Soundscape measurements of moderators for perception of road noise

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FORCE TECHNOLOGY

LÄRMKONTOR GmbH

SINTEF

TECHNICAL NOTE

Soundscape measurements
of moderators of perception of road noise

Performed for CEDR, Conference of European Directors of Roads

Project no.: 119-35797

TC-101728

Page 1 of 53

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SenseLab

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OVERVIEW

Title	Soundscape measurements of moderators of perception of road noise
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Summary

This report has been produced as a part of the FAMOS project, FActors MOderating people's Subjective reactions to road noise. The project is financed by the Conference of European Road Directors (CEDR).

A soundscape is: The acoustic environment as perceived or experienced and/or understood by a person or people, in context. Soundscape measurements are seen as supplement to the traditional noise measurements. The soundscape measurement described in this report consists of two elements:

1. Sound walks where the test persons state their perception in 14 attributes (soundscape descriptors) and note the perceived sound sources.
2. Sound level measurements/calculations.

The soundscape measurement was tested as a mean to quantify the effect of non-acoustic factors that can have an effect on the perceived noise annoyance. The influence of greenery (trees, bushes, plants, grass etc.) and the visibility of the traffic was investigated.

Four sound walks including six positions within walking distance in the central part of Copenhagen were completed in the beginning of October 2020, a time of the year with green leaves on trees and bushes. The effect of rush hour traffic was minimized by different starting points and starting times. During the soundwalks the test persons answered questions regarding their perception of noise using iPads. 18 test persons participated.

The sound walks were successful in the sense that they gave a good representation of the sound sources in a sound source hierarchy. The diversity of sound sources was dominated by sounds from human activity, especially traffic noise. Results with acceptable uncertainty were obtained for the 14 soundscape attributes used to describe the soundscape and the annoyance.

A soundscape index for the quality of the soundscapes was calculated for the six positions.

By combining the assessments of annoyance from the sound walks with the measured noise levels, it was possible to make a model (dose-response curve) for the annoyance as function of the noise level (L_{Aeq}) with a good fit (R^2 = 0,9).

The influence of greenery and the visibility of the traffic was also sought to be modelled. Due to insufficient variations and correlation with the traffic noise levels, the modelled influence of these moderators was not significant. A trend was found that the effect of the presence of greenery decreased the annoyance equivalent level with around 3 dB, but the uncertainty was large.

The results suggest that soundscape measurements may be a useful tool for investigating the annoyance from traffic noise and the effect of non-acoustic variables, e.g. greenery and visible traffic. For this to be successful the following should be considered:

- As the holistic situations at the places of interest may differ for other reasons than the differences in the variables under investigation a higher number of positions is needed so unwanted bias can be corrected for or averaged out. Alternatively, special care should be taken that the main differences only or primarily are caused by differences in the variables of interest.
- There shall be sufficient and independent variation in the variables under investigation in the chosen measuring positions. As an example: Greenery may be related to lower noise levels e.g. if measurements are made in a park away from the traffic. If so, both other "green" positions with high noise levels should be found and also no-green positions with low noise levels
- As rule of thumb we would recommend having four times as many measuring positions as the number of variables of interest. So, if we want to investigate the influence of noise level, greenery, and the visibility of the traffic, this means 12 measuring positions. For construction of a dose-response curve we will recommend at least 6 measuring positions, where the main variable is the noise level of the traffic with a level range of 15-20 dB or more.
- At least 20 persons (e.g. in groups of 5-7 persons) shall make the assessments. If not the same group of persons is assessing all positions, more persons and some experimental design is needed. With the current questionnaire the assessment time is 5-10 minutes in each position.

TABLE OF CONTENTS

1. Preface

This report has been produced as a part of the FAMOS project. FAMOS responds to the questions of the Conference of European Road Directors (CEDR) call in 2018 on Noise and Nuisance: Psycho-Acoustics: Improved Understanding of People’s Subjective Reactions to Road Noise.

