The effect of urban green space on soundscape perception

Summary

Recently, researchers show an increased interest in the "Soundscape" of an environment. "Soundscape" is defined as "the acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO, 2014). Soundscape perception is a complex issue, where it is important to understand the effects of audio-visual interaction. Visual landscape factors are essential factors in influencing soundscape perception. Recent evidence suggests that the visibility of greenery can have a major positive influence on soundscape perception. It is one of the most important aspects of an environment, affecting its pleasantness and it is an important tool to reduce noise. However, the type of natural features and the site affects the extent to which noise annoyance is reduced. Moreover, when a person's sight is obstructed and the person feels enclosed by nature, that person may feel more unsafe and this can even have a negative impact on soundscape perception. The main object of this thesis is to determine the relationship between the characteristics of urban green spaces and soundscape perception. The research was conducted using online questionnaires about the soundscape perception and greenery perception of three urban parks in Groningen: Noorderplantsoen, Stadspark and Sterrebos. The three parks differ in amount and setting of greenery. The amount of greenery is calculated using the Green View Index formula. Remarkably, the results of this research showed only the positive influence of greenery. Therefore, the positive visual aspect of green space outweighs the lack of spatial openness. This thesis concludes that the characteristics of urban green space, which mostly influence soundscape are the dominance of human sight and the quality of nature.

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1. Introduction

1.1 Background

Greenery has always played a vital role in urban environments, by providing a number of ecosystem services (Wood et al., 2018). To begin with, urban greenery provides important environmental benefits, such as supporting the preservation of biodiversity, improving the quality of air, water and soil quality and reducing urban heat islands (Jeon et al., 2018).

Urban green space also improves the health and wellbeing of citizens, a lesser known bt nonetheless important ecosystem service. Access to green spaces in an urban environment can provide psychological and emotional restoration of stress. Therefore, it can facilitate psychological recovery and effectively combat the mental fatigue of modern life. Humans react positively to the natural content by engaging the mind and evoking a positive emotion of well-being, especially when mentally fatigued. Positive emotions help to reduce unpleasant thoughts and feelings and thus support the recovery from physiological stress. Apart from relieving stress by restoring mental fatigue, greenery also turns out to lower blood pressure and muscle aches (Li et al., 2010).

Over the past few years, research into soundscape is emerging and can provide new perspectives on how to improve the relationship between the "acoustic space" and the living environment (Brambilla et al., 2013). The soundscape approach is most effective when applied at an early phase of the planning process (De Coensel et al., 2010). This is because it is an integral part of the visual environment, people's sense of safety, the perceived air quality, and so on. A mismatch between the various components of the living environment, including soundscapes, can negatively influence the perceived quality of an environment (Botteldooren et al., 2006). In contrast, a good balance between the visual aspects of an environment and the noise aspects of an environment have a positive influence on the environment's quality.

Research has shown that the presence of greenery plays an important role in soundscape perception. It turns out that the visibility of the greenery can be very effective in increasing the pleasantness of the environment and can have a noise reducing effect (Echevarria Sanchez et al., 2017). In order to understand people's visualization of urban greenery, the Green View Index formula can be used (Li et al., 2015). It is an objective assessment method for measuring urban greenery form a human perspective. However, the noise reduction of a visible environmental characteristic cannot always be considered proportional to the perceived percentage within a given field of vision. This is because spatial openness also influences soundscape perception. Openness promotes visibility, which is a classic predictor of safety. If people feel completely enclosed by nature and their sight is obstructed, this can even have a negative influence on their sense of safety and therefore on their soundscape perception. Therefore, it is important to maintain the amount of perceived open space in the environment.

In this thesis, I will include these studies by focusing on the influence of different characteristics of urban green spaces on soundscape perception. In the aforementioned studies different characteristics of urban green space are examined individually, but hardly any research has been done that combines these characteristics. This aspect is what makes this research scientifically relevant. In addition, it is relevant for urban planners to design urban soundscapes that meet people's wishes, with the optimal amount and setting of green space.

1.2 Research problem

As described above, urban parks play an important role in the quality of life of urban residents. These spaces significantly benefit the individual's and community's wellbeing. For this reason, there is an increasing awareness to preserve and improve the environmental quality in urban parks (Brambilla et al., 2013). When assessing the quality of an urban park, the soundscape environment of that park plays a vital role. Unfortunately, urban parks are often surrounded by noisy areas that can have negatively influence on the soundscape environment of the parks. However, research shows that the visual characteristics of a place influence the extent to which a person suffers from noise annoyance. Therefore, visible vegetation in urban parks can be used to mitigate environmental noise perception and consequently have a positive influence on soundscape perception (Van Renterghem, 2019). However, research shows that if spatial openness is obstructed by nature, this can have a negative influence on soundscape perception (Herzog & Chernick, 2000). Little is known about the influence of different settings and the amount of green in urban green spaces on soundscape perception. The aim of this thesis is to explore the relationship between different characteristics of urban green space and soundscape perception. In order to meet this aim, the following research question is designed:

"To what extent is there a relationship between the different characteristics of urban green spaces and soundscape perception in urban parks?"

The main research question can be divided into the following sub-questions:

- How the greenery and soundscape perception vary among the three parks?
- To what extent does the dominance of vision by nature and the feeling of enclosure by nature influence the soundscape perception?
- To what extent does the quality and the maintenance of nature influence soundscape perception?

1.3 Overview of the thesis

This thesis is divided into five sections. The first section describes the relevance, research questions and the structure of this thesis. The second part gives a brief review of the relevant literature and frameworks in order to discuss the place of this research within a broader academic context. The third section will examine the methodology and data collection. In the results paragraph, section four, all sub-questions are answered, and the findings are related to previous studies. Section five presents the conclusions in which the main question is recapped, and the reflection.

2. Theoretical framework

2.1 Definition of soundscape

In most scientific research, noise is referred to in negative terms such as intrusive and undesirable. Consequently, conventional research and policy in the field of environmental noise management focuses mainly on noise as a physical measure and assesses the efficiency of noise reduction on the basis of the reduction of the sound pressure level (Jennings & Cain, 2013; van Kempen et al., 2014). This is reflected in efforts to reduce the high noise levels of the transport and industrial sectors below the defined limit values (Aletta et al., 2016). However, this multifaceted problem goes much deeper than just reducing the sound pressure level. Noise annoyance is influenced by a variety of factors such as acoustic, environmental and personal factors and only 30% of the variance in noise annoyance can be allocated to the sound pressure level (Jennings & Cain, 2013; Van Renterghem, 2019). Besides, reducing noise levels from certain sound sources does not necessarily improve living conditions and quality of life in urban areas. This is because the character of the sound is equally important and goes beyond just the noise level (Aletta et al., 2016).

As a result, attention for the physical aspect of noise pollution is shifting towards trying to understand meanings and the role of content in the perception of acoustic environments. An approach that is increasingly popular in this context is the so-called "Soundscape approach" (van Kempen et al., 2014). According to the international standard ISO 12913-1 the term "Soundscape" can be defined as follows "The acoustic environment as perceived or experienced and/or understood by a person or people, in context" (ISO, 2014). Thus, the soundscape concept is broad and covers the complete sound environment at a location and the human interaction with it (van Kempen et al., 2014). The soundscape approach is a complex issue and a step forward in noise control.

