendix C). While some variables still showed signs of non-normality due to a large proportion of zero values, this was not considered problematic for conducting multinomial logistic regression. The log transformation reduced some skewness. Because multinomial logistic regression does not assume normally distributed predictors, only that each continuous predictor relates linearly to the log-odds, it is acceptable to include these skewed variables (Field, 2012; Roni et al., 2019). The log transform did reduce extreme skew and stabilised coefficient estimates.

4.5 Conclusion

This chapter describes the specific collected data and the steps taken to prepare it for analysis. It included information on GPS routes, survey responses, and spatial data on public space characteristics. All data sources were cleaned and transformed to make sure they could be combined. The GPS tracks were turned into walkable paths, and buffers were added to analyse the surrounding environment. The survey was used to classify emotional responses into four categories. Public space characteristics were selected based on the literature and added using QGIS. All three data sources were matched, so every participant has linked data on their walking route, emotional experience, and the physical environment. This dataset serves as the basis for the statistical analysis presented in Chapter 5.

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5 RESULTS

5.1 DESCRIPTIVE STATISTICS

Before analysing relationships between spatial characteristics and emotional responses, it is important first to understand the data itself. Descriptive statistics provide insight into the composition and distribution of the dataset, helping to identify patterns, outliers, and potential biases. This section presents descriptive information about the GPS-tracked walking routes, the participants, and the public space characteristics encountered along the routes. This provides an overview of the data, making it easier to understand the results later.

5.1.1 Walking route characteristics

Each participant walked a GPS-tracked route through the urban environment. The route lengths were calculated in meters and are shown in Table 10. On average, participants walked 2768 meters (SD = 750 m), which is approximately 2.8 kilometres. This distance aligns with the expected outcome of a walk lasting about 30 minutes.

The shortest recorded route was 772 meters, while the longest route reached 6034 meters. These extremes suggest variation in walking duration and pace among participants. As discussed in Chapter 4, some participants walked significantly longer than instructed. Approximately 20 participants walked for nearly an hour, which is about twice as long as most others. These deviations in walking time and distance may affect the exposure to environmental characteristics and should be considered when interpreting the results of the regression analysis.

Table 10, Descriptive statistics of the routes

Statistics

Length_Routes

N	Valid	301
	Missing	0
Mean		2767.853
Std. Deviation		749.9172
Minimum		772.3
Maximum		6033.5

As described in Section 4.2.2. the routes are spatially distributed across different parts of Eindhoven. About one-third of the participants walked in the city centre, one-third around the university campus, and the remaining third in other surrounding neighbourhoods. This distribution supports variation in exposure to different public space characteristics across the sample.

5.1.2 Respondent characteristics

The sample group is checked with the gender division of the Eindhoven and Dutch population for young adults. For comparison, the available numbers of CBS are used for the age category between 20-25 years old in the Netherlands and between 20-30 years old in Eindhoven (CBS, 2022). The sample consisted of 47.8% women and 52.2% men (n = 301). The numbers from the CBS and the test results are presented in Table 11 on the next page. The comparison with the Dutch population showed no significant difference, $\chi^2(1) = 0.223$, $p = 0.637$. Similarly, the comparison with the Eindhoven population also showed no significant difference, $\chi^2(1) = 1.443$, $p = 0.230$. These findings indicate that the gender distribution in the sample does not significantly deviate from population proportions, suggesting that the sample is demographically appropriate for further analysis.

Table 11, Representativeness test: chi-square goodness-of-fit

Level	*Sample group: young adults*	*Dutch population 20-25years (CBS, 2022)*	*Eindhoven population 20-30years (CBS, 2022)*
Female	47.8%	49.2%	*44.4%*
Male	52.2%	50.8%	*55.6%*
Chi-Square test		χ^2(df=1) = 0.223, p = 0.637	χ^2(df=1) = 1.443, p = 0.230

Additional descriptive statistics of the survey responses, such as frequencies and percentages, can be found in Appendix D. The descriptives are also visualised with histograms shown in Appendix E.

Since this study focuses on emotional responses during walking, special attention is given to the questions related to valence and arousal. The distribution of the responses is visualised in Figures 18 and 19. The bar charts about the emotion questions show that the participants were overall positive about their walking route. The bar chart of the question about happy or sad emotions (the valence scale) is left-skewed, indicating that the majority of participants experienced a happier feeling. The histogram of the question, "energetic or tired" (the arousal scale), is also right-skewed, indicating that most participants were energetic during their walk.

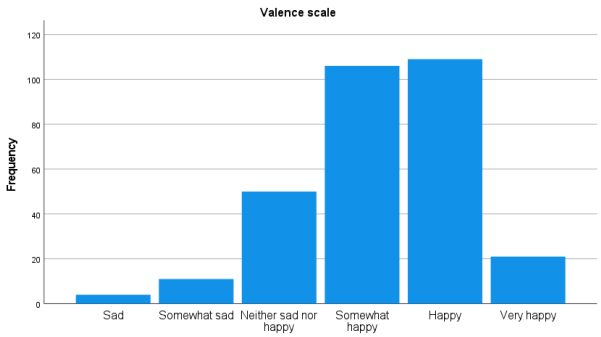

Figure 18, Distribution of responses on the valence scale

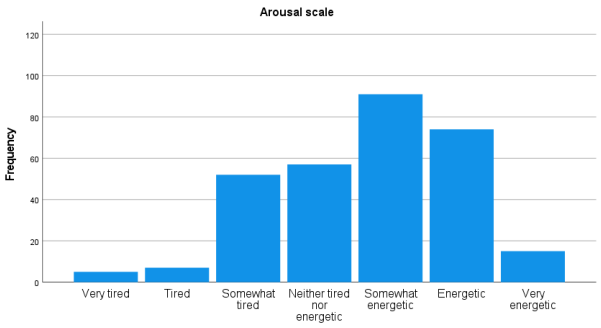

Figure 19, Distribution of responses on the arousal scale

A new column based on the four quadrants of emotions was created. This categorical variable is now the dependent variable for the multinomial logistic regression model. To give an impression of this new variable, a descriptive analysis of the four emotional categories is conducted. This can be seen in Table 12 below, as well as in the visualisation of the numbers in the bar chart in Figure 20. All four categories are represented, although some more frequently than others. The emotion of relaxation has the fewest number of respondents.

Table 12, Frequency table of the four emotions

Emotion	**Frequency**	**Percentage**
Excited	101	33.6
Relaxed	29	9.6
Bored	92	30.6
Stressed	79	26.2
Number of respondents	301	100.0

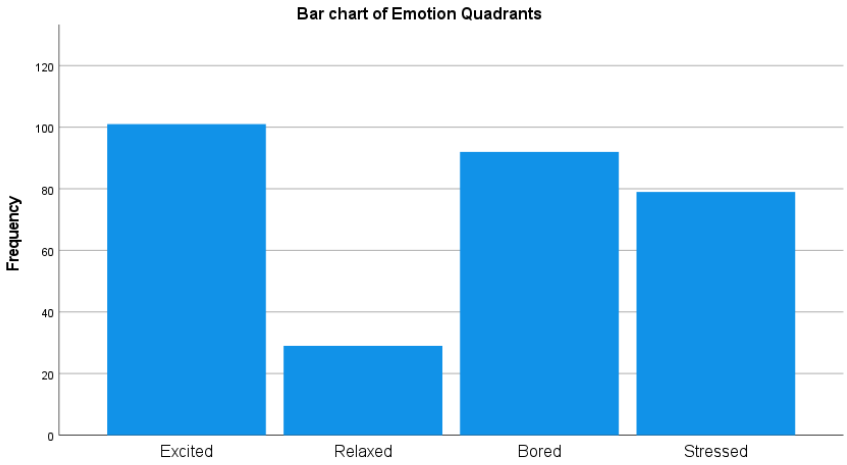

Figure 20, Bar chart of the emotions

5.1.3 Public space characteristics along walking routes

The presence of different public space characteristics was measured along each participant's walking route and standardised per 100 meters. Tables 13 to 16 present the descriptive statistics of these variables across all 301 routes.

Greenery elements were among the most frequently observed characteristics. On average, participants encountered 13.3 meters of grass, 4.7 trees, and 1.1 flowering elements per 100 meters. However, there was considerable variation between routes. For example, the maximum grass coverage was over 66 meters per 100 meters, suggesting some routes went through park-like environments, while others had almost none.

Table 13, Descriptive statistics of green public space characteristics

Statistics

		Trees	Water	Flower	Grass
N	Valid	301	301	301	301
	Missing	0	0	0	0
Mean		4.664	4.982	1.059	13.257
Std. Deviation		1.5077	6.8415	2.0172	10.4126
Minimum		1.2	.0	.0	.1
Maximum		9.9	49.8	19.3	66.1

In terms of traffic-related features, low-traffic roads were most common (mean = 8.1), followed by medium-traffic roads (mean = 6.5). High-traffic roads appeared less frequently (mean = 0.5), but were present on some routes (up to 10.1 per 100m). The presence of bike lanes (mean = 13.6) and parked cars (mean = 3.0) also varied notably between participants, reflecting the diversity of route types from quiet residential streets to busier urban areas.

Table 14, Descriptive statistics of traffic public space characteristics

Statistics

		Low_traffic	Medium_traffic	High_traffic	Parked_cars	Bikelanes	Crossings
N	Valid	301	301	301	301	301	301
	Missing	0	0	0	0	0	0
Mean		8.066	6.452	.481	3.028	13.557	.332
Std. Deviation		5.0521	4.9560	1.1169	3.3883	5.8876	.2664
Minimum		.0	.0	.0	.0	1.1	.0
Maximum		23.2	23.9	10.1	15.6	29.7	1.8

Pedestrian infrastructure included an average of 0.16 waste baskets and 0.15 benches per 100 meters. Street lighting (mean = 4.8) was more frequently observed, though with variation between routes. Different types of sidewalk surfaces also appeared along the routes, with clinkers being the most dominant surface (mean = 29.3), followed by asphalt (mean = 1.9) and semi-paved or unpaved surfaces occurring less frequently. The mean number of public art objects was 0.08, and underpasses occurred rarely (mean = 0.04).

Table 15, Descriptive statistics of pedestrian infrastructure public space characteristics

Statistics

		Surface_unpaved	Surface_semipaved	Surface_clinkers	Surface_asphalt	Benches	Street_lighting	Wastebaskets	Public_art	Underpasses
N	Valid	301	301	301	301	301	301	301	301	301
	Missing	0	0	0	0	0	0	0	0	0
Mean		.049	1.277	29.293	1.925	.150	4.750	.160	.076	.037
Std. Deviation		.5216	4.0691	13.5704	2.8791	.1451	2.3300	.1314	.1491	.0703
Minimum		.0	.0	.7	.0	.0	.0	.0	.0	.0
Maximum		8.7	37.4	79.3	16.8	.8	11.3	.7	1.5	.4

Visual and social features were less commonly observed. Restaurants, shops, and playgrounds were present on some routes but with lower averages overall (e.g., restaurants: mean = 0.14). These elements, though less frequent, may still play a role in shaping emotional responses during the walk.

Table 16, Descriptive statistics of social facilities public space characteristics

Statistics

		Shops	Restaurants	Playground	Community
N	Valid	301	301	301	301
	Missing	0	0	0	0
Mean		.426	.143	.576	.001
Std. Deviation		.6606	.1856	1.4857	.0081
Minimum		.0	.0	.0	.0
Maximum		3.7	.8	12.3	.1

Overall, the descriptives reveal a wide variation in public space exposure across routes, which supports further analysis of how these characteristics may influence emotional experiences. The differences in exposure suggest that the routes offer diverse environmental conditions. This variation is worth considering for the upcoming regression analysis, as it increases the likelihood of detecting relationships between specific spatial characteristics and reported emotional states. In the next section, the internal reliability of the emotional indicators will be evaluated before testing these relationships more thoroughly.

5.2 Reliability analysis: Cronbach's alpha

For the emotion measurements, a reliability analysis was conducted using Cronbach's alpha. This test indicates whether the individual items in a scale measure the same concept. For this study, the analysis was first run on all three emotion items: the valence scale, the arousal scale, and the separate item asking participants how stressed or relaxed they felt during their walking tour.

The results show a Cronbach's alpha of .647 (see Table 17), which is just below the threshold of .70 typically considered "good". However, it still exceeds the minimum of .60 that is considered acceptable for exploratory research (Taber, 2018). According to Taber (2018) A value of Cronbach's alpha of 0.65 can be considered reasonable. This suggests that the items show reasonable internal consistency, but with room for improvement.

