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Towards the assessment of soundscape and urban morphological parameters at four market squares. Case study: city of Groningen.

[BACHELOR THESIS]

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Abstract

The main objective of this research is to study the relation between the sound perception at market squares in the city of Groningen and how these are influenced by the urban morphology. Scientific research shows sound perception is of big influence on people's experience of the environment and is also seen as a determining factor concerning their quality of life. It is therefore of relevance to study the influence of the urban morphology on the sound perception. In order to investigate this relation several methods have been applied. First of all questionnaires have been conducted at four market squares in the city of Groningen. In addition, sound level measurements have been executed simultaneously with the questionnaires. At last, a GIS analysis has been used to indicate the urban morphological indices. The sound level measurements show a variation of the equivalent continuous sound level. Further, the questionnaires provide knowledge about the average value of the sound and visual perception and show they differ from square to square, likewise the urban morphological parameters. The datasets are analysed and linked, leading to better insight regarding a possible relation between the sound and visual perception. In answer to the research question, the statistical tests do not show a significant result. This indicates there is no linear relation found between urban morphology and sound perception at market squares in Groningen.

Content

1. Introduction

1.1 Background

An increasing amount of people lives in urban areas: currently even up to 55% of the total world population. According to United Nations, Department of Economic and Social Affairs, Population Division (2019) this percentage in Europe, measured in 2018 is 74 %, which is even higher than the expected global average. This high number emphasizes the need to study and investigate the design of cities, in order to secure the liveability for its citizens.

In order to create a pleasant and enjoyable city with a high quality of life, the urban design process should not only focus on the visual aspects, but also on the acoustic environment (Rehan, 2016), commonly referred to as the urban soundscape. Rehan (2016) claims that the urban soundscape is of importance to the quality of city life, promoting for example, well-being, comfort, enjoyment and excitement. In some situations, sounds are even needed to give a vibrant character to the area. The soundscape of modern cities however, is becoming an increasing problem, and low soundscape quality, noise pollution, can be perceived negative (Southworth, 1970), the urban soundscape can have a severe impact on our health (Rehan, 2016). Further, the perception of sound in the city does not only depend on the equivalent continuous sound level, (Leq) but also on several sound source parameters (see section 2 'Theoretical Framework). In addition to Rehan's research, Hong and Jeon (2007) found proof that reducing the Leq does not automatically result in a pleasant sound perception. When addressing the sound perception it is important to take all sound sources into account (Yang & Kang, 2005). Apart from the variety of sound sources, the visual environment is of influence on the sound perception as well (Hong & Jeon, 2017). According to Zhou (2008), the visual perception determines over 60% of how people perceive their environment. Moreover, the perceived sound can differ per environment. Environments such as cities, neighbourhoods and squares are all differently designed, all with their own spatial structure, commonly referred to as urban morphology (Hong & Jeon, 2017). Since the visual perception is influencing the soundscape it is relevant to investigate this relationship and determine the impact of urban morphology on the quality of life in an urban area.

1.2 Research problem

The city of Groningen with over 200.000 inhabitants, a car-free city centre (Nicholson Lord 1993), and a vibrant city life, produces a lot of urban sounds; for example market vendors selling fruit and vegetables, busses, cyclists; and more. Some of these sounds might be experienced as noise pollution, others might be experienced as pleasant. As mentioned before, whether a sound is perceived as pleasant or not, depends not only on the sound source and the sound pressure level, but also on the visual environment (He et al. 2018). Urban morphology has a significant influence on soundscape appraisal. In order to draw conclusions about people's sound perception, the influence of urban morphology needs to be studied by conducting research on the influence of the urban morphology on the soundscape.

The central research question is:

'How does the urban morphology of different market squares in the city centre of Groningen, influence the pleasantness of the soundscape perceived by passers-by?'

In order to answer this research question the following sub-questions need to be answered.

1. *What is the Leq variation at the four different squares?*
2. *To what extent are the sound and visual perception affected by the Leq levels at the four different squares?*
3. *What is the correlation between the visual stimuli and the sound perception at the four different squares?*
4. *How are the urban morphological parameters of influence on the sound perception at the four different squares?*

1.3 Research objectives

The aim of this research is to investigate the influence of urban morphology on the sound perception by people, specifically focused on market squares in the city centre of Groningen. Since a positive sound perception increases the quality of life, better knowledge regarding the linkage between urban morphology and soundscape will be gained as a result of this research. Hence a deeper understanding of the soundscape in Groningen is generated and could eventually be used for future spatial planning policy.

1.4 Thesis structure

The second chapter of this research describes the theoretical framework on which this research is based. Previous research and academic articles are discussed in order to compare relevant methods, theories, and concepts. The third chapter introduces the conceptual framework in which the earlier discussed theories and concepts schematically are presented and clarified. The applied research methods, used to answer the research question, are elucidated in chapter four, followed by the results of the data collection in chapter five. Finally a conclusion based on the results, in the broader context of the theoretical framework, is drawn in the sixth chapter. The thesis ends with a short reflection on this research and recommendations for possible further research.

2. Theoretical framework

This chapter clarifies concepts and theories in order to answer the research question in a science based way. This implies the concepts of soundscape and urban morphology including the parameters used in the data collection. As this research focuses on market squares the features of these spatial areas are clarified in the theoretical framework as well.

Soundscape

The concept of soundscape has been introduced by R. Murray Schafer in 1977 (He et al. 2018). Ever since, this concept has been defined differently in various academic articles. However, the International Organization for Standardization (ISO, 2018) has formulated one general definition: ''the acoustic environment as perceived or experienced by and/or understood by a person or people, in context''. What stands out in this definition is the importance of the perception. It clearly emphasizes the sounds and their perception in any given environment. The sound source parameters used in this research have been determined by the ISO (2018) and adjusted to the case study of Groningen: motorised traffic; human movement; construction sounds; voices and instruments; natural sounds and social/ communal sounds (for a schematic overview see section 3). The sound source categories not included in this research are considered irrelevant since they would not be noticeable in the city centre of Groningen, due to absence of the producers of these specific sounds. Examples of sound sources not included are rail traffic, marine traffic, and air traffic.

In some cases the total combination of sound sources is perceived as a background stressor. Miedema (2007) discusses the concept of environmental noise and the annoyance it causes. According to his study, as well as the research conducted by Rehan (2016), environmental noise is widespread across urban areas and affects human well-being and health. Noise in cities therefore has become a growing problem (Southworth, 1970). Brambilla, Gallo and Zambon (2013) lift the issue of noise control to a higher level by stating that this has to be addressed in a holistic way, and therefore stressing the relationship between the soundscape and living environment.

Urban morphology

Another important concept for this research is urban morphology. Kropf defines this as follows: ''the urban morphology refers to the shape of a city, including its architecture, layout of streets, and different densities of habitation'' (Kropf, 2009, p. 108). Academic literature refers to urban morphology in many different aspects. Hong & Jeon (2017) link the urban morphology to soundscape. Their central claim is that ''the urban morphology provides useful knowledge to understand the spatial structure and character of an urban environment'' (Hong & Jeon, 2017 p. 383). The urban morphological parameters, and therefore also the visual environment, have an influence on people's expectations with regard to sound sources, present at different land use areas (Brambilla, Gallo and Zambon 2013). This implies the importance of urban morphology and justifies including this as a variable to this research. In order to quantify the parameters, they are, according to the article by Hong & Jeon (2017) classified into four groups: (1) buildings; (2) exposed ground and road surfaces; (3) green and open public areas; and (4) water features.

Market squares

While in the data gathering process of Hong & Jeon (2017) varying land-use areas have been investigated, this research focuses specifically on market squares as case study sites, with resembling land-use functions. In this research a market square is defined as a place where people gather to, for example, go to the market and visit the surrounding shops. Squares with other land use functions, such as a parking lot or roundabout, are not included in this research. In addition, the squares used for this research are all located in the inner city or directly to the canals.