2.2 Factors influencing the perception of soundscape

As mentioned before, soundscapes are very content-specific and usually have many environmental sounds that occur simultaneously or over time. These sounds provide information and can therefore be viewed as meaningful. Some of these sounds are considered to be positive such as nature sounds, while others have a negative character or effect such as traffic sounds, regardless of the sound level (Aletta et al., 2016). To illustrate, even though the sound of a waterfall is high as to the number of decibels, it is often considered pleasant. Currently, studies are focusing on the hedonic value of sound, i.e. whether sound sources are perceived as pleasant or unpleasant. Moreover, several studies have found that pleasantness is the most important dimension underlying the soundscape perception (Axelsson et al., 2010). Axelsson et al. (2010) have developed a two-dimensional model defined by the two main components: Pleasantness and Eventfulness. These two dimensions are measured by means of the following soundscape perceptual attributes: Pleasant, Unpleasant, Eventful, Uneventful, Chaotic, Calm, Exciting. An example of the principal components model of soundscape is set out in Figure 1.
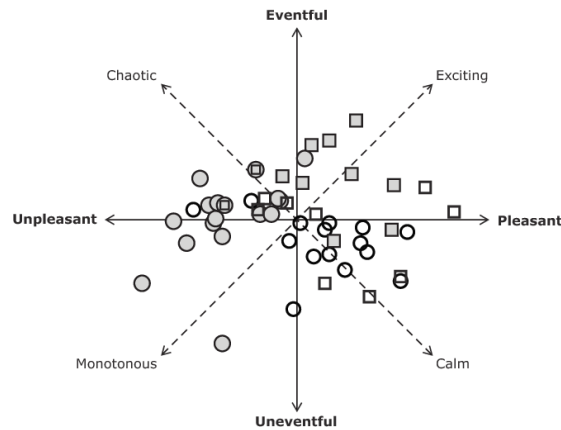
Figure 1: A principal components model of soundscape perception, (Axelsson et al., 2010).

2.3 Influential role of greenery

Vegetation is often used as an effective way of reducing noise by separating the receiver and the sound source. This is because green features can be seen as an important moderator of noise reduction. However, this is often not supported by measured sound pressure level reductions. Even dense and thick hedges or a single row of trees do not perform well in reducing road traffic decibels (Van Renterghem, 2019). This certainly does not mean that vegetation is not effective in reducing noise annoyance. In particular, the noise level and the presence of green spaces in the field of vision appear to have a great influence on the perception of tranquility or, conversely, on noise annoyance and the associated perception dimensions (Aletta et al., 2018). This is because the view of vegetation can strongly reduce self-reported noise annoyance (Van Renterghem & Botteldooren, 2016). In a study conducted by Aletta et al. (2018) it was shown that a large ring road with a measured equivalent level of more than 70db and with a large amount of visible vegetation, was still rated as quiet by 40% of the respondents. Moreover, in a study to determine the factors that influence the soundscape perception of urban parks, Brambilla et al. (2013) found that the visibility of vegetation is the most important factor in influencing the pleasantness of a park (Figure 2). While the pleasantness itself turns out to be one of the most important dimensions in explaining the soundscape perception. Furthermore, the pleasantness of an environment increases with the reduction of unpleasant sounds, but the visual design has a stronger impact. Therefore, it is more effective to improve the visual design of a lower barrier then increasing the height of noise barriers. The visual design performs significantly better than other soundscape indicators affecting the pleasantness of an environment. Vegetated visual designs are rated most pleasant (Echevarria Sanchez et al., 2017).
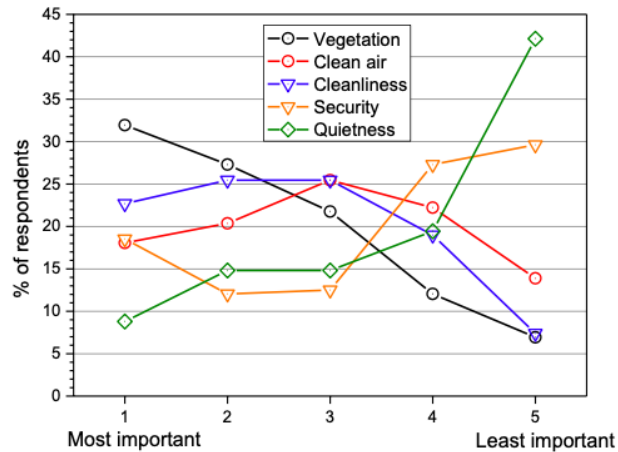
Figure 2: Factors that influence a park's pleasantness, (Brambilla et al, 2013).

It can be assumed that audiovisual interactions influence the overall assessment of a place (Aletta et al., 2018). Human perception is a multi-sensory process. For this reason, an urban sound scene is rarely perceived in isolation, but rather within a global context that contains, in addition to auditory information, information from other sensory modalities such as vision and touch (Viollon et al., 2002). In this multi-sensory process, at the higher levels of the nervous system, several inputs are merged, in which information from some senses can be neglected or suppressed in favour of information from others that can lead to different responses. Therefore, attention to the visual stimulus reduces the conscious perception of sound and vice versa, because auditory and visual settings are linked. Moreover, individuals do not distinguish between physical noise reduction and perception-related effects. In their assessment of noise annoyance, the perception effects are implicitly not taken into account and, to a certain extent, translated into a seemingly physical noise reduction (Van Renterghem, 2019). The two sensory modalities vision and audition seem to interact and reinforce each other in a complex way that makes them inseparable (Viollon et al., 2002). Therefore, visual aspects can be used to limit the negative perception of noise (Van Renterghem, 2019).

As described above, a number of authors have recognised that the presence of greenery view might have a positive noise abatement effect. However, the type of natural features and the site affects the degree to which noise pollution is reduced. An example of this is the study carried out by Li et al. (2010) that demonstrated that wetland parks and garden parks seem to be able to reduce noise pollution more than grassy hills. Moreover, a study by Chau et al. (2018) showed that greenery is also able to increase noise annoyance, which involves nearby mountain greenery. One reason for this could be that a view of mountain greenery is very different from a horizontal view of the water space because the former view at different distances from the viewer will cause a significantly different degree of intervention. Therefore, the obstruction of the view may hinder the ability to reduce noise.

In general, the noise annoyance moderation of a visible environmental feature was considered to be proportional to its perceived percentage within a view. To illustrate, nearby water spaces have a greater influence on improving acoustic comfort than water spaces farther away (Ren & Kang, 2015). Conversely, the probability of annoyance increases with the percentage of mountain greenery that is in sight. This is because the negative moderate effect of the mountain greenery dominated view is caused by the presence of dense and almost impenetrable vegetation near homes. Nearly dense and impenetrable mountain greenery at a short distance has a major influence on people's perception of safety. As a result, the openness of vision decreases, which is a strong

predictor of perceived danger (Loewen et al., 1993, cited by Herzog & Chernick, 2000, p. 30) This means that the dense and impenetrable mountain greenery at a short distance influences people's perception of safety (Herzog & Chernick, 2000). People will feel as if they are enclosed by nature, causing a feeling of insecurity and presumably reversing the restorative effect. As the separating distance between the greenery and the residents increased, the blockage of the field of vision decreased. This suggests that the effect of spatial openness probably outweighs the effect of the visual connection with the greenery if dense greenery is nearby. Therefore, people only enjoy nature if they consider nature to be safe. This implies that the ability of greenery to mitigate noise annoyance does not only depend on the ratio within a certain point of view. Factors related to the spatial openness of a viewpoint must also be taken into account. When the spatial openness of a view is limited by greenery, the chance of a higher annoyance response is high (Chau et al., 2018).