Table 17, Reliability statistics

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.647	.660	3

Looking more closely at the inter-item correlation matrix in Table 18, the valence and arousal scales have the strongest correlation (r = .494), which is a positive relationship and suggests that these two items are related in how people experience their emotional state. The correlation between valence and stress is weaker (r = .392), and even lower between arousal and the separate stress item (r = .294). These lower correlations indicate that the stress item may not align as strongly with the others in measuring a consistent emotional dimension.

Table 18, Inter-item correlation matrix

Inter-Item Correlation Matrix

	Valance scale	Arousal scale	How stressed or relaxed did you feel during your walking tour?
Valance scale	1.000	.494	.392
Arousal scale	.494	1.000	.294
How stressed or relaxed did you feel during your walking tour?	.392	.294	1.000

The item-total statistics in Table 19 further support this indication. The corrected item-total correlations are all above 0.3, which is good according to the book of Field (2012). This indicates limited shared variance with the overall scale. Moreover, the Cronbach's alpha would be the same if the stress item were removed, suggesting that the overall consistency of the scale would not improve by including it. This means that even though the number of items was reduced, the overall consistency will not decrease. So, the two core emotional scales, valence and arousal, still form a reasonably coherent scale. Based on these outcomes, it was decided to proceed with only the valence and arousal scales to measure emotions in the statistical analysis.

Table 19, Item-total statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Valance scale	9.65	4.260	.552	.311	.454
Arousal scale	10.20	3.622	.458	.256	.553
How stressed or relaxed did you feel during your walking tour?	9.90	4.033	.388	.167	.647

Based on these outcomes, it was decided to proceed with only the valence and arousal scales to measure emotions in the statistical analysis. These will be included in the multinomial logistic regression in the following parts.

5.3 MULTINOMIAL LOGISTIC REGRESSION ASSUMPTION RESULTS

Before conducting the multinomial logistic regression analysis, several important assumptions needed to be checked and met to ensure reliable and valid results.

Firstly, the dependent variable must be measured at a nominal level, meaning it should have categories without any inherent order. For this study, the dependent variable represents emotional states categorised into "Relaxed," "Bored," "Stressed," and "Excited." These categories have no natural order, making them appropriate for multinomial logistic regression.

Secondly, the analysis requires independent variables that are continuous, ordinal, or nominal, including dichotomous variables. In this research, the public space characteristics, which are primarily continuous measures, served as independent variables, meeting the criteria for multinomial logistic regression.

The third assumption is the independence of observations. Each participant in this study independently completed their walking tour and responded to the survey individually, thereby ensuring that the observations were independent of one another. Moreover, each participant was uniquely assigned to one emotional state based on their responses, fulfilling the assumption of mutually exclusive categories.

As the fourth assumption states, it is essential to verify whether the public space characteristics exhibit any issues with multicollinearity. Multicollinearity occurs when two or more predictor variables are highly correlated, making it difficult to discern the independent effect of each variable. A correlation matrix was created to examine the relationships between all public space characteristics, which is presented in Appendix F. This matrix displays pairwise Pearson correlations. There were no correlations higher than $|r| > .80$, indicating that there is no serious multicollinearity among these variables at this stage. However, specific medium correlations require attention, notably between Shops and Restaurants ($r = 0.735$, $p < 0.001$), Lamps and Grass ($r = -0.540$, $p < 0.001$), and Lamps and Shops ($r = 0.298$, $p < 0.001$). These correlations suggest that moderate multicollinearity effects may occur when these variables are included together in the regression model. For instance, the strong positive correlation between Shops and Restaurants is expected, as commercial areas with numerous shops typically also have multiple restaurants. Similarly, the negative correlation between Lamps and Grass is understandable because urbanised areas with extensive street lighting generally contain fewer grass-covered spaces. To further check multicollinearity, a linear regression was performed using the valence scale as the dependent variable, calculating Tolerance and Variance Inflation Factor (VIF) values for all public space characteristics. These values can be seen in Appendix G. All Tolerance values were greater than .25, and all VIF values were lower than 3.7, comfortably within accepted thresholds (Tolerance > .10, VIF < 10) (Senaviratna & A. Cooray, 2019). This indicates that, although some pairwise correlations, there are no significant multicollinearity issues when all public space characteristics are included in the model. Condition indices were also analysed to verify these results. These values can be found in Appendix H. The highest condition index was 30.78 (Dimension 24), primarily influenced by Bike lanes (.44), Community centres (.35), and Parked cars (.20). However, none of these dimensions showed high variance proportions above 0.50. Therefore, there are no severe multicollinearity clusters. This supports the conclusion drawn from the Tolerance and VIF values that there are no multicollinearity issues within the public space characteristics. A similar check, using arousal as the dependent variable, confirmed the findings, which are presented in Appendix I. Although higher condition indices appeared, no dimension contained problematic clusters of variables. Overall, the analysis using

correlation matrices, Tolerance, VIF values, and condition indices clearly shows that the public space characteristics do not have significant multicollinearity problems. Therefore, these characteristics can reliably be used in the multinomial logistic regression analysis.

The fifth assumption is the linear relationship between continuous independent variables and the logit of the dependent variable. The Box–Tidwell test was not conducted for continuous predictors that were already log-transformed based on their skewed distribution. Therefore, the Box-Tidwell test was only applied to the variables: Trees, lamps, wastebaskets, road clinkers, road low, road medium and bike lanes. These variables were computed with "*variable*LN(variable +0.01)*". The original variable values and the transformed variable values were added in a multinomial logistic regression to check the linearity with the log-odds. The results are presented in Appendix J. It can be seen that road low has $p < 0.05$. This indicates that the assumption is not met for road classification low. Therefore, this variable will also be log-transformed, allowing it to be included in the multinomial logistic regression.

Finally, the last assumption is checked. To validate this assumption, it was essential to check for potential outliers and highly influential cases, as these could impact the regression model. Outliers and influential data points were identified by examining standardised residuals and leverage values. After inspection, no influential points required removal.

5.4 MULTINOMIAL LOGISTIC REGRESSION RESULTS

To explore how public space characteristics contribute to the emotional states during urban walking, a multinomial logistic regression (MLR) was performed. The dependent variable consisted of four emotion categories: *Excited*, *Relaxed*, *Bored*, and *Stressed*. The emotion '*Excited'* was used as the reference category.

The model fitting information showed that the final model significantly improved compared to the intercept-only model, as shown by the Model Fitting Information in Table 20. The likelihood ratio test was significant with a chi-square value of 101.352 with 69 degrees of freedom ($p = .007$). This indicates that the set of spatial predictors collectively contributes to explaining variation in emotional states.

Table 20, Model fitting information

Model Fitting Information

Model	Model Fitting Criteria -2 Log Likelihood	Likelihood Ratio Tests Chi-Square	df	Sig.
Intercept Only	784.355			
Final	683.003	101.352	69	.007

The Goodness-of-Fit statistics provided further support for the model's validity. The Goodness-of-Fit statistics provide insight into how well the model fits the observed data. It can be found in Table 21. Both the Pearson chi-square ($\chi^2 = 857.500$, df = 822, $p = .190$) and the Deviance chi-square ($\chi^2 = 681.617$, df = 822, $p = 1.000$) were non-significant. This means the model's predicted values are not significantly different from the actual values, suggesting that the model fits the data well.

Table 21, Goodness-of-fit

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	857.500	822	.190
Deviance	681.617	822	1.000

To assess how much variance in emotional states can be explained by the model, the Nagelkerke pseudo R-squared value was reviewed in Table 22. The Nagelkerke R^2 was 0.309, indicating that approximately 31% of the variation in emotional responses can be explained by the included public space characteristics.

Table 22, Pseudo R-Square

Pseudo R-Square

Cox and Snell	.286
Nagelkerke	.309
McFadden	.129

The Parameter Estimates in Table 23 offer detailed insight into how each predictor influences the odds of reporting each emotional state, compared to the reference category (*Excited*). Only statistically significant results, which are highlighted in bold in the table, are discussed below. The complete table of the MLR parameter estimates can be found in Appendix K.

Table 23, Multinomial Logistic Regression - Parameter estimates

	Relaxed			Bored			Stressed		
	B	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**	**B**	**Sig**	**Exp(B)**
Trees	-0,174	0,430	0,840	-0,143	0,348	0,866	-0,290	0,083	0,748
Water	0,131	0,675	1,140	-0,219	0,334	0,803	-0,287	0,223	0,751
Flower	0,288	0,461	1,334	-0,052	0,871	0,949	-0,320	0,345	0,726
Grass	-0,269	0,631	0,764	-0,010	0,981	0,990	0,277	0,518	1,319
Low traffic	**-0,676**	**0,073***	**0,509**	**-0,750**	**0.010*****	**0,472**	**-0,870**	**0,002*****	**0,419**
Medium traffic	0,012	0,883	1,012	-0,071	0,192	0,931	0,002	0,974	1,002
High traffic	-0,301	0,630	0,740	-0,353	0,437	0,703	-0,151	0,749	0,860
Parked cars	-0,016	0,869	0,985	**0,109**	**0,072***	**1,115**	0,101	0,114	1,106
Bike lanes	-0,089	0,177	0,915	**0,087**	**0,021****	**1,091**	0,053	0,200	1,055
Crossings	1,797	0,317	6,030	-0,143	0,907	0,867	0,288	0,819	1,334
Surface Clinkers	0,008	0,785	1,008	**0,044**	**0,021****	**1,045**	**0,043**	**0,030****	**1,044**
Surface semi paved	0,207	0,542	1,230	-0,231	0,427	0,793	-0,010	0,975	0,990
Surface asphalt	-0,120	0,729	0,887	0,415	0,100	1,514	**0,550**	**0,038****	**1,734**
Surface unpaved	0,269	0,793	1,308	-1,274	0,288	0,280	-10,685	0,266	2,289E-05
Benches	1,060	0,685	2,887	-2,654	0,167	0,070	**-4,915**	**0,017****	**0,007**
Street lighting	0,200	0,323	1,221	-0,035	0,783	0,965	-0,043	0,749	0,958
Wastebaskets	0,183	0,932	1,201	2,572	0,081	13,089	1,261	0,437	3,529
Public art	-4,434	0,234	0,012	**-5,778**	**0,018****	**0,003**	-0,120	0,935	0,887
Underpasses	-9,875	0,145	5,144E-05	**-7,466**	**0,045****	**0,001**	**-7,332**	**0,058****	**0,001**
Shops	0,928	0,455	2,529	0,107	0,901	1,113	-0,984	0,268	0,374
Restaurants	**-9,351**	**0,011****	**8,688E-05**	**-7,030**	**0,001*****	**0,001**	**-4,713**	**0,036****	**0,009**
Playground	0,126	0,788	1,135	-0,299	0,412	0,741	-0,016	0,966	0,984
Community	-137,350		2,237E-60	-137,872	0,988	1,327E-60	-153,393	0,986	2,410E-67

a. The reference category is: Excited.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

c. ***, **, * = Significance at 1%, 5%, 10% level

In the comparison between *Relaxed* and the reference category *Excited*, the presence of restaurants showed a strong negative relationship (B = -9.351, p = 0.011, Exp(B) = 8.688E-5). Fewer restaurants within the walking environment were associated with a higher likelihood of reporting a relaxed emotional state. No other predictors showed significant effects for the relaxed emotion category, which suggests that the predictors included in this model have little explanatory power for relaxation (Field, 2012).

In the comparison between *Bored* and *Excited*, five public space characteristics were found to influence emotional outcomes. A lower proportion of low-traffic roads increased the probability of boredom (B = -0.750, p = .010, Exp(B) = 0.472), suggesting that calmer street environments reduce the likelihood of experiencing boredom. A higher density of bike lanes also contributed positively to boredom (B = 0.087, p = .021, Exp(B) = 1.091). This suggests that the presence of bike lanes is associated with increased boredom. The presence of clinker road surfaces showed a positive association with boredom (B = 0.044, p = .021, Exp(B) = 1.045), meaning that as the percentage of clinker surfaces increased, the likelihood of feeling bored also increased. Furthermore, fewer public art elements were associated with more feelings of boredom (B = -5.778, p = .018, Exp(B) = 0.003). The same holds for fewer underpasses (B = -7.466, p = .045, Exp(B) = 0.001). Lastly, a significantly lower number of restaurants was strongly associated with boredom (B = -7.030, p = 0.001, Exp(B) = 0.001).

For the category *Stressed*, four spatial predictors were significant. A lower proportion of low-traffic roads was significantly associated with increased stress (B = -0.870, p = .002, Exp(B) = 0.419). Similarly, higher presence of clinker surfaces increased stress (B = 0.043, p = .030, Exp(B) = 1.044), as did asphalt surfaces (B = 0.550, p = .038, Exp(B) = 1.734). A lower availability of benches significantly increased stress (B = -4.915, p = .017, Exp(B) = 0.007), as did fewer restaurants (B = -4.713, p = .036, Exp(B) = 0.009).