In the past, several studies have investigated soundscape. However, they are often either not linked to urban morphology or based on a case study site very different to the situation in Groningen. As mentioned earlier, Groningen has a car-free city centre which results in a different urban morphology and set of sound sources, opposed to car friendly city centres, as present in the mainstream European cities. Moreover, Groningen's urban morphology differs significantly from, for example, Seoul, one of the case study sites used in other research. The results obtained by other researchers are therefore not applicable to the city of Groningen. This research will be a new approach of this field of study, adding value to the existing research literature.

3. Conceptual model

In table 3.1 the conceptual model is schematically illustrated. The urban morphology of market squares is the independent variable; soundscape is the dependent variable, meaning that the soundscape pleasantness of the sound sources will depend on all different parameters categorized under 'urban morphology'. The sound sources are the moderator variable and may affect the strength of the relationship between urban morphology and soundscape.

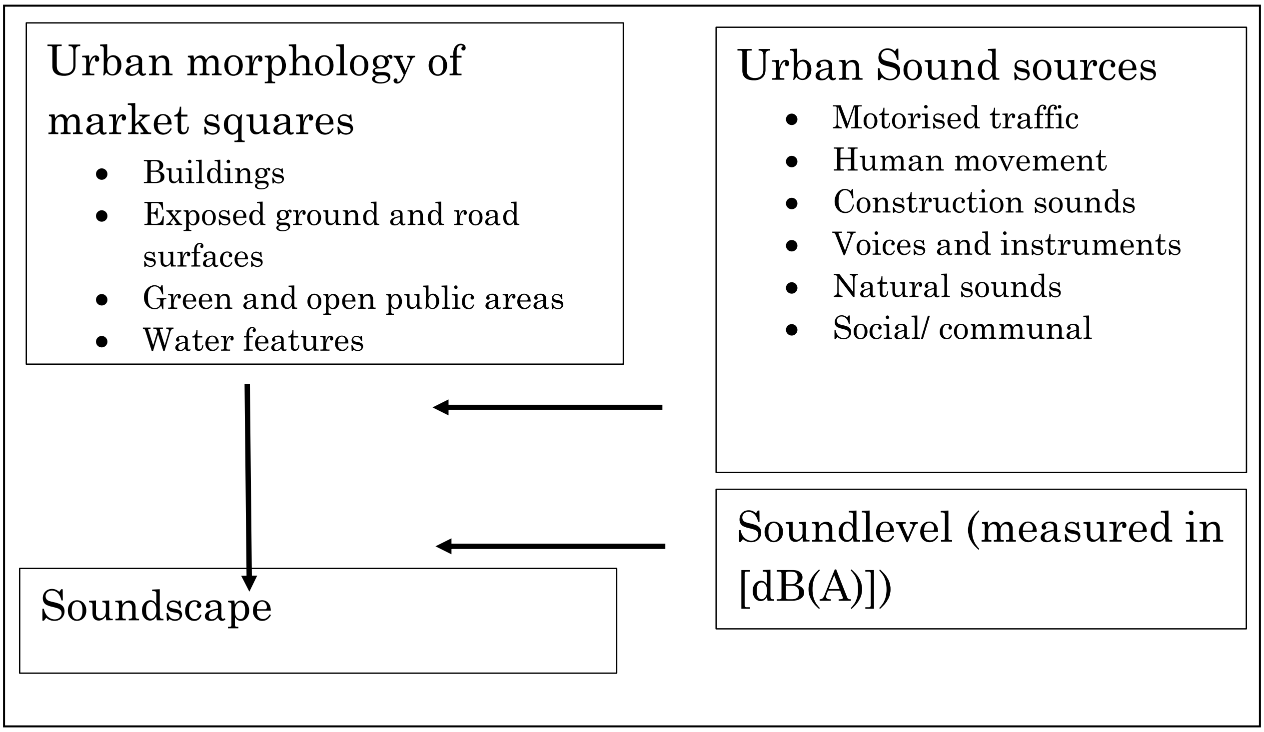

Table 3.1 Conceptual Model

4. Methodology

In the first section of this chapter the case study sites are introduced, including reasons and criteria for these choices. Second, the data collection instruments are described in relation to this research and the research questions.

4.1 Case study sites

As stated in the research question, this research is focused on four market squares in the city center of Groningen: the Grote Markt; ;Vismarkt; Ossenmarkt and Westerhaven.
The four case study sites are all of about the same size and the actual sound level is expected

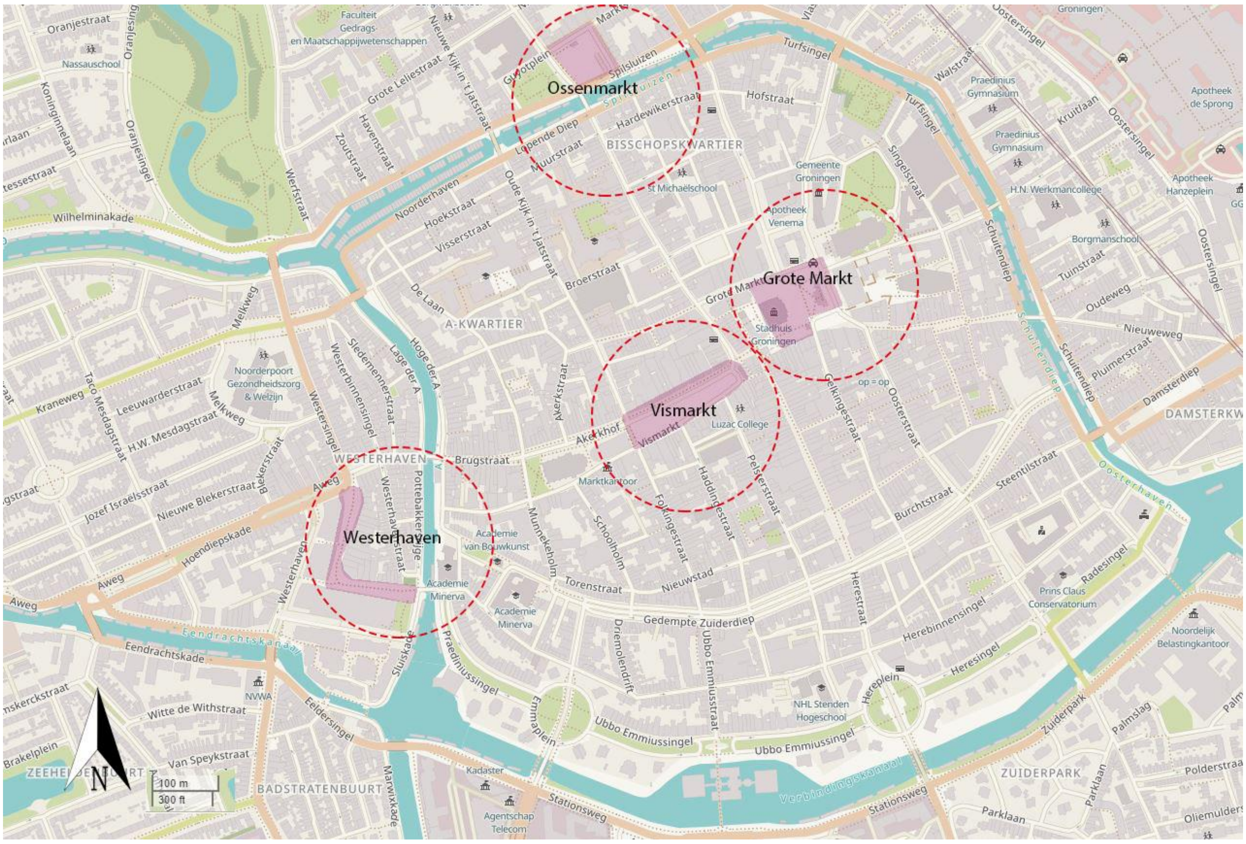

Figure 4.1 Map with an overview of the market squares

to be approximately similar. Other squares such as the Emmaplein and Hanzeplein in Groningen were not included in this research because their land use function do not match with the definition mentioned in the theoretical framework (chapter 2). Moreover, the Sontplein is less suitable for this study, since the square is located outside the area defined in the theoretical framework.