Another predictor of perceived safety is the care for the environment. This means looking at how well the environment is maintained. If an environment is taking care of, this implies the continuous supervision of a caring agent. A well-kept environment stimulates a sense of order and safety. Research shows that there is a clear link between lack of care and fear of crime in urban areas (Herzog & Chernick, 2000). This implies that a well-kept environment also positively contributes positively to the soundscape of that environment.
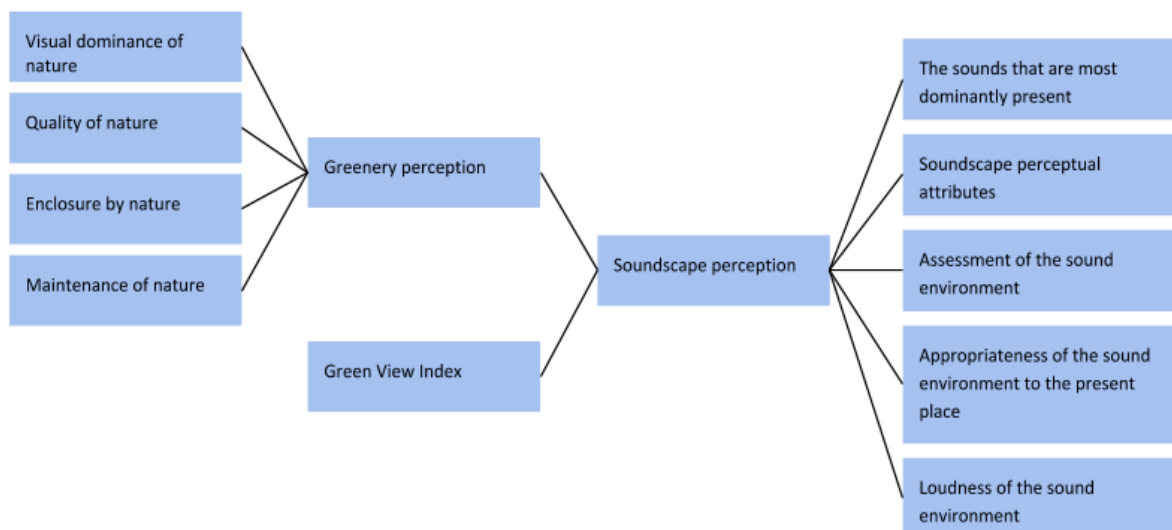

Figure 3: Conceptual model

2.4 Conceptual model

This conceptual model visualises the concepts that have emerged in the existing literature. It shows which characteristics of greenery according to the theoretical framework can influence soundscape perception. In addition, the soundscape aspects that have been used in this research are set out.

3. Methodology

3.1 Data collection method

Primary data will be used in order to gather information needed to form a conclusion. For the collection of primary data to understand a geographical phenomenon, both qualitative and quantitative research methods can be carried out. This research aims to investigate the correlation between the characteristics of urban green space and soundscape perception. Considering the aim of this research it was decided to use quantitative data. Quantitative research is used to quantify the problem and focuses more on involving concepts, models and statistics. This method approaches more respondents and more information about the experiences and collects more perceptions of a group of people (Clifford et al., 2016). This should provide a general overview of the extent in which the different characteristics of the urban green space influence the perception of the soundscape.

3.2 Selection of cases

As a first step of the process, the following three different parks have been selected in the city of Groningen: Stadspark, Noorderplantsoen and Sterrebos. These parks were chosen for two reasons. The first is that they have to differ in terms of greenery. The following is assessed: the quality of the green space, the openness of the green space and the available green space features. In addition, there has been looked at parks with a similar soundscape. All parks are located in bustling areas, surrounded by busy roads, as can be seen in figure 4. To get a better image of the soundscape of the parks, noise levels have been recorded in each park.
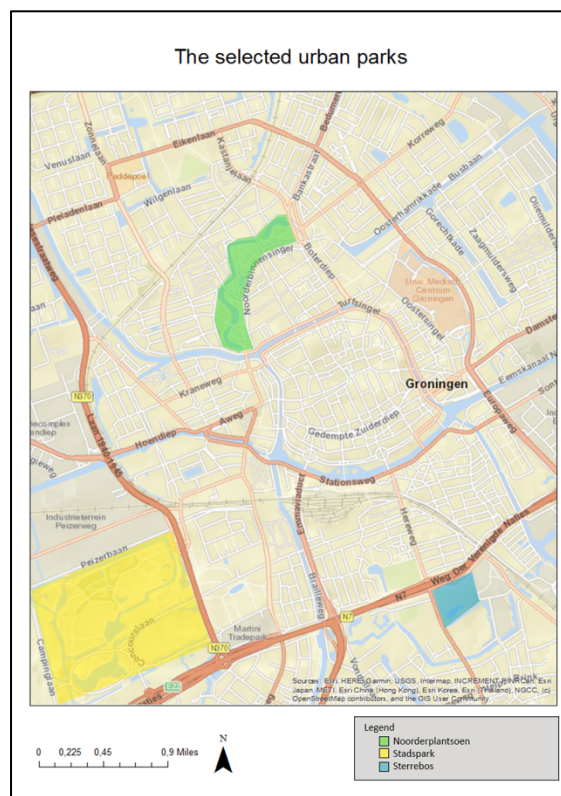

Figure 4: Map of research locations

3.3 Green view index

The green view index (GVI) can be used as an urban greenery assessment tool. It calculates the amount of visual green through an image segmentation method. An advantage of the GVI is that it uses Google Street View, instead of satellite images, reflecting human perception of the environment at street level. The following formula for the Green View Index is modified by Li et al., (2015):

$$\frac{\sum_{i=1}^{4} Area_{g-i}}{\sum_{i=1}^{4} Area_{t-i}} \text{ x } 100\%$$

$Area_{g-i}$ refers to the number of green pixels that are present in the picture taken in the i-th direction; $Area_{t-i}$ refers to the total number of pixels of the picture taken in the i-th direction.

The formula for the Green View Index has been used in this study to compare the three different parks in amount of greenery. In this research, the Green View Index indicates the percentage of green that respondents see on each video of the different parks. However, no use was made of Google Street View, but instead self-made photos were used. In this formula they assume four directions (north, south, east and west), but this research only describes photos in the following three directions; left, right and straight ahead. The total number of pixels ($Area_{t-i}$) and the number of green pixels ($Area_{g-i}$) were determined by using Adobe photoshop. The calculations of the green view index are set out in the appendix B.

3.4 Questionnaire

To answer the main question of this research, we use data from a questionnaire. The data collection of this survey consists of an online questionnaire, which has been set up in Qualtrics, an online survey programme. For each site, a 40-second video was recorded that visualises walking on that site, the video is included in the questionnaire. The questionnaire can be found in Appendix A and consists of four parts. In the first part, respondents were asked to fill in questions about their demographic characteristics. The last three parts each start with a video that makes it look as if you are walking in a park, respondents then answer questions about their soundscape perception and greenery perception. The design of the soundscape perception part of the questionnaire was based on the questionnaire used in ISO (2014), but we made a number of adjustments to tune it to the context of this research. The characteristics of urban green space requested were examined in the theoretical framework. All of the questions were neatly structured and required a short answer or a selection from a number of alternatives. Once the questionnaire was finished, it was distributed through social media.

A questionnaire comprising 36 questions was administered to the respondents. The data from the questionnaire were exported from Qualtrics to the statistical programme SPSS, that is used for data analysis. Table 1 presents a list of the variables used in this research. Since all variables in our data are ordinal or nominal, we only use non-parametric tests in our data analysis. First of all, we use a Wilcoxon signed rank test for the data analysis to unravel the differences between the three parks in greenery perception and soundscape perception. This is a non-parametric statistical test use to compare two matches to assess whether their population means rank differ. This test was carried out three times, each time with a different pair of the three parks. In addition, with the datasets of each park individually, different Spearman's rank correlations were performed to explore significant correlations between the greenery perception variables and the soundscape perception variables. A Spearman's rank correlation is a non-parametric measure of rank correlation and determines how well the relation between two variables can be described using a monotonic function.

