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Perceived Accessibility to Urban Green Spaces Among Students in Groningen

*The Influence of the **Built Environment**, **Temporal Component** and **Individual Components***

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Abstract

Access to urban green space is crucial for human well-being and life satisfaction. In recent years there has been a notable shift from the measurement of accessibility based on objective components to the use of perceived components. This research investigated what factors influence perceived accessibility to urban green space, with particular emphasis placed on the built environment, temporal component, socio-economic characteristics and personal attitudes and preferences for students in the city of Groningen. Quantitative surveys were used to collect data, after which correlation tests were conducted to investigate relationships between the aforementioned factors and perceived accessibility to urban green spaces. Furthermore, a spatial analysis has been conducted to ascertain the extent to which the outcomes may differ between the objective and perceived measures of accessibility. The study demonstrated that the availability of amenities, visual evaluation of the neighbourhood, and perception of both quantity and quality of urban green spaces are positively related to perceived accessibility to urban green spaces. Furthermore, additional correlations were identified for the perception of cycling infrastructure, ease of reaching transit stops, and the satisfaction with time and effort spent travelling. Additionally, analysis revealed that women exhibited statistically significant higher levels of perceived accessibility than men. It is essential that policymakers and spatial planners consider perception alongside conventional methods of measuring accessibility, in order to guarantee accessible urban green spaces for all.

Keywords: *Perceived Accessibility, Urban Green Space, Students, Groningen, Perceived Built Environment, Perceived Temporal Component, Individual Components*

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1. Introduction

The main function of any transportation system is to provide people with the opportunity to interact and engage in spatially dispersed activities of different kinds (e.g. social, economic, etc.) (Miller, 2018; Pot et al., 2021). This interaction potential of people is more commonly known by the term of *accessibility* (Hansen, 1959). Some key factors influencing accessibility are transport demand, mobility, transport system diversity, user information, affordability and land-use factors (Litman, 2023).

Accessibility has received considerable attention in academic literature. One of the reasons for this is that the main goal of spatial and urban planning is to improve the quality of life, well-being and life satisfaction (Van den Berg et al., 2019; Yin et al., 2020). Accessibility is one of the factors related to spatial and urban planning influencing quality of life and (subjective) well-being (Ettema et al., 2010; Van den Berg et al., 2019; Waygood et al., 2017). For example, Ettema et al. (2010) found that a higher accessibility relates to improvements in subjective well-being, as people more easily access daily activities to facilitate progress to life goals. The consequences of reduced accessibility during the COVID-19 has been researched by Liu et al. (2022). They found that a reduction in accessibility of daily necessities and social activities may be an underlying cause of mental health problems.

Thus, improving accessibility is an important goal for planners. In the field of transportation planning, previous approaches focused on improving accessibility for primarily cars by often large-scale infrastructure investments (Miller, 2018). However, current trends focus on planning for proximity of land-uses to improve accessibility by active and sustainable modes of transport, such as walking, cycling and public transport (Bos & Lee, 2012; Pot et al., 2021; Yan, 2021). Bos & Lee (2012) therefore see a clear paradigm shift within the field of transport planning towards an *accessibility-based planning* approach.

This rise of planning for accessibility resulted in a new way to measure accessibility, which recently got more attention: *perceived accessibility* (Lättman et al., 2018; Liu et al., 2022; Pot et al, 2021, Scott et al., 2007; Sotoudehnia & Comber, 2011) Perceived accessibility (PA) can be described as *'the perceived potential to participate in spatially dispersed opportunities'* (Pot et al., 2021, p.2). Pot et al. (2021) state that the perceived or cognitive environment in which people make travel related decisions differ from the real physical environment. It closely relates to planning for accessibility in the way that it looks at how people perceive space instead of how planners think that people perceive it, based on for example calculations and models (Lättman et al., 2018). Additionally, Pot et al. (2021) claim that PA can be viewed as the *'real basis'* (p.1) for decision making and therefore should be considered in policy making. Even though PA can be regarded as fundamental for decision making, the topic has not been researched frequently.

Within the field of planning for accessibility and PA, urban planners intentionally design for improved access to urban green space (UGS). UGS is crucial for human well-being, life satisfaction and sustainable urban development (Bertram & Rehdanz, 2015; Jing et al., 2023; Thwaites et al., 2024). Accessibility to UGS is therefore a frequently studied topic. However, research on PA related to UGS has not been studied often (Sotoudehnia & Comber, 2011). As the municipality of Groningen wants to create an accessible city with more room for UGS (Municipality of Groningen, 2018), it is relevant to investigate what factors affect PA to UGS.

Groningen is of particular interest because of its ambitious '*Vitamine G*' (*Vitamin G*) green plan, which aims to add 30.000 square meters of UGS and 1.000 trees planted each year (Municipality of Groningen, 2020). Especially, it is relevant to examine the PA to UGS of students, as they make up 25% of the city's 238.200 inhabitants (University of Groningen, 2022; Municipality of Groningen, 2023). This makes Groningen the third largest student city in the Netherlands in terms of absolute numbers, following Amsterdam and Rotterdam (Municipality of Groningen, 2022). In relative terms however, it has the highest student density in the country (Groningen.nl, n.d.).

Access to UGS is of particular importance for students (Collins et al., 2022). Students living in densely populated inner-cities, such as Groningen, often lack access to private gardens (OIS Groningen, n.d.; James et al., 2009). Therefore, students are dependent on free, and publicly accessible UGS for recreational activities, such as exercising, social interacting and relaxing. Collins et al. (2022) state that UGSs are also important to meet new friends outdoors in a natural environment or to escape the home environment. Another key finding of their qualitative research is that students who frequently visit UGSs report higher levels of well-being and life satisfaction. This makes frequency of visiting UGSs another interesting factor to investigate in relation to PA.

1.2 Research problem

The aim of this research is to investigate what factors influence PA to UGS among students in different neighbourhoods in Groningen. In order to fill the research gap, come up with policy recommendations based on research and ultimately plan for more accessible UGS, the influence of the perceived built environment, perceived temporal component, personal attitudes and preferences and socio-economic characteristics on PA to UGS will be explored. Therefore, the following research question is developed:

> *''What factors influence the perceived accessibility (PA) to urban green space (UGS) among students in neighbourhoods of Groningen?''*

In order to answer the main question, the following sub-questions are posed:

> *''How and to what extend does the perceived build environment affect perceived accessibility (PA) of students to urban green spaces (UGS)?''*
>
> *''How and to what extend do socio-economic characteristics influence perceived accessibility (PA) of students to urban green spaces (UGS)?''*
>
> *''How and to what extent do personal attitudes and preferences influence perceived accessibility (PA) of students to urban green spaces (UGS)?''*
>
> *''Is there a relationship between perceived accessibility (PA) of students and frequency of visiting urban green spaces (UGS)?''*

2. Theoretical Framework

In this study, UGSs are defined as free and publicly accessible urban environments, which typically include grass, shrubs and trees (Collins et al., 2022). Examples of such spaces include public parks, playgrounds, sport fields, urban forests, urban gardening facilities and vegetation along infrastructure such as trees (WHO, 2016). This section presents a discussion of the concepts relevant to the research, and it explores the relationships between them. Furthermore, a conceptual framework is presented as a visual representation of the core components' relation to PA to UGS (Figure 1).

2.1 Perception of Accessibility Components

Accessibility is a multidimensional concept. Geurs & Van Wee (2004) highlight four components that directly relate to accessibility; *land-use*, *transportation*, *temporal* and *individual component*. In line with previous planning approaches on how to improve accessibility, measuring accessibility adopted a rational approach in which accessibility is seen as a quantifiable reality that can be calculated based on spatial data (Geurs & Van Wee, 2004; Miller, 2018; Pot et al., 2021). However, it is argued by Pot et al. (2021) and Lättman et al. (2018) that in order to investigate PA, one should consider people's perception of the components influencing PA, such as the ones introduced by Geurs & Van Wee (2004). Pot et al. (2021) refer to this as the *'perception of accessibility components'* (p.3).

2.1.1 Perceived Accessibility (PA) and Perceived Built Environment (PBE)

Pot et al. (2021) state that the perceived or '*cognitive environment'* (p.2) in which people make travel related decisions differ from the physical built environment. Perceived accessibility analyses how people perceive space instead of how planners think that people perceive it (Lättman et al., 2018). Bandura's socio-cognitive theory highlighted this importance already in 1986. He states that there is a crucial distinction to make between objectively measured and perceived built environment, which influences people's decisions on for instance mode choice and activity participation (Bandura, 1986). This relates to a study conducted by Boakye et al. (2023), who found that perceiving your neighbourhood as more attractive is associated with higher odds of active modes of transportation. Lättman et al. (2018) highlight the importance of PBE in relation to PA, as it is the perception of the ease to access and use the land-use and transportation system that influences PA. In this study, PBE is therefore divided into two components; Perceived Land-Use System (PLUS) and Perceived Transportation System (PTS).

2.1.1.1 Perceived Accessibility (PA) and Perceived Land-Use System (PLUS)

PLUS considers people's perception on the amount, quality and spatial distribution of different opportunities in a certain area (Geurs & Van Wee, 2004; Pot et al., 2021). Perceptions of the amount, quality and spatial distribution of UGSs can differ among individuals, as they can have unique cognitive environments (Pot et al., 2021). This makes PLUS a crucial factor to consider in PA. Accepted claims in the field of accessibility research are summarised by Geurs & Van Wee (2004). Regarding PLUS, they state that if the number of opportunities for an activity increases, the accessibility to that activity should increase. Research on the accessibility to and the spatial distribution of UGSs highlights the importance of proximity to UGS (Iraegui et al., 2020). They state that nearby, but smaller UGSs tend to be visited more frequently than larger, more distant UGSs. This is relevant to PLUS in relation to UGSs. The way in which people evaluate the distance to and size of UGSs, and make a decision based on this (i.e. whether or not to visit certain UGSs), is influenced by the individual's cognitive environment (Pot et al., 2021).

2.1.1.2 Perceived Accessibility (PA) and Perceived Transportation System (PTS)

PTS can be expressed as people's perception on travel time, costs and effort, referred to as disutility of travel (Geurs & Van Wee, 2004). It differs from PLUS, as PTS refers more to the infrastructural and transportation elements of the PBE (Pot et al., 2021). Iraegui et al. (2020) state that UGSs are used more frequently if they are accessible within walking distance. The European Environmental Agency acknowledges this and recommends that every urban resident should have access to UGS within a 1.600 meter walking radius (EEA, 2022). This however contradicts with the distance people are actually willing to walk, which is 400 meter (Yang & Diez-Roux, 2012). The difference between these findings highlights the importance to conduct research on people's perception on transportation systems, rather than models and calculations, as the willingness to walk certain distances is also influenced by individuals' PBE (Sukor & Fisal, 2018; Weinstein Agrawal et al., 2008). Furthermore, Friman et al. (2020) found that perceived characteristics of the travel environment in terms of organisational functions (e.g. clear and readable information signs) and temporal functions (e.g. information on departure and arrival time of public transport) are related to PA. In addition, Pot et al. (2021) suggests that individuals may also have incomplete awareness of route possibilities and travel time to an activity location, which in turn could affect PA.