WHO has estimated that about 1.2 million healthy life-years are lost annually in Europe due to road traffic noise. About half of these can be related to the subjective element: annoyance. This is a huge challenge for the National Road Administrations. Analyses of results from noise surveys reveal that only about 1/3 of the variance in the annoyance response is caused by the noise level itself, whereas the other 2/3 are determined by so-called non-acoustic factors. This means that the annoyance response can be altered within wide limits without doing any changes to the actual noise level. So, when road administrations have used all the technically feasible and economically possible measures, the noise impact can still be reduced by making changes in the non-acoustic factors known to moderate the annoyance response.

The objective of FAMOS is to quantify how different factors modify people's subjective reactions to road traffic noise. The project uses scientific methods to find, extract and analyze data from existing annoyance surveys. The most promising findings will be tested experimentally by the use of questionnaire studies, listening testing in the laboratory and soundscape measurements/sound walks. The results will be used to develop a handbook on how “moderators” can be used by road administrations to reduce noise annoyance.

FAMOS is the acronym for “FActors MOderating people's Subjective reactions to road noise”. The project is carried out over two years and started in December 2019. The project consortium consists of three partners:

- FORCE Technology in Denmark (Project leader)
- LÄRMKONTOR in Germany
- SINTEF in Norway

The report has been produced within Work Package WP 2 of the project which deals with "Analysing data and hypotheses testing” and is led by the FORCE. This report presents the results of a series of soundwalks performed to investigate moderators related to presence of greenery as well as visibility of the road/traffic. The importance of these two moderators was among others highlighted in the international literature study performed in WP1 of the FAMOS project. The report is produced by Torben Holm Pedersen from FORCE as milestone M.2.4 of the FAMOS project. The report has quality control been reviewed by Hans Bendtsen from FORCE and Truls Gjestland from SINTEF. The CEDR Transnational Road Research Programme funded by Belgium – Wallonia, Denmark, Ireland, Netherlands, Norway, Sweden and United Kingdom has financed the FAMOS project.

2. Introduction

2.1 Background

The annoyance from road traffic noise is a challenge for the National Road Administrations. Only a part of the variance in the annoyance response is directly related to the noise level, and the rest determined by factors not related to the noise exposure, L_{den}. This means that the noise annoyance may be lowered without doing any changes to the actual noise exposure when the influence of these non-acoustic factors is known.

The purpose of FAMOS is to quantify how different moderators modify people's subjective reactions to road traffic noise. In Work Package 1 an international literature study has been performed, cf. [1]. One of the results was to develop a list of moderators that can have an influence on people's subjective reactions to road traffic noise.

Soundscape measurements were to be tested as a mean to quantify the effect of non-acoustic factors in Work Package 2. This report presents the testing of soundscape measurements with focus on moderators related to visual appearance of the road and its immediate surroundings. Sound walks were performed at alternative locations with different conditions with regard the two selected moderators:

1. Presence of vegetation or greenery situated between and near the road and the people exposed to the noise.
2. Visibility of road and traffic for the people exposed to the noise.

2.2 Soundscape measurements

A soundscape measurement is a new type of measurement in which one registers both the acoustic surroundings and people's perceptions of them. The concept of soundscape is defined in the standard ISO DSF / ISO / DIS 12913-1, cf. [2], as: The acoustic environment as perceived or experienced and/or understood by a person or people, in context.

The idea of the soundscape measurement is to get a holistic picture of the sound environment in a given place in order to obtain information about how the sound environment is perceived and which factors are influencing the perception. Soundscape measurements are seen as supplement to the traditional noise measurements. The soundscape measurement described in this report has been carried out according to the principles of the draft standard ISO DSF / ISO / DIS 12913-2, cf. [3], with various additions and omissions.

The soundscape measurements consist of three elements:

1. Sound walks where test persons fills out a questionnaire.
2. Sound measurements/calculations.
3. Interviews.

In this project only the first two points are addressed. A systematic procedure is used to obtain reliable assessment of the soundscapes. The assessed attributes in the sound walks are defined in the questionnaire and several people rate the same soundscapes at different times to get representative averages. Noise measurements are made simultaneously at the same positions.

The sound walks represent the holistic perception of the selected scenarios (here visibility and presence of greenery). The results of the sound walks are expressed in perceptual and affective dimensions and is quantified as a simple soundscape index which expresses the difference between the assessed and the preferred soundscape characteristics.

In the practical implementation of the sound walk method the test persons walk from position to position but while they answer the questionnaire related to a specific measurement position they stand still while perceiving and evaluating the soundscape at the measurement position.