Table 1: Research variables

	Variable	Level of measurement	Datatype
Soundscape perception	Hearing of traffic noise	Likert scale	ordinal
	Hearing of other noise (e.g., sirens, construction, industry, loading of goods)	Likert scale	ordinal
	Hearing of sounds from human beings	Likert scale	ordinal
	Hearing of natural sounds	Likert scale	ordinal
	Soundscape perceptual attributes	Likert scale	ordinal
	Assessment of the sound environment	Likert scale	ordinal
	Appropriateness of the sound environment to the present place	Likert scale	ordinal
	Loudness of the sound environment	Likert scale	ordinal
Greenery perception	Quality of nature	Likert scale	ordinal
	Visual dominance of nature	Likert scale	ordinal
	Feeling of enclosure by nature	Likert scale	ordinal
	Maintenance of nature	Likert scale	ordinal
	Green space features	Plants, hedges, shrubs, grass, trees (multiple response)	nominal

3.5 Data quality

The data obtained is not fully representative. At first, this research has been conducted during the coronavirus pandemic. Consequently, it was not possible to do on-site research in the parks, but the research had to be done by an online questionnaire instead. This may influence the soundscape perception and greenery perception of the respondents. In addition, an online questionnaire is not able to explain the questions, and that may lead to different interpretations of respondents as not everyone is familiar with the concept of soundscape.

4. Results

A total of 83 respondents have completed the questionnaire. The respondents were highly disproportionate between genders. Around 20 percent of the respondents was male and around 80 percent was female. The average age was 32 and most of the respondents were highly educated. 66 percent of respondents had completed a Bachelor's or a Master's degree.

4.1.1 Differences in greenery perception

First of all, the different parks were compared in the amount of greenery present and the greenery perception of the respondents. For this purpose, first the green view index of each park was calculated, as shown in figure 5. The Green View Index is an important index because the percentage of green is calculated by the eyes of everyday pedestrians. Self-made pictures have been used from three different directions, representing the sight of a pedestrian. A few examples of those pictures are displayed below in figure 6. The Green View Index is related to the extent of which a person's vision is dominated by nature. The higher the Green View Index, the more a person's vision is dominated by nature.
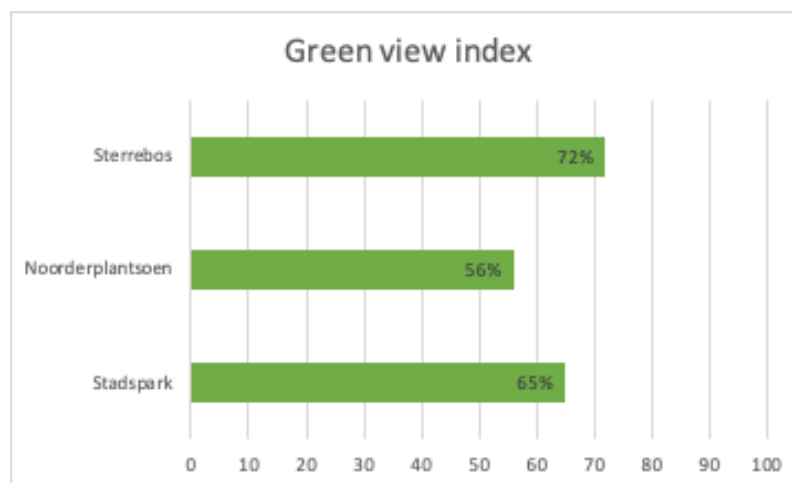

Figure 5: The green view index of each park

Figure 6: Photographs of research locations (from left to right)
Stadspark, Sterrebos, Noorderplantsoen

To get a fuller picture of the greenery settings in the parks, the respondents were asked what they considered to be the most dominant green space features in each park, as illustrated in figure 7. The following green space features were requested: plants, hedges, shrubs, grass and trees. The present green space features can influence the extent to which a person feels enclosed by nature. To illustrate, higher green space features such as trees can make people feel more enclosed by nature and obstruct vision. Sterrebos is mainly dominated by shrubs, plants and trees and hardly any grass, which explains its highest green view index.
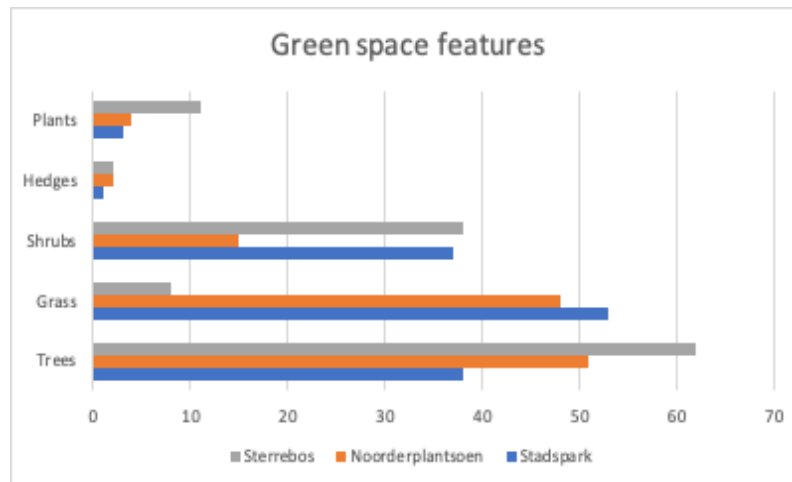

Figure 7: The green space features of each park

A Wilcoxon signed rank test was conducted to evaluate the significance of the difference in greenery perception between the three parks. We first compared Stadspark and Noorderplantsoen and found significant differences. Table 2 demonstrates the significant difference in the quality of nature, the extent in which nature dominates one's view and the feeling of enclosure by nature. In all these areas, Stadspark scored significantly higher than Noorderplantsoen. The significant difference in the extent to which one's view is dominated by nature is in line with the difference in green view index.

Table 2: Wilcoxon signed rank test of the differences in greenery perception between Stadspark and Noorderplantsoen.

Stadspark - Noorderplantsoen	Asymp. Sign. (2-tailed)	Z	Park with the highest score
Quality of nature	.001	-3.238[a]	Stadspark
Nature's visual dominance	.000	-6.179[a]	Stadspark
Feeling of enclosure by nature	.000	-3.532[a]	Stadspark

a.   Based on positive ranks = Noorderplantsoen score > Stadspark score

Secondly, we compared Stadspark and Sterrebos in greenery perception, using a Wilcoxon signed rank test. There was only one significant difference: respondents felt more enclosed by nature in Sterrebos than in Stadspark. These results correspond well to previous results showing that Sterrebos' green view index is higher and there are more trees, shrubs and plants.

Finally, Sterrebos and Noorderplantsoen were compared in greenery perception through a Wilcoxon signed rank test. Table 3 shows that Sterrebos has the highest scores on all three variables. This is not surprising, given the huge difference in green view index between the two parks.

Table 3: Wilcoxon signed rank test of the differences in greenery perception between Sterrebos and Noorderplantsoen

Sterrebos - Noorderplantsoen	Asymp. Sign. (2-tailed)	Z	Park with the highest score
Quality of nature	.006	-2.759[a]	Sterrebos
Nature's visual dominance	.000	-5.649[a]	Sterrebos
Feeling of enclosure by nature	.000	-5.518[a]	Sterrebos

a.   Based on negative ranks = Sterrebos score < Noorderplantsoen score

The three different parks are similarly compared with respect to soundscape perception. First, we looked at the different noise levels as shown in Table 4. The table below illustrates the rather different noise levels of the three parks. The noise level (LAeq) in Noorderplantsoen is the highest, followed by Sterrebos and finally Stadspark.

Table 4: The noise level of each park

Park	LAeq	Max. Level
Stadspark	47.0 dB	63.7 dB
Noorderplantsoen	53.9 dB	63.2 dB
Sterrebos	50.8 dB	57.6 dB

Secondly, we compared the soundscape perception of the three parks, by observing and analysing the data of the parks. Noorderplantsoen not only significantly differs in green view index and greenery perception. It also differs from Sterrebos and Stadspark in soundscape perception. This could be expected as the noise level at that location is highest.