2.1.2 Perceived Accessibility (PA) and Perceived Temporal Component (PTC)

Perceived Temporal Component (PTC) relates to the perceived feasibility of participating in spatially distributed activities (Geurs & Van Wee, 2004; Pot et al., 2021). The perception of, for instance, opening and closing times of amenities and individual time restrictions influences PA (Pot et al., 2021).

2.2 Individual Components

Individual components are divided into two groups; socio-economic characteristics and personal attitudes and preferences. The individual components can also influence the individual's perception on accessibility components through factors such as gender, age, personal attitudes and physical ability (Ma & Dill, 2015). This means that different people can form different perception of the same built environment.

2.2.1 Perceived Accessibility (PA) and Socio-Economic Characteristics

Socio-economic characteristics relate to different individual and demographic characteristics of people and their related needs, abilities and opportunities. This component consists of factors as age, income, education, employment and gender. Vitman-Schorr et al. (2017) state that these factors influence PA and even causes mismatches between objectively measured accessibility and PA. Wang et al. (2021) indicate socio-economic characteristics as travel disadvantages, which are factors that prevent people from reaching their travel demands. Socio-economic disadvantages are likely associated with inaccessibility (Wang et al., 2021). Examples are low-income, younger and older age, gender and immigrants. These results are in line with a study conducted by Lättman et al. (2016b) on PA to public transport. They found that people aged around 34 and elderly aged around 68 reported significantly lower levels of perceived accessibility than people in their twenties and fifties.

Gender is frequently considered as a factor that influences accessibility (Kwan & Kotsev, 2014; Lättman et al., 2016b; Olsson et al., 2021; Vitman-Schorr et al., 2017). Kwan & Kotsev (2014) found that women have lower accessibility compared to man who used the same mode of transportation. This is because women tend to have a more restrictive spatial reach to urban opportunities as compared to men. This study, used objective measures of accessibility, whereas gender can also affect PA. Contrastingly, Olsson et al. (2021) found that women indicate higher levels of PA in major city areas. However, in their study no other effects were observed outside of major city areas. Lättman et al. (2018) found similar outcomes, stating that women perceive their accessibility higher than men. No direct explanation for this outcome was provided, but Lättman et al. (2018) suggest it could possibly related to modal choice. In their sample, men use the car as main mode of transportation, whereas women use public transport more. Other studies did not find differences between gender in terms of PA (Lättman et al., 2016b; Vitman-Schorr et al., 2017).

2.2.2 Perceived Accessibility (PA) and Personal Attitudes and Preferences

Personal attitudes and preferences also influence PA (Biernacka & Kronenberg, 2019; Pot et al., 2021; Van Wee, 2022). Biernacka & Kronenberg (2019) found through extensive surveys that people prefer different kinds of UGSs (e.g. more nature versus more entertainment), which in turn affects their perception on how accessible UGSs are. In their study on perceived and geographic access to UGS in New York, Mustafa et al. (2023) found that of the various types of UGSs, the designed park is the most accessible to the majority of people. Van Wee (2022) also highlights personal attitudes and preferences as important indicators for PA. This, because people have preferred activities and modes of transport, regardless of their socio-economic characteristics (Kitamura, 1997). Also, Scheepers et al. (2016) discovered a strong association between PA and active modes of transportation.

2.3 Conceptual Model

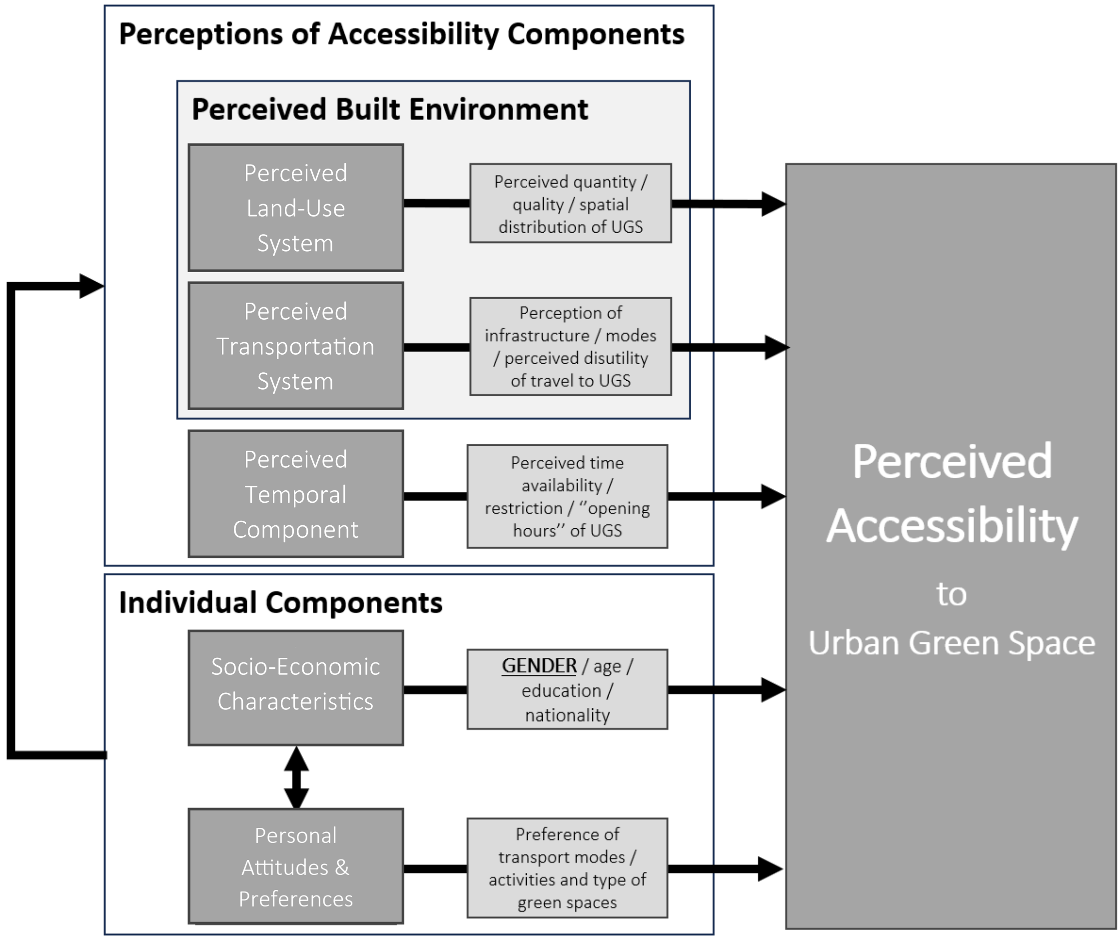

Figure 1: Conceptual framework indicating the relationships between Perceptions of Accessibility Components (PLUS, PTS, PTC), Individual components (Socio-economic Characteristics, Personal Attitudes & Preferences) and Perceived Accessibility (PA) to Urban Green Space (UGS)

2.4 Hypotheses

The following hypotheses are defined based on literature as discussed in the *Theoretical Framework.*

- A **positive** perception of the built environment (PBE), such as availability of amenities and the visual evaluation of one's neighbourhood, has a significant **positive** effect on the perceived accessibility (PA) to urban green spaces (UGS).
- The perceived temporal component (PTC) is **significantly associated** with the perceived accessibility (PA) to urban green spaces (UGS).
- There is a **significant difference** in perceived accessibility (PA) to urban green space (UGS) between male and female students.
- Positive personal attitudes and preferences to active modes of transportation have a **significant positive effect** on the perceived accessibility (PA) to urban green spaces (UGS).

3. Methodology

The study is based on primary and secondary quantitative data. Surveys are conducted to collect primary data in order to perform a statistical analysis between the perception of accessibility components, individual components and PA to UGS. To compare neighbourhoods that differ in the amount of UGS within their administrative boundary and in close proximity, secondary data is used to perform a spatial analysis. The neighbourhoods were selected through the application of objective accessibility (OA) calculations and data on student residence. The decision to employ quantitative research methodologies was made deliberately to gather a large sample size and come to statistically valid results within the limited timeframe of this research.

3.1 Primary Data Collection

Quantitative surveys were distributed among students living in the municipality of Groningen to collect primary data (Appendix A). The survey consists of a structured questionnaire compromising 27 questions, which are divided into four sections: individual components, PBE, PTC and PA to UGS. To get information on perception, most questions required the respondent to indicate how much they agreed or disagreed with statements using a 7-point Likert scale.

The first section focuses on socio-economic characteristics, requiring general information about the respondent, before addressing personal attitudes and preferences with regard to different types of UGSs and transport modes. The three types of UGSs are pre-selected based previous research (Biernacka & Kronenberg, 2019; Mustafa et al., 2023; Nor & Abdullah, 2019; Van den Berg et al., 2014).

The second section focusses firstly on PLUS components. It examines how respondents perceive the availability of shops, stores and markets and how they perceive the visual environment of their neighbourhood. Furthermore, respondents' perception is gathered on the quantity and quality of UGSs in and around their neighbourhood. In addition, this section also incorporates PTS components, which aim to measure perception of general transportation facilities in their neighbourhood and the disutility in terms of perceived time, effort and costs to travel to UGSs. This section also collects information about the actual mode used to travel to UGSs and the average frequency of visits to UGSs.

The third section measures the perceived temporal component by investigating respondents' personal time availability in daily life for UGS and their evaluation on the time availability of UGSs.

The fourth part examines PA to UGS, based on adjusted *perceived accessibility scale* statements (Lättman et al., 2016a). Originally, this measure uses four statements to assess PA. However, in order to align with the research aim, these statements have been adjusted to three. Respondents are asked to indicate their (dis)agreement with these statements on a 10-point Likert scale. This allows to perform a more advanced analysis, as the scale provides more accuracy and granularity. The statements respectively relate to the general PA to UGS, the possibility to reach their preferred UGS and the satisfaction received regarding the accessibility to their preferred UGS. In order to perform inferential statistics with one dependent variable of PA to UGS, the three components have been combined into one value by taking their mean.

3.2 Secondary Data Collection

The secondary data consists of datasets with spatial and demographic information on neighbourhoods and their characteristics in Groningen. Data on the number of students per neighbourhood is derived from *Gronometer* (2023). Gronometer is the interactive spatial information system of the municipality of Groningen (OIS Groningen, n.d.). The information on the students' place of residence is based on data from Hanzehogeschool, University of Groningen and Statistics Netherlands (CBS). It concerns the address at which students are registered at these institutions (Gronometer, 2023). The data on green space is derived from the national BGT (BZK, 2017).