There are limitations, advantages, disadvantages and uncertainties for the soundscape method:

The advantage is that it relates to real life situations. The disadvantage is that variations in individual and other context variables also moderates the annoyance effect, and it may be difficult to isolate the effect of the moderators under investigation without influence of the other.

2.3 Purpose

The main purpose for making soundscape measurements in this project is to investigate the possibility for using this tool for measuring the effect of moderators in specific scenarios along roads and highways.

If moderators can be quantified with this method, the results will be taken into account when merging findings in other parts of the FAMOS project (Work Package 3 and 4).

3. The measuring positions

The measuring positions for the sound walks were selected so that there were variations in the moderators of interest, i.e.: the noise levels, the visibility of the traffic and the amount of greenery (trees, bushes and grass). The positions were chosen in the central part of Copenhagen, within walking distance of each other for practical reasons. The speed limit in the area is 50 km/h.

An overview of the positions is given in Table 1.

Positions	Type	Traffic Visible	Greenery	L_{Aeq} dB	L_{A50} dB	L_{A95} dB
1. HCA Boulevard	Major road	100 %	47 %	71	70	65
2. Rådhuspladsen	Major road	100 %	3 %	66	66	59
3. Studiestræde	Minor street	100 %	0 %	60	54	48
4. Larslejstræde	Minor street	100 %	11 %	60	57	52
5. Kongens Have pos. a	Park	50 %	100 %	55	52	46
6. Kongens Have pos. b	Park	0 %	100 %	52	52	47

Table 1 *The measuring positions for the sound walks and their main characteristics.*

The traffic was fully visible in positions 1-4. In position 5 the traffic could be seen through trees and bushes and in position 6 the visibility of traffic was complete blocked by a large hedge.

The percentage of greenery is calculated from the horizontal angle where greenery could be seen from the measuring position.

The noise levels indicated are the average values from measurements in each sound walk. L_{Aeq} denotes the energy average of the sound levels in the measuring periods (3-8 minutes). L_{A50} indicates the level that has been exceeded 50 % of the time, and L_{A95} is the level that has been exceeded 95 % of the time

Annotated level recordings that give an impression of the soundscapes can be found in Appendix 1.

3.1 Position 1 – H.C. Andersens Boulevard

This position was close to the townhall facade with view to the road which is one of the busiest roads in the central Copenhagen with four lanes in each direction. There are crossings with traffic lights to both sides some hundred meters from the measuring position.

Figure 1 *Position 1. Photos taken during the sound walks. The noise measurement setup can be seen in the middle of the photos.*

3.2 Position 2 – Town Hall Square

The measuring position is next to and in the same distance to the same road as in position 1.

The noise level is slightly lower partly because of the lack of reflections from the town hall facade, and maybe also because of slower traffic at that point. Not much greenery is seen in this position.