First of all, there is a difference in sounds that respondents predominantly hear. In Noorderplantsoen traffic is perceived as the most dominant sound source. 14% of the respondents said that traffic sound dominated completely and 68% said that it dominated a lot. In contrast to Noorderplantsoen, natural sounds are most dominant in Stadspark and Sterrebos. When asked about the surrounding sound environment, Noorderplantsoen again deviates. Respondents judge the surrounding sound environment of Noorderplantsoen as: vibrant, eventful and chaotic. In contrast, the surrounding sound environment of Stadspark and Sterrebos is seen as more pleasant and calm. In addition, the whole sound environment is rated lower at Noorderplantsoen than in the other parks, as figure 8 shows. Besides, while the surrounding sound environment of Sterrebos and Stadspark was experienced as moderately loud, respondents perceive the surrounding sound environment of the Noorderplantsoen as very loud.
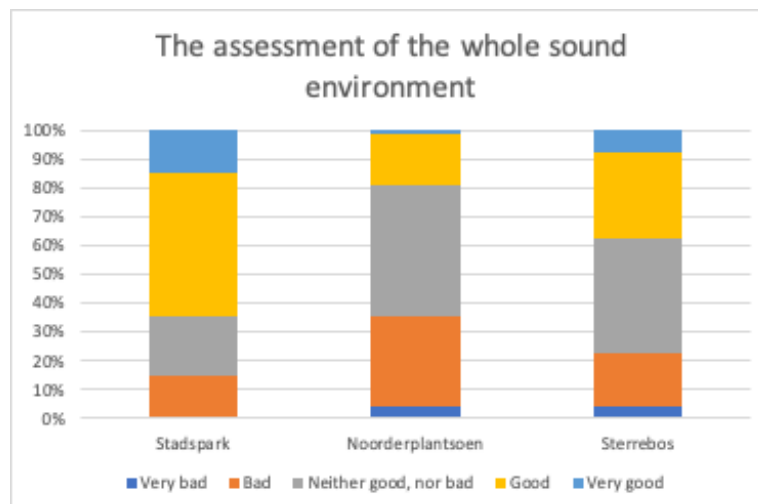
Figure 8: The assessment of the whole soundscapes of each park

The observations above were tested by a Wilcoxon signed rank test to determine significant differences in soundscape perception between the three parks. We first compared parks Stadspark and Noorderplantsoen and noticed that the soundscape perception of Noorderplantsoen is significantly different from that of Stadspark with respect to several key features shown in Table 5.

Table 5: Wilcoxon signed rank test of the differences in soundscape perception between Stadspark and Noorderplantsoen

Stadspark - Noorderplantsoen	Asymp. Sign. (2-tailed)	Z	Park with the highest score
Hearing of traffic noise	.000	-6.024[a]	Noorderplantsoen
Hearing of other noise (e.g., sirens, construction, industry, loading of goods)	.000	-5.211[a]	Noorderplantsoen
Hearing of sounds from human beings	.000	-4.490[a]	Noorderplantsoen
Hearing of natural sounds	.000	-6.299[b]	Stadspark
Perceived soundscape pleasantness	.000	-5.185[b]	Stadspark
Soundscape perceived as chaotic	.000	-5.854	Noorderplantsoen
Perceived soundscape vibrancy	.004	-2.875[a]	Noorderplantsoen
Perceived soundscape as uneventful	.004	-2.898[b]	Stadspark
Perceived soundscape calmness	.000	-5.768[b]	Stadspark
Perceived soundscape as annoying	.000	-3.854[a]	Noorderplantsoen
Perceived soundscape as eventful	.000	-4.453[a]	Noorderplantsoen
Assessment of the sound environment	.000	-5.432[b]	Stadspark
Loudness of the sound environment	.000	-4.713[a]	Noorderplantsoen

a. Based on negative ranks = Noorderplantsoen score < Stadspark score
b. Based on positive ranks = Noorderplantsoen score > Stadspark score

As we expected, the soundscape of Stadspark was generally rated as better than the soundscape of Noorderplantsoen. Firstly, respondents scored the overall sound environment of Stadspark as better and less loud than the overall sound environment of Noorderplantsoen. Closer inspection of the results shows that sounds that are perceived as unpleasant, such as traffic noise, were more clearly heard and sounds considered as pleasant, such as natural sounds, were less clearly heard in Noorderplantsoen than in Stadspark. Additionally, there is a difference between the assessment of the eight dimensions of soundscape. Stadspark is seen as more pleasant, uneventful and calm, while Noorderplantsoen is judged as more chaotic, vibrant, annoying, eventful and monotonous.

Secondly, the parks Stadspark and Sterrebos were compared using a Wilcoxon signed rank test. There were a number of significant differences between Stadspark and Sterrebos, as Table 6 shows, however, not as much as between Stadspark and Noorderplantsoen. Remarkably, the sound environment of Stadspark is considered as more vibrant and eventful, while the sound environment of Sterrebos is seen as monotonous and uneventful. We would expect the results to be opposite, because Sterrebos has a higher noise level.

Table 6: Wilcoxon signed rank test of the differences in soundscape perception between Stadspark and Sterrebos

Stadspark - Sterrebos	Asymp. Sign. (2-tailed)	Z	Park with the highest score
Hearing of other noise (e.g., sirens, construction, industry, loading of goods)	.001	-3.179[a]	Sterrebos
Hearing of sounds from human beings	.001	-3.460[b]	Stadspark
Hearing of natural sounds	.000	-4.343[b]	Stadspark

Perceived soundscape vibrancy	.000	-3.657[b]	Stadspark
Perceived soundscape as uneventful	.001	-3.314[a]	Sterrebos
Perceived soundscape as eventful	.002	-3.051[b]	Stadspark
Perceived soundscape as monotonous	.000	-4.743[a]	Sterrebos

    a.   Based on negative ranks = Sterrebos score < Stadspark score

    b.   Based on positive ranks = Sterrebos score > Stadspark score

Finally, a Wilcoxon signed rank test was performed to compare the soundscape perception between Noorderplantsoen and Sterrebos, where we found many significant differences as illustrated in Table 7. The results from this test reasonably match those of the Wilcoxon signed rank test with Noorderplantsoen and Stadspark. To illustrate, the entire soundscape environment in Sterrebos is again rated better and perceived as less loud than Noorderplantsoen. Additionally, this test shows that in Noorderplantsoen the traffic noise, human sounds and other sounds (e.g., sirens and industry) are heard much more clearly in Noorderplantsoen, while in Sterrebos the sounds of nature are heard more clearly. In addition, Noorderplantsoen is seen as more chaotic, vibrant, annoying and eventful and Sterrebos scores higher on the following dimensions: pleasantness, calm, uneventful and monotonous.

Table 7: Wilcoxon signed rank test of the differences in soundscape perception between Noorderplantsoen and Sterrebos.

Noorderplantsoen - Sterrebos	Asymp. Sign. (2-tailed)	Z	Park with the highest score
Hearing of traffic noise	.000	-5.954[a]	Noorderplantsoen
Hearing of other noise (e.g., sirens, construction, industry, loading of goods)	.005	-2.784[a]	Noorderplantsoen
Hearing of sounds from human beings	.000	-6.102[a]	Noorderplantsoen
Hearing of natural sounds	.005	-2.818[b]	Sterrebos
Perceived soundscape pleasantness	.000	-3.698[b]	Sterrebos
Soundscape perceived as chaotic	.000	-5.801[a]	Noorderplantsoen
Perceived soundscape vibrancy	.004	-5.535[a]	Noorderplantsoen
Perceived soundscape as uneventful	.000	-5.418[b]	Sterrebos
Perceived soundscape calmness	.000	-5.370[b]	Sterrebos
Perceived soundscape as annoying	.025	-2.238[a]	Noorderplantsoen
Perceived soundscape as eventful	.000	-5.514[a]	Noorderplantsoen
Perceived soundscape as monotonous	.001	-3.357[b]	Sterrebos
Assessment of the sound environment	.009	-2.605[b]	Sterrebos
Loudness of the sound environment	.000	-4.571[a]	Noorderplantsoen

    a.   Based on positive ranks = Sterrebos score < Noorderplantsoen score

    b.   Based on negative ranks = Sterrebos score > Noorderplantsoen score

4.2.1 Feeling of enclosure

Apart from comparing the parks, we have performed tests with the individual parks to study the influence of the individual characteristics of urban green space on soundscape perception. At first, we tested the feeling of enclosure by nature and the different variables of soundscape perception in each park. In Stadspark no significant results were obtained. However, there were just a few respondents who felt enclosed by nature, making the sample size too small for conclusions. Nevertheless, in Noorderplantsoen we obtained significant results from Spearman's rank correlations with the data about the feeling of enclosure by nature and the soundscape perception, as shown in Table 8.