3.2.1 Neighbourhood Selection: Objective Accessibility

Polygon data on green spaces for the municipality of Groningen, in combination with data on student residence is used in to rank eight neighbourhoods. These eight neighbourhoods have at least 1.000 residents with a minimum of 30 percent of the population compromising students. This threshold has been selected to ensure that the neighbourhoods under analysis represent a substantial portion of the urban student population in Groningen. This selection resulted in the following eight neighbourhoods: *Binnenstad-Noord* (1)*, Binnenstad-West* (2)*, Zeeheldenbuurt* (3)*, Binnenstad-Oost* (4)*, Professorenbuurt* (5)*, Schildersbuurt* (6)*, Hortusbuurt-Ebbingekwartier* (7)*,* and *Binnenstad-Zuid* (8) (Figure 2). The aim of this spatial analysis is to rank the eight neighbourhoods based on objective accessibility (OA) to UGS and compare this with a ranking based on PA to UGS levels.

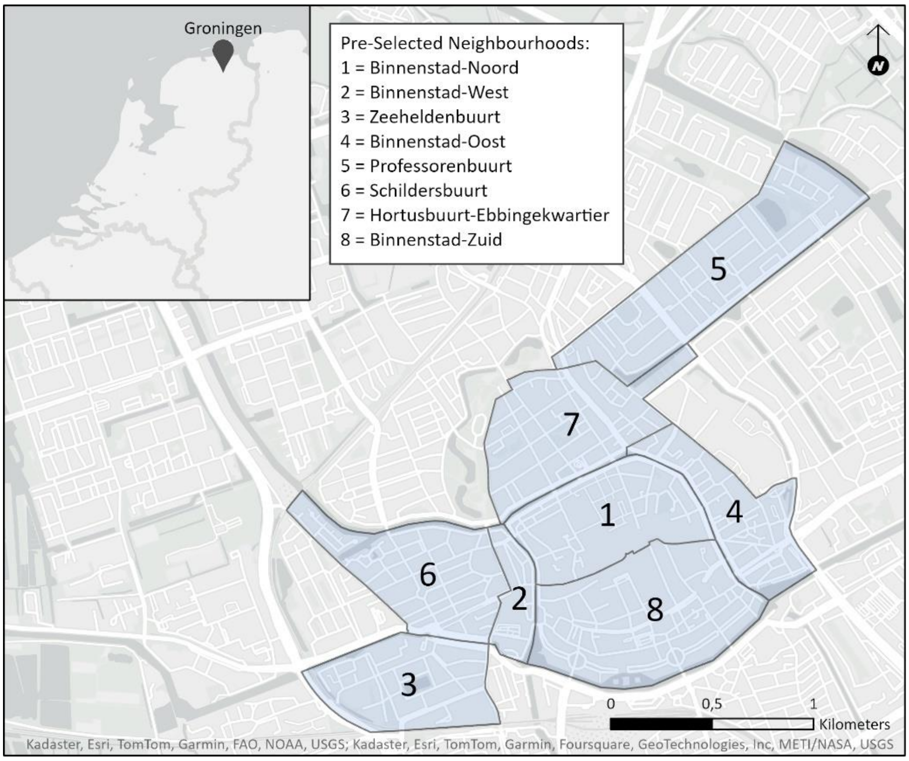

Figure 2: Eight pre-selected neighbourhoods

A commonly used measure to calculate OA is the *cumulative opportunities measure* that considers the number of opportunities (i.e. UGS) one can reach within a given travel time or distance (Handy & Niemeier, 1997). Geurs & Van Wee (2004) refers to this type of measurement as *contour measure*. It is part of the *distance measure group* and is often regarded as one of the simplest, but also one of the most popular classes of location-based accessibility measures in urban planning (Handy & Niemeier, 1997; Geurs & Van Wee, 2004; Kim & Lee, 2019). It partly satisfies the transport, land-use and temporal component, but disregards individual components, such as socio-economic characteristics or personal attitudes and preferences (Geurs & Van Wee, 2004). It therefore can be called an objective measure of accessibility. *Table 1* presents a ranking of the eight neighbourhoods based on the total surface area of UGS within their respective administrative boundaries.

Tabel 1: Neighbourhood ranking based on the surface area of UGSs in absolute numbers (Rank number 8 indicating the highest amount of OA and 1 indicating the lowest amount of OA)

Rank	*Neighbourhood (Number corresponding with Figure 2)*	*km2 UGS*
8	Professorenbuurt (5)	0,057
7	Hortusbuurt-Ebbingekwartier (7)	0,034
6	Zeeheldenbuurt (3)	0,033
5	Binnenstad-Zuid (8)	0,026
4	Schildersbuurt (6)	0,017
3	Binnenstad-Noord (1)	0,011
2	Binnenstad-Oost (4)	0,010
1	Binnenstad-West (2)	0,002

Schindler et al. (2022) found that people are willing to travel for UGSs. It is therefore necessary to also consider UGSs outside of the administrative boundaries of neighbourhoods. The WHO (2016) considers 300 meter a reasonable distance, as this corresponds with approximately 5 minutes walking. For the analysis this means that all green spaces within a buffer of 300 meter should be considered. In addition to walking, students in Groningen commonly use bicycles to travel from one place to another (IOS Groningen, 2022). To conduct a comprehensive spatial analysis, it is necessary to include a buffer of 5 minutes of cycling. With an average cycling speed of 16km/h (the base speed that Google assumes in *Google Maps*), this translates to a buffer of approximately 1.333 meter.

The spatial analysis is conducted in ArcGIS Pro (version 3.0.0). The *Buffer* tool was used to generate buffers around each of the eight pre-selected neighbourhoods' boundaries (Figure 2). Two separate analyses were performed: a buffer for walking distance (*Distance:* 300 meter) and a buffer for cycling distance (*Distance:* 1.333 meter). For both analyses, the *Summarize Within* tool was utilised to calculate the total surface area of UGSs by aggregating the surface area of individual UGS polygons within the boundaries of the buffers, using the *'sum'* option (Appendix C).

However, to provide a more accurate representation of the relative values of UGSs, the summed values have been relativised by dividing them by the area of the administrative neighbourhoods. It can be concluded that, in both analyses, Binnenstad-West has the highest amount of UGS surface area, while Binnenstad-Zuid has the lowest amount of UGS surface area, relative to neighbourhood size. It is important to note that Binnenstad-West is the smallest neighbourhood analysed, whereas Binnenstad-Zuid is the largest (Appendix C).

Nevertheless, the summed values of UGSs can also be relativised by dividing them by the surface area of the buffer. This additional analysis resulted into different outcomes. Not only from a research perspective is it prudent to consider various methodologies for calculating OA, relativising UGS area by buffer size may also be more relevant than neighbourhood size. This, because the buffers effectively balance out '*extreme*' neighbourhood sizes, be they large (e.g. Binnenstad-Zuid) or small (e.g. Binnenstad-West) (Appendix C).

Given the lack of clarity regarding the optimal approach for determining the OA to UGS, a decision was made to employ both methods in the determination of the mean rank of the different neighbourhoods (Table 2). This table illustrates that, across all four aforementioned categories based on two relativisation strategies and two different buffer sizes, Zeeheldenbuurt exhibits the highest OA to UGS, while Binnenstad-Zuid and Binnenstad-Noord exhibit the lowest OA to UGS (Figure 3).

Tabel 2: Neighbourhood ranking based on the mean rank of the four methods of calculating OA to UGS (Rank number 8 indicating the highest amount of OA and 1 indicating the lowest amount of OA)

Rank	*Neighbourhood (Number corresponding with Figure 2)*	*Mean Rank*
8	Zeeheldenbuurt (3)	7,75
7	Professorenbuurt (5)	6,75
6	Binnenstad-West (2)	5,75
5	Schildersbuurt (6)	5,50
4	Binnenstad-Oost (4)	4,25
3	Hortusbuurt-Ebbingekwartier (7)	3,00
2	Binnenstad-Noord (1)	2,00
1	Binnenstad-Zuid (8)	2,00

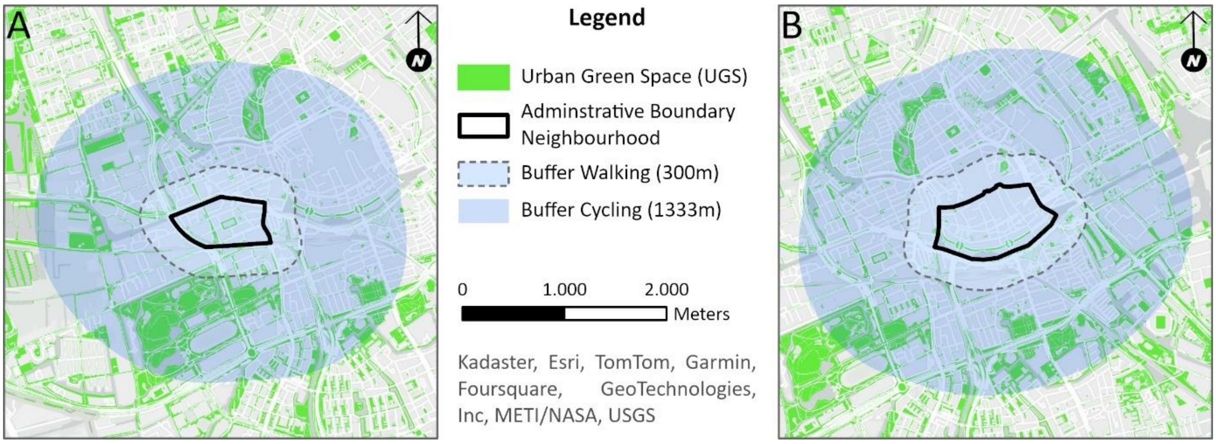

Figure 3: Zeeheldenbuurt is the highest ranked neighbourhood based on OA to UGS (A). Binnenstad-Zuid is the lowest ranked neighbourhood (B), together with Binnenstad-Noord

3.3 Sampling Procedure

The collection of responses through online survey tool *Qualtrics* started on the 18th of April and was stopped on the 2nd of May. Over a two-week period, 178 responses were recorded, of which 125 were finished and valid. A total of 53 unfinished surveys were excluded from the data set. Respondents are obtained using non-probability sampling techniques, as they must meet certain conditions (i.e. being a student and living in the municipality of Groningen). To ensure a sufficient number of respondents per neighbourhood, within the limited research time and scale, convenience, self-selection (i.e. voluntarily based), and snowball sampling is utilized. The survey is digitalised and spread online via social media and physically via QR-codes. In order to conduct a comparison between neighbourhoods, a minimum of 30 respondents is required for parametric statistical analysis. To reach this point, the QR-codes have been distributed to households and residents were asked in person to take part in the study. Respondents were asked to forward the online survey. The invitational flyer to take part in this survey can be found in *Appendix B*.