The overall classification in Table 24 shows that 47.5% of the model's predictions are correct. The highest prediction accuracy was observed for the emotion *Excited*, which was correctly predicted in 64.4% of cases. The emotion *Bored* was correctly classified in 46.7% of cases, while *Stressed* was correctly predicted in 40.5% of cases. The emotion *relaxed* showed the lowest classification accuracy at 10.3%.

Table 24, Classification

Classification

		Predicted			
Observed	Excited	Relaxed	Bored	Stressed	Percent Correct
Excited	65	1	19	16	64.4%
Relaxed	13	3	10	3	10.3%
Bored	28	1	43	20	46.7%
Stressed	21	0	26	32	40.5%
Overall Percentage	42.2%	1.7%	32.6%	23.6%	47.5%

5.5 CONCLUSION

The results of the analyses indicate that some relations were found between public space characteristics and emotional experiences during a walk. Before diving into these analyses, descriptive statistics were reviewed to understand the general distribution and variation in walking routes, participant characteristics, and public space characteristics. These descriptives revealed substantial diversity in environmental exposure, which justified the use of regression analysis to identify potential relationships.

The reliability analysis shows that there is internal consistency for the valence and arousal scales. Based on the results of this Cronbach's alpha test, it is found that including stress will not improve the internal consistency of the emotion measurements. Based on these results, the survey question about stress is not included in the multinomial logistic regression.

Furthermore, a multinomial logistic regression was conducted. First, the assumptions were checked. These confirmed that the data were suitable for analysis, as there was no multicollinearity and the variables were linearly related to the log-odds. There was only one variable that needed to be log-transformed; the variable 'low traffic' did not meet the linearity assumption. Therefore, this variable is included in the analysis with a log-transformation.

After verifying the public space characteristics against the assumptions, they were included in the regression model. The multinomial logistic regression results showed that specific public space characteristics influenced emotional states. The last sub-question can be answered, which is *'Which public space characteristics have a statistically significant effect on emotional states during walking?'*. The ones that were found to be statistically significant in the regression are bike lanes, road type low, clinker surfaces, public art, benches, and restaurants. These were related to the emotions of young adults in multiple ways. The direction and strength of these effects varied depending on the emotion. Fewer restaurants were consistently associated with increased likelihoods of both relaxation and stress. Likewise, fewer restaurants, fewer public art elements, and fewer underpasses were all linked to higher boredom levels. Increased densities of bike lanes and clinker surfaces also contributed to both boredom and stress. In contrast, a higher availability of benches was associated with reduced stress levels, and low-traffic road types were linked to reduced probabilities of both boredom and stress.

The regression model correctly predicts 47.5% of the differences in how young adults felt during their walk. Looking at the overall classification accuracy of the model, it performed especially well in predicting emotions such as excitement and boredom.

6 DISCUSSION

This research aimed to explore which specific public space characteristics influence the emotional experiences of young adults during urban walks. The results from the multinomial logistic regression in Chapter 5 showed that only a few public space characteristics had a significant effect on emotional states. This section discusses the results and compares them to those from earlier studies in the literature review presented in Chapter 2.

6.1 DISCUSSION OF THE RESULTS

To begin with, the presence of restaurants showed a significant effect on emotions. Fewer restaurants were related to more boredom, more stress, and more relaxation. This is in line with previous research stating that commercial spaces like shops and restaurants increase vitality and stimulate positive emotional engagement (Ettema & Smajic, 2015). Their absence may make areas feel empty or less secure, which can lead to feelings of boredom or stress. However, the finding that fewer restaurants are also related to relaxation could mean that quieter environments are sometimes preferred for peaceful walks. This might depend on personal needs during walking, as suggested by Alfonzo's hierarchy of walking needs (Alfonzo, 2005).

Bike lanes also significantly influenced boredom. A higher density of bike lanes was associated with an increased likelihood of boredom. This was surprising, as they are often seen as indicators of well-planned infrastructure. One explanation might be that bike lanes are often found along long, straight roads, with few visual or social stimuli. For pedestrians, this may feel monotonous, as described in the literature review (Brunner et al., 2025). It could also be due to discomfort from sharing space with cyclists. The link between bike lanes and boredom is not widely addressed in the literature, making it an interesting topic for further research. Clinker road surfaces were found to be positively related to low valence. These surfaces may be less comfortable to walk on or be associated with older or poorly maintained areas. This matches findings from Sundling & Jakobsson (2023), who argued that the quality of pedestrian infrastructure has a clear impact on emotional comfort. Poor surfaces can reduce walking comfort and increase feelings of stress.

Fewer public art elements and underpasses were also related to increased boredom and stress. These features are often part of a lively and visually diverse environment. Their absence might result in environments that feel less engaging and boring. Brunner et al. (2025) found that visual variation and design diversity are important for keeping pedestrians emotionally stimulated. Public art can add visual diversity and creativity to a space. Additionally, fewer underpasses were also found to be related to feelings of boredom and stress. Underpasses can contribute to spatial variation and connectivity. A well-designed underpass with good lighting and visual openness can enhance the walking experience and make movement between areas easier. In contrast, when underpasses are missing, pedestrians may need to take longer or more exposed routes, which could lead to frustration or stress. This aligns with the idea that functional and safe underpasses are important parts of a comfortable and emotionally positive walking route (Hillnhütter, 2022; Johansson et al., 2016).

Benches were another significant factor for stress. Participants who walked in areas with fewer benches reported higher stress levels. This aligns with previous literature highlighting the importance of rest points in promoting comfort and relaxation during walks (Li et al., 2016). Benches allow people to pause, reflect, and find a sense of ease. Their absence may therefore create stress.

Notably, other spatial characteristics that were expected to influence emotional states did not have a significant effect in the regression analysis. These include natural elements such as tree density, water features, flower beds, and grass surfaces. Additionally, several traffic features, such as parked cars, bike lanes, and pedestrian crossings, were not found to be significant. The same holds for the following pedestrian infrastructure features: sidewalk surface, street lighting, and waste baskets. From the social facilities category, the shops, playgrounds, and community centres were also not found to be significant. These findings differ from previous studies that did find the significant effects of natural elements, traffic, pedestrian infrastructure and public spaces on emotional experiences (Bornioli et al., 2018; Brunner et al., 2025; Gidlow et al., 2016; Hillnhütter, 2022; Zhang et al., 2022).

One possible explanation for the high number of nonsignificant characteristics is that their influence may be less direct or only noticeable in specific environments. For example, trees and grass may contribute to emotional well-being over longer exposure periods or in specific settings, such as parks, rather than street segments (Ayala-Azcárraga et al., 2019; Gidlow et al., 2016; Janeczko et al., 2020). Moreover, some features, such as waste baskets or lighting, may contribute more to functional perceptions like cleanliness or safety, rather than directly triggering emotional responses in the moment. These features could have a better link with the hierarchy of walking needs (Alfonzo, 2005).

Another reason might be that these characteristics were similar across most walking routes. If a feature like trees is present almost everywhere, it becomes harder to find differences in how people react to them (Verplanken, 2006). Additionally, when a characteristic is common, young adults might not consciously notice it. Therefore, the effect of those characteristics on the emotional experience is less notable. It is also possible that individual differences, such as personal preferences or familiarity with the area, shaped how participants responded emotionally (Sundling & Jakobsson, 2023). These personal preferences may have hidden the effects of the public space characteristics.

It is also possible that some public space characteristics may only influence emotions under certain conditions that were not included in this study. For example, tree coverage may have a greater impact on emotional comfort during hot or sunny days, when shade becomes particularly important (Zhang et al., 2022). On cooler or cloudy days, people might not notice the trees as much. Likewise, street lighting may only matter for emotional experiences during evening or night walks (Zhu et al., 2023). In daylight, lighting is less relevant, so its emotional effect may disappear. Additionally, the purpose of walking can alter how they respond to the environment. Someone walking for exercise might prioritise smooth sidewalks, while someone walking for fun might value aesthetics or variety more (Pae & Akar, 2020; Rahman et al., 2019). These additional factors, such as time of day, weather, or walking purpose, were not part of this research but could be important. Future studies should include such contextual factors to better understand how and when public space characteristics influence emotions.

Overall, the absence of significant results for some expected variables does not mean they are unimportant; instead, it suggests that their influence may be more complex or dependent on other conditions (Gelman & Stern, 2006). These non-significant findings can still provide a starting point for further exploration and practical insights. For policymakers, it is important not to focus only on statistically significant effects but also to consider the broader patterns and relationships that can guide urban design and planning. This highlights the need for further research into how combinations of public space characteristics and contextual factors influence emotional experiences while walking.

6.2 DISCUSSION ON METHODOLOGICAL CHOICES

The way this research was set up combined different methods to give a clear picture of how public space characteristics relate to emotions while walking in urban environments. Participants tracked their walking routes using GPS. These GPX files were then used in QGIS to measure the spatial characteristics along each route. After the walks, participants answered questions about their emotions during the walk. This combination of spatial and emotional data helped to connect what people saw and experienced in the public space to how they felt.

The decision to use the Circumplex Model of Affect worked well in this context. It gave a structured and straightforward way to group emotional responses into four clear categories: excited, relaxed, bored, and stressed. These categories matched well with the kind of experiences people might have during a walk (Brunner et al., 2025). The emotions, as measured by the CMA, were assessed through self-reported answers in the survey. This is a simple and accessible method, but it also has limitations. Emotions can shift during a walk. By asking people to pick just one emotion at the end of the route, smaller mood changes might have been missed.

The use of multinomial logistic regression made it possible to examine the relationship between the various spatial characteristics and the categorised emotions. This method is chosen because it can handle different predictors and compare several emotion categories at the same time. It showed which public space characteristics had a significant influence on emotions. However, this method also works best when clear patterns are present. If the emotional effect of a public space characteristic is small, it may not be detected in the regression, especially when many variables are tested at once (Field, 2012). Additionally, some emotional responses may not be caused by a single feature, but rather by a combination of several, which this model does not fully capture.

Another choice was to work with pre-defined spatial characteristics. These were based on existing literature and mapped using spatial data from OpenStreetMap and the municipality of Eindhoven (Municipality Eindhoven, 2025). This made the analysis structured and comparable, but it also meant that not all possible environmental influences were measured. Not all public space characteristics were publicly available to include in this research. As the literature review found, street appearance features may also contribute to emotional experiences (Agustí & Lladós, 2022; Bornioli et al., 2018, 2019; Mouratidis & Hassan, 2020). However, these could not be included because the necessary data were not available. These might also play a role in emotional responses during walking, but are now not included in this research.

Finally, the method assumed that all parts of the walking route contributed equally to someone's emotional response. This was necessary to run the analysis, but in real life, certain parts of a route may have a stronger impact than others. For example, walking through a crowded area for just two minutes may have a greater impact than spending ten minutes on a quiet street.

6.3 LIMITATIONS

This research has several limitations that are worth considering. First, the way emotions were measured could be improved. Participants reported how they felt only once, at the end of the walk. Because of this, it is difficult to determine precisely what caused the emotions. It is possible that emotions were influenced by earlier events or moods unrelated to the walk. Additionally, some participants completed the emotion survey several days after their walk, which may have influenced their ability to recall their emotions. Additionally, the emotional data was collected through self-report. This method is easy and widely used, but it also has limits.

People may not always be aware of their emotions or may give answers that seem more socially acceptable. Additionally, changes in feelings during the walk might have been overlooked by asking participants to select only one emotion at the end.

Another limitation is the spatial data used. The study relied on OpenStreetMap and municipal datasets. This data was reliable, but did not include all possible features. Public space characteristics that the datasets cannot capture include temporary elements (such as crowdedness and street vendors), sensory stimuli (such as smell and noise), or detailed conditions of sidewalks (including litter and obstacles). These might still affect how people feel during walks.

Within the collected spatial data, some variables in the analysis had many zero values. This means that for many walking routes, specific public space characteristics were not present at all. To fix this, log transformations were used to reduce skewness and improve linearity. While this helps the statistical model, it can also reduce the natural variation in the data. As variation decreases, it becomes more challenging for the model to identify genuine effects. Results for variables with many zero values should be treated carefully. Some features, like community centres or playgrounds, were rare in the data. Because they appeared in only a few walking routes, the model struggled to detect their effect.

Finally, it is important to mention that emotions during a walk are shaped by many things other than just public space. Personal factors, social factors, and external factors also contribute to the emotions of young adults, as explained in the literature review with the SEM (Hu et al., 2021). This was also highlighted in the theoretical framework of this research. Previous research has shown that people may feel negative emotions or feel unmotivated to walk, even in nice environments (Gao et al., 2023). These other factors were not included in this research. However, acknowledging their influence is important, as it highlights the complexity of emotional experiences. It also suggests that the results of this study should be interpreted in the context of a broader picture. While not all influencing factors were captured, this research still contributes valuable knowledge about how specific characteristics of public space relate to emotional experiences during walking. It provides a starting point for further exploration into the role of the built environment in emotional well-being.