Table 8: Spearman rank correlation test with the feeling of enclosure by nature in Noorderplantsoen

Noorderplantsoen – Feeling of enclosure by nature	Perceived soundscape calmness	Hearing of natural sounds
Correlation Coefficient	.263*	.273*
Sig. (2-tailed)	.028	.021
N	70	71

*. Correlation is significant at the 0.05 level (2-tailed).

The most interesting aspect in this table is that the more the respondents feel enclosed by nature, the calmer they experience their environment. These results differ slightly from earlier findings, that demonstrated that people's vision is obstructed by dense and impenetrable greenery and this has a major impact on people's perception of safety. The feeling of being enclosed by nature can lead to a feeling of insecurity. This feeling of insecurity can even amplify the noise nuisance and subsequently has a negative influence on the perception of the soundscape (Chau et al., 2018; Herzog & Chernick, 2000). Our results do not correspond to this assumption, because the feeling of unsafety and calmness are opposites.

Additionally, we performed a Spearman's rank correlation on the data about the feeling of enclosure by nature of Sterrebos. In this park respondents felt most enclosed by nature and the results were most significant, as can be seen in Table 9. Again, it is noteworthy that in general the feeling of being enclosed by nature has a positive influence on soundscape perception. For example, it contributes to a better assessment of the entire sound environment. These results also contradict earlier findings (Chau et al., 2018; Herzog & Chernick, 2000).

Table 9: Spearman rank correlation test with the feeling of enclosure by nature in Sterrebos

Sterrebos – Feeling of enclosure by nature	Hearing of traffic noise	Hearing of sounds from human beings	Hearing of natural sounds	Perceived soundscape vibrancy	Assessment of the sound environment
Correlation Coefficient	-.279*	-.245*	.476**	.253*	.416**
Sig. (2-tailed)	.020	.043	.000	.036	.000
N	69	69	69	69	67

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

4.2.2 Nature's visual dominance

When asked to what extent nature dominates your view, further significant correlations were found. In each park correlations have been found with these variable and different sounds, but in general the visual dominance of nature contributes to a better hearing of positive sounds, such as natural sounds, and to a noise reduction effect for negative sounds. The results shown in Table 10 demonstrate that the extent to which one's sight is dominated by nature contributes to the extent to which the environment is considered pleasant and calm. In addition, an environment is considered less chaotic as the degree to which nature dominates your view increases. Furthermore,

in the parks Noorderplantsoen and Sterrebos, the dominance of one's view by nature has a positive influence on the assessment of the sound environment.

Table 10: Results of the Spearman rank correlation test with the domination of your view by nature in all three parks

All three parks	Perceived soundscape pleasantness	Perceived soundscape calmness	Soundscape perceived as chaotic
Nature's visual dominance	Positive correlation	Positive correlation	Negative correlation

Again, our study did not confirm the findings of Chau et al. (2018) and Herzog & Chernick (2000), that show that spatial openness, can negatively influence an individual's soundscape perception when it is obstructed by nature. However, it is important to note that if one's vision is dominated by nature it may not necessarily mean that one's vision is actually obstructed. Nevertheless, the present study confirms earlier findings that visibility of vegetation can have a major positive influence on the overall soundscape perception (Aletta et al., 2018; Brambilla et al, 2013).

4.3 Quality and maintenance of nature

We also performed multiple spearman rank correlations to see if the quality of nature affects soundscape perception. These results showed that the quality of nature has a positive influence on many soundscape aspects that can be seen in table 11. For instance, a good quality of nature provides a good assessment of the sound environment and ensures that the sound environment is considered to be less loud.

Table 11: Spearman rank correlation test with the quality of nature in all three parks

All three parks	The quality of nature
Perceived soundscape pleasantness	Positive correlation
Perceived soundscape calmness	Positive correlation
Soundscape perceived as chaotic	Negative correlation
Soundscape perceived as annoying	Negative correlation
Assessment of the sound environment	Positive correlation
Sound environment appropriate for the place	Positive correlation
Loudness of the sound environment	Negative correlation

Finally, there are multiple spearman rank correlations performed to look at the influence of the maintenance of nature on soundscape perception. In Stadspark and Sterrebos, there are not many correlations between the maintenance of nature and the different soundscape perception variables. This is remarkable, because one might think that the assessment of nature and the maintenance of nature are closely related. However, In Noorderplantsoen, several significant correlations have been found between the maintenance of nature and the soundscape perception variables. Here the maintenance of nature has a positive influence on the soundscape perception. A good maintenance of nature creates a good sound environment that is seen as calm and pleasant instead of annoying and chaotic. This is consistent with previous studies, which say that the care of the environment is a predictor of perceived safety (Herzog & Chernick, 2000). The fact that an environment is well cared for means that there is constant supervision by an attendant and this stimulates the feeling of order and safety, which influences soundscape perception.

4.4 Summary of the comparison among the three parks

The results described earlier show that Noorderplantsoen deviates from Sterrebos and Stadspark in both green view index, greenery perception and soundscape perception. Noorderplantsoen has a lower green view index than Stadspark and Sterrebos and as a result, the view of respondents in Noorderplantsoen is less dominated by nature and respondents feel less enclosed by nature. In addition, they judge the nature of Noorderplantsoen as worse than that of Stadspark and Sterrebos.

Also, the entire soundscape of Noorderplantsoen is assessed as worse than the soundscape of Stadspark and Sterrebos. To begin with, the noise environment of Noorderplantsoen is considered worse and loudest compared to Stadspark and Sterrebos. Furthermore, the traffic sounds in Noorderplantsoen are the most dominant sounds and the sound environment in Noorderplantsoen is considered as annoying and chaotic, while the natural sounds are most dominant in Stadspark and Sterrebos, and the sound environment of these parks are experienced as more pleasant and calming.

We assume that the lower assessment of the soundscape of Noorderplantsoen in relation to Sterrebos and Stadspark may be due to the lowest quality of nature and the lowest green view index of Noorderplantsoen. However, it has to be taken into account that the lower soundscape assessment of Noorderplantsoen is partly due to the higher noise level of Noorderplantsoen.

Another key thing to remember is that people feel much more enclosed by nature than in Sterrebos than in Stadspark and Noorderplantsoen. Research demonstrated that this can negatively influence soundscape perception as well, because people feel more unsafe when their sight is obstructed (Chau et al., 2018). However, the results mentioned above do not indicate that feeling enclosed by nature has a negative influence on the soundscape perception in Sterrebos.

5. Conclusion and reflection

5.1 Conclusion

This thesis analyses the influence of different characteristics of urban green space on soundscape perception. The following three urban green spaces have been selected and compared: Stadspark, Noorderplantsoen and Sterrebos. The results show that Noorderplantsoen - the park with the lowest green view index, poorest quality of nature and where the respondents' sight is least dominated by nature - is rated significantly lower in soundscape perception. Therefore, there could be a connection between these characteristics of urban green spaces and soundscape perception. In order to further investigate this, we have conducted some tests for each park and the individual characteristics of urban green space to study the influence on soundscape perception.