Apart from the similarities the urban morphology of the four squares differs considerably, which is of additional value to this research. To get an impression of the varying urban morphology at the squares a panorama picture of each square has been taken (see fig. 4.2a – 4.2d)

Figure 4.2a Vismarkt


Figure 4.2b Ossenmarkt


Figure 4.2c Westerhaven


Figure 4.2d Grote Markt

4.2 Data collection instrument and analysis

In this section the data collection instruments are explained and the relation between the sub-questions is clarified.

The data for this research is collected by:

1) Using a decibel meter to obtain the sound levels at the case study areas;
2) Conducting on-site questionnaires to measure the pleasantness of the soundscape, perceived by the respondents.
3) Carrying out a GIS analysis to quantify the urban morphological indices.

4.2.1 Sound level measurements

First, at the four market squares the sound level is measured by using a decibel meter (in [dB(A)]), the Voltcraft SL 451. The analysis of the sound levels is used in order to answer the first and second sub question. However, for the second sub question not only the sound level data is used, but also the data obtained by the questionnaires. This will therefore be discussed in 4.2.2.

At each square the measurements are performed simultaneously with the questionnaires, which means that the days at which the sound measurements are conducted are working days (e.g. Monday until Friday), from 9 o'clock until 16 o'clock, one day for the data collection at each market square. Since there is a significant difference between daytime and night time in terms of activities, the focus of this research is on the day time situation. In this way, varying circumstances with a significant influence, such as the audible sounds and people's mood, are avoided. Note that data was not collected during market days (Tuesday, Friday and Saturday), but only on days which represent the situation during the majority of the week. Thence, by taking these possible factors of influence into account, the quality of the collected data is guaranteed as much as possible and bias caused by possible changes as a result of a changing environment, is avoided.

In addition to the considered choice for the data collection days, the time frame during which the sound measurements have been conducted has been set consciously, with eye on consistency and representativeness, to avoid bias. Since the sound levels may not only vary per day, they vary during the day as well. It is therefore of importance to execute several measurements throughout the day and eventually calculate the equivalent continuous sound pressure level (Leq). The sound level measurements have been executed every hour during a five-minute time frame, in order to get a reliable result, with a two-minute time frame to be the minimum according to the ISO (2018). The measurements have not been executed starting at every full hour because of the hourly bell stroke, ringing at exactly this moment. This would influence the results significantly and is not representative for the entire hour. Instead, the measurements started at five minutes past the hour until ten minutes past the hour. During this period the measurement have been taken with a 1 second interval. Further, in order to avoid bias and gain a good representation of reality, every sound measurement has been conducted at another spot at the square. This way, the possible influence of one specific sound source, located at one site of the square will be reduced. In addition, the Leq is calculated by using the following formula: $Leq = 10log_{10}\left(\frac{1}{T_M}\int_Q^{T_M}\left(\frac{P(t)}{P_0}\right)^2 dt\right)$ This formula shows how the average of the logarithmic dB(A) scale can be computed. By using this formula and analysing the data, the equivalent level for every research hour as well as the entire day is obtained. As a result of the analysis the sound distribution throughout the day is generated. This results in quantitative data which contributes to providing an answer to both the first and second sub-question (see section 5.1 and 5.2).

4.2.2 Questionnaires

As a second data collection method, on-site questionnaires (see, 'Appendix 1') have been distributed. At each square passers-by were asked to fill in a questionnaire regarding their perception of both the sound and visual environment of the square. However, before the respondents get to these questions, more general questions, regarding for example their age and gender, have been asked in order to get a profile of the respondent. Subsequently, the respondents are asked about the activities they carry out, with what reason they visit the square and their hearing ability. These different factors might have an influence on the result and are therefore of relevance. An example of one of these questions:

- What is the reason of your visit to this square?
  - I need to be here
  - It is part of my route

Sound source related questions are included in the questionnaire as well. It is likely that both the urban morphology and sound sources influence the respondents perception. Therefore, respondents were asked to specify the sound sources at the given moment, by choosing from a list of 11 different sources. They had to point out the three most prevalent sound sources, whether they perceive them as 'pleasant', 'unpleasant' or 'neither pleasant nor unpleasant' and to what extent they are present. The same scale as used by Hong & Jeon (2017) was applied. In their research respondents had to indicate the dominance of the sound sources according to the following categories: 'not heard at all'; 'heard a little'; 'heard moderately'; 'heard a lot'; 'sound dominates completely'. However, in this research the first category was left out, because the respondents were asked to only fill out this question for the three most prevalent sound sources. Besides the earlier mentioned questions, the respondents were also asked about how they value the sound and visual perception and indicate this on a Likert scale. An example of these questions is shown beneath:

- How do you value the overall sound perception at this square?
  Value your experience on a scale of 1 to 10; with 1 being unpleasant and 10 pleasant

In order to obtain a sufficient sample size, a minimum of 30 respondents had to fill in the questionnaire at each square. Both the sample size and the consistent times at which the questionnaires were conducted, guarantee the quality of the data and avoid possible bias. Besides, in order to prevent any ethical dilemmas people need to feel comfortable when they are answering questions and they need to have the feeling they can say everything they want. Thus, their answers are treated confidentially and are solely used for this research. The respondents are made aware of this in a consent form, which they got to read prior to the questionnaire.

The collected data has been analysed in order to answer the second and third sub question (section 5.2 and 5.3). The second sub question focuses mainly on the sound level measurements, combined with the average value of the visual perception, obtained by the questionnaires. The third sub question studies the relation between the visual stimuli and the sound perception and is purely based on the outcomes of the questionnaires.

4.2.3 GIS analysis

At last, the urban morphological indices of the four different squares have been determined by using Geographical Information Systems (GIS). This analysis has been executed in order to answer the fourth sub question. To obtain the necessary results the *Basiskaart Grootschalig Topografie (BGT)* has been used for the urban morphological parameters, the dependent variable of this research. For each square the coverage ratio for all urban morphological parameters has been counted. This means, for example, the percentage of 'Green and open public areas' of the total area at that specific market square. For this research a 20-meter buffer has been applied, which has been determined by using the maximum distance between the visible buildings and the borders of the square. Since the respondents of the questionnaires, were asked about their visual perception it is necessary that all of these buildings, visible from the square, are included in the analysis. Opposed to other research (Wang & Kang, 2011), this research merely looks at the 2D model of the city.

In order to draw conclusions regarding the fourth sub question, a Pearson's correlation test has been executed, using SPSS.

5.Results

In this chapter the results are discussed in the context of the theory and linked to the four sub-questions (see '1.2 research problem'*)*. The collected data is analysed according to the earlier mentioned methods (see '*4,3* data analyses'), in order to acquire insight into what information the data provides and how this information relates to the research question. First, in section 5.1 the Leq variation will be discussed. Second, both the sound perception as well as the visual perception are analysed, in relation to the Leq. The correlation between the sound perception and the visual perception are analysed in section 5.3, to find out how these variables are related to each other. Lastly, in section 5.4 the urban morphological parameters are linked to the average levels of sound perception at the four different squares. The obtained results give a clear overview of the data and ensures that the research question can be answered in the conclusion.

5.1 Leq variation

As mentioned in section 4.2 'data collection instrument', sound measurements are executed at each research location. Analysis of the dataset shows the Leq for each hour. Additional, the Leq for each day is calculated in order to get an idea of the average sound level at each of the four market squares. These results help to answer the first sub-question, regarding the Leq variation.

Figure 5.1 shows the sound level distribution for every research location. The graph provides an overview of the relative differences at each square, during different time periods. It is clear from this graph that the sound distribution during the day is different per square. How the sound level (measured in [dB(A)]) increases and decreases throughout the day is different for each square. Similar for the four research locations is the relation between the sound level at the beginning of the day and the sound level measured in the afternoon, in all four cases the measured sound level is lower at the end of the day compared to the measured sound level at the beginning of the day. There is no general explanation for this phenomenon. However, for the Grote Markt, Vismarkt and Westerhaven this can be explained by so-called '*venstertijden*' (literally translated: 'window times'), which allows cars and trucks to enter the inner-city until 12 o clock. Afterwards the access for cars and trucks is prohibited. This is reflected in the table where the sound level either decreases or continues at the same level, without any increase. Since the Ossenmarkt is located outside the city centre, cars are allowed to pass this square throughout the entire day and therefore the just mentioned explanation is not applicable to this square. However, a possible explanation for the difference in the measured sound level during the morning and afternoon for this Ossenmarkt, is the construction work which was noticeable during the first hour.