6.4 RECOMMENDATIONS FOR FURTHER RESEARCH

Future research could expand the context in which this kind of data is collected. This study focused only on young adults in Eindhoven, which limits how well the results apply to other places. Repeating the study in different cities could help demonstrate whether the findings are consistent across various locations.

Future studies could also investigate how emotions evolve in response to the characteristics of public spaces. This study captured emotions only once, at the end of a single walk. Repeating the walk or collecting emotional responses at different moments during the walk could help identify how specific public space characteristics contribute to emotions throughout the walking experience. It would also make it possible to assess changes in emotional responses before and after adjustments in public space, offering more insight into the direct emotional effects of environmental improvements.

Another valuable approach for future research is to use different methods to measure emotions. In this study, only self-reported emotions were used. These are useful but can be biased. Using

tools like heart rate monitors or skin conductance sensors could add objective data to support the survey results. This would provide a more detailed view of how people physically interact with public space characteristics.

The list of public space characteristics can also be expanded. In this study, only characteristics available through open data and municipal sources were included. Other characteristics mentioned in the literature review, although not measured, may still affect emotions. Including more detailed and sensory features in the analysis would help capture a fuller picture of the walking experience.

Additionally, future research should give more consideration to external factors, such as time and weather. People may respond very differently to a space depending on whether it is sunny or rainy, or whether they are walking during the day or evening. These details were not included in this research, because the focus was on the relation with the public space characteristics. But including these external factors could help explain variations in emotional response.

Another important step would be to make more extensive use of the Social Ecological Model (SEM). This study mainly focused on the physical environment layer. However, the survey also included information about personal, social, and external factors, such as whether the participant walked alone or with others, and how they generally felt about walking. These answers could be analysed to see how the different SEM layers work together to shape emotions. For example, someone might feel bored in a visually interesting area simply because they are tired or stressed.

Finally, walking is part of a larger lifestyle. Future research could connect the findings of this kind of study to broader questions about health, motivation, and well-being. Studies could examine how emotions experienced during walking relate to daily routines, mental health, or physical activity levels. This would help show how better urban design might support not just more walking, but healthier and happier lives overall.

Combining these ideas could provide future research with a more comprehensive understanding of how walking, place, and emotions interact, and how cities can be designed to support this experience.

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7 CONCLUSION

This thesis examined how public space characteristics contribute to the emotions of young adults while walking in urban areas. The central research question was: *"What is the contribution of public space characteristics to the emotions of young adults while walking in urban areas?"*

The results of this study indicate that specific public space characteristics have a measurable impact on how young adults perceive their urban walks. The multinomial logistic regression analysis revealed that specific characteristics, including the presence of bike lanes, low-traffic roads, public art, and restaurants, had a significant influence on the emotions of the young adults. Figure 21 visually summarises the findings by mapping the significant predictors onto the Circumplex Model of Affect. This model plots emotions along two axes: valence (positive to negative) and arousal (high to low). The positioning of public space characteristics in the figure reflects their statistical influence on each emotional quadrant, as revealed by the multinomial logistic regression analysis.

The visual clearly shows that low-traffic roads and restaurants were influential across multiple emotional states. For instance, a lower number of restaurants was associated both with relaxation and stress, highlighting the dual role of social environments. Boredom was more often reported on routes with fewer underpasses, less public art, and more bike lanes and clinker surfaces. Stress was linked to environments with fewer benches and more clinker and asphalt surfaces, as well as low availability of low-traffic roads. Excitement, which served as the reference category in the regression model, was associated with higher levels of restaurants, benches, low-traffic roads, and public art. In other words, these characteristics were significantly less present when participants reported other emotions instead of excitement. This suggests that these features may contribute to a more lively and positive walking experience.

These results suggest that even small elements in urban design can have a meaningful impact on how a place feels to young adults.

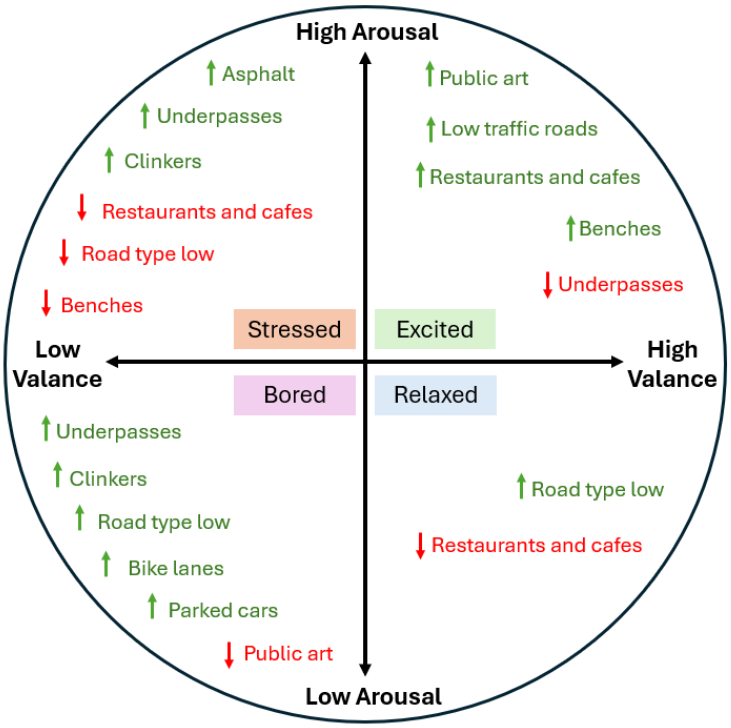

Figure 21, Significant pubic space characteristics positioned within the CMA

7.1 SCIENTIFIC RELEVANCE

Reflecting on its scientific relevance, this study contributes to the research area of environmental psychology by offering a quantitative approach to understanding emotional experiences in public spaces. It fills a gap in the existing literature by integrating detailed spatial data with emotional outcomes, focusing on young adults. The combined use of the Social-Ecological Model and the Circumplex Model of Affect created a strong theoretical foundation. It enabled a multi-layered interpretation of how environmental stimuli shape emotional responses. This combination of frameworks allowed the study to link concrete public space characteristics to emotional outcomes more meaningfully.

However, there are scientific shortcomings that should be acknowledged. The current model primarily focuses on environmental predictors, overlooking the broader context of the complete Social-Ecological Model. Emotional experiences are not shaped solely by spatial characteristics; personal, social, and external factors also contribute to these. Variables of these other SEM layers, such as individual mood, social interactions, and weather conditions, could provide a better understanding. Additionally, expanding the sample size and including a more diverse participant group across different cities could improve the generalisation of the findings. Longitudinal studies would also help to explore whether emotional responses to urban space are consistent over time or situation-dependent.

7.2 SOCIETAL RELEVANCE

This research highlights the societal value of designing urban environments that emotionally support walking. Among young adults, physical activity levels are often low, despite the well-known health benefits associated with it. Walking is a simple, accessible, and sustainable form of movement, but it is not always emotionally appealing in urban settings. According to the Mehrabian-Russell model, people are more likely to approach environments that evoke positive emotions (Ortiz-Ramirez et al., 2021). By identifying which public space characteristics foster relaxation or excitement and reduce stress or boredom, this study provides insights into how emotional experiences can encourage walking.

Creating emotionally supportive walking environments can therefore help promote more active lifestyles in urban populations. The findings indicate that public space influences how people navigate the city and their motivation to walk. In this way, designing for emotional experience is crucial in addressing broader societal issues, such as physical inactivity and its long-term health consequences. By improving emotional comfort in public spaces, cities can indirectly contribute to better mental health, increased outdoor activity, and stronger social connections. Better public space not only improves how a city looks, but they also help make walking easier, healthier, and more attractive for daily life.

7.3 IMPLICATIONS FOR URBAN DESIGN

This research provides valuable insights for both urban design and future research. The results indicate that the connection between public space and emotions warrants further exploration. It would be helpful to repeat this study in other cities, both in the Netherlands and in other countries. This could help assess whether the relationships between public space and emotions apply more broadly. It would also show whether cultural or demographic differences influence emotions.

The findings also have clear value for urban designers. Small changes can make a significant difference in how people feel while walking through a city. Characteristics like benches, public art, or reducing traffic congestion are not just aesthetic or functional; they can also support emotional well-being. Urban designers and planners can use this insight to improve walkability and emotional comfort in cities. For instance, placing benches at key resting points or maintaining visually stimulating environments can turn routine urban walks into more engaging and emotionally positive experiences.

Overall, this study suggests that cities should be designed with emotional health in mind. By treating emotional responses more seriously in urban design, urban planners and policymakers can create public spaces that support mental well-being, social connection, and a more vibrant urban life.

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APPENDICES

APPENDIX A. SURVEY

The complete survey consisted of 15 questions, of which four were used in this research. The remaining questions are included in the Appendix for transparency and potential future relevance. Questions 1, 13, 14 and 15 are used in this research.

Q1. Gender: What is your gender?
1 Female
2 Male
3 Do not prefer to say

Q2. Did you have any mobility constraints that limited your walking tour?
1 No
2 Yes
3 Do not prefer to say

Q3. How familiar are you with the environment of your walking tour?
1 Not familiar
2 Slightly familiar
3 Medium familiar
4 Somewhat familiar
5 Very familiar

Q4. Who did you walk the tour with?
1 Alone
2 Family
3 Friends
4 Peers
5 Other

Q5. Did it rain during your walking tour?
1 No, it was totally dry
2 Yes, it did rain lightly
3 Yes, it did rain heavily

Q6. What temperature level did you experience during your walking tour?
1 Cold (lower than 10 degrees Celcius)
2 Average (between 10 and 20 degrees Celcius)
3 Warm (between 21 and 25 degrees Celcius)
4 Hot (more than 25 degrees Celcius)

Q7. How windy was it during your walking tour?
1 No wind at all
2 Light wind
3 Heavy wind

Q8. How satisfied are you regarding the overall QUALITY of your walking tour?
1 Very unsatisfied
2 Unsatisfied
3 Average
4 Satisfied
5 Very satisfied

Q9. How satisfied are you regarding the level of COMFORT during your walking tour?

1 Very unsatisfied
2 Unsatisfied
3 Average
4 Satisfied
5 Very satisfied

Q10. How satisfied are you regarding the level of SAFETY during your walking tour?

1 Very Unsatisfied
2 Unsatisfied
3 Average
4 Satisfied
5 Very satisfied

Q11. How satisfied are you regarding the level of AESTHETIC during your walking tour?

1 Very unsatisfied
2 Unsatisfied
3 Average
4 Satisfied
5 Very satisfied

Q12. How satisfied are you regarding the level of HEALTHINESS of the environment during your walking tour?

1 Very unsatisfied
2 Unsatisfied
3 Average
4 Satisfied
5 Very satisfied

Q13. How happy or sad did you feel during your walking tour?

1 Very happy
2 Happy
3 Somewhat happy
4 Neither happy nor sad
5 Somewhat sad
6 Sad
7 Very sad

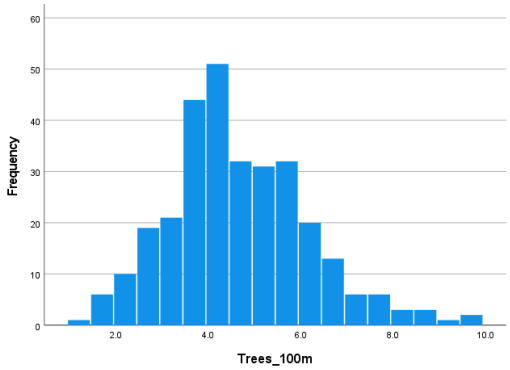
Q14. How energetic or tired did you feel during your walking tour?