Our findings show that the extent to which nature dominates your view has a positive influence on soundscape perception. To begin with, a positive correlation was found between nature's visual dominance and the perceived pleasantness in every park. These findings confirmed the findings of Brambilla et al. (2013) about the positive influence of the visibility of vegetation on the pleasantness of an environment. Additionally, a negative correlation was found between nature's visual dominance and sounds perceived as unpleasant. These results are in agreement with those obtained by Van Renterghem & Botteldooren (2016), who found that the view of vegetation can reduce self-reported noise annoyance.

Another finding of this research was the positive influence of the feeling of enclosure by nature on soundscape perception. Surprisingly, these findings do not support previous findings by Herzog & Chernick (2000), which suggest that the effect of spatial openness probably outweighs the effect of the visual connection to the greenery when one's vision is dominated and obstructed by nature and one feels enclosed by nature (Herzog & Chernick, 2000). This research only shows a positive influence of nature's visual dominance and feeling of enclosure by nature on soundscape perception.

We also discovered that the quality of nature has a major positive influence on soundscape perception. To illustrate, a positive correlation has been found between the quality of nature and perceived pleasantness of the environment in every park. These results reflect those of Echevarria Sanchez et al. (2017), who found that the visual design of an environment has a strong influence on the perceived pleasantness, with vegetated visual designs being the most pleasant. In addition, the quality of nature has a negative influence on the loudness of the surroundings. This means this research not only shows that visibility of nature has a noise reducing effect, but that the extent to which sound is reduced is influenced by the quality of nature.

Remarkable is that we did not find many significant correlations between the maintenance of nature, which is expected to be closely related to the quality of nature. Therefore, the findings of this research do not support the study done by Herzog & Chernick (2000), which argues that a well-kept environment stimulates a sense of order and safety that has a positive influence on soundscape perception.

To conclude and answer to our main research question, the characteristics of urban green spaces having most influence on soundscape perception are the extent to which nature dominates your view and the quality of nature. The more a respondent's view is dominated by good quality nature the better the soundscape perception. This means that the visibility of greenery has a major influence on soundscape perception and outweighs the negative effects such as obstructing one's vision. Therefore, urban green spaces with a higher green view index and where your view is more dominated by nature do score higher on soundscape perception. Green space features such as trees and plants can help to increase the green view index.

5.2 Future research

This research shows that the assessment of nature has a great influence on soundscape perception. For this reason, further research is needed to establish the factors that influence the assessment of the respondent's nature. For example, investigate whether the colour of greenery can have an influence. Secondly, the empirical part of this study was carried out in March. The soundscape of a park can vary from season to season; therefore, this study should be repeated in other seasons, preferably in all seasons. The final recommendation for further research is to perform statistical tests with the Green View Index. In this study, the Green View Index has only been used to compare the different parks.

5.3 Reflection

This research took place during the COVID-19 pandemic. Therefore, the surveys had to be conducted online instead of in real life in the parks, and that could have affected the soundscape perception of the respondents. Besides, all the chosen parks are rather large. This means that the sites from which the data was collected are not representative for the entire park.

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Survey questionnaire

This questionnaire is part of a bachelor project of the study Spatial planning and design, Faculty of spatial sciences at the University of Groningen. The questionnaire is about the influence of green space features on the soundscape perception. A soundscape is the acoustic environment as perceived by humans, in context. The questionnaire will be conducted anonymously, and the results of the questionnaire will only be used for this study. You need headphones or earphones for the questionnaire. The questionnaire will take 10 minutes. Thank you in advance for filling it in.

_____

This is the first block of the questionnaire. The questions in this block contain your personal characteristics.

Question 1: What is your gender?

- Female
- Male
- Rather not say

Question 2: What is your age?

Question 3: What is the highest level of education you have completed?
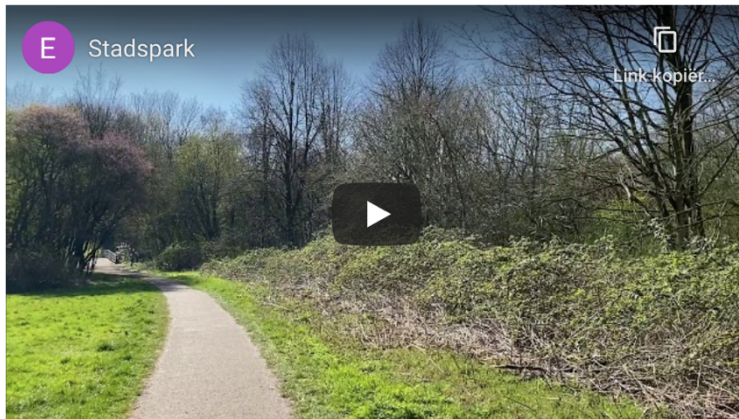
- Less than a high school diploma
- High school degree or equivalent
- Trade/technical/vocational training
- Bachelor's degree
- Master's degree
- Doctorate (e.g. PhD, EdD)
- Other

_____

Before we start with the second part, first a quick calibration. Go to the following site: https://hearingtest.online. Listen to the calibration file under section 1: "Calibrate your sound levels". Put on your headphones or earphones and listen to the calibration file. Take your headphones off and bring your hands to your nose. Rub your hands firmly and compare it to the loudness of the fragment. Put your headphones back on again and adjust your sound level so that both levels match: the calibration file through your headphones, and your hands rubbing, without headphones.

_____

This is the second part of the questionnaire. This part consists of three sections. At the beginning of each section, you will see a video. While watching the video, try to listen carefully to the sounds and look at the images and imagine yourself in that space. After seeing each video, you will answer questions about the video.

Question 4: To what extent do you hear the following type of sound sources?

Traffic noise (e.g., cars, buses, trains, airplanes)

- o   Not at all
- o   A little
- o   Moderately
- o   A lot
- o   Dominates completely

Other noise (e.g., sirens, construction, industry, loading of goods)

- o   Not at all
- o   A little
- o   Moderately
- o   A lot
- o   Dominates completely

Sounds from human beings (e.g., conversation, laughter, children at play, footsteps)

- o   Not at all
- o   A little
- o   Moderately
- o   A lot
- o   Dominates completely

Natural sounds (e.g., singing birds, flowing water, wind)

- o   Not at all
- o   A little
- o   Moderately
- o   A lot
- o   Dominates completely

Question 5: For each of the 8 scales below, to what extent do you agree or disagree that the surrounding sound environment is …

Pleasant

- o   Strongly disagree
- o   Somewhat disagree
- o   Neither agree nor disagree
- o   Somewhat agree
- o   Strongly agree

Chaotic

- o   Strongly disagree
- o   Somewhat disagree
- o   Neither agree nor disagree
- o   Somewhat agree
- o   Strongly agree

Vibrant

- o   Strongly disagree
- o   Somewhat disagree
- o   Neither agree nor disagree
- o   Somewhat agree
- o   Strongly agree

Uneventful

- o   Strongly disagree
- o   Somewhat disagree
- o   Neither agree nor disagree
- o   Somewhat agree
- o   Strongly agree

Calm

- o   Strongly disagree
- o   Somewhat disagree
- o   Neither agree nor disagree
- o   Somewhat agree
- o   Strongly agree

Annoying

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Eventful

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Monotonous

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Question 6: Overall, how would you describe the surrounding sound environment?

- o Very bad
- o Bad
- o Neither good, nor bad
- o Good
- o Very good

Question 7: Overall, to what extent is the surrounding sound environment appropriate to the present place?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Perfectly

Question 8: How loud would you say the sound environment is?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Extremely

Question 9: From a visual point of view, how would you rate the nature in this place?

- o Very bad
- o Bad
- o Neither good, nor bad
- o Good
- o Very good

Question 10: How much would you say the nature dominates your point of view?