3.4 Data Analysis Scheme

The data is subjected to a descriptive analysis, after which an inferential statistical analysis of the survey results is conducted in SPSS (version 28) (Figure 4). To determine whether and to what extent the different components influence PA to UGS, a Spearman's Rho correlation test was chosen to investigate potential relationships between variables. To compare the mean PA to UGS for nominal variables, a Kruskal-Wallis test or Independent Samples T-test was first carried out to investigate if there are significant differences per groups within the variable. In order to indicate significance, a confidence interval of 95% is used in all statistical tests ($p < 0,05$). To talk about the strength and direction of the correlations, the correlation coefficients are interpreted in the following way: <0,3: *weak*, 0,3-0,5: *moderate*, 0,5-0,7: *strong*, 0,7-0,9: *very strong*, >0,9: *extremely strong*.

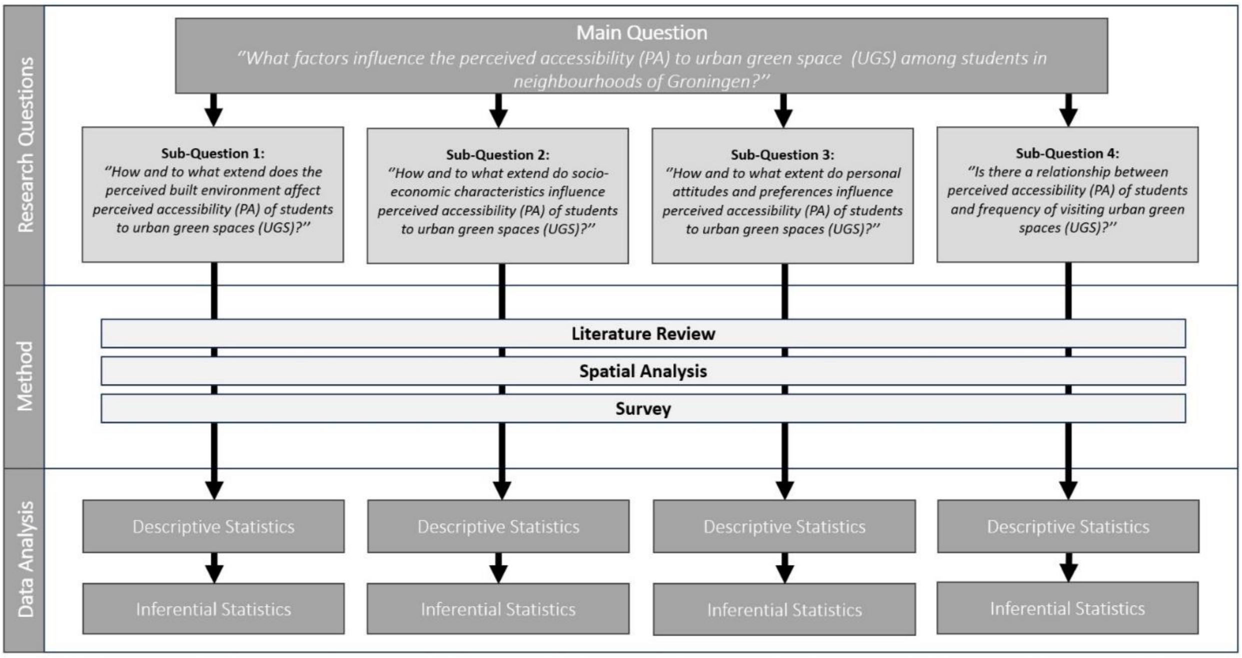

Figure 4: Data Analysis Scheme

3.5 Ethical Considerations

The surveys are conducted online. This has multiple benefits, such as a wider reach to the sample, time effectiveness, user-friendly and the protection of the respondents' privacy. Especially with closed questions, a large sample can be gathered in shorter times. To further enhance the respondents' privacy, the surveys were conducted anonymously and no private information was gathered. The survey was shared digitally online and via QR-codes and may be forwarded. Before answering any questions, the respondents were informed about the research they participate in and were asked to give their consent. Should questions arise or if any aspect of the survey is unclear, the researcher could be contacted via the email address provided on the flyer and in the survey itself.

4. Results and Discussion

4.1 Descriptive Results

The results are described in the order of the survey. The descriptive results for the Likert scale variables are summarised in *Table 3*.

4.1.1 Neighbourhood Selection and Socio-Economic Characteristics

Figure 5 shows the distribution of respondents per neighbourhood. The majority of the respondents live in Binnenstad-Zuid (n= 11). 10 respondents come from Hortusbuurt-Ebbingekwartier, 8 from Binnenstad-West, 8 from Binnenstad-Oost. Additionally, 7 respondents indicated to live in Indische buurt. 7 respondents selected *'Other'.*

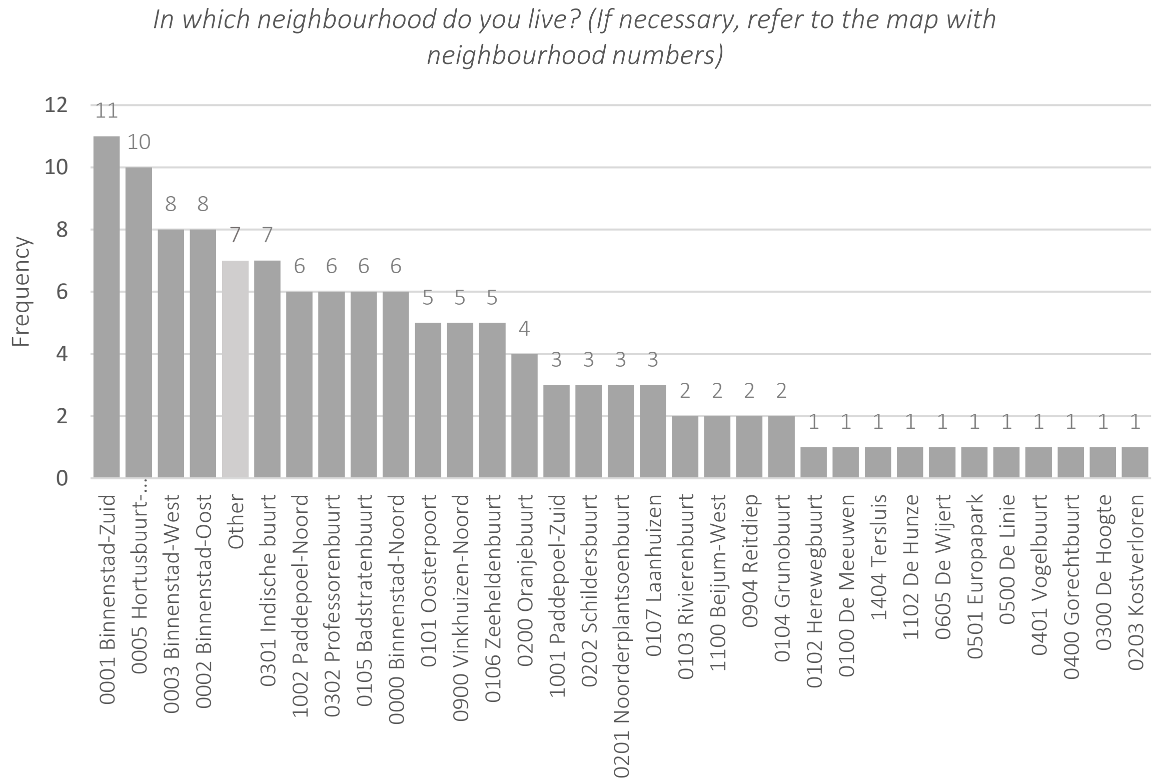

Figure 5: Number of respondents per neighbourhood (neighbourhoods without any response are excluded)

Of the 125 cases, 56,8% of the respondents is male (n= 71), 39,2% is female (n= 49) and 4% selected '*Other'* (n= 5). The distribution of age across the targeted categories is not uniform: 85,6% with an age of 18-23 (n= 107), 13,6% with an age of 24-28 (n= 17), no recorded responses of 29-33, and 0,8% with an age of 34-38 (n= 1). A comparable distribution can be observed with regard to education: 88,8% follows academic education (n= 111), 9,6% follows higher vocational education (n= 12), 0,8% follows secondary vocational education (n= 1) and 0,8% indicated '*Other'* (n= 1). The distribution of nationality is more balanced, with 61,6% indicating that they are Dutch (n= 77), and 38,4% non-Dutch (n= 48).

4.1.2 Personal Attitudes and Preferences: Type of UGS & Mode of Transportation

The respondents were most positive about UGSs as designed parks (*mean:* 5,46; *mode:* 6). Moreover, respondents were slightly less positive about UGSs with exclusively nature (*mean:* 5,14; *mode:* 5). Respondents were least positive, and essentially neutral, about UGS offering entertainment and amenities (*mean:* 4,30; *mode:* 5).

The respondents had a strongly positive attitude towards active modes of transportation (Walking: *mean:* 6,40; *mode:* 7, Cycling: *mean:* 6,22; *mode:* 7). The results regarding public transport were negative, but relatively balanced in comparison to the other motorised modes of transportation (*mean:* 3,26; *mode:* 2). The questions regarding scooters and cars received strongly negative attitudes (Scooter: *mean:* 2,33; *mode:* 1, Car: *mean:* 1,80; *mode:* 1).

4.1.3 Perceived Built Environment (PBE): PLUS & PTS

The respondents generally had positive perceptions of the availability of shops, stores and markets (*mean:* 6,31; *mode:* 7) and were also moderately positive about the visual environment of their neighbourhood (*mean:* 5,06; *mode:* 5). The results with regard to quality and quantity of UGSs in and around the respondents' neighbourhood are balanced. Responses on quantity exhibit a slightly higher mean value (Quantity: *mean:* 4,89; *mode:* 6, Quality: *mean:* 4,74, *mode:* 6).

Additionally, the respondents mostly exhibited a positive perceptions regarding PTS (Sidewalks: *mean:* 6,28; *mode:* 7, Cycling facilities: *mean:* 5,77; *mode:* 6, Transit stop: *mean:* 6,09, *mode:* 7). Furthermore, responses regarding satisfaction with the time and effort spent travelling to UGSs are positive (*mean:* 5,71; *mode:* 6 & 7). In line with this, respondents largely disagreed with travelling to UGSs being costly (*mean:* 2,03; *mode:* 1).

4.1.4 Actual Mode of Transportation & Frequency of Visiting UGSs

The results demonstrated that the vast majority, 60,0% (n= 75), utilises bicycles as their actual mode of transportation. Additionally, over one-third, 37,6% (n= 47), chooses to walk, while only 0,8% (n= 1) uses the car. A similar trend was observed in the utilisation of public transportation, with 0,8% (n= 1) of the respondents. Notably, no respondents indicated the use of scooters for transportation to UGSs (Figure 6).