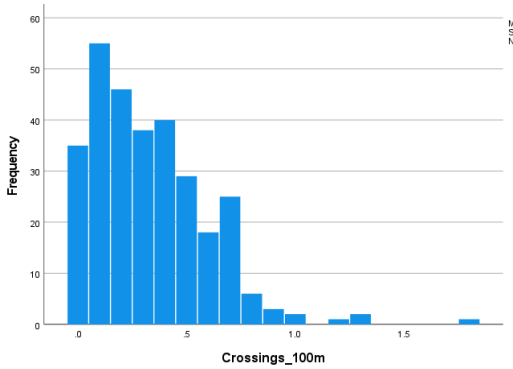
1 Very energetic
2 Energetic
3 Somewhat energetic
4 Neither energetic nor tired
5 Somewhat tired
6 Tired
7 Very tired

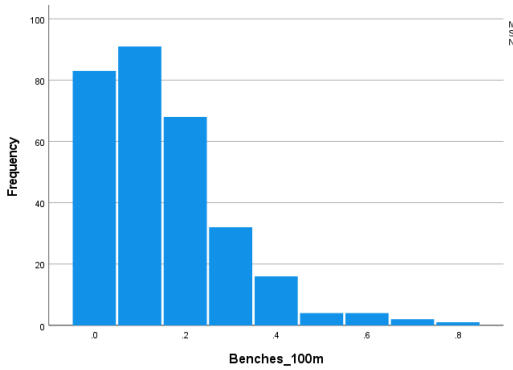
Q15. How stressed or relaxed did you feel during your walking tour?

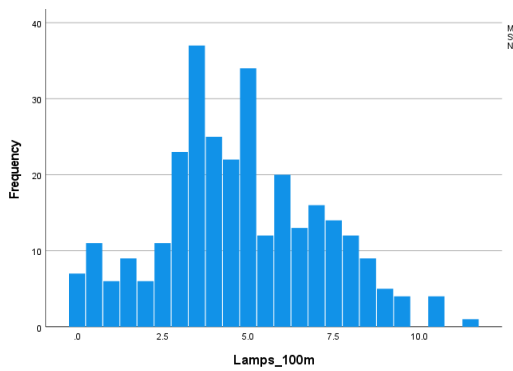
1 Very stressed
2 Stressed
3 Somewhat stressed
4 Neither stressed nor relaxed
5 Somewhat relaxed
6 Relaxed
7 Very relaxed

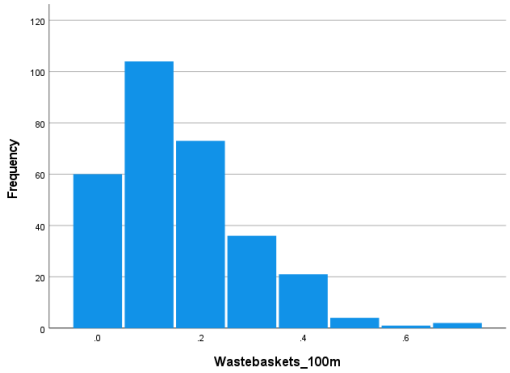
APPENDIX B. HISTOGRAMS OF THE SPATIAL ANALYSIS RESULTS BEFORE TRANSFORMATION

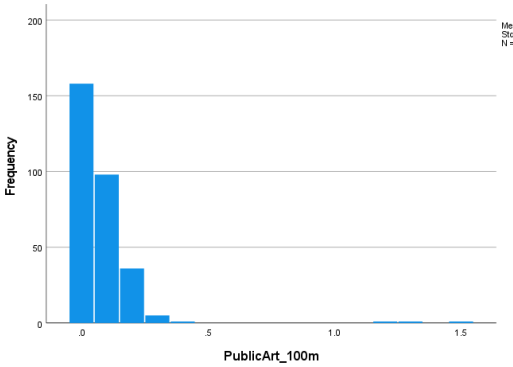


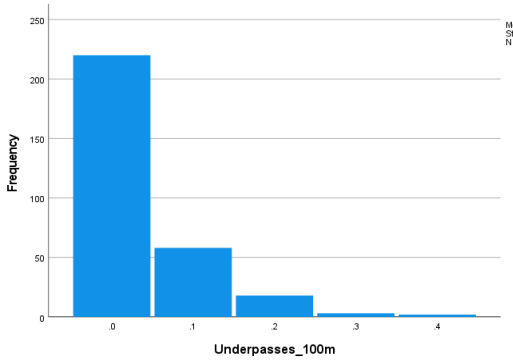


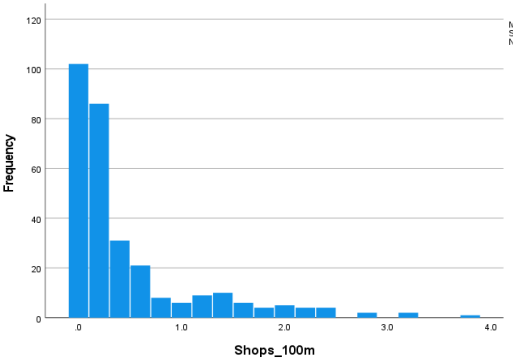


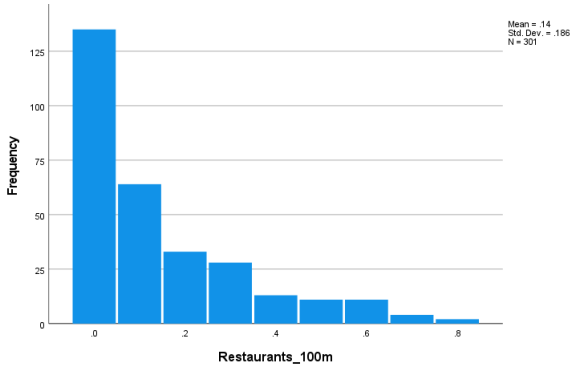








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Std. Dev. = .186
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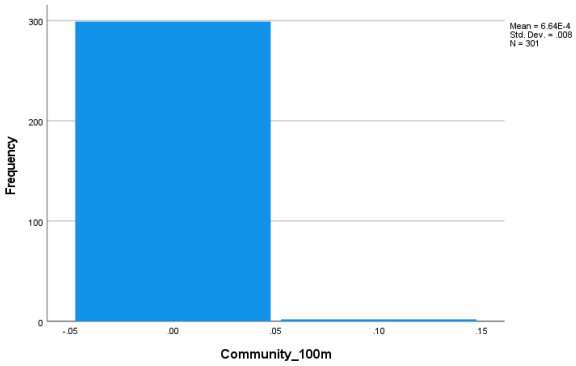
Frequency
Restaurants_100m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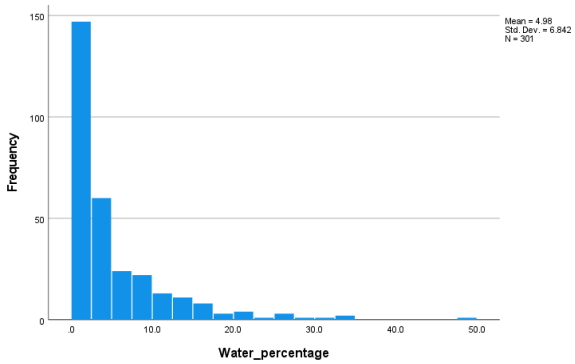
Frequency
Community_100m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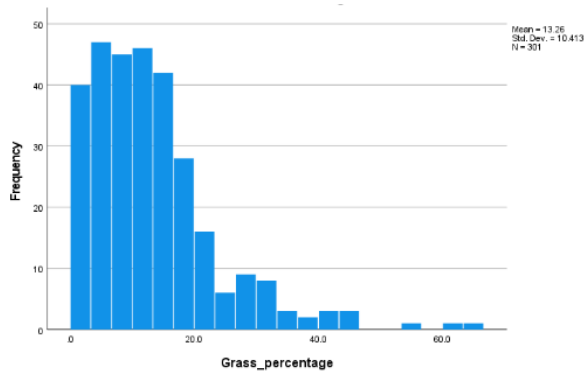
Frequency
Water_percentage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Std. Dev. = 10.413
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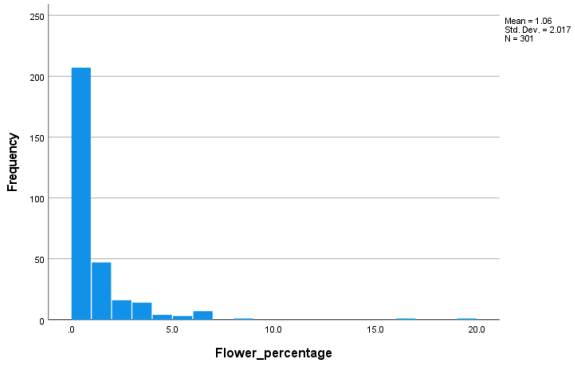
Frequency
Grass_percentage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Std. Dev. = 2.017
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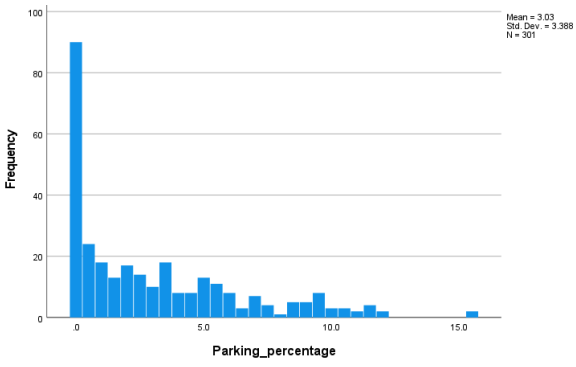
Frequency
Flower_percentage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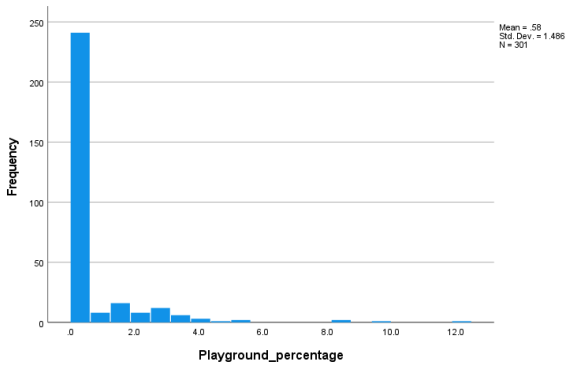
Frequency
Parking_percentage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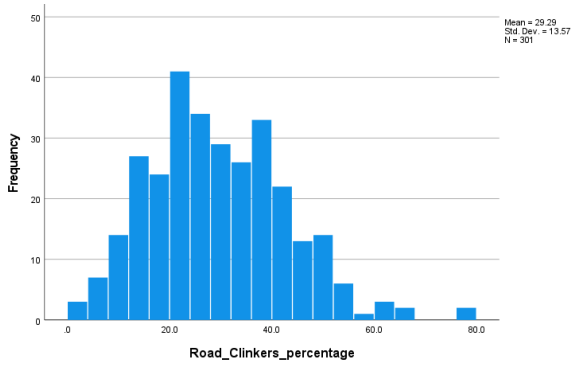
Std. Dev. = 1.486
N = 301
Frequency
Playground_percentage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Std. Dev. = 13.57
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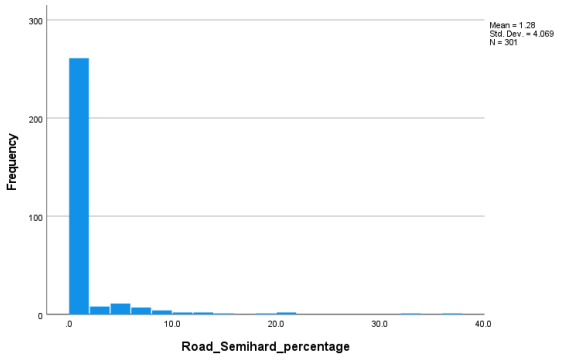
Frequency
Road_Clinkers_percentage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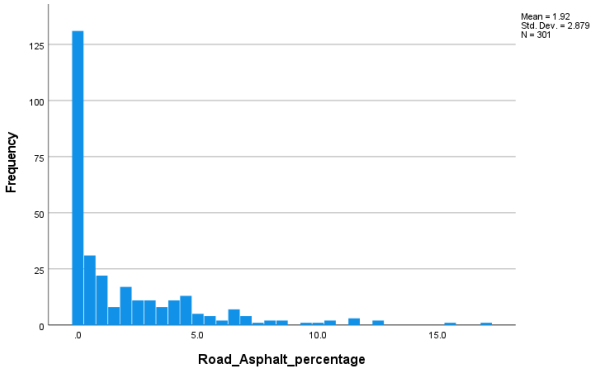
Frequency
Road_Semihard_percentage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Frequency
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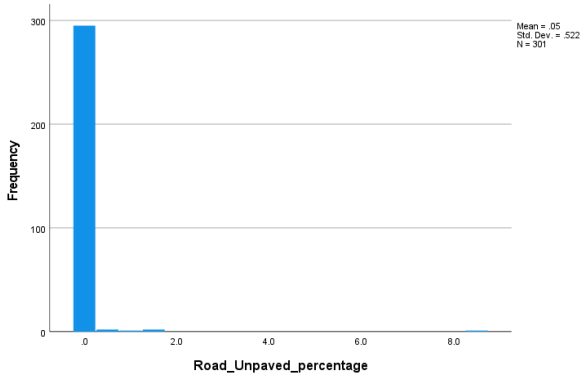
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Std. Dev. = .522
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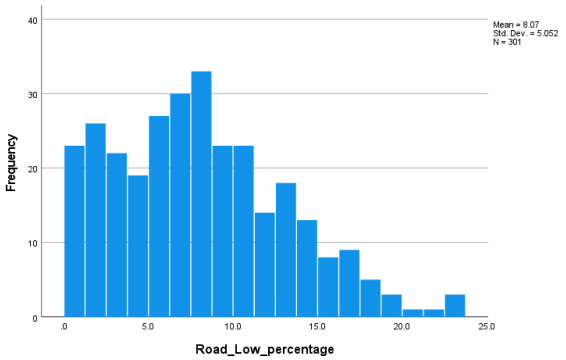
Frequency
Road_Unpaved_percentage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Std. Dev. = 5.052
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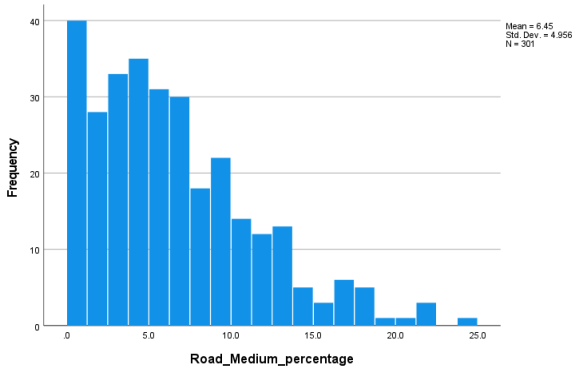
Frequency
Road_Low_percentage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Std. Dev. = 4.956
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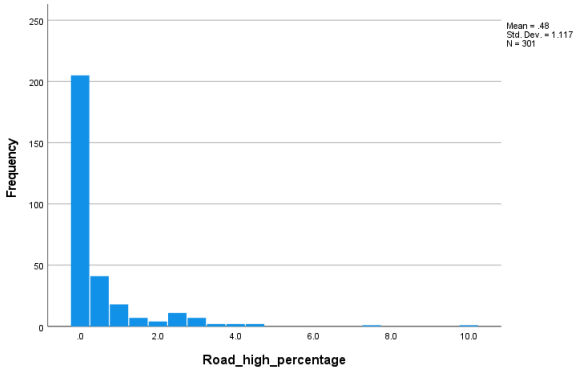
Frequency
Road_Medium_percentage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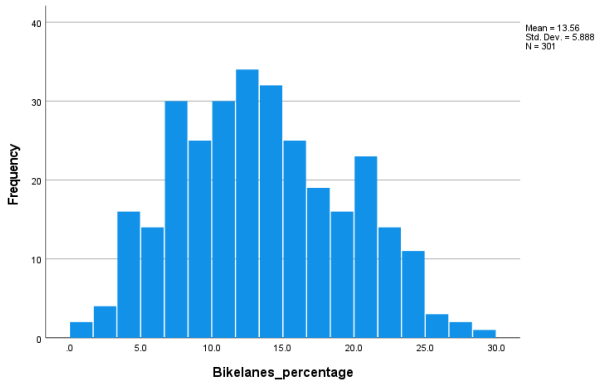
Road_high_percentage