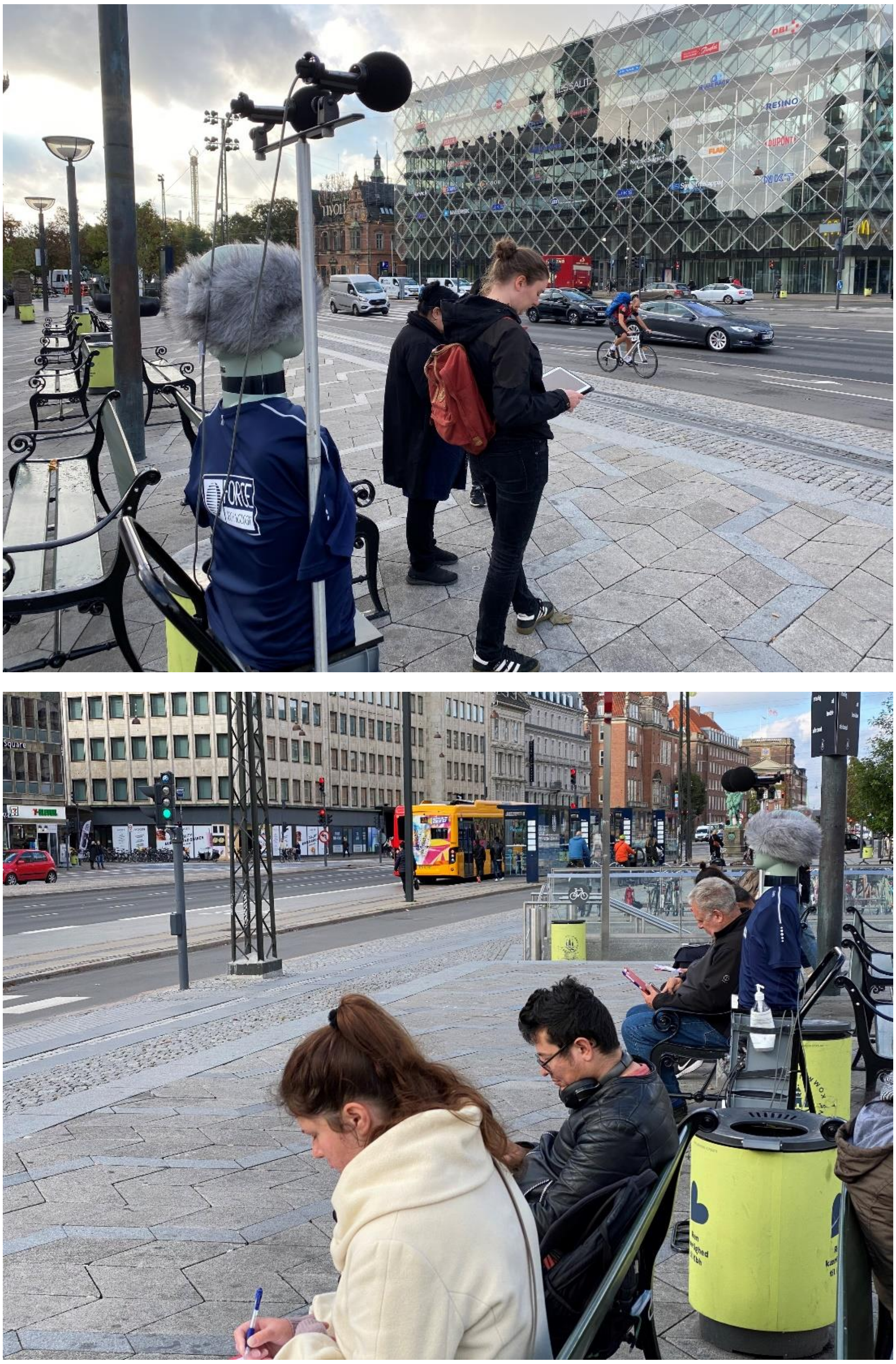


Figure 2 *Position 2. Photos taken during the sound walks.*

3.3 Position 3 – Studiestræde

This is a small narrow street with only little and local traffic. Besides a small cafe and a shop, not much is going on near the measuring position. Only a few cars are passing now and then, and the traffic from major roads in the area is heard as background noise.

Figure 3 *Position 3. Photos taken during the sound walks.*

3.4 Position 4 – Larslejstræde

This street seems like a small and calm street just like in position 3, but a school at each side of the street, and some building activity in the far end of the street gave the feeling of a rather chaotic soundscape.

A major road with slow and sparse traffic at the end of Larslejstræde was not heard much during the measurements.

Figure 4 *Position 4. Photos taken during the sound walks.*

3.5 Position 5 and 6 – City park

The measuring positions 5 and 6 are both surrounded by grass, bushes, and trees all around. The nearest road is a two-lane road with slow traffic. The distance to the road is approx. 30 m on both positions.
In position 5 the traffic can be seen through trees and bushes, in position 6 the traffic cannot be seen due to a large dense hedge.

Figure 5 *Measuring positions 5 and 6 in the city park: Kongens Have.*

Figure 6 *Position 5. Photos taken during the sound walks. The road and traffic can be seen under the trees.*

Figure 7 *Position 6. Photos taken during the sound walks.*

4. Method

Sound walks were performed where the participants assessed the soundscapes using a questionnaire in 6 positions along the route. At the same time, noise measurements were performed in the same positions.

4.1 Sound walks

Four sound walks with four groups of persons were made 5th and 6th of October 2020. The vegetation was still green and there was some bird activity in the trees. Outdoor activities were taking place (people on cafes, children playing, people talking etc.).