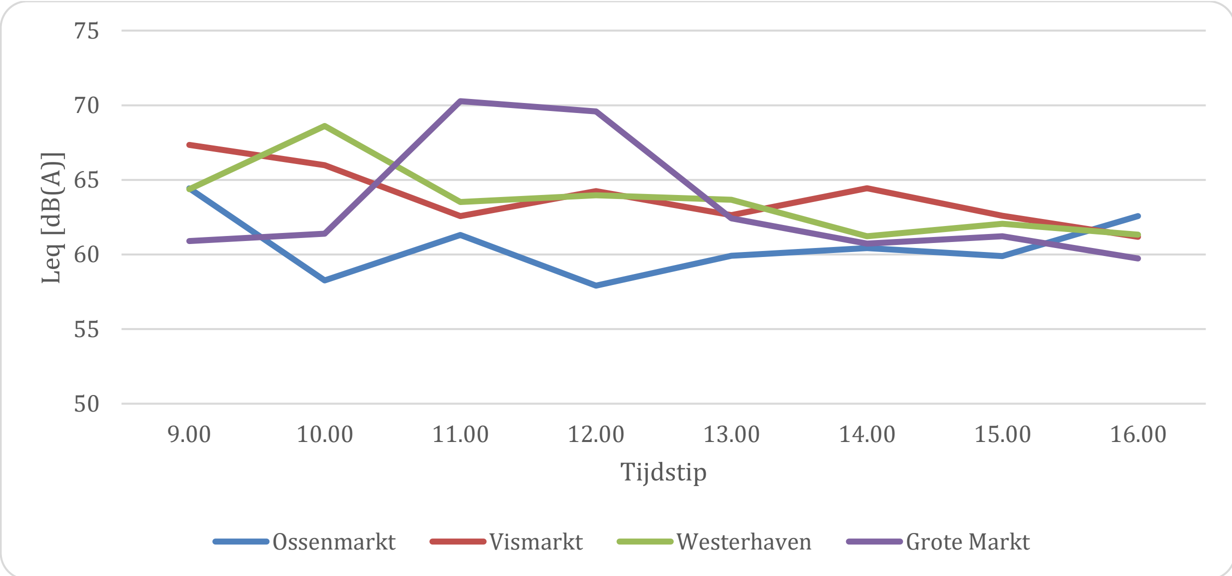

Figure 5.1 Sound level distribution

Moreover, a second analysis using the same formula as before shows the equivalent sound level of each day. The Leq's, differ from square to square (see table 5.1). However, they are all within the same range: 55-75 dB(A). At the Ossenmarkt the Leq is measured as the lowest with 61,09 dB(A). The Leq of both the Vismarkt and Westerhaven are slightly higher, with a difference of only 0,49 dB(A) between the two. The Leq at the Grote Markt, on the other hand, is with 74,40 dB(A) much higher than at any other square.

In addition, these results and the differences between the results are discussed to get an idea of how the four squares relate to each other. First of all, the relatively high Leq measured at the Grote Markt is outstanding and can possibly be lead back to the measured sound level at 11.00 o'clock and 12.00 o'clock. Both sound levels are notably higher than the sound levels at the other times. This is possibly caused by activities undertaken by visitors of the market square. Apart from the regular visitors, employees are visiting the square around 11.00 o'clock and 12.00 o'clock as well. It is likely that they go for a walk during their lunch break. This may add to the Leq and is a possible explanation for the measured peak. Though, whether this is indeed the correct reason cannot be said with 100% certainty.

Time	Ossenmarkt	Vismarkt	Westerhaven	Grote Markt

9.00	64,4	67,3	64,4	60,9
10.00	58,2	66,0	68,6	61,4
11.00	61,3	62,6	63,5	70,3
12.00	57,9	64,2	64,0	69,6
13.00	59,9	62,6	63,7	62,4
14.00	60,4	64,4	61,2	60,7
15.00	59,9	62,6	62,1	61,2
16.00	62,6	61,1	61,3	59,7
Equivalent level_Day	**61,1**	**64,3**	**64,8**	**74,4**

Tabel 5.1 Noise level (in [dB(A)]) overview including equivalent level per day

In section 5.2 the Leq is plotted against the pleasantness of the sound perception as well as the pleasantness of the visual perception.

5.2 The sound and visual perception affected by Leq levels

In order to get a better idea of the situation at the four market squares and to provide an answer to the second sub question, regarding the extent to which the sound and visual perception are affected by the Leq level, the quantitative sound measurements are analysed in combination with the subjective results concerning the sound and visual perception. The average value of the sound and visual perception are retrieved by conducting questionnaires. This section starts with an analysis of these questionnaires. Additionally, the relation between the Leq level, analysed in the previous section, and the average sound and visual perception values is analysed.

The questionnaires were conducted at the four market squares. At each market square a sufficient number of at least 30 respondents was obtained, which resulted in an entire dataset consisting of 164 respondents. By analysing the questionnaires the average value per square of the sound and visual perception is obtained. In table 5.1 an overview of the Leq level, the average sound perception and the average visual perception is provided. Figure 5.2 and 5.3 show the same data in a graph.

Square	**Leq**	**Sound perception**	**Visual perception**
Ossenmarkt	61,1	6,5	5,8
Vismarkt	64,3	6,5	6,3
Westerhaven	64,8	6,8	6,7
Grote Markt	74,4	6,0	6,3