Mean = 13.56
Std. Dev. = 5.888
N = 301
Frequency
Bikelanes_percentage

APPENDIX C. SKEWNESS VALUES BEFORE/AFTER LOG TRANSFORMATION

Table 25, Skewness values of the public space characteristics

Variable	*Measurement*	*Statistic original values*	*Statistics after Log-transformation*
Trees	Skewness	.526	
	Kurtosis	.545	
Crossings	Skewness	1.250	.575
	Kurtosis	3.133	.227
Benches	Skewness	1.329	.935
	Kurtosis	2.384	.887
Lamps	Skewness	.186	
	Kurtosis	-.288	
Wastebaskets	Skewness	1.006	
	Kurtosis	1.358	
Public art	Skewness	6.310	4.269
	Kurtosis	51.959	28.420
Underpasses	Skewness	2.246	2.024
	Kurtosis	5.796	4.240
Shops	Skewness	2.150	1.445
	Kurtosis	4.615	1.168
Restaurants	Skewness	1.436	1.174
	Kurtosis	1.393	.480
Community	Skewness	12.206	12.206
	Kurtosis	147.973	147.973
Water	Skewness	2.567	.278
	Kurtosis	9.082	-.905
Grass	Skewness	1.716	-.490
	Kurtosis	4.333	.052
Flower	Skewness	4.935	1.393
	Kurtosis	35.042	1.897
Parking	Skewness	1.176	
	Kurtosis	.735	
Playground	Skewness	4.126	2.048
	Kurtosis	22.194	3.444
Clinkers	Skewness	.537	
	Kurtosis	.399	
Semi-paved	Skewness	5.449	2.315
	Kurtosis	36.870	4.702
Asphalt	Skewness	2.147	.739
	Kurtosis	5.373	-.716
Unpaved	Skewness	15.506	10.906
	Kurtosis	254.814	137.584
Low roads	Skewness	.544	
	Kurtosis	-.158	
Medium roads	Skewness	.950	
	Kurtosis	.716	
High roads	Skewness	4.137	1.977
	Kurtosis	24.483	3.491
Bike lanes	Skewness	.217	
	Kurtosis	-.620	

APPENDIX D. DESCRIPTIVE ANALYSIS SURVEY

The complete survey consisted of 15 questions, of which four were used in this research. Questions 1, 13, 14 and 15 are used in this research.

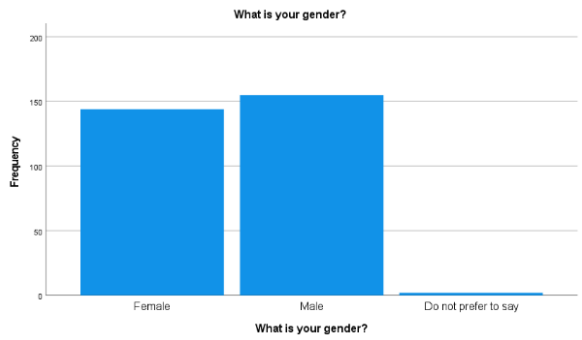
Table 26, Frequency table of the survey answers

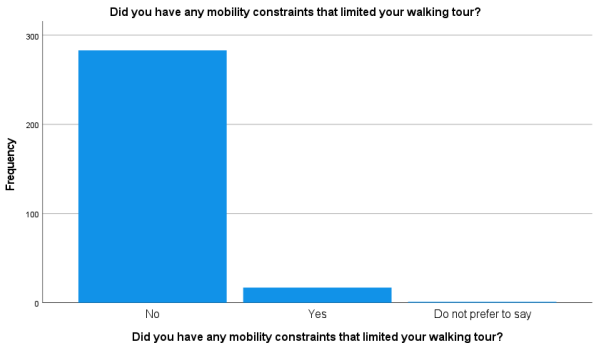
Category	*Characteristics*	*Level*	*Frequency*	*Percentage*	*Cum. Percentage*
Personal details	Gender	Female	144	47.8	47.8
		Male	155	51.5	99.3
		Do not prefer to say	2	0.7	100.0
	Mobility constraints	No	283	94.0	94.0
		Yes	17	5.6	99.7
		Do not prefer to say	1	0.3	100.0
	Familiar with environment	1 (Not familiar)	23	7.6	7.6
		2	29	9.6	17.3
		3 (Average)	86	28.6	45.8
		4	89	29.6	75.4
		5 (Very familiar)	74	24.6	100.0
	Companion	Alone	202	67.1	67.1
		Family	2	0.7	67.8
		Friend	86	28.6	96.3
		Peers	7	2.3	98.7
		Other	4	1.3	100.0
Walking tour details	Rain	No, totally dry	277	92.0	92.0
		Yes, lightly	20	6.6	98.7
		Yes, heavily	4	1.3	100.0
	Temperature	Cold	188	62.5	62.5
		Average	113	37.5	100.0
		Warm	0	0	
		Hot	0	0	
	Wind	No wind	106	35.2	35.2
		Light wind	177	58.8	94.0
		Heavy wind	18	6.0	100.0
Evaluation of walking tour	Satisfaction with overall quality	Very unsatisfied	0	0	0
		Unsatisfied	12	4.0	4.0
		Average	73	24.3	28.2
		Satisfied	188	62.5	90.7
		Very satisfied	28	9.3	100.0
	Satisfaction with level of comfort	Very unsatisfied	0	0	0
		Unsatisfied	26	8.6	8.6
		Average	102	33.9	42.5
		Satisfied	153	50.8	93.4
		Very satisfied	20	6.6	100.0
	Satisfaction with level of safety	Very unsatisfied	0	0	0
		Unsatisfied	17	5.6	5.6
		Average	72	23.9	29.6
		Satisfied	136	45.2	74.8
		Very satisfied	76	25.2	100.0
	Satisfaction with level of aesthetics	Very unsatisfied	2	0.7	0.7
		Unsatisfied	45	15	15.6
		Average	112	37.2	52.8
		Satisfied	107	35.5	88.4
		Very satisfied	35	11.6	100.0
	Satisfaction with level of healthiness	Very unsatisfied	1	0.3	0.3
		Unsatisfied	32	10.6	11.0
		Average	120	39.9	50.8

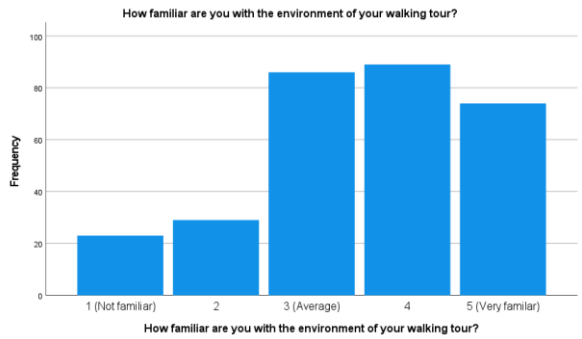
		Satisfied	116	38.5	89.4
		Very satisfied	32	10.6	100.0
Emotions during walking tour	Happy or sad	Very happy	21	0	0
		Happy	109	7.0	7.0
		Somewhat happy	106	36.2	43.2
		Neither happy nor sad	50	35.2	78.4
		Somewhat sad	11	16.6	95.0
		Sad	4	3.7	98.7
		Very sad	0	1.3	100.0
	Energetic or tired	Very energetic	15	5.0	5.0
		energetic	74	24.6	29.6
		Somewhat energetic	91	30.2	59.8
		Neither energetic/tired	57	18.9	78.7
		Somewhat tired	52	17.3	96.9
		Tired	7	2.3	98.3
		Very tired	5	1.7	100.0
	Stressed or relaxed	Very stressed	0	0	0
		stressed	9	3.0	3.0
		Somewhat stressed	34	11.3	14.3
		Neither stress/ relaxed	60	19.9	34.2
		Somewhat relaxed	75	24.9	59.1
		Relaxed	97	32.2	91.4
		Very relaxed	26	8.6	100.0
Number of respondents			301	100,0	