In total 18 assessors participated in the sound walks in four groups. The persons participating were ordinary persons (non-expert listeners) recruited from SenseLabs group of "consumers" via Facebook. The participants received a gift card to shops for their participation. The ages of the participants were between 24 and 58 years with a mean of 40.3 years with 50 % male and female.

To create a balanced order effect of the positions, and the starting times, two of the four sound walks started in position 1, then 2, 3, 4, 5 and 6 while the two other sound walks began in position 6 and the positions in reverse order.

Monday 05-10-2020

- Dry, partly cloudy to cloudless, 14-17 degrees C. Easterly wind 3-4 m/s
- 9:00 start from position 6. 5 participants (LV1-LV5)
- 12:00 start from position 1. 5 participants (LV7-LV11)

Tuesday 06-10-2020.

- Dry, partly cloudy, 12-14 degrees C, South westerly wind 4-5 m/s
- 9:00 start from position 1. 3 participants (LV13-LV15)
- 12:00 start from position 6. 5 participants LV16, LV19-LV22)

Before each sound walk the participants were introduced to the task and to the attributes and the scales used. The participants were instructed that "traffic noise" did not include trucks backing and unloading and emergency vehicles with sirens.

In each position the participants assessed the 14 attributes listed in Table 2 for the soundscape on iPads with direct connection to the SenseLabOnline software for listening tests. The assessments took approx. 5 minutes for each group in each position. The 14 attributes are part of the soundscape procedure developed by FORCE technology.

The definitions of the attributes were shown to the participants next to the answering scales, see Figure 8.

No.	Attribute	Definition	Scale
1	Local traffic noise	To what extent do you hear noise from local traffic on this/the nearest road?	Not at all, Slightly, Moderately, Very, or Extremely?
2	Traffic noise	To what extent do you hear noise both from local traffic and from more distant roads?	Not at all, Slightly, Moderately, Very, or Extremely?
3	Sounds from humans	To what extent do you hear sounds from people? (speech, laughter, children, footsteps…)	Not at all, Slightly, Moderately, Very, or Extremely?
4	Nature sounds	To what extent do you hear sounds of nature? (birds, animals…, water ..., wind in the trees…)	Not at all, Slightly, Moderately, Very, or Extremely?
5	Pleasantness	State how you perceive the sound as a whole. Pleasant: Gives satisfaction, joy or well-being. Unpleasant: Gives dissatisfaction, unwillingness or reluctance.	Unpleasant, Neutral, Pleasant
6	Event richness	State how you perceive the sound as a whole. Event-rich: Characterized by variety and exciting or interesting events. Event-poor: Monotonous and without exciting or interesting events or any other kind of variation.	Event-poor, Neutral, Event-rich
7	Exciting	State how you perceive the sound as a whole. Exciting: Fascinating, attractive or interesting. Boring: Without invigorating or interesting elements.	Boring, Neutral, Exciting
8	Chaotic	State how you perceive the sound as a whole. Chaotic: Characterized by disorder or confusion. Calm: Free from disturbances, characterized by calm and regularity.	Calm, Neutral, Chaotic
9	Stressful	State how you perceive the sound as a whole. Stressful: Causes tension. Soothing: Make yourself relaxed, safe, peaceful; provides peace of mind.	Calming, Neutral, Stressful
10	Loudness	State how loud you perceive the sound as a whole. Volume: The perceived loudness.	Soft, Strong
11	Annoying	Indicate how annoying you perceive the sound as a whole. Annoying: Is the sound annoying or bothering?	Not at all, Slightly, Moderately, Very, or Extremely?
12	Intrusive	Indicate how intrusive you perceive the sound as a whole. Intrusive: Which presses on the consciousness; which strongly affects the sound perception.	Not at all, Slightly, Moderately, Very, or Extremely?
13	Like	State how you like the sound as a whole. Like: Do you like what you hear?	Very bad, Bad, Neutral, Good, Very good
14	The sound fits the place	State how you think the sound as a whole fits the place. Appropriate: Look around. Does the sound fit what you see and the possible activities that could take place here?	Very bad, Bad, Neutral, Good, Very good

Table 2 *The attributes with which the soundscape was assessed. Attributes 1-4 and 11-14 came in the order indicated while attributes 5-10 came in random order for each position and each person.*

Normally there is a high correlation among attributes with negative connotations[1] and a high correlation among attributes with positive connotations.