Table 5.1 Overview Leq; sound perception and visual perception per market square

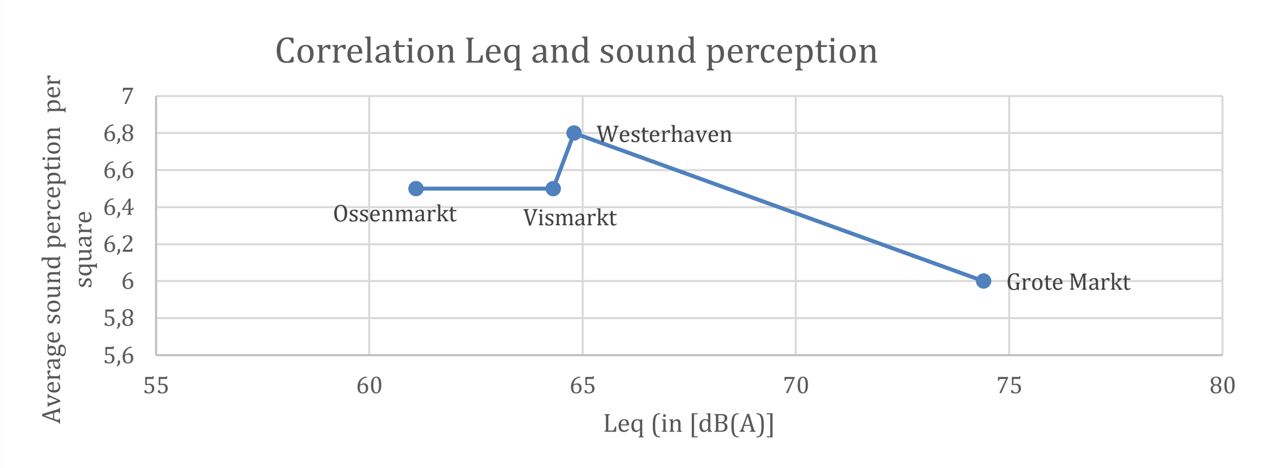

Figure 5.2 Relation Leq and average sound perception value per market square

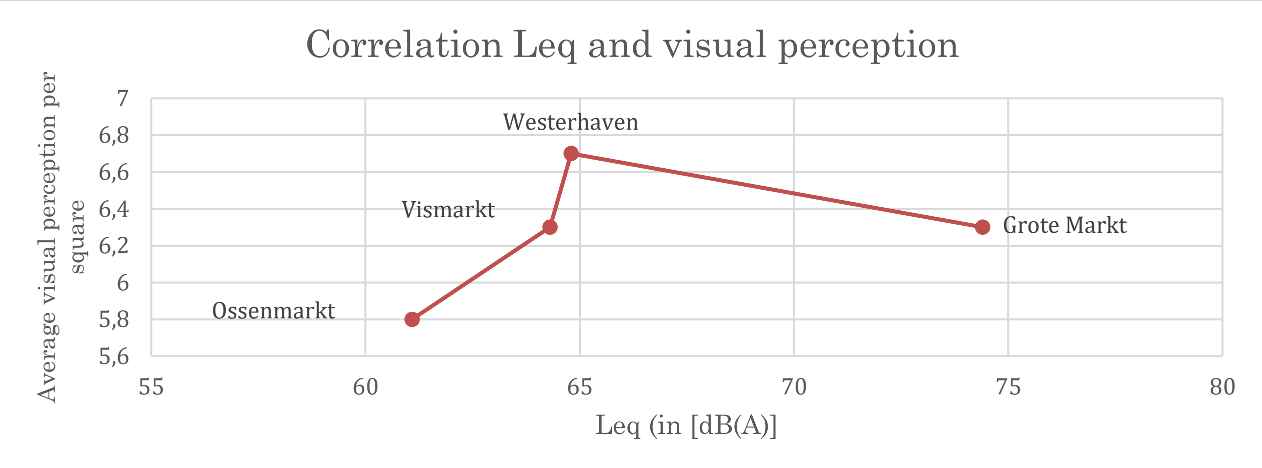

Figure 5.3 Relation Leq and average sound perception value per market square

The average perception values are varying from square to square and a low value of the average sound perception does not necessarily imply a low value of the average visual perception. Possible explanations for the differences and variation in terms of these two variables are discussed here as well as in section 5.3 and 5.4.

By analysing the Leq at the different squares together with the average value of the sound perception and the visual perception, the relation between these variables gets clearer. First of all, at the Grote Markt a Leq of 74,4 dB(A) was measured, and therefore has the highest Leq of all four squares. Besides, with a 6,0 the sound perception was valued lowest. According to this effect a possible statement could be the following: a higher sound level results in a lower pleasantness of the sound perception. However, since there is no linear relationship between these two variables, any given change of the Leq level does not necessarily cause a corresponding change of the visual perception. Thus, the previous statement has to be rejected.

Further, at the Westerhaven, with a 6,8, the average sound perception was valued highest, as well as the visual perception, which was valued with a 6,7. This assumes a positive correlation between the visual stimuli and the sound perception. On the other hand, where at the Grote Markt the average visual perception is, with a 6,3, relatively high, the sound perception has scored lowest of all four market squares. This implies a negative correlation between the two variables and therefore, in answer to the second sub question, it is not possible to say to what extent the sound perception and visual perception are affected by the Leq. Section 5.3 examines the correlation between the visual stimuli and the sound perception.

5.3 Correlation between the visual stimuli and the sound perception

In this section the questionnaires are analysed using statistical tests (for the complete output tables see 'Appendix 2') in order to answer the third sub question regarding the correlation between the visual stimuli and the sound perception at the four different squares. The squares are analysed using a linear regression analysis. This determines the strength of the correlation between the variables. However, this section starts with an overview of the respondents profile generated per square.

Figure 5.4 and 5.5 show the information about the respondents at the Ossenmarkt where a total of 41 respondents filled out the questionnaire.

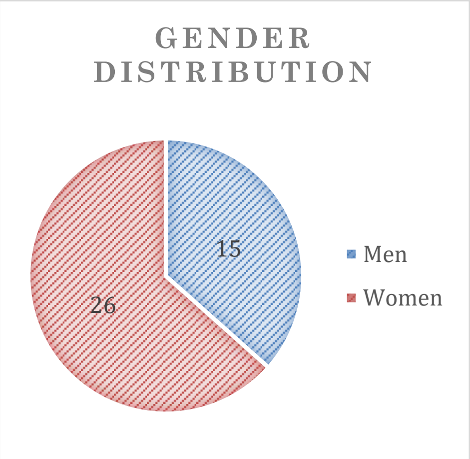

Figure 5.4 Gender distribution of respondents at the Ossenmarkt

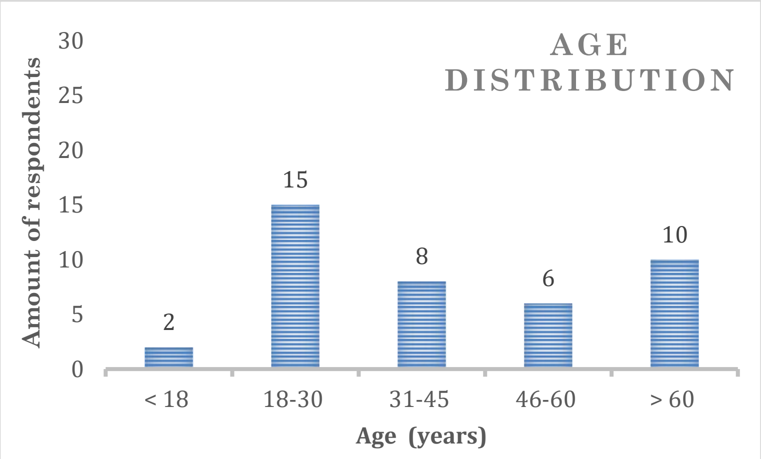

Figure 5.5 Age distribution of respondents at the Ossenmarkt

At the Vismarkt the sample size consists of 44 respondent. Figure 5.6 and 5.7 show how the sample is build up in terms of gender and age.

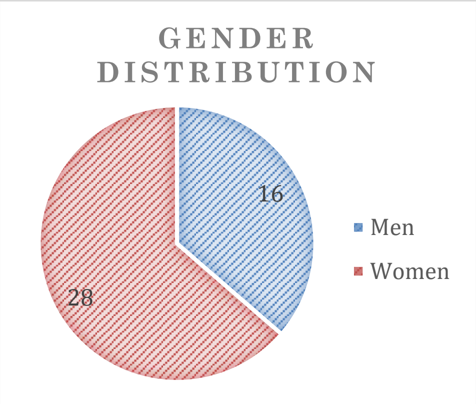

Figure 5.6 Gender distribution of respondents at the Vismarkt

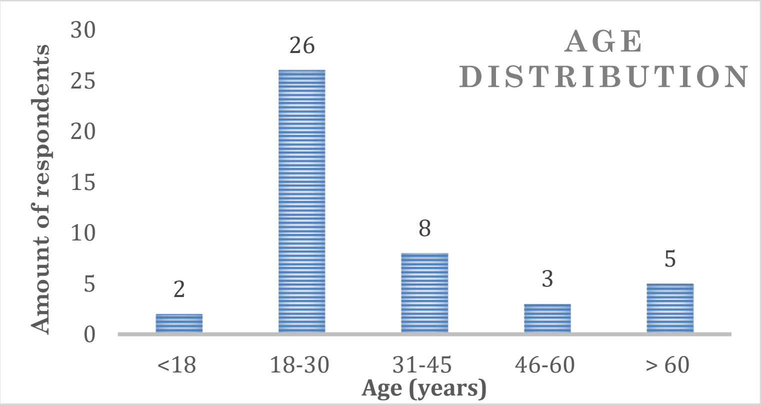

Figure 5.7 Age distribution of respondents at the Vismarkt

At the Westerhaven the sample size consists of 35 respondents. Figure 5.8 and 5.9 schematically show gender- and age information about the sample.