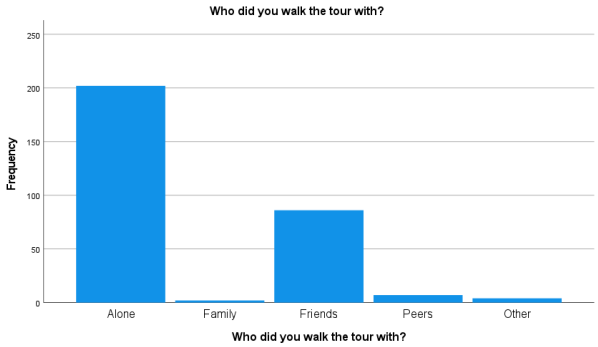
APPENDIX E. HISTOGRAMS OF SURVEY ANSWERS

Personal details

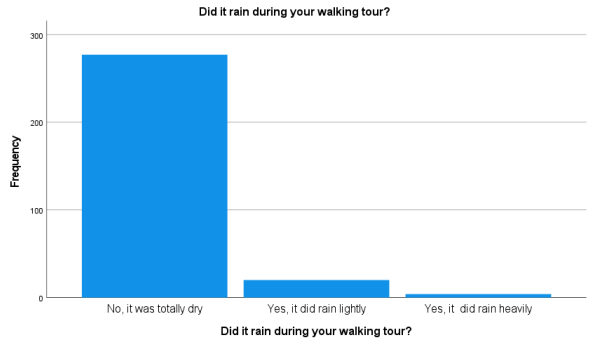


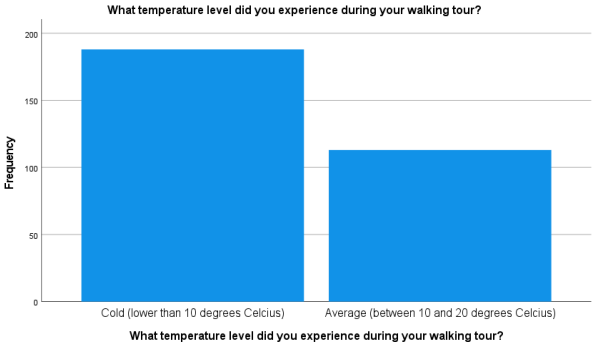


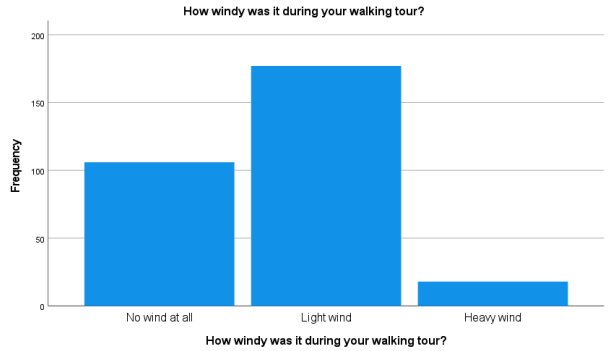




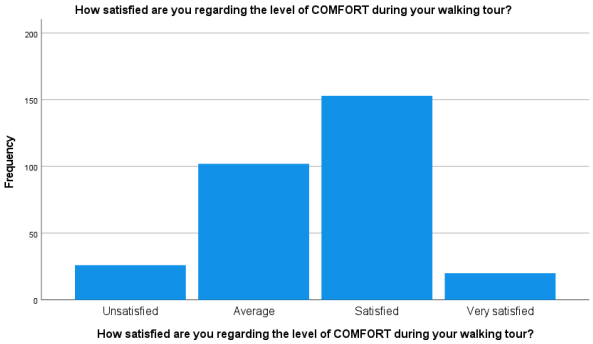
Walking tour details

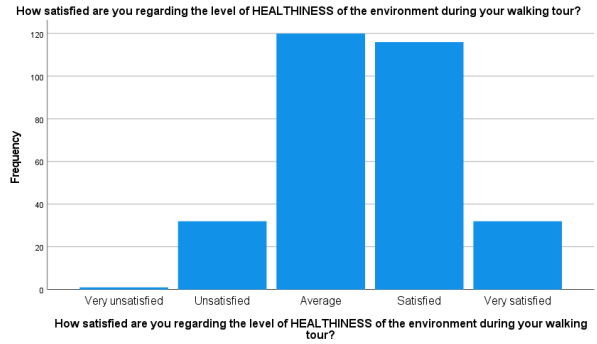






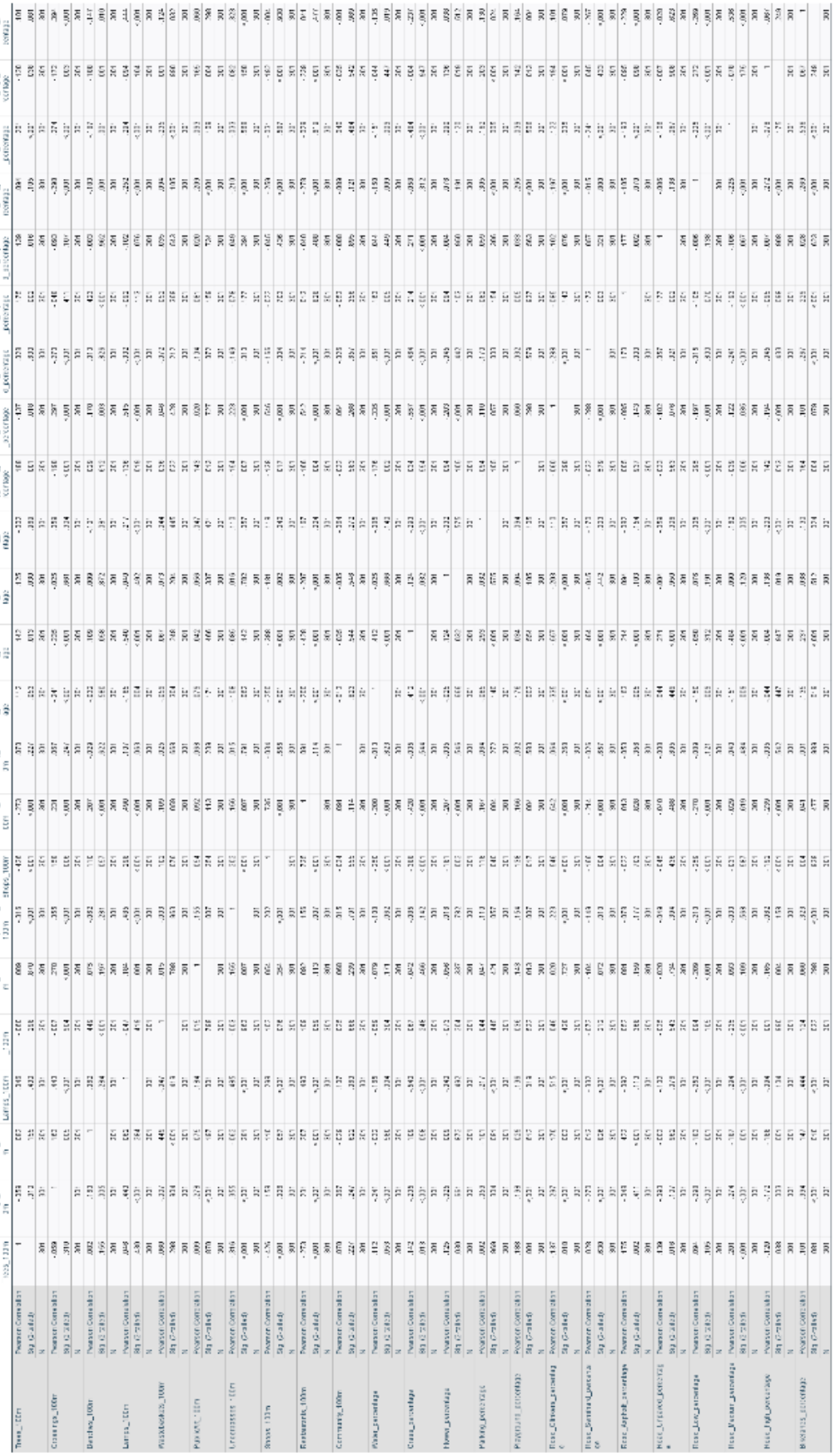
Evaluation of walking tour





APPENDIX F. CORRELATION MATRIX

Table 27, Correlation Matrix



APPENDIX G. LINEAR REGRESSION COEFFICIENTS FOR MULTICOLLINEARITY CHECK

Table 28, Linear regression coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	.283	.450		.630	.529		
	Trees_100m	.057	.051	.086	1.122	.263	.492	2.033
	Crossings_100m	.088	.260	.024	.340	.734	.603	1.659
	Benches_100m	1.376	.528	.200	2.605	.010	.491	2.038
	Lamps_100m	.012	.044	.029	.282	.778	.272	3.678
	Wastebaskets_100m	-.726	.495	-.095	-1.468	.143	.682	1.467
	PublicArt_100m	.329	.396	.049	.830	.407	.827	1.210
	Underpasses_100m	1.122	1.131	.079	.992	.322	.456	2.191
	Shops_100m	-.029	.140	-.019	-.204	.839	.335	2.981
	Restaurants_100m	1.765	.526	.328	3.352	<,001	.302	3.313
	Community_100m	5.223	6.856	.043	.762	.447	.926	1.080
	Water_percentage	.020	.012	.138	1.680	.094	.429	2.330
	Grass_percentage	-.010	.010	-.101	-.942	.347	.251	3.989
	Flower_percentage	.034	.029	.069	1.193	.234	.851	1.176
	Parking_percentage	-.042	.020	-.142	-2.085	.038	.625	1.599
	Playground_percentage	.014	.041	.020	.335	.738	.776	1.288
	Road_Clinkers_percentage	-.024	.006	-.332	-4.027	<,001	.425	2.354
	Road_Semihard_percentage	.009	.019	.037	.473	.637	.466	2.148
	Road_Asphalt_percentage	-.028	.023	-.081	-1.238	.217	.670	1.493
	Road_Unpaved_percentage	.272	.112	.142	2.427	.016	.846	1.183
	Road_Low_percentage	.016	.017	.082	.973	.331	.402	2.488
	Road_Medium_percentage	.016	.018	.079	.874	.383	.353	2.833
	Road_high_percentage	.053	.058	.059	.914	.361	.686	1.458
	Bikelanes_percentage	-.033	.013	-.193	-2.484	.014	.480	2.085

a. Dependent Variable: Zscore: Valance scale

APPENDIX H. COLLINEARITY DIAGNOSTICS VALENCE

Table 29, Collinearity diagnostics of valence

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Trees_100m	Crossings_100m	Benches_100m	Lamps_100m	WasteBaskets_100m	PublicArt_100m	Underpasses_100m	Shops_100m	Restaurants_100m	Community_100m	Water_percentage	Grass_percentage	Flower_percentage	Parking_percentage	Playground_percentage	Road_Climbers_percentage	Road_Samhar_percentage	Road_Asphalt_percentage	Road_Unpaved_percentage	Road_Low_percentage	Road_Medium_percentage	Road_high_percentage	Bikelanes_percentage
1	1	11.278	1.000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
	2	2.158	2.286	00	00	00	00	00	00	01	00	01	01	00	02	00	01	00	01	00	00	04	01	01	00	00	01	00
	3	1.431	2.808	00	00	00	00	00	00	01	00	01	01	00	02	00	03	00	09	00	04	02	03	01	00	07	00	00
	4	1.083	3.227	00	00	00	01	00	01	04	02	02	01	21	01	00	01	00	06	00	01	03	06	00	00	00	00	00
	5	1.027	3.313	00	00	00	00	00	00	04	00	01	00	13	02	00	03	01	00	00	05	02	35	00	00	00	00	00
	6	.993	3.387	00	00	00	00	01	01	01	04	00	01	49	00	00	04	00	06	00	00	00	04	00	00	00	00	00
	7	.865	3.570	00	00	00	03	00	00	13	00	01	00	02	00	00	03	01	02	00	01	05	27	00	00	08	00	00
	8	.777	3.810	00	00	00	00	00	00	01	07	01	00	00	00	00	01	10	00	00	00	01	02	00	01	25	00	00
	9	.704	4.004	00	00	00	00	00	00	00	27	00	00	00	04	00	00	45	01	06	00	02	01	01	00	02	00	00
	10	.655	4.190	00	00	00	00	00	00	10	03	23	00	00	00	00	00	09	30	00	00	01	01	00	00	01	14	00
	11	.497	4.592	00	00	00	02	00	00	15	04	02	04	01	00	00	00	09	14	00	00	05	01	01	01	02	00	00
	12	.497	4.783	00	00	00	04	03	00	10	34	00	01	02	00	00	00	07	17	00	00	01	00	00	02	03	01	01
	13	.456	4.975	00	00	00	00	00	00	09	03	03	01	00	01	00	00	13	03	01	00	51	01	00	00	03	05	00
	14	.274	6.413	00	00	00	15	02	00	02	01	00	00	02	38	00	00	00	02	02	00	00	46	00	00	01	00	00
	15	.265	6.520	00	01	00	00	10	00	10	02	01	03	00	03	00	09	02	09	07	00	08	03	09	04	03	05	00
	16	.222	7.134	00	00	17	05	01	19	19	00	03	14	14	01	04	00	01	02	02	00	01	08	00	00	11	02	01
	17	.184	7.832	00	01	29	04	02	02	01	01	03	10	01	01	04	05	00	16	10	05	06	02	01	07	00	06	00
	18	.156	8.515	00	00	30	27	00	23	00	01	00	00	01	07	10	03	16	00	00	00	06	03	08	01	08	01	01
	19	.136	9.102	00	00	01	20	00	16	00	00	25	44	03	20	01	00	00	00	00	05	11	06	02	01	01	00	03
	20	.097	11.358	00	01	00	19	03	07	00	08	03	07	01	05	01	02	16	00	03	29	02	01	01	36	10	02	01
	21	.068	12.923	00	01	00	00	10	00	00	13	14	16	01	01	06	00	00	00	03	11	03	00	00	00	36	01	43
	22	.052	14.733	00	24	01	00	18	00	04	01	13	02	01	04	01	02	00	03	00	26	00	03	01	01	03	00	44
	23	.031	19.100	00	70	01	01	64	00	01	28	00	07	00	02	20	00	01	00	00	00	00	03	00	04	07	08	03
	24	.012	30.783	99	02	00	00	01	01	01	00	04	02	00	04	44	00	01	00	24	01	01	01	01	35	20	04	03