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

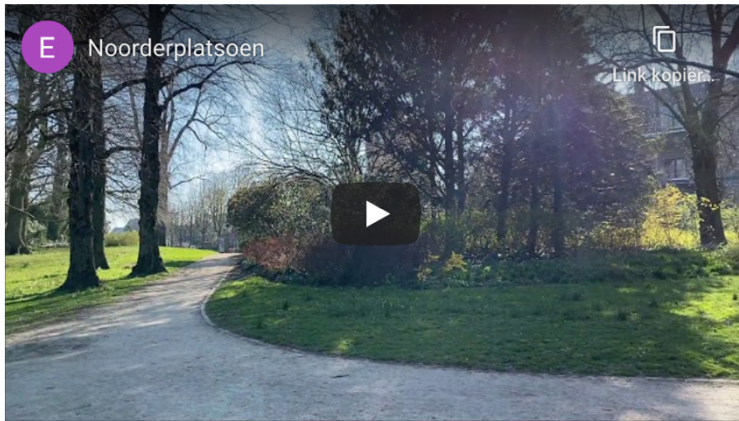Question 11: How much do you feel enclosed by the greenery?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Extremely

Question 12: In your opinion, is the nature in this area well kept?
- o Not at all
- o Slightly
- o Moderately
- o Very
- o Perfectly

Question 13: Which green space feature(s) dominates the most? (Multiple answers are possible)

- ▪ Trees
- ▪ Grass
- ▪ Shrubs
- ▪ Hedges
- ▪ Plants

_____

Question 14: To what extent do you hear the following type of sound sources?

Traffic noise (e.g., cars, buses, trains, airplanes)

- ○ Not at all
- ○ A little
- ○ Moderately
- ○ A lot
- ○ Dominates completely

Other noise (e.g., sirens, construction, industry, loading of goods)

- ○ Not at all
- ○ A little
- ○ Moderately
- ○ A lot
- ○ Dominates completely

Sounds from human beings (e.g., conversation, laughter, children at play, footsteps)

- ○ Not at all
- ○ A little
- ○ Moderately
- ○ A lot
- ○ Dominates completely

Natural sounds (e.g., singing birds, flowing water, wind)

- ○ Not at all
- ○ A little
- ○ Moderately
- ○ A lot
- ○ Dominates completely

Question 15: For each of the 8 scales below, to what extent do you agree or disagree that the surrounding sound environment is …

Pleasant

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Chaotic

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Vibrant

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Uneventful

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Calm

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Annoying

- o Strongly disagree
- o Somewhat disagree

- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Eventful

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Monotonous

- Strongly disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Strongly agree

Question 16: Overall, how would you describe the surrounding sound environment?

- Very bad
- Bad
- Neither good, nor bad
- Good
- Very good

Question 17: Overall, to what extent is the surrounding sound environment appropriate to the present place?

- Not at all
- Slightly
- Moderately
- Very
- Perfectly

Question 18: How loud would you say the sound environment is?

- Not at all
- Slightly
- Moderately
- Very
- Extremely

Question 19: From a visual point of view, how would you rate the nature in this place?

- Very bad

- Bad
- Neither good, nor bad
- Good
- Very good

Question 20: How much would you say the nature dominates your point of view?

- Not at all
- A little
- Moderately
- A lot
- Dominates completely

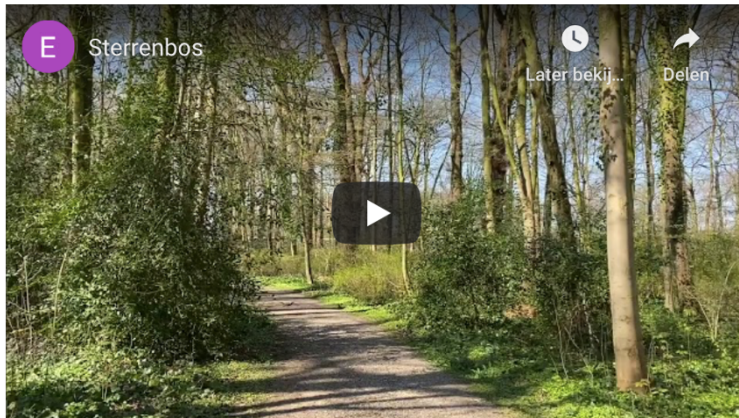Question 21: How much do you feel enclosed by the greenery?

- Not at all
- Slightly
- Moderately
- Very
- Extremely

Question 22: In your opinion, is the nature in this area well kept?
- Not at all
- Slightly
- Moderately
- Very
- Perfectly

Question 23: Which green space feature(s) dominates the most? (Multiple answers are possible)

- Trees
- Grass
- Shrubs
- Hedges
- Plants

_____

Question 24: To what extent do you hear the following type of sound sources?

Traffic noise (e.g., cars, buses, trains, airplanes)

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

Other noise (e.g., sirens, construction, industry, loading of goods)

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

Sounds from human beings (e.g., conversation, laughter, children at play, footsteps)

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

Natural sounds (e.g., singing birds, flowing water, wind)

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

Question 25: For each of the 8 scales below, to what extent do you agree or disagree that the surrounding sound environment is …

Pleasant

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Chaotic

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Vibrant

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Uneventful

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Calm

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Annoying

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Eventful

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Monotonous

- o Strongly disagree
- o Somewhat disagree
- o Neither agree nor disagree
- o Somewhat agree
- o Strongly agree

Question 26: Overall, how would you describe the surrounding sound environment?

- o Very bad
- o Bad
- o Neither good, nor bad
- o Good
- o Very good

Question 27: Overall, to what extent is the surrounding sound environment appropriate to the present place?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Perfectly

Question 28: How loud would you say the sound environment is?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Extremely

Question 29: From a visual point of view, how would you rate the nature in this place?

- o Very bad
- o Bad
- o Neither good, nor bad
- o Good
- o Very good

Question 30: How much would you say the nature dominates your point of view?

- o Not at all
- o A little
- o Moderately
- o A lot
- o Dominates completely

Question 31: How much do you feel enclosed by the greenery?

- o Not at all
- o Slightly
- o Moderately
- o Very
- o Extremely

Question 32: In your opinion, is the nature in this area well kept?
- o Not at all
- o Slightly
- o Moderately
- o Very
- o Perfectly

Question 33: Which green space feature(s) dominates the most? (Multiple answers are possible)

- ▪ Trees
- ▪ Grass
- ▪ Shrubs
- ▪ Hedges
- ▪ Plants

_____

Appendix B

Calculating green view index

Sterrebos	Total number of pixels	Pixels of the road	Pixels of the air	The number of green pixels
Photo 1: Front view	12192768	3069745	1596081	12192768 – 4665826 =7526942
Photo 2: Left side-view	12192768	1150560	1324150	12192768 – 2474710 = 9718058
Photo 3: Right side-view	12192768	1707006	1286585	12192768 – 2993591 = 9199177

Stadspark	Total number of pixels	Pixels of the road	Pixels of the air	The number of green pixels
Photo 1: Front view	12192768	953590	3400147	12192768 – 4353737= 7839031
Photo 2: Left side-view	12192768	327242	4637588	12192768 – 4964830 = 7227938
Photo 3: Right side-view	12192768	862715	2798097	12192768 – 3660812 = 8531956

Noorderplantsoen	Total number of pixels	The number of green pixels
Photo 1: Front view	12192768	4830697
Photo 2: Left side-view	12192768	6146833
Photo 3: Right side-view	12192768	9495130

Green view index Noorderplantsoen = 20472660/36578304 = 0,55969407
0,55969407 x 100 = 55,9694074 = 56%

Green view index Stadspark = 23598925/36578304 = 0,64516182
0,64516182 x 100 = 64,5161815 = 65%

Green view index Sterrebos = 26444177/36578304 = 0,72294705
0,72294705 x 100 = 72,2947051 = 72%