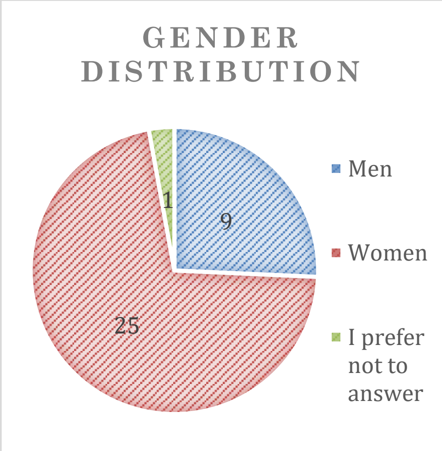

Figure 5.8 Gender distribution of respondents at the Westerhaven

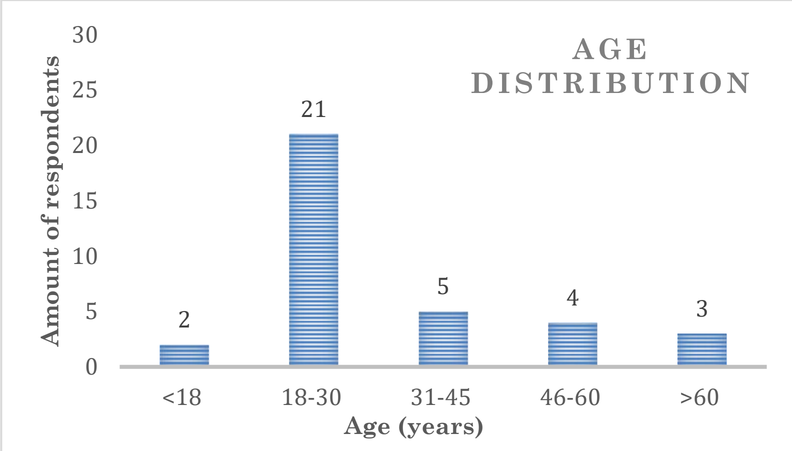

Figure 5.9 Age distribution of respondents at the Westerhaven

At the Grote Markt the sample size consists of 44 respondents. Figure 5.10 and 5.11 show how respondents from a different age and gender are divided over the gender.

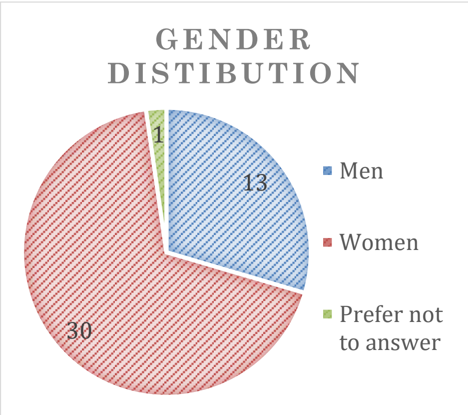

Figure 5.10 Gender distribution of respondents at the Grote Markt

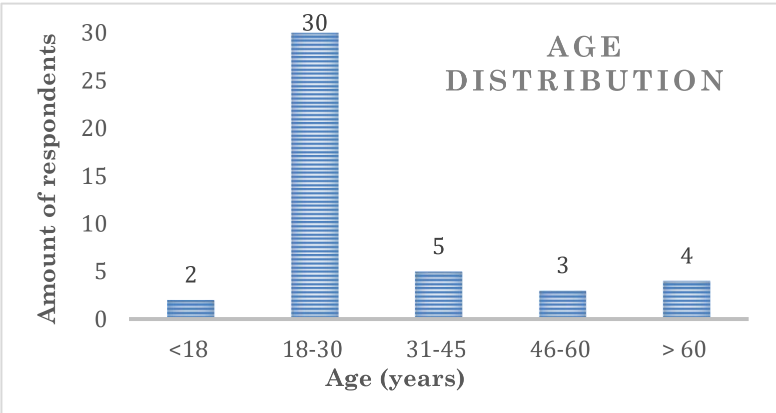

Figure 5.11 Age distribution of respondents at the Grote Markt

As can be concluded out of these figures, the samples obtained at all four squares consist of a good variation of men and women. Moreover, the sample is well build up in terms of age. Respondents from every age group participated in the research. This contributes to the quality of the study. However, similar at all market squares is the majority of women and 18-30 year olds who conducted the questionnaire. A possible explanation for this might be the 61.110 students studying in the city of Groningen, which is about 30% of the inhabitants of the city (*Het aantal studenten in Groningen, 2019*).

Squares	P_{value}	R	*P <0,5?*	B
Ossenmarkt	0,022	0,356	Yes	0,232
Vismarkt	0,000	0,528	Yes	0,443
Westerhaven	0,016	0,411	Yes	0,287
Grote Markt	0,267	0,171	No	0,159

Tabel 5.2 Overview statistical tests per square

A linear regression analysis has been executed for each of the four squares, with the appreciation of the sound as dependent variable, and the visual perception as the independent variable. In table 5.2 the results are shown, the tests for the Ossenmarkt, Vismarkt and Westerhaven are significant. At the Grote Markt R is <0,3 and therefore the correlation is weak, at the Ossenmarkt and Westerhaven a moderate correlation is found with R = 0,3-0,5. A strong correlation is found at the Vismarkt (R >0,5), the value of the sound perception increases with 0,443 point if the valued visual perception of the Vismarkt increases with one point.

Squares	P_{value}	R	P<0,5?
Ossenmarkt	0,349	0,228	No
Vismarkt	0,011	0,113	Yes
Westerhaven	0,229	0,279	No
Grote Markt	0,035	0,132	Yes

Table 5.3 Output table regression analysis visual perception

Squares	P_{value}	R	P<0,5?
Ossenmarkt	0,745	0,227	No
Vismarkt	0,010	0,531	Yes
Westerhaven	0,558	0,252	No
Grote Markt	0,900	0,162	No

Table 5.4 Output table regression analysis sound perception

In order to gain better insight into the sound and visual perception and how this is influenced by other variables, linear regressions has been executed where the effect of age and gender on both the sound and visual perception are analysed. An overview of the output is shown in table 5.3 and 5.4, from which can be concluded that the regression analysis with the visual perception as dependent variable, is significant for both the Vismarkt and the Grote Markt. Moreover, regarding the regression analysis where sound perception is the dependent variable, only the Vismarkt shows a significant result. Though, in neither of these cases exists a strong correlation.

Consequently, it is not possible to conclude that the visual environment has a direct influence on the soundscape. Section 5.4 follows a different approach, and takes the urban morphological parameters into account.

5.4 Urban morphological parameters and sound perception

In this section the results of the GIS analysis, based on the data provided by the BGT, are discussed and the fourth sub-question, regarding the influence of the urban morphological parameters on the sound perception at the four different squares, is answered.

Market square	Sound perception	Buildings	Exposed ground and road surfaces	Green and open public areas	Water features	Total
Ossenmarkt	6,5	11%	84%	4%	1%	100%
Vismarkt	6,5	76%	24%	0%	0%	100%
Westerhaven	5,8	44%	52%	2%	2%	100%
Grote Markt	6	28%	72%	0%	0%	100%

Table 5.5 Ratio urban morphological parameters per square

The urban morphological parameters have unique values for each market square and for every parameter. For example, the Vismarkt has, with 16%, the lowest ratio of 'exposed ground and road surfaces', whereas this same parameter counts for 73% at the Ossenmarkt. Further, the Ossenmarkt, together with the Westerhaven are the only two squares where 'Green and open public areas' are present. These parameters may have an influence on the visual perception values. Since, at the market square with the highest visual perception, the Westerhaven, is a relatively low 'Exposed ground and road surfaces' ratio and the existence of 'Green and open public areas'. This is statically tested with a Pearson correlation test.

Table 5.6 Output Pearson correlation test

	Buildings	Exposed ground and road surfaces	Green and open public areas	Water features
Pearson Correlation	0,098	-0,1	0,196	-0,489
Sig. (2-tailed)	0,902	0,9	0,804	0,511
N	4	4	4	4

So, as mentioned a Pearson correlation test has been executed. Since the tests in section 5.3 were either insignificant or did not show a strong correlation, the statistical analysis has been executed with the average valued sound perception per square, instead of using the sound perception per individual. The other variables included in the statistical test are the urban morphological parameters. Table 5,6 gives an overview of the output of the test. For all urban morphological parameters the test is highly insignificant and therefore the null hypothesis has to be accepted. This means that, in answer to the fourth sub question, there is no linear relationship between the urban morphological parameters and the sound perception.

6. Conclusion

In conclusion, this research has investigated the influence of the urban morphology on the pleasantness of the perceived sounds at different market squares in the city of Groningen. Before the main research question could be answered, sub questions had to be formulated and data collection was executed. In addition, the data was analysed in order to answer the sub question. In this section the results are briefly summarised and conclusions are drawn.