a. Dependent Variable: Zscore: Valiance scale

APPENDIX I. COLLINEARITY DIAGNOSTICS AROUSAL

Table 30, Collinearity diagnostics of arousal

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	(Constant)	Time_Effort	Cognitive_Effort	Emotional_Effort	Duration_Effort	Variance Proportions: Frustration_Effort	Task_Difficulty	Achievement_Effort	Temporal_Effort	Mental_Effort	Physical_Effort	Performance_Effort	Control_Effort	Risk_Aversion	Risk_Seeking	Risk_Neutral	Time_Preference	Risk_Averse	Risk_Loving	Risk_Medium_Severity	Risk_High_Severity	Risk_Low_Severity
1	1	11.228	1.000	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	2	2.908	1.966	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	3	1.487	2.750	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	4	1.003	3.347	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	5	1.000	3.353	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	6	.885	3.560	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	7	.885	3.563	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	8	.799	3.753	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	9	.704	4.294	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	10	.695	4.323	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	11	.591	4.362	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	12	.487	4.793	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	13	.458	4.919	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	14	.374	5.473	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	15	.282	6.323	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	16	.225	7.046	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	17	.154	8.532	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	18	.145	8.775	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	19	.138	9.012	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	20	.097	10.756	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	21	.081	11.778	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	22	.021	23.233	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	23	.005	46.773	.00	.74	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	24	.003	58.743	.00	.23	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

a. Dependent Variable: Arousal_Index

APPENDIX J. BOX-TIDWELL RESULTS

Table 31, Box-Tidwell results in the parameter estimates

Parameter Estimates

Emotion Quadrant[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
Relaxed	Intercept	-.154	3.735	.002	1	.967			
	Trees	.439	1.750	.063	1	.802	1.550	.050	47.877
	Trees_LN_Trees	-.159	.670	.057	1	.812	.853	.229	3.168
	StreetLighting_LN_StreetLighting	.127	.289	.193	1	.661	1.135	.644	2.001
	Wastebaskets_LN_Wastebaskets	-.694	3.254	.045	1	.831	.500	.001	293.956
	RoadMedium_LN_RoadMedium	.101	.112	.803	1	.370	1.106	.887	1.379
	Bikelanes_LN_Bikelanes	-.048	.143	.111	1	.739	.953	.720	1.263
	StreetLighting	-.447	.769	.338	1	.561	.640	.142	2.888
	Wastebaskets	-1.130	3.371	.112	1	.737	.323	.000	238.998
	RoadType_Low	-.701	.361	3.773	1	.052	.496	.244	1.006
	RoadType_Medium	-.225	.351	.410	1	.522	.799	.401	1.590
	Bikelanes	.103	.509	.040	1	.841	1.108	.408	3.007
	Surface_Clinkers	.239	.252	.905	1	.342	1.270	.776	2.080
	Surface_Clinkers_LN_Surface_Clinkers	-.056	.058	.957	1	.328	.945	.844	1.058
	RoadLow_LN_RoadLow	.209	.115	3.338	1	.068	1.233	.985	1.544
Bored	Intercept	-.828	2.574	.103	1	.748			
	Trees	-.405	1.112	.133	1	.716	.667	.075	5.895
	Trees_LN_Trees	.157	.426	.135	1	.713	1.170	.507	2.697
	StreetLighting_LN_StreetLighting	.244	.217	1.271	1	.260	1.277	.835	1.953
	Wastebaskets_LN_Wastebaskets	1.154	2.173	.282	1	.595	3.169	.045	224.025
	RoadMedium_LN_RoadMedium	.061	.087	.490	1	.484	1.063	.896	1.261
	Bikelanes_LN_Bikelanes	-.067	.111	.365	1	.546	.935	.753	1.162
	StreetLighting	-.874	.585	2.233	1	.135	.417	.133	1.313
	Wastebaskets	1.665	2.026	.675	1	.411	5.284	.100	279.966
	RoadType_Low	-.430	.268	2.568	1	.109	.651	.385	1.101
	RoadType_Medium	-.178	.269	.438	1	.508	.837	.495	1.417
	Bikelanes	.329	.406	.658	1	.417	1.390	.627	3.078
	Surface_Clinkers	.338	.178	3.608	1	.057	1.402	.989	1.987
	Surface_Clinkers_LN_Surface_Clinkers	-.069	.040	3.013	1	.083	.933	.863	1.009
	RoadLow_LN_RoadLow	.137	.085	2.595	1	.107	1.147	.971	1.356
Stressed	Intercept	-2.051	2.860	.514	1	.473			
	Trees	.605	1.282	.223	1	.637	1.831	.148	22.587
	Trees_LN_Trees	-.285	.498	.328	1	.567	.752	.283	1.996
	StreetLighting_LN_StreetLighting	.029	.245	.014	1	.906	1.029	.637	1.663
	Wastebaskets_LN_Wastebaskets	.982	2.384	.170	1	.680	2.670	.025	285.555
	RoadMedium_LN_RoadMedium	.079	.088	.798	1	.372	1.082	.910	1.285
	Bikelanes_LN_Bikelanes	-.185	.125	2.177	1	.140	.831	.650	1.063
	StreetLighting	-.300	.656	.210	1	.647	.740	.205	2.680
	Wastebaskets	-.175	2.460	.005	1	.943	.839	.007	104.234
	RoadType_Low	-.600	.275	4.740	1	.029	.549	.320	.942
	RoadType_Medium	-.198	.272	.530	1	.467	.820	.481	1.398
	Bikelanes	.722	.461	2.447	1	.118	2.058	.833	5.083
	Surface_Clinkers	.135	.164	.679	1	.410	1.144	.830	1.578
	Surface_Clinkers_LN_Surface_Clinkers	-.027	.037	.525	1	.469	.974	.906	1.047
	RoadLow_LN_RoadLow	.180	.088	4.164	1	.041	1.197	1.007	1.424

a. The reference category is: Excited.

APPENDIX K. MULTINOMIAL LOGISTIC REGRESSION RESULTS

Table 32, Multinomial logistic regression results in the parameter estimates

Parameter Estimates

Emotion Quadrant[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
Relaxed	Intercept	1.790	2.448	.534	1	.465			
	Trees	-.174	.221	.622	1	.430	.840	.545	1.296
	Log_Water	.131	.313	.175	1	.675	1.140	.618	2.103
	Log_Flower	.288	.391	.544	1	.461	1.334	.620	2.870
	Log_Grass	-.269	.560	.231	1	.631	.764	.255	2.290
	Log_RoadType_Low	-.676	.378	3.205	1	.073	.509	.243	1.066
	RoadType_Medium	.012	.078	.022	1	.883	1.012	.868	1.179
	Log_RoadType_High	-.301	.624	.232	1	.630	.740	.218	2.515
	Parked_cars	-.016	.095	.027	1	.869	.985	.818	1.185
	Bikelanes	-.089	.066	1.826	1	.177	.915	.804	1.041
	Log_Crossings	1.797	1.794	1.003	1	.317	6.030	.179	203.118
	Surface_Clinkers	.008	.029	.074	1	.785	1.008	.953	1.066
	Log_Surface_Semihard	.207	.339	.372	1	.542	1.230	.633	2.392
	Log_Surface_Asphalt	-.120	.346	.120	1	.729	.887	.450	1.748
	Log_Surface_Unpaved	.269	1.025	.069	1	.793	1.308	.175	9.752
	Log_Benches	1.060	2.612	.165	1	.685	2.887	.017	483.022
	StreetLighting	.200	.202	.978	1	.323	1.221	.822	1.814
	Wastebaskets	.183	2.143	.007	1	.932	1.201	.018	80.123
	Log_PublicArt	-4.434	3.725	1.417	1	.234	.012	8.001E-6	17.588
	Log_Underpasses	-9.875	6.772	2.126	1	.145	5.144E-5	8.849E-11	29.904
	Log_Shops	.928	1.242	.559	1	.455	2.529	.222	28.829
	Log_Restaurants	-9.351	3.663	6.517	1	.011	8.688E-5	6.621E-8	.114
	Log_Playground	.126	.471	.072	1	.788	1.135	.451	2.857
	Log_Community	-137.350	.000	.	1	.	2.237E-60	2.237E-60	2.237E-60
Bored	Intercept	1.536	1.752	.769	1	.381			
	Trees	-.143	.153	.880	1	.348	.866	.642	1.169
	Log_Water	-.219	.227	.934	1	.334	.803	.515	1.253
	Log_Flower	-.052	.321	.026	1	.871	.949	.505	1.782
	Log_Grass	-.010	.404	.001	1	.981	.990	.449	2.185
	Log_RoadType_Low	-.750	.289	6.717	1	.010	.472	.268	.833
	RoadType_Medium	-.071	.055	1.699	1	.192	.931	.837	1.037
	Log_RoadType_High	-.353	.453	.605	1	.437	.703	.289	1.708
	Parked_cars	.109	.061	3.230	1	.072	1.115	.990	1.257
	Bikelanes	.087	.038	5.317	1	.021	1.091	1.013	1.175
	Log_Crossings	-.143	1.224	.014	1	.907	.867	.079	9.545
	Surface_Clinkers	.044	.019	5.308	1	.021	1.045	1.007	1.085
	Log_Surface_Semihard	-.231	.292	.630	1	.427	.793	.448	1.405
	Log_Surface_Asphalt	.415	.252	2.711	1	.100	1.514	.924	2.481
	Log_Surface_Unpaved	-1.274	1.198	1.130	1	.288	.280	.027	2.930
	Log_Benches	-2.654	1.922	1.906	1	.167	.070	.002	3.046
	StreetLighting	-.035	.128	.076	1	.783	.965	.751	1.240
	Wastebaskets	2.572	1.475	3.040	1	.081	13.089	.727	235.687
	Log_PublicArt	-5.778	2.433	5.639	1	.018	.003	2.626E-5	.365
	Log_Underpasses	-7.466	3.722	4.023	1	.045	.001	3.886E-7	.843
	Log_Shops	.107	.867	.015	1	.901	1.113	.204	6.089
	Log_Restaurants	-7.030	2.211	10.109	1	.001	.001	1.161E-5	.067
	Log_Playground	-.299	.365	.674	1	.412	.741	.363	1.515
	Log_Community	-137.872	8940.772	.000	1	.988	1.327E-60	.000	.[b]
Stressed	Intercept	1.682	1.818	.856	1	.355			
	Trees	-.290	.168	2.999	1	.083	.748	.539	1.039
	Log_Water	-.287	.235	1.483	1	.223	.751	.473	1.191
	Log_Flower	-.320	.340	.890	1	.345	.726	.373	1.412
	Log_Grass	.277	.429	.417	1	.518	1.319	.569	3.055
	Log_RoadType_Low	-.870	.287	9.158	1	.002	.419	.239	.736
	RoadType_Medium	.002	.058	.001	1	.974	1.002	.895	1.122
	Log_RoadType_High	-.151	.472	.103	1	.749	.860	.341	2.170
	Parked_cars	.101	.064	2.492	1	.114	1.106	.976	1.254
	Bikelanes	.053	.042	1.644	1	.200	1.055	.972	1.144
	Log_Crossings	.288	1.260	.052	1	.819	1.334	.113	15.763
	Surface_Clinkers	.043	.020	4.730	1	.030	1.044	1.004	1.085
	Log_Surface_Semihard	-.010	.302	.001	1	.975	.990	.548	1.790
	Log_Surface_Asphalt	.550	.265	4.312	1	.038	1.734	1.031	2.915
	Log_Surface_Unpaved	-10.685	9.609	1.236	1	.266	2.289E-5	1.516E-13	3457.001
	Log_Benches	-4.915	2.061	5.688	1	.017	.007	.000	.417
	StreetLighting	-.043	.134	.103	1	.749	.958	.736	1.246
	Wastebaskets	1.261	1.623	.604	1	.437	3.529	.147	85.010
	Log_PublicArt	-.120	1.472	.007	1	.935	.887	.050	15.883
	Log_Underpasses	-7.332	3.871	3.588	1	.058	.001	3.319E-7	1.290
	Log_Shops	-.984	.889	1.226	1	.268	.374	.066	2.133
	Log_Restaurants	-4.713	2.246	4.403	1	.036	.009	.000	.733
	Log_Playground	-.016	.383	.002	1	.966	.984	.464	2.084
	Log_Community	-153.393	8640.359	.000	1	.986	2.410E-67	.000	.[b]

a. The reference category is: Excited.

b. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.