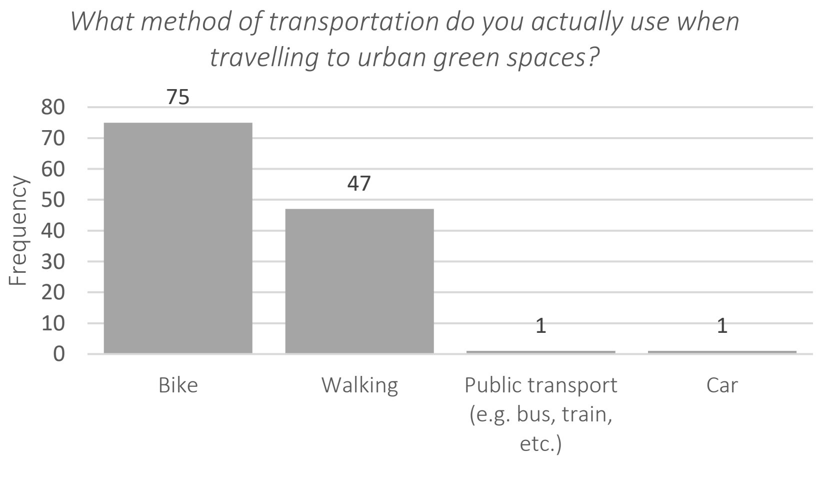

Figure 6: Modal split of respondents regarding their travel to UGSs

The results of the frequency of visits to UGSs indicate that the majority of respondents, 27,2% (n= 34) visits UGSs on average once per week. 24,0% (n= 30) indicates to visit UGSs 2 or 3 times per week. A slightly smaller proportion, 23,3% (n= 29), says to visit UGSs only a couple times per month. 14,4% (n= 18) indicates to visit UGSs almost every day. In contrast, 6,4% (n= 8) of the respondents indicated that they visit UGSs only once a month, while 4% (n= 5) visits UGSs less than once a month.

4.1.5 Perceived Temporal Component (PTC): Personal and UGS Time Availability

The outcome for the first statement indicated generally positive responses, indicating that people tend to find their personal time availability sufficient in order to visit UGSs (*mean:* 4,59; *mode:* 5). The respondents were even more positive regarding UGSs time availability (*mean:* 5,85; *mode:* 6).

4.1.6 Perceived Accessibility (PA) to Urban Green Space (UGS)

Of the three statements, general PA to UGS was identified most positively (*mean:* 8,26; *mode:* 10). This was followed by the statement regarding PA to preferred UGS (*mean:* 7,90; *mode:* 10). Although still positive, the respondents indicated the least satisfaction with the accessibility to their preferred UGS (*mean:* 7,52; *mode:* 8). The mean rating for PA to UGS in the sample is 7,89.

Tabel 3: Summarising descriptive statistics Likert scale variables

Variables		*Descriptive Outcome*		
*Personal Attitudes and Preferences (7-point Likert Scale)**	*N*	*Mean*	*Mode*	*St. Dev.*
UGS – Exclusively nature	125	5,14	5	1,41
UGS – Designed parks	125	5,46	6	1,24
UGS – Entertainment and Amenities	125	4,30	5	1,66
Mode of transport – Car	125	1,80	1	1,21
Mode of transport – Public transport	125	3,26	2	1,69
Mode of transport – Scooter	125	2,33	1	1,55
Mode of transport – Bike	125	6,22	7	0,96
Mode of transport – Walking	125	6,40	7	1,01
*PLUS (7-point Likert Scale)**				
Availability of amenities	125	6,31	7	1,04
Visual evaluation neighbourhood	125	5,06	5	1,42
Quantity of UGS	125	4,89	6	1,59
Quality of UGS	125	4,74	6	1,60
*PTS (7-point Likert Scale)**				
Sidewalks	124	6,28	7	0,96
Cycling facilities	124	5,77	6	1,33
Ease of reaching transit stop	124	6,09	7	1,20
Satisfaction time and effort travelling to UGS	124	5,71	6 & 7	1,37
Travelling to UGS is costly	124	2,03	1	1,41
*PTC (7-point Likert Scale)**				
Personal time availability	124	4,59	5	1,50
UGS time availability	124	5,85	6	1,17
PA to UGS *(10-point Likert Scale)***				
Ease of reaching UGS (*General)*	123	8,26	10	1,76
Possibility reaching preferred UGS	121	7,90	10	1,99
Satisfaction PA to preferred UGS	121	7,52	8	1,91

*1= Strongly disagree, 2= Disagree, 3= Somewhat disagree, 4= Neither disagree nor agree, 5= Somewhat agree, 6= Agree, 7= Strongly agree

**1 = Strongly disagree, 10 = Strongly agree

4.2 Inferential Results & Discussion

This section initially follows the order of the secondary questions posed in section *1.2 Research Problem*. The SPSS outcome tables can be found in *Appendix D*.

4.2.1 Perceived Built Environment (PBE) and PA to UGS

4.2.1.1 PLUS and PA to UGS

All four statements regarding PLUS are significantly correlated, indicating a relationship between PLUS and PA to UGS. (Table 4). The correlation coefficient indicates that all variables exhibit a positive relationship with PA to UGS, although to varying degrees. The general statements about neighbourhood characteristics are weakly positively correlated with PA to UGS. This means that respondents who indicate high agreement with statements regarding the availability of amenities and who are positive about the visual characteristics of their neighbourhoods tend to indicate higher values of PA to UGS. The statement evaluating the perception of quantity of UGS is moderately correlated with PA to UGS, while the statement evaluating the perception of the quality of UGS is strongly correlated with PA to UGS. Geurs & Van Wee (2004) study support these results, by stating that if the number of opportunities for an activity increases (i.e. quantity of UGSs), accessibility should increase as well. This is also related to the research conducted by Iraegui et al. (2020). They observed that UGSs that are readily available in close proximity are used more frequently and can therefore be perceived as more accessible. Their outcome is closely linked to the results on frequency of visiting, which will be discussed in more detail later.

4.2.1.2 PTS and PA UGS

All statements, except the statement on the availability of sidewalks, show statistically significant results, indicating that there is a relationship between them and PA to UGS (Tabel 4). Cycling facilities and the ease to reach a transit stop have a weak positive relationship to PA to UGS, whereas satisfaction with the time and effort spent travelling to UGS is strongly positively correlated to PA to UGS. In line with this, travelling to UGSs being costly is moderately negatively correlated. These findings are in line with the statement made by Geurs & Van Wee (2004), that there is a negative correlation between travel time, costs and effort and accessibility. Therefore, the respondent's agreement with the statements on infrastructural neighbourhood characteristics, could be indicative of their satisfaction to reach UGS.

Tabel 4: Summarising statistics PBE and PA to UGS

Variables	*Inferential Outcome*		
PLUS	*Spearman's Rho*	*Strength*	*p-value*
Availability of amenities & PA to UGS	+0,236	Weak	0,009
Visual evaluation neighbourhood & PA to UGS	+0,246	Weak	0,006
Quantity of UGS & PA to UGS	+0,432	Moderate	<0,001
Quality of UGS & PA to UGS	+0,512	Strong	<0,001
PTS			
Sidewalks & PA to UGS	+0,134	N/A	0,139
Cycling facilities & PA to UGS	+0,193	Weak	0,032
Ease of reaching transit stop & PA to UGS	+0,289	Weak	0,001
Satisfaction time and effort travelling to UGS & PA to UGS	+0,596	Strong	<0,001
Travelling to UGS is costly	-0,312	Moderate	<0,001

4.2.2 Socio-Economic Characteristics and PA to UGS

The results of the T-test indicated a statistically significant difference between males (*mean:* 7,59) and females (*mean:* 8,46) in terms of PA to UGS (Tabel 5). Female respondents tend to indicate higher levels of PA to UGS. In 95% of the cases between 0,27 and 1,47 point higher than men. This outcome is consistent with the findings of Olsson et al. (2021) and Lättman et al. (2018), who observed that females indicate higher PA in comparison to males. However, the argument put forth by Lättman et al. (2018) that this could possibly be attributed to female respondents' tendency to utilise more active modes of transportation does not apply in this context, as female and male students rarely indicated the use of cars or public transport. This difference can also not be explained through the frequency of visits to UGS, as there appeared no clear pattern between gender and frequency of visiting. To rule out the possibility of a statistical association, an unsuccessful attempt was made to perform a Chi-square test, due to the failure to meet the test requirements.

Even though the Dutch respondents have a mean PA to UGS of 7,69 and non-Dutch respondents of 8,22, the test turned out to be insignificant (Tabel 5). Consequently, there is no statistical evidence to assume that there is a difference between Dutch and non-Dutch respondents with regard to PA to UGS.

The conditions for using a parametric test are not met for both age and education. Categories with only one response are considered outliers. Only descriptive statements can be made about the results with regard to PA to UGS. Comparing the mean of PA to UGS, age group 18-23 (*mean:* 7,93) with 24-29 (*mean:* 7,84), the younger age indicates slightly higher levels of PA to UGS, yet the observed differences are minimal. The similar trend can be recognised considering education. There is only a small difference between respondents who follow academic education (*mean:* 7,96) and higher vocational education (*mean:* 7,39).

Tabel 5: Summarising statistics Socio-Economic Characteristics and PA to UGS

Variables	*Inferential Outcome Test*		*p-value*
Gender & PA to UGS	Independent Samples T		0,005
Nationality & PA to UGS	Independent Samples T		0,136
Age & PA to UGS	N/A		N/A
Education & PA to UGS	N/A		N/A
	Inferential Outcome		
	Spearman's Rho	*Strength*	*p-value*
Gender & PA to UGS	-0,288*	Weak	0,002

*Gender tested as dummy variable; female= 0, male= 1

4.2.3 Personal Attitudes and Preferences and PA to UGS

Only one respondent reported using the car to travel to UGSs and only one reported using public transport. These responses have been excluded from the data, because they are considered outliers. The results of the T-test indicated a statistically significant difference between respondents who cycle and those who walk in terms of PA to UGS (Tabel 6). Cyclists tend to indicate lower levels of PA to UGS. In 95% of the cases between 1,51 and 0,27 point lower than respondents who walk. One potential explanation could be related to distance travelled. Respondents who walk may use this mode of transportation when UGSs are in closer proximity to their residence compared to those who cycle, who generally have to travel greater distances and therefore perceive larger travel disutility. Despite investigating the effect on PA by mode of transportation, Scheepers et al. (2016) did not investigate the difference between walking and cycling. No other literature has been found that adequately explained this specific difference.

Of the three statements regarding different types of UGS, only the preference for designed parks as UGS is (weakly positively) correlated with PA to UGS. This finding says that respondents who are more positive about designed parks tend to indicate higher levels of PA to UGS (Tabel 4). One potential explanation for this, is that for many respondents designed parks are also the type of UGS that is most accessible within the city (i.e. in contrast with purely natural UGS, which are often found at greater distances from the city centre (Bijker & Sijtsma, 2017)). This is in line with the findings of Mustafa et al. (2023), who indicate that the designed park is the type of UGS that is perceived as the most accessible within cities.