[1] A feeling which a word invokes for a person in addition to its literal or primary meaning.

There are two reasons for having all 14 attributes in the test:

- Nuances in the attributes and the understanding of these may give extra information.
- The participants are kept in an active listening mode for approx. 5 minutes when assessing the 14 attributes.

The Ideal Profile Method[2] was used for the test. The method uses two scales for each attribute: One scale for the assessment and one scale for the ideal point, i.e. the ideal size of the attribute according to the holistic perception in the actual situation, see Figure 8.

Figure 8 *Example on answering scales according to the Ideal profile method for the sound walk. This example is for the assessment of traffic noise. For other attributes, definitions and scale labels (translated to English), see Table 2. In the data processing the position of the sliders ar measured on a 0-100 scale.*

In each position also a questionnaire with a table on paper had to be filled. The questionnaires contained the following:

- Note which sound sources are heard, in order of decreasing prominence.
- Only one sound on each row, and a total of up to the most 8 prominent.
- Fill the sounds in the tree columns: Bad Sounds, Neutral, Good Sounds.

See Appendix 2.

4.2 Noise measurements and sound recordings

Four channel sound recordings were made with a hard disk recorder in the same periods in time, and in the same positions as the assessments. A stereo setup with measuring microphones for loudspeaker reproduction and noise analysis and a dummy head for recordings to 3D headphone reproduction was used.

The equipment was made portable in a setup shown in Figure 9 and a list of the equipment used can be found in Table 3.

[2] The Ideal Profile Method is a sensory methodology. It is performed by the participants who are asked to rate each product (here a measuring position) on both their perceived and ideal intensities for a list of attributes.

Figure 9 *The portable equipment for the sound recordings. The "hair" on the HATS is a windscreen.*

Equipment	Make	Type no.
Acoustic calibrator	Brüel & Kjær	4230
Measuring microphones with wind screens, 2 pcs.	Brüel & Kjær	4165
Preamplifiers, 2 pcs.	Brüel & Kjær	2669
Dummy head, HATS (Head And Torso Simulator)	Brüel & Kjær	4100
Microphone power supply, 2 pcs.	Brüel & Kjær	5935
Four channel hard disk recorder	Sound Devices	744t
Closed monitor headphones	Sennheiser	HD 280 Pro

Table 3 *The equipment used for the sound recordings.*

The calibrated sound recordings with the measuring microphones were analysed with the NoiseLab noise analysis software (see https://noiselabdk.wordpress.com/product-overview/). Detailed results and annotated level recordings can be found in Appendix 1. These should be consulted for a better understanding of the soundscapes in the six positions.

5. Results

5.1 Sound source hierarchical classification

It is relevant to know which sound sources create the soundscape. The hierarchical classification (i.e. the taxonomy) of the sound sources lists the sources in the measuring points where the assessors were standing. It is deduced from the answers on the paper questionnaire, see Appendix 2. According to [3], the hierarchical classification can be reported as shown in Table 4.

Twenty-nine different sound types have been mentioned. The vast majority of the sounds in the city are caused by human activity. Only three sound types, birds, dogs barking, and wind are not related to human activity. The sounds that get the most dominant role come from motorised transport (mainly road traffic, lorries and busses).

Outdoor acoustic environment				
	Urban acoustic environment			
		Sounds generated by human activity		
			Motorized transport	
				Road traffic noise
				Lorry’s
				Busses
				Motorcycles
				Car horns
				Emergency horns
				Helicopter
			Human movements	
				Footsteps
				Bicycles
			Mechanical sounds	
				Car doors
				Hammering
				Work machines & tools
				Compressors
				Lorry’s idle
				Road work
				Garden works
				Goods delivery
			Human sounds	
				Adult talk, laughs
				Whistling
				Children passing
				Children playing
				Radio/mobile
			Social/communal	
				Bells (Church, townhall)
				Music
				Traffic light beeps
				Lorry reverse alarms
		Sounds not generated by human activity		
			Nature	
				Birds
				Wind in trees and leaves
			Domestic animals	
				Dogs barking

Table 4 *The hierarchical classification of the sounds in the measuring positions as evaluated by the 18 assessors.*

5.2 Sound source diversity

The participants were asked to name the most prominent sound source, the next prominent and so forth up to the eights at most. In Figure 10 the number of occurrences of the most prominent is weighted with eight, the next prominent with seven and so forth. The purpose of the weighting is to give the most prominent sound sources the largest weight in the analysis. Figure 10 shows the results for each of the 6 measurement positions.