Moreover, there is a focus on the strengths and weaknesses of this research including recommendations on further research.

The answer to the first sub question, *What is the Leq variation at the four different squares?,* The Leq levels at the four squares range from 61,1 to 74,4 dB(A). This indicates a significant variation which has therefore been included in the following sub question.
Moreover, in answer to the second sub question, *To what extent are the sound and visual perception affected by the Leq levels at the four different squares?,* there was no linear relationship found between the Leq level and the visual and sound perception. They do not seem to be affected by the Leq levels at the four different squares.
For the third sub question, *What is the correlation between the visual stimuli and the sound perception at the four different squares?* there is a likewise outcome. The regression tests only show a significant output for the minority of the cases, even when including variables such as age and gender. This indicates there is no relation between the visual stimuli and the sound perception. These outcomes are surprising since other researchers such as Het et al. (2018) found a close correlation between these two variables. A possible explanation for these diverging outcome is the different urban morphological case study site where this research was conducted.
Lastly, the fourth sub question, *How are the urban morphological parameters of influence on the sound perception at the four different squares?*, focused on the influence of the different urban morphological parameters. The Pearson correlation test which was executed in order to provide an answer gives a highly insignificant result. This supports the answers to the earlier sub questions.

Thus, based on the before mentioned results of the data analysis an answer to the main research question*, 'How does the urban morphology of different market squares in the city centre of Groningen, influence the pleasantness of the soundscape perceived by passers-by?'*, can be given. In conclusion, the urban morphological parameters are not of influence on the sound perception at the four market squares studied in this research. However, since this research was conducted at only four markets squares, a type II error has possibly occurred, therefore a relation between these variables cannot be excluded for the entire city of Groningen. The number of research locations has been a limitation and needs to be significantly expanded for future research, just like Hong & Jeon (2017) has done, however now focused on the city of Groningen. By further research regarding this topic a proper answer to whether or not there is a relationship between the visual stimuli and sound perception, can be given and appropriate policy advice can be provided.

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Appendix 1: questionnaire

Bachelor thesis questionnaire

Bachelor project Consent Form

This research is being carried out by Floor Kortman, undergraduate student from the Faculty of Spatial Planning in Groningen University, Netherlands.

The aim of the research is to identify the significance of urban morphology on the sound perception by people, with the aim of creating more sustainable and liveable cities.

What will the findings be used for?

The aim of the findings is to write a Bachelor project dissertation for assessment purposes. The Bachelor project contributes to the third year of our degrees. The research will not be circulated beyond the normal examination and assessment processes within the Faculty of Spatial Planning.

Participation in this study is voluntary. You are free to withdraw at any point. All data collected will be kept confidential and used for research purposes only. All primary data will be destroyed after the end of this project. Other than in specific circumstances, (i.e. you are being interviewed due to your professional role), any identifying characteristics will be removed and your anonymity preserved.

CONSENT

This part of the form is for direct participants in the research. Please read the information above, and then read the points below. Please feel free to ask questions.

- I agree to participate in the research outlined above.

- I understand the purpose and nature of the study and have had the opportunity to ask questions for clarification. I am participating voluntarily.

- I understand that I can withdraw from the study, without repercussions, at any time, whether before it starts or while I am participating.

If you have any questions or comments you can contact my supervisor:
Email: e.margaritis@rug.nl

Thank you in advance!

1. **I agree and understand the above mentioned** *

   ◯ Yes

General, personal, information.

2. **What is your age?** *

- <18 years
- 18-30 years
- 31-45 years
- 46-60 years
- >60 years

3 **How would you value your hearing ability?** *

Value this on a scale of 1 to 5; with 1 being 'below average'; 3 'on average' and 5 'above average'.

	1	2	3	4	5	
Below average						Above average

4. **To which gender do you identify yourself?** *

- Male
- Female
- Prefer not to answer

5. **Do you have any knowledge on the field of urban planning; architecture or environmental noise?** *

- Yes
- No

General information; person-square relation.

6. **What is the reason of your visit to this square?** *

- I need to be here
- It is part of my route

7. **Which one is applicable to you?** *

- I live in direct proximity to the square
- I live in the city of Groningen
- I am a visitor

Specific, research related, information. All answers need to be given refering to the current situation.

8 **Please indicate the following sounds in this section as 'present' or 'not present'.** *

	Present	Not present
1. Motorised traffic		
2. Music from passenger cars		
3. Cyclists		
4. Footsteps		
5. Construction		
6. Surrounding speech		
7. Music played on streets		
8. Bird sounds		
9. Domesticated animals		
10. Church bells		
11. Store alarm		

9. **Please list the three most prevalent sound sources in this square.**

To answer this question, note the numbers used in the question above

10. **From the three most prevalent sound sources, indicate to what extent they are present.** You only need to answer this for the three most prevalent sound sources (as answered in the previous question)

	A little	Moderate	A lot	Dominating
Motorised traffic				
Music from passenger cars				
Cyclists				
Footsteps				
Construction				
Surrounding speech				
Music played on streets				
Bird sounds				
Domesticated animals				
Church bells				
Store alarm				

11 **From the three most prevalent sound sources, indicate to what extent they are pleasant or unpleasant**

You only need to answer this for the three most prevalent sound sources

	Pleasant	Neither pleasant nor unpleasant	Unpleasant
Motorised traffic	◯	◯	◯
Music from passenger cars	◯	◯	◯
Cyclists	◯	◯	◯
Footsteps	◯	◯	◯
Construction	◯	◯	◯
Surrounding speech	◯	◯	◯
Music played on streets	◯	◯	◯
Bird sounds	◯	◯	◯
Domesticated animals	◯	◯	◯
Church bells	◯	◯	◯
Store alarm	◯	◯	◯

12 **What sound, present at this square, do you find most unpleasant?** *

You can choose from all sounds present at this square.

13. **Do the sounds you hear match with what you see at the square?** *

◯ Yes

◯ No

14. **If not, which sound does not (or which sounds do not) fit?**

Perception.

All answers need to be given referring to the current situation.

15. **How do you value the overall sound perception at this square?** *

Value your experience on a scale of 1 to 10; with 1 being unpleasant and 10 pleasant

	1	2	3	4	5	6	7	8	9	10	
unpleasant	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	pleasant

16. **How do you value the overall visual perception at this square?** *

Value your experience on a scale of 1 to 10; with 1 being unpleasant and 10 pleasant

	1	2	3	4	5	6	7	8	9	10	
unpleasant	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	pleasant

Appendix 2: Tables statistical analyses

Ossenmarkt

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,356[a]	,127	,104	1,307

a. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9,671	1	9,671	5,666	,022[b]
	Residual	66,573	39	1,707		
	Total	76,244	40			

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

b. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	5,169	,600		8,612	,000
	Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.	,232	,098	,356	2,380	,022

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

Table 8.1 Regression analysis Ossenmarkt

Vismarkt

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,528[a]	,279	,262	1,465

a. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34,869	1	34,869	16,253	,000[b]
	Residual	90,108	42	2,145		
	Total	124,977	43			

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is
b. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	3,723	,729		5,108	,000
	Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.	,443	,110	,528	4,031	,000

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

Table 8.2 Regression analysis Vismarkt

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,411[a]	,169	,143	1,406

a. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12,862	1	12,862	6,507	,016[b]
	Residual	63,256	32	1,977		
	Total	76,118	33			

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

b. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4,835	,794		6,088	,000
	Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.	,287	,112	,411	2,551	,016

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

Table 8.3 Regression analysis Westerhaven

Grote Markt

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,171[a]	,029	,006	1,520

a. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2,919	1	2,919	1,264	,267[b]
	Residual	96,991	42	2,309		
	Total	99,909	43			

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

b. Predictors: (Constant), Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5,041	,922		5,467	,000
	Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.	,159	,141	,171	1,124	,267

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

Table 8.4 Regression analysis Grote Markt

Comparing the four market squares in one statistical test; the influence of age and gender on the visual perception