No correlations were found between preference for public transport, and scooter and PA to UGS. However, a weak negative correlation was found between preferences for car, while weak positive correlations were found between preference for walking and cycling and PA to UGS (Tabel 6). Summarising, respondents who prefer driving exhibit lower levels of PA to UGS compared to those who prefer walking and cycling, who indicate higher levels of PA to UGS. This finding directly relates to Scheepers et al. (2016), who found a strong association between PA and active modes of transportation.

Tabel 6: Summarising statistics PBE and PA to UGS

Variables *Actual mode of transport*	*Inferential Outcome*		
	Test		*p-value*
Cycling and Walking & PA to UGS	Independent Samples T		0,005
	Inferential Outcome		
Preferences - *UGS*	*Spearman's Rho*	*Strength*	*p-value*
Exclusively nature & PA to UGS	+0,082	N/A	0,370
Designed park & PA to UGS	+0,185	Weak	0,040
Entertainment and amenities & PA to UGS	+0,085	N/A	0,351
Preferences - Method of Transportation			
Car & PA to UGS	-0,188	Weak	0,037
Public transport & PA to UGS	+0,065	N/A	0,472
Scooter & PA to UGS	-0,058	N/A	0,521
Bike & PA to UGS	+0,239	Weak	0,008
Walking & PA to UGS	+0,206	Weak	0,022

4.2.4 Frequency of Visiting and PA to UGS

While analysing the mean PA to UGS for the different frequency of visit categories, it can be observed that individuals who visit UGS less frequently on average exhibit lower levels of PA to UGS, whereas those who do visit UGS on a regular basis demonstrate higher levels of PA towards UGS (Table 7). Due to a lack of respondents in several groups regarding the frequency of visits, the non-parametric Kruskal-Wallis test was performed. The test turned out to be statistically significant. This suggests that there are statistically significant differences between respondents' PA to UGS values who visit UGS at different frequencies. The correlation test turned out to be significant as well. The correlation coefficient indicates a moderately positive relationship between frequency of visiting and the level of PA to UGS (Tabel 8). This means that respondents who visit UGSs frequently indicate higher PA to UGS, whereas those who visit UGS less frequently indicate lower levels of PA to UGS.

Tabel 7: Frequency of visiting UGS and Mean PA to UGS

Frequency of visiting UGS	*N*	*Mean PA to UGS*
Less than once a month	5	6,20
Once a month	8	7,71
A couple of times per month	29	7,57
Once per week	34	7,28
2-3 times per week	29	8,69
Almost every day	18	8,85

It is reasonable to assume, in accordance with the findings of Iraegui et al. (2020), that this correlation is somehow related to the abundance of UGS in or in close proximity to the neighbourhoods of the respondents. The results of a Kendall's Tau-B non-parametric correlation test also supports this assumption by a significant correlation between the frequency of visits and satisfaction with the quantity of UGSs in and around respondents' neighbourhoods (Tabel 8). This could mean that people who are satisfied with the quantity of UGSs are more likely to visit these more frequently, which in turn leads to a higher valuation of PA to UGS.

Tabel 8: Summarising statistics Frequency of visiting UGS and PA to UGS (and Satisfaction with Quantity UGS)

Variables	*Inferential Outcome*		
	Test		*p-value*
Frequency of visiting UGS & PA to UGS	Kruskal-Wallis		<0,001
	Inferential Outcome		
	Spearman's Rho	*Strength*	*p-value*
Frequency of visiting UGS & PA to UGS	0,407	Moderate	<0,001
	Inferential Outcome		
	Kendall's Tau-B	*Strength*	*p-value*
Frequency of visiting UGS & Satisfaction with Quantity UGS	+0,224	Weak	0,002

4.2.5 Perceived Temporal Component (PTC) and PA to UGS

Both statements related to PTC show significant results in the correlation test. Personal time availability is weakly positively correlated with PA to UGS and UGS time availability is moderately correlated with PA to UGS (Tabel 10). Thus, respondents who agree to have enough time to visit UGSs also indicate higher levels of PA to UGS. This is also true for respondents who indicate that UGS are available at any time of the day. This correlation is also explained by Pot et al. (2021). In essence, they state that when individuals perceive their personal time allocation and the time availability of a destination more positively, they tend to be less restricted by time and therefore tend to indicate higher PA to UGS levels.

Tabel 10: Summarising statistics Perceived Temporal Component and UGS and PA to UGS

Variables	*Inferential Outcome*		
	Spearman's Rho	*Strength*	*p-value*
Personal time availability & PA to UGS	+0,280	Weak	0,002
UGS time availability & PA to UGS	+0,432	Moderate	<0,001

4.2.6 PA versus OA

Although the number of respondents per neighbourhood is insufficient for parametric statistics, it is still possible to use non-parametric alternatives. A Kruskal-Wallis test was performed and turned out to be significant, indicating that there are significantly different PA to UGS values between the neighbourhoods. *Figure 6* displays the different mean PA to UGS values per neighbourhood. This allows another ranking to be made. Binnenstad-Zuid clearly has the lowest PA to UGS, whereas Hortusbuurt-Ebbingekwartier has the highest PA to UGS. Notably, these are also the neighbourhoods with the most respondents. The PA to UGS ranking is presented alongside the ranking of OA to UGS in *Table 11*. It would appear that the majority of positions have been reassigned in a random manner. Only Binnenstad-Zuid remains at the lowest rank, being the least accessible in terms of PA and OA. The first place ranking of Hortusbuurt-Ebbingekwartier of PA to UGS could possibly be attributed to its proximity to the *Noorderplantsoen,* which is widely regarded as one of Groningen's UGS with the highest quality (Tiesinga, 2017). A similar argument can be made with regard to Binnenstad-Zuid, being distant from large, high quality UGSs (i.e. Noorderplantsoen and *Stadspark,* which is located in the southwest of the city).

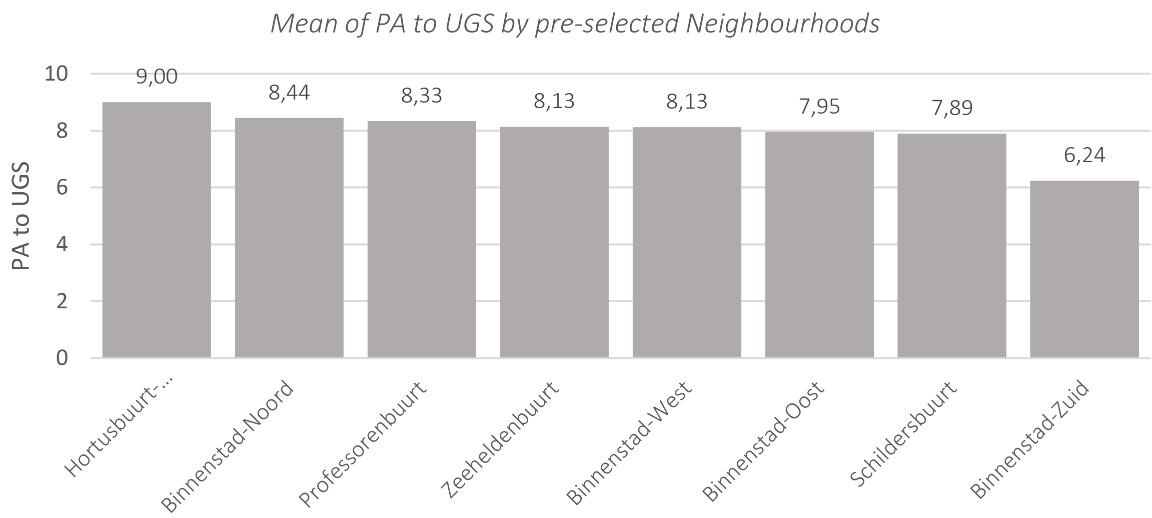

Figure 6: Mean PA to UGS per pre-selected Neighbourhoods as explained in section 3.2.1

Tabel 11: Comparison of the ranking of neighbourhoods based on PA to UGS and OA to UGS

Rank PA	*Neighbourhood*	*Rank OA*	*Neighbourhood*
8	Hortusbuurt-Ebbingekwartier (7)	8	Zeeheldenbuurt (3)
7	Binnenstad-Noord (1)	7	Professorenbuurt (5)
6	Professorenbuurt (5)	6	Binnenstad-West (2)
5	Zeeheldenbuurt (3)	5	Schildersbuurt (6)
4	Binnenstad-West (2)	4	Binnenstad-Oost (4)
3	Binnenstad-Oost (4)	3	Hortusbuurt-Ebbingekwartier (7)
2	Schildersbuurt (6)	2	Binnenstad-Noord (1)
1	Binnenstad-Zuid (8)	1	Binnenstad-Zuid (8)

5. Conclusion

The aim of this research was to investigate what factors influence the perceived accessibility (PA) to urban green space (UGS). This study focused specifically on the perceived built environment (PBE), perceived temporal component (PTC) and individual components on the one hand and PA to UGS on the other hand. In order to answer the research question, four sub-questions were posed.

Regarding the first sub-question, this study found that for almost all analysed characteristics, positive perception on both PLUS and PTS influence the PA to UGS positively. The characteristics include the availability of amenities, the visual evaluation of the neighbourhood of residence, the perception of the quantity of UGS, the perception of the quality of UGS, the availability of cycling facilities, the ease of reaching transit stops, and the satisfaction with the time and effort spent travelling to UGSs. The perception of the cost of travelling to UGS was found to be negatively correlated. The only characteristic that did not show a significantly correlated relationship with PA to UGS was the availability of sidewalks. This finding is therefore to a large degree consistent with the initial hypothesis. For future spatial policies, it is recommended that neighbourhoods where perceptions of the local area are negative, are considered as a priority when allocating new UGS developments or features that enhance the attractiveness of a neighbourhood. Concretely, this could be achieved by the implementation of, for example, separated and designated cycling lanes or Dutch *fietsstraten* (*cycling streets*).

Secondly, female students tend to indicate higher values of PA to UGS than males. A significant relationship was found between being a female and PA to UGS, which is consistent with the hypothesis. Reasons for this outcome are not clear. However, a possible explanation for this could be gender related differences regarding the cognitive environment (Pot et al., 2021). Nonetheless, to confidently state that for example female students perceive distance or travel disutility differently than male students, further qualitative research is required. Other variables such as nationality, education, and age did not demonstrate significant relationships or differences with regard to PA to UGS. Nevertheless, the outcome is of interest to policymakers, as previously employed OA methods do not account for this difference in gender. Further attention should be directed towards the pursuit of gender equality, including in the context of PA to UGS, in light of the gender equality plan introduced by the Province of Groningen in 2022.