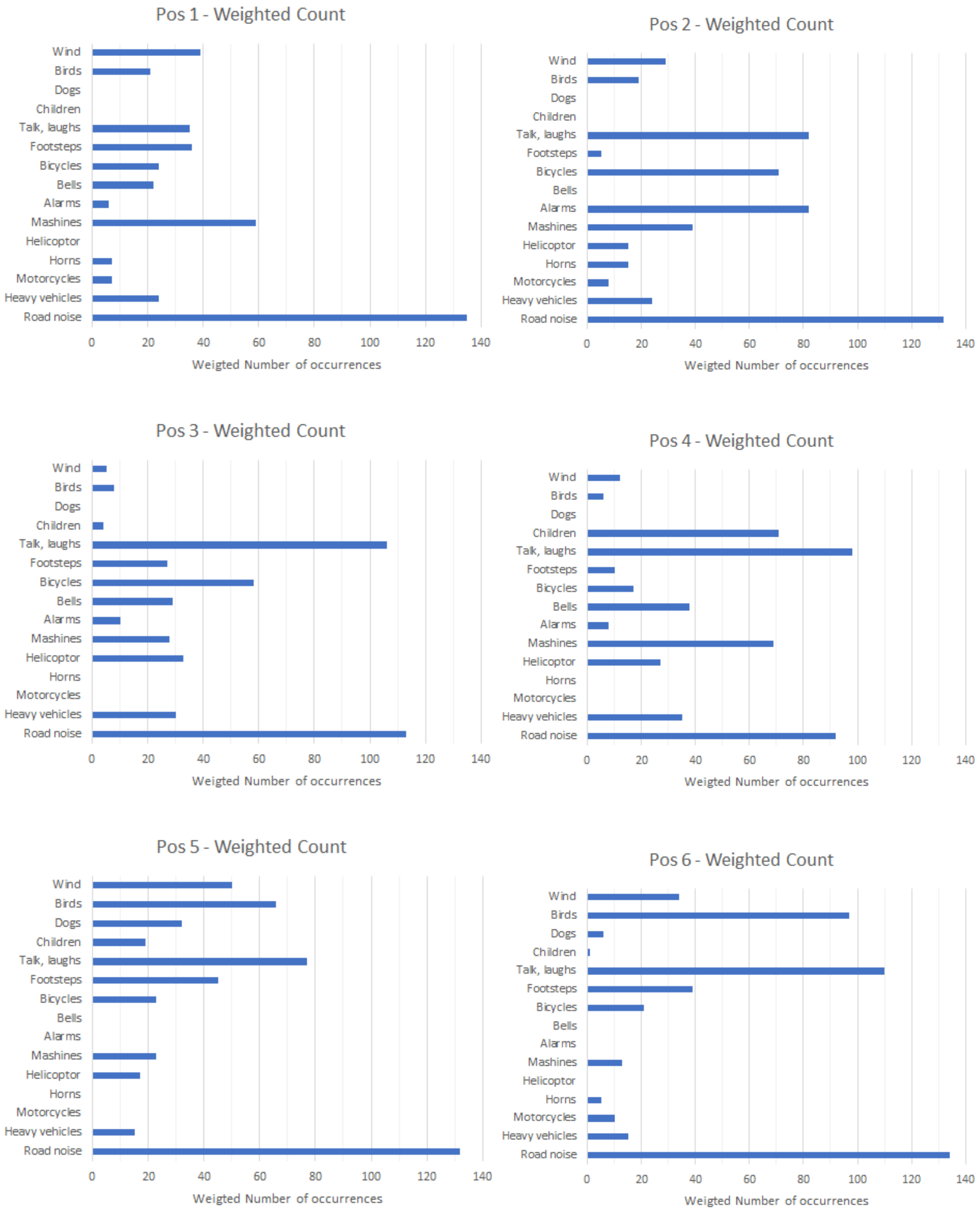


Figure 10 *The weighted number of occurrences of various types of sound sources in each position. The most prominent is weighted with eight, the next prominent with seven and so forth.*

Position 1 and 2 are both close to the same street with high traffic volume. It is seen that the assessment of road noise sources is the same, but the sound source diversity is larger in position 2. This may be because it is close to a road crossing and the town hall square with benches nearby.