Model Summary

Locatie	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Grote Markt	1	,478[a]	,228	,149	1,512
Ossenmarkt	1	,337[b]	,113	,015	2,100
Vismarkt	1	,528[c]	,279	,205	1,812
Westerhaven	1	,363[d]	,132	,045	2,129

a. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, c31tot45jaar, Vrouw

b. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, Vrouw, c31tot45jaar

c. Predictors: (Constant), < 60 jaar, Vrouw, 46 tot 60 jaar, c31tot45jaar

d. Predictors: (Constant), 46 tot 60 jaar, c31tot45jaar, Vrouw

ANOVA[a]

Locatie	Model		Sum of Squares	df	Mean Square	F	Sig.
Grote Markt	1	Regression	26,399	4	6,600	2,887	,035[b]
		Residual	89,146	39	2,286		
		Total	115,545	43			
Ossenmarkt	1	Regression	20,288	4	5,072	1,150	,349[c]
		Residual	158,736	36	4,409		
		Total	179,024	40			
Vismarkt	1	Regression	49,453	4	12,363	3,764	,011[d]
		Residual	128,093	39	3,284		
		Total	177,545	43			
Westerhaven	1	Regression	20,669	3	6,890	1,520	,229[e]
		Residual	135,948	30	4,532		
		Total	156,618	33			

a. Dependent Variable: Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

b. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, c31tot45jaar, Vrouw

c. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, Vrouw, c31tot45jaar

d. Predictors: (Constant), < 60 jaar, Vrouw, 46 tot 60 jaar, c31tot45jaar

e. Predictors: (Constant), 46 tot 60 jaar, c31tot45jaar, Vrouw

Coefficients[a]

Table 8.5 Output table regression analysis; the influence of gender and age on the relation between urban morphology and visual perception

Grote Markt	1	(Constant)	5,530	,436		12,671	,000
		Vrouw	1,410	,502	,405	2,810	,008
		c31tot45jaar	,023	,728	,005	,032	,975
		46 tot 60 jaar	-,941	,926	-,146	-1,016	,316
		< 60 jaar	-1,236	,807	-,219	-1,530	,134
Ossenmarkt	1	(Constant)	6,366	,697		9,135	,000
		Vrouw	-,112	,735	-,026	-,152	,880
		c31tot45jaar	,078	,900	,015	,087	,931
		46 tot 60 jaar	-,921	1,030	-,156	-,894	,377
		< 60 jaar	-1,622	,856	-,333	-1,894	,066
Vismarkt	1	(Constant)	7,266	,496		14,654	,000
		Vrouw	-,320	,590	-,077	-,542	,591
		c31tot45jaar	-1,986	,744	-,381	-2,671	,011
		46 tot 60 jaar	-3,159	1,113	-,396	-2,839	,007
		< 60 jaar	-1,474	,880	-,233	-1,675	,102
Westerhaven	1	(Constant)	7,189	,712		10,101	,000
		Vrouw	,016	,839	,003	,019	,985
		c31tot45jaar	-1,605	1,077	-,265	-1,490	,147
		46 tot 60 jaar	-1,947	1,156	-,292	-1,684	,103

a. Dependent Variable: Hoe waardeer je de algemene inrichting op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is.

Comparing the four market squares in one statistical test;
the influence of age and gender on the visual perception

Model Summary

Locatie	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Grote Markt	1	,162[a]	,026	-,074	1,579
Ossenmarkt	1	,227[b]	,051	-,054	1,417
Vismarkt	1	,531[c]	,282	,208	1,517
Westerhaven	1	,252[d]	,064	-,027	1,517

a. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, c31tot45jaar, Vrouw
b. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, Vrouw, c31tot45jaar
c. Predictors: (Constant), < 60 jaar, Vrouw, 46 tot 60 jaar, c31tot45jaar
d. Predictors: (Constant), 46 tot 60 jaar, c31tot45jaar, Vrouw

ANOVA[a]

Locatie	Model		Sum of Squares	df	Mean Square	F	Sig.
Grote Markt	1	Regression	2,618	4	,654	,262	,900[b]
		Residual	97,291	39	2,495		
		Total	99,909	43			
Ossenmarkt	1	Regression	3,921	4	,980	,488	,745[c]
		Residual	72,323	36	2,009		
		Total	76,244	40			
Vismarkt	1	Regression	35,241	4	8,810	3,829	,010[d]
		Residual	89,736	39	2,301		
		Total	124,977	43			
Westerhaven	1	Regression	4,848	3	1,616	,702	,558[e]
		Residual	71,324	31	2,301		
		Total	76,171	34			

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is
b. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, c31tot45jaar, Vrouw
c. Predictors: (Constant), < 60 jaar, 46 tot 60 jaar, Vrouw, c31tot45jaar
d. Predictors: (Constant), < 60 jaar, Vrouw, 46 tot 60 jaar, c31tot45jaar
e. Predictors: (Constant), 46 tot 60 jaar, c31tot45jaar, Vrouw

Coefficients[a]

Locatie	Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
Grote Markt	1	(Constant)	5,841	,456		12,811	,000
		Vrouw	,368	,524	,114	,701	,487
		c31tot45jaar	,138	,761	,029	,182	,857
		46 tot 60 jaar	-,209	,968	-,035	-,216	,830
		< 60 jaar	-,525	,843	-,100	-,622	,537
Ossenmarkt	1	(Constant)	6,576	,470		13,979	,000
		Vrouw	,019	,496	,007	,038	,970
		c31tot45jaar	,287	,608	,083	,472	,639
		46 tot 60 jaar	-,762	,695	-,197	-1,095	,281
		< 60 jaar	-,084	,578	-,026	-,145	,886
Vismarkt	1	(Constant)	7,791	,415		18,774	,000
		Vrouw	-1,244	,494	-,355	-2,516	,016
		c31tot45jaar	-1,078	,622	-,247	-1,732	,091
		46 tot 60 jaar	-2,043	,931	-,306	-2,193	,034
		< 60 jaar	-1,245	,736	-,234	-1,690	,099
Westerhaven	1	(Constant)	7,218	,507		14,233	,000
		Vrouw	-,759	,593	-,232	-1,279	,210
		c31tot45jaar	,741	,763	,176	,972	,339
		46 tot 60 jaar	-,088	,823	-,019	-,107	,915

a. Dependent Variable: Hoe waardeer je de algemene geluidsbeleving op dit plein? Waardeer uw ervaring op een schaal van 1 tot 10; waarbij 1 onaangenaam en 10 aangenaam is

Table 8.6 Output table regression analysis; the influence of gender and age on the relation between urban morphology and sound perception

Comparing the four market squares in one statistical test;
the influence of urban morphological parameters on the sound perception

Correlations

		Sound perception	Buildings	Exposed ground and road surfaces	Green and open public areas	Water features
Sound perception	Pearson Correlation	1	,098	-,100	,196	-,489
	Sig. (2-tailed)		,902	,900	,804	,511
	N	4	4	4	4	4
Buildings	Pearson Correlation	,098	1	-,997**	-,670	-,255
	Sig. (2-tailed)	,902		,003	,330	,745
	N	4	4	4	4	4
Exposed ground and road surfaces	Pearson Correlation	-,100	-,997**	1	,611	,186
	Sig. (2-tailed)	,900	,003		,389	,814
	N	4	4	4	4	4
Green and open public areas	Pearson Correlation	,196	-,670	,611	1	,636
	Sig. (2-tailed)	,804	,330	,389		,364
	N	4	4	4	4	4
Water features	Pearson Correlation	-,489	-,255	,186	,636	1
	Sig. (2-tailed)	,511	,745	,814	,364	
	N	4	4	4	4	4

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

Table 8.7 Output Pearson correlation test urban morphology and soundscape

Appendix 3: tables urban morphological parameters

Market square	Sound perception	Road coverage	Houses	Bare terrain	Green covered area	Waterpart	Supporting road part	Seperation	Remaining buildings	Total
Ossenmarkt	6,5	73%	11%	5%	4%	1%	0%	5%	0%	100%
Vismarkt	6,5	16%	76%	8%	0%	0%	0%	0%	0%	100%
Westerhaven	5,8	46%	44%	5%	2%	2%	1%	0%	0%	100%
Grote Markt	6	60%	27%	12%	0%	0%	0%	0%	1%	100%

Table 8.8 Overview urban morphology according to characteristics of BGT