Thirdly, significant relationships were found between positive perceptions towards UGS as designed parks, preference for active modes of transportation (i.e. walking, cycling) and PA to UGS. The latter finding being consistent with the hypothesis regarding active modes of transportation. The preference of car-use is statistically negatively correlated to PA to UGS. These findings are a clear indication for policymakers and spatial planners to promote active modes of transportation, or conversely reduce car use through soft policies. The use of educational campaigns has the potential to alter individuals' attitudes, which could subsequently encourage walking and cycling. This could, in the long term, stimulate PA to UGS.

The final sub-question examined frequency of visiting UGS, which was found to be significantly correlated with PA to UGS. Additional testing found that frequency of visiting UGS is positively correlated with satisfaction with the quantity of UGS. Moreover, the study proved the hypothesis regarding PTC correct, as both personal time perception and perception of UGS time availability demonstrated positive relationships with PA to UGS. As distance is directly related to travel time and the frequency of visits, it remains important for urban planners to ensure that UGSs are accessible to residents within close proximity. Furthermore, the period during which UGSs are accessible could be extended by illuminating them during night and winter times.

5.1 Limitations and Future Research Suggestions

This study tried to gain insight into a number of human perceptions relating to PA to UGS in a quantitative way. The following limitations can be identified, including the absence of contextual information with a given response (i.e. the rationale or reason behind a given answer in the survey), although this may be the most valuable information for policymakers. Moreover, for practical reasons (limited time and scope of the project), a lack of respondents resulted in the use of non-parametric tests, which affects the quality of the data and the outcome. Finally, as the research is based on a specific case study in Groningen with a particular focus on students, one should be careful with generalising the results to other contexts (i.e. other geographical locations, different focus groups).

To get a better understanding into human perception and behaviour regarding accessibility to UGSs, future research could take a more qualitative approach, using interviews. Researchers can ask for further clarification and elaboration after a given answer. This allows the researcher to gain more in-depth understanding of the respondents' perceptions and cognitive environments. In addition to focusing on only students, it is valuable to consider other age groups from a range of socio-economic backgrounds. This approach could provide a more comprehensive understanding of the relationship between PA and OA, and could add the development of more accessible green spaces for all.

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Appendix A: Survey overview

<table>
<tr><th colspan="3">Survey Overview</th></tr>
<tr><th colspan="3">Introduction</th></tr>
<tr><td colspan="3">By taking part in this research, you give consent to participate in an online survey used in quantitative research of “Perceived Accessibility to Urban Green Spaces Among Students in Groningen”, Bachelor Thesis at the Faculty of Spatial Science, University of Groningen. The personal data you provide in your answers will only be used for the research paper and is completely anonymous. In case of misunderstanding or any further questions, contact the responsible researcher: Wessel Idema, w.m.idema@student.rug.nl.

Thank you for participating in this survey on the perceived accessibility of urban green spaces in and around your neighbourhood. Urban green spaces, in short, are areas within the city reserved for parks and other green spaces, including plants, trees and other types of natural environments. The landscape of urban green spaces can range from playing fields, to highly maintained environments, to relatively natural landscapes.</td></tr>
<tr><th>Statements & Questions</th><th>Answer</th><th>Type of Data</th></tr>
<tr><td>Neighbourhood Selection
0. In which neighbourhood do you live? (If necessary, refer to the map with neighbourhood numbers)</td><td>0.
o 0000 Binnenstad-Noord
o 0001 Binnenstad-Zuid
o 0002 Binnenstad-Oost
o 0003 Binnenstad-West
o 0005 Hortusbuurt-Ebbingekwartier
o 0008 Stationsgebied
o 0100 De Meeuwen
o 0101 Oosterpoort
o 0102 Herewegbuurt
o 0103 Rivierenbuurt
o 0104 Grunobuurt
o 0105 Badstratenbuurt
o 0106 Zeeheldenbuurt
o 0107 Laanhuizen
o 0110 Peizerweg
o 0200 Oranjebuurt
o 0201 Noorderplantsoenbuurt</td><td>Nominal</td></tr>
</table>

	o 0202 Schildersbuurt o 0203 Kostverloren o 0300 De Hoogte o 0301 Indische buurt o 0302 Professorenbuurt o 0400 Gorechtbuurt o 0401 Vogelbuurt o 0402 Bloemenbuurt o 0403 Florabuurt o 0404 Damsterbuurt o 0500 De Linie o 0501 Europapark o 0503 Kop van Oost o 0600 Sterrebosbuurt o 0601 Coendersborg o 0602 Klein Martijn o 0603 Villabuurt o 0604 Helpman o 0605 De Wijert o 0606 De Wijert-Zuid o 0700 Corpus den Hoorn o 0701 Hoornse Meer o 0702 Hoornse Park o 0704 Piccardthof o 0800 Hoogkerk Dorp o 0801 Hoogkerk-Zuid o 0806 Gravenburg o 0809 Bangeweer o 0810 De Buitenhof o 0900 Vinkhuizen-Noord	

	o 0901 Vinkhuizen-Zuid o 0903 Friesestraatweg o 0904 Reitdiep o 0906 De Held o 0907 Westpark o 0908 Suikerzijde-Noord o 1000 Selwerd o 1001 Paddepoel-Zuid o 1002 Paddepoel-Noord o 1005 Tuinwijk o 1100 Beijum-West o 1101 Beijum-Oost o 1102 De Hunze o 1103 Van Starkenborgh o 1104 Noorderhoogebrug o 1200 Lewenborg-Noord o 1201 Lewenborg-Zuid o 1202 Lewenborg-West o 1203 Oosterhoogebrug o 1204 Ulgersmaborg o 1208 Drielanden o 1210 Ruischerbrug o 1211 Ruischerwaard o 1301 Engelbert o 1400 Meeroevers o 1404 Tersluis o 1500 Ten Boer o 1502 Garmerwolde o 1503 Thesinge o 1700 Haren-Centrum	

	o 1701 Haren-Zuidwest o 1702 Haren-Zuidoost o 1703 Haren-Noord o 1704 Essen o 1708 Buitengebied Haren-Zuidoost o 1800 Oosterhaar o 1801 Tuindorp o 1900 Glimmen Dorp o 1901 Onnen Dorp o Other	
Individual Components *Socio-economic characteristics* 1. What is your gender? 2. What is your age? 3. What type of education do you follow? 4. What is your nationality?	1. o Male o Female o Other 2. o 18-23 o 24-28 o 29-33 o 34-38 3. o Academic education *(WO)* o Higher vocational education *(HBO)* o Secondary vocational education *(MBO)* o Other 4. o Dutch o Non-Dutch	*Nominal*

Personal attitudes and preferences *UGS* 5. I prefer urban green spaces with **exclusively nature** *(e.g. areas with high ecological values, natural and planted vegetation where flora and fauna is conserved and protected, etc.)* 6. I prefer urban green spaces that are **designed parks** *(e.g. areas with medium ecological values such as unique parks, planned for recreation, while providing aesthetic values through planted shade trees, shrubs, fountains, grasslands, etc.)* 7. I prefer urban green spaces that offer **entertainment and amenities** *(e.g. areas with low ecological value which provide options for activities through open green meadows, sport facilities, playgrounds, music, etc.)* *Mode of transportation* 8. I prefer to use **car** to reach urban green spaces. 9. I prefer to use **public transport** (e.g. bus, train, etc.) to reach urban green spaces. 10. I prefer to use **scooter** to reach urban green spaces. 11. I prefer to **bike** to reach urban green spaces. 12. I prefer to **walk** to reach urban green spaces.	5, 6, 7. 1= strongly disagree 2= disagree 3= somewhat disagree 4= neutral 5= somewhat agree 6= agree 7= strongly agree 8, 9, 10, 11, 12. 1= strongly disagree 2= disagree 3= somewhat disagree 4= neutral 5= somewhat agree 6= agree 7= strongly agree	*Ordinal* *Ordinal*
PBE *PLUS* 13. Many shops, stores, markets or other places to buy things I need are within easy walking distance (10-15 minutes) of my home. 14. There are many interesting things to look at while walking in my neighbourhood. 15. I am satisfied with the amount of urban green spaces in and around my neighbourhood. 16. I am satisfied with the quality of urban green spaces in and around my neighbourhood. *PTS* 17. There are sidewalks on most of the streets in my neighbourhood.	13, 14, 15, 16. 1= strongly disagree 2= disagree 3= somewhat disagree 4= neutral 5= somewhat agree 6= agree 7= strongly agree 17, 18, 19, 20, 21. 1= strongly disagree	*Ordinal*

18. There are facilities to cycle, in or near my neighbourhood, such as special lanes or separate paths. 19. It is easy to walk to a transit stop (e.g. station, bus stop) from my home. 20. I am satisfied with the time and effort spent travelling to an urban green space. 21. Travelling to urban green spaces is costly for me. *Frequency of Travel* 22. What method of transportation do you actually use when travelling to urban green spaces? (Select one option. When in doubt or using multiple methods, use the one you use most frequently.) *Frequency of Travel* 23. How often do you visit urban green spaces on average?	2= disagree 3= somewhat disagree 4= neutral 5= somewhat agree 6= agree 7= strongly agree 22. o Car o Public transport (e.g. bus, train, etc.) o Scooter o Bike o Walking o Other 23. 1= less than once a month 2= once a month 3= a couple of times per month 4= once per week 5= 2-3 times per week 6= almost every day	
PTC 24. In my daily life, I have enough time to visit urban green spaces. 25. Urban green spaces are available to visit any time of the day.	24, 25. 1= strongly disagree 2= moderately disagree 3= somewhat disagree 4= neutral 5= somewhat agree 6= moderately agree 7= strongly agree	*Ordinal*
PA to UGS 26a. It is **easy** for me to get to urban green spaces. 26b. It is possible to reach my **preferred** urban green space. 26c. The access to my preferred urban green space is **satisfying**.	26a, 26b, 26c. 1= strongly disagree 2= 3= 4= 5= 6= 7= 8= 9= 10= strongly agree	*Ordinal*

Appendix B: Invitational flyer survey

Appendix C: Outcome tables spatial analysis

Tabel a: Neighbourhood ranking based on the surface area of UGSs in absolute numbers (Rank number 8 indicating the highest amount of OA and 1 indicating the lowest amount of OA)

Rank	*Neighbourhood (Walking Buffer, 300m)*	*Rank*	*Neighbourhood (Cycling Buffer, 1333m)*
8	Professorenbuurt (5)	8	Professorenbuurt (5)
7	Schildersbuurt (6)	7	Zeeheldenbuurt (3)
6	Zeeheldenbuurt (3)	6	Schildersbuurt (6)
5	Hortusbuurt-Ebbingekwartier (7)	5	Binnenstad-Zuid (8)
4	Binnenstad-Oost (4)	4	Hortusbuurt-Ebbingekwartier (7)
3	Binnenstad-Noord (1)	3	Binnenstad-Oost (4)
2	Binnenstad-Zuid (8)	2	Binnenstad-Noord (1)
1	Binnenstad-West (2)	1	Binnenstad-West (2)

Tabel b: Neighbourhood ranking based on the surface area of UGSs relative to neighbourhood size (Rank number 8 indicating the highest amount of OA and 1 indicating the lowest amount of OA)

Rank	*Neighbourhood (Walking Buffer, 300m)*	*Rank*	*Neighbourhood (Cycling Buffer, 1333m)*
8	Binnenstad-West (2)	8	Binnenstad-West (2)
7	Zeeheldenbuurt (3)	7	Zeeheldenbuurt (3)
6	Professorenbuurt (5)	6	Binnenstad-Oost (4)
5	Schildersbuurt (6)	5	Schildersbuurt (6)
4	Binnenstad-Oost (4)	4	Professorenbuurt (5)
3	Hortusbuurt-Ebbingekwartier (7)	3	Binnenstad-Noord (1)
2	Binnenstad-Noord (1)	2	Hortusbuurt-Ebbingekwartier (7)
1	Binnenstad-Zuid (8)	1	Binnenstad-Zuid (8)

Tabel c: Neighbourhood ranking based on the surface area of UGSs relative to buffer size (Rank number 8 indicating the highest amount of OA and 1 indicating the lowest amount of OA)

Rank	*Neighbourhood (Walking Buffer, 300m)*	*Rank*	*Neighbourhood (Cycling Buffer, 1333m)*
8	Professorenbuurt (5)	8	Zeeheldenbuurt (3)
7	Zeeheldenbuurt (3)	7	Professorenbuurt (5)
6	Schildersbuurt (6)	6	Schildersbuurt (6)
5	Hortusbuurt-Ebbingekwartier (7)	5	Binnenstad-Zuid (8)
4	Binnenstad-Oost (4)	4	Binnenstad-West (2)
3	Binnenstad-West (2)	3	Binnenstad-Oost (4)
2	Binnenstad-Noord (1)	2	Hortusbuurt-Ebbingekwartier (7)
1	Binnenstad-Zuid (8)	1	Binnenstad-Noord (1)

Appendix D: Outcome tables SPSS

Tabel a: Results Spearman's Rho correlation between PLUS and PA to UGS

Correlations

			PBE_PLUS_amen | Many shops, stores, markets or other places to buy things I need are within easy walking distance (10-15 minutes) of my home.	PBE_PLUS_visual | There are many interesting things to look at while walking in my neighbourhood.	PBE_PLUS_quaNUGS | I am satisfied with the amount of urban green spaces in and around my neighbourhood.	PBE_PLUS_quaLUGS | I am satisfied with the quality of urban green spaces in and around my neighbourhood.
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	,236	,246	,432	,512
		Sig. (2-tailed)	,009	,006	<,001	<,001
		N	123	123	123	123

Tabel b: Results Spearman's Rho correlation between PTS and PA to UGS

Correlations

			PBE_PTS_swalk | There are sidewalks on most of the streets in my neighbourhood.	PBE_PTS_cyclfac | There are facilities to cycle, in or near my neighbourhood, such as special lanes or separate paths.	PBE_PTS_transit | It is easy to walk to a transit stop (e.g. station, bus stop) from my home.	PBE_PTS_timeffort | I am satisfied with the time and effort spent travelling to an urban green space.	PBE_PTS_cost | Travelling to urban green spaces is costly for me.
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	,134	,193	,289	,596	-,312
		Sig. (2-tailed)	,139	,032	,001	<,001	<,001
		N	123	123	123	123	123

Tabel c: Results Independent Samples T Test for gender with and PA to UGS

Independent Samples Test

		t-test for Equality of Means							
				Significance				95% Confidence Interval of the Difference	
		t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
PA_to_UGS_MEAN	Equal variances assumed	2,868	116	,002	,005	,86944	,30316	,26899	1,46990

Tabel d: Results Spearman's Rho correlation between gender and PA to UGS. 'Female' is coded as 0

Correlations

			PA_to_UGS_MEAN	Gender
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	1,000	-,288**
		Sig. (2-tailed)	.	,002
		N	123	118
	Gender	Correlation Coefficient	-,288**	1,000
		Sig. (2-tailed)	,002	.
		N	118	120

**. Correlation is significant at the 0.01 level (2-tailed).

Tabel e: Frequency of visiting UGSs and gender

Freq.visit_UGS | How often do you visit urban green spaces on average? * Gender Crosstabulation

Count

		Gender		
		Female	Male	Total
Freq.visit_UGS | How often do you visit urban green spaces on average?	Less than once a month	2	2	4
	Once a month	1	7	8
	A couple of times per month	12	15	27
	Once per week	10	22	32
	2-3 times per week	16	14	30
	Almost every day	7	11	18
Total		48	71	119

Tabel f: Results Chi-square test between frequency of visiting and gender. The requirements were not met

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6,140[a]	5	,293
Likelihood Ratio	6,564	5	,255
Linear-by-Linear Association	,651	1	,420
N of Valid Cases	119		

a. 4 cells (33,3%) have expected count less than 5. The minimum expected count is 1,61.

Tabel g: Results Independent Samples T Test for Dutch and non-Dutch with regard to PA to UGS

Independent Samples Test

		t-test for Equality of Means							
				Significance				95% Confidence Interval of the Difference	
		t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
PA_to_UGS_MEAN	Equal variances not assumed	-1,507	70,722	,068	,136	-,52249	,34671	-1,21386	,16888

Tabel h: Group statistics age and PA to UGS

Group Statistics

	Age_1_2 | Only 18-23 & 24-29	N	Mean	Std. Deviation	Std. Error Mean
PA_to_UGS_MEAN	18-23	105	7,9302	1,72444	,16829
	24-29	17	7,8431	1,60778	,38994

Tabel i: Group statistics education and PA to UGS

Group Statistics

	Education_WO_HBO	N	Mean	Std. Deviation	Std. Error Mean
PA_to_UGS_MEAN	Academic education (WO)	110	7,9636	1,73842	,16575
	Higher vocational education (HBO)	11	7,3939	1,45158	,43767

Tabel j: Results Independent Samples T Test for actual cyclists and pedestrians to UGS with regard to PA to UGS

Independent Samples Test

		t-test for Equality of Means							
				Significance				95% Confidence Interval of the Difference	
		t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
PA_to_UGS_MEAN	Equal variances assumed	-2,848	119	,003	,005	-,88879	,31204	-1,50666	-,27092

Tabel k: Results Spearman's Rho correlation between Personal Preferences and Attitudes and PA to UGS

Correlations

			PPREF_excl_nat | I prefer urban green spaces with exclusively nature (e.g. areas with high ecological values, natural and planted vegetation where flora and fauna is conserved and protected, etc.)	PPREF_des_park | I prefer urban green spaces that are designed parks (e.g. areas with medium ecological values such as unique parks, planned for recreation, while providing aesthetic values through planted shade trees, shrubs, fountains, grasslands, etc.)	PPREF_ent_amen | I prefer urban green spaces that offer entertainment and amenities (e.g. areas with low ecological values which provide options for activities through open green meadows, sport facilities, playgrounds, music, etc.)	PPREF_CAR | I prefer to use car to reach urban green spaces.	PPREF_PT | I prefer to use public transport (e.g. bus, train, etc.) to reach urban green spaces.	PPREF_SCOOTER | I prefer to use scooter to reach urban green spaces.	PPREF_BIKE | I prefer to bike to reach urban green spaces.	PPREF_WALK | I prefer to walk to reach urban green spaces.
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	,082	,185	,085	-,188	,065	-,058	,239	,206
		Sig. (2-tailed)	,370	,040	,351	,037	,472	,521	,008	,022
		N	123	123	123	123	123	123	123	123

Tabel l: Descriptive statistics on frequency of visiting UGS and PA to UGS

Descriptives

PA_to_UGS_MEAN

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound	Minimum	Maximum
Less than once a month	5	6,2000	2,08966	,93452	3,6053	8,7947	2,67	7,67
Once a month	8	7,7083	1,36204	,48155	6,5696	8,8470	5,33	9,67
A couple of times per month	29	7,5747	1,41111	,26204	7,0380	8,1115	5,33	10,00
Once per week	34	7,2843	2,07459	,35579	6,5605	8,0082	1,33	10,00
2-3 times per week	29	8,6897	1,09447	,20324	8,2733	9,1060	6,00	10,00
Almost every day	18	8,8519	1,33931	,31568	8,1858	9,5179	4,67	10,00
Total	123	7,8970	1,71149	,15432	7,5915	8,2025	1,33	10,00

Tabel m: Results Kruskal-Wallis test between frequency of visits and PA to UGS

Test Statistics[a,b]

	PA_to_UGS_MEAN
Kruskal-Wallis H	25,091
df	5
Asymp. Sig.	<,001

a. Kruskal Wallis Test

b. Grouping Variable: Freq. visit_UGS | How often do you visit urban green spaces on average?

Tabel n: Results Spearman's Rho correlation test between frequency of visiting UGS and PA to UGS

Correlations

			PA_to_UGS_MEAN	Freq. visit_UGS | How often do you visit urban green spaces on average?
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	1,000	,407**
		Sig. (2-tailed)	.	<,001
		N	123	123
	Freq.visit_UGS | How often do you visit urban green spaces on average?	Correlation Coefficient	,407**	1,000
		Sig. (2-tailed)	<,001	.
		N	123	124

**. Correlation is significant at the 0.01 level (2-tailed).

Tabel o: Results Kendall's Tau B correlation test between frequency of visiting UGS and Satisfaction with quantity UGS

Correlations

			Freq. visit_UGS | How often do you visit urban green spaces on average?	PBE_PLUS_quaNUGS | I am satisfied with the amount of urban green spaces in and around my neighbourhood.	PBE_PLUS_quaLUGS | I am satisfied with the quality of urban green spaces in and around my neighbourhood.
Kendall's tau_b	Freq.visit_UGS | How often do you visit urban green spaces on average?	Correlation Coefficient	1,000	,224**	,122
		Sig. (2-tailed)	.	,002	,093
		N	124	124	124
	PBE_PLUS_quaNUGS | I am satisfied with the amount of urban green spaces in and around my neighbourhood.	Correlation Coefficient	,224**	1,000	,628**
		Sig. (2-tailed)	,002	.	<,001
		N	124	125	125
	PBE_PLUS_quaLUGS | I am satisfied with the quality of urban green spaces in and around my neighbourhood.	Correlation Coefficient	,122	,628**	1,000
		Sig. (2-tailed)	,093	<,001	.
		N	124	125	125

**. Correlation is significant at the 0.01 level (2-tailed).

Tabel p: Results Spearman's Rho correlation test between perceived temporal components and PA to UGS

Correlations

			PTC_enoughtime | In my daily life, I have enough time to visit urban green spaces.	PTC_UGS_avail. | Urban green spaces are available to visit any time of the day.
Spearman's rho	PA_to_UGS_MEAN	Correlation Coefficient	,280	,432
		Sig. (2-tailed)	,002	<,001
		N	123	123