In position 3 and 4 the road noise sources are less (low traffic volume), and other sounds are prominent also. The activity from schools and building activity is seen as a higher diversity in position 4.

Finally, it is a bit surprising that the traffic noise sources are rated that high in position 5 and 6 situated in a park area close to a two-lane road with slow traffic. The explanation may be that although the traffic noise levels are lower, the traffic is still the most dominant source. Sources as wind, birds and other are also prominent in these positions.

The results also show that the method used can give informative and consistent results relating to soundscapes investigated.

The participants were also asked to note the above-mentioned sources in three columns: Good, Neutral and Bad. The results are shown in Figure 11.

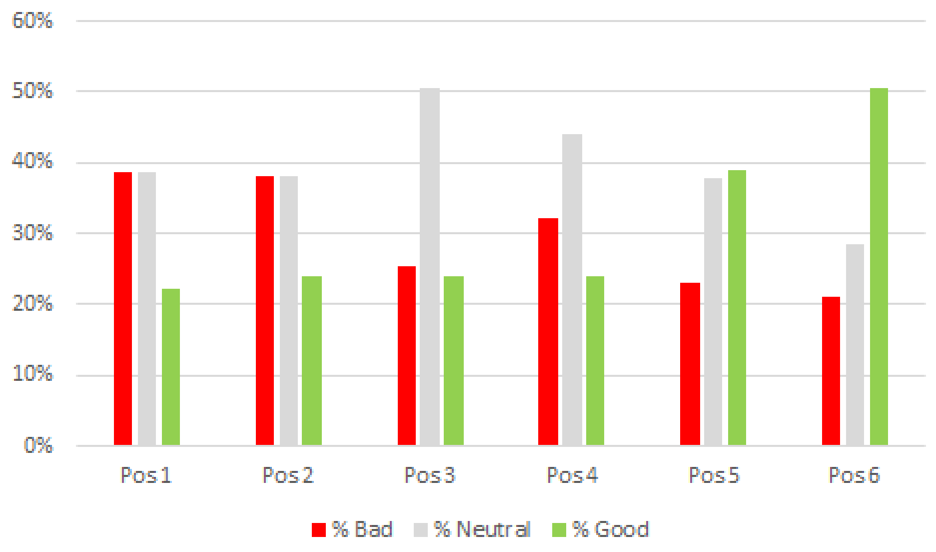


Figure 11 *The percentage of Good, Neutral and Bad sound sounds in each of the measuring positions according to the participants assessments.*

It is seen that positions 1 and 2 close to the road with high traffic volume have the highest percentage of Bad sounds and that positions 5 and 6 in the park have the highest percentage of Good sounds. Position 3 and 4 have a high percentage of neutral sounds, and the higher activity in position 4 gives rise to a higher percentage of Bad sounds than in position 3.

5.3 Perception of soundscape

In this clause the results of the perception of the soundscape evaluated by the 18 assessors are presented as the mean results of the assessment of the 14 attributes. The attributes are defined in Table 2, and the scales used are shown in Figure 8 as well as in Table 2. In the following the verbal scales used for the attributes are converted to a numerical scale ranging from 0 to 100. The assessors were asked to evaluate the actual soundscape at each measurement position (in the following named "actual" situation).

They were also asked to evaluate how the ideal soundscape at each measurement position should be according to their preferences according to a holistic perception of the situation (in the following named “ideal” situation). The data in the graphs are the mean values of the assessment of the actual situation and of the ideal situation in each position for all 18 participants in the four sound walks.

By comparing the evaluation of the actual and the ideal situation, it can be seen how far from ideal the soundscape is for each attribute in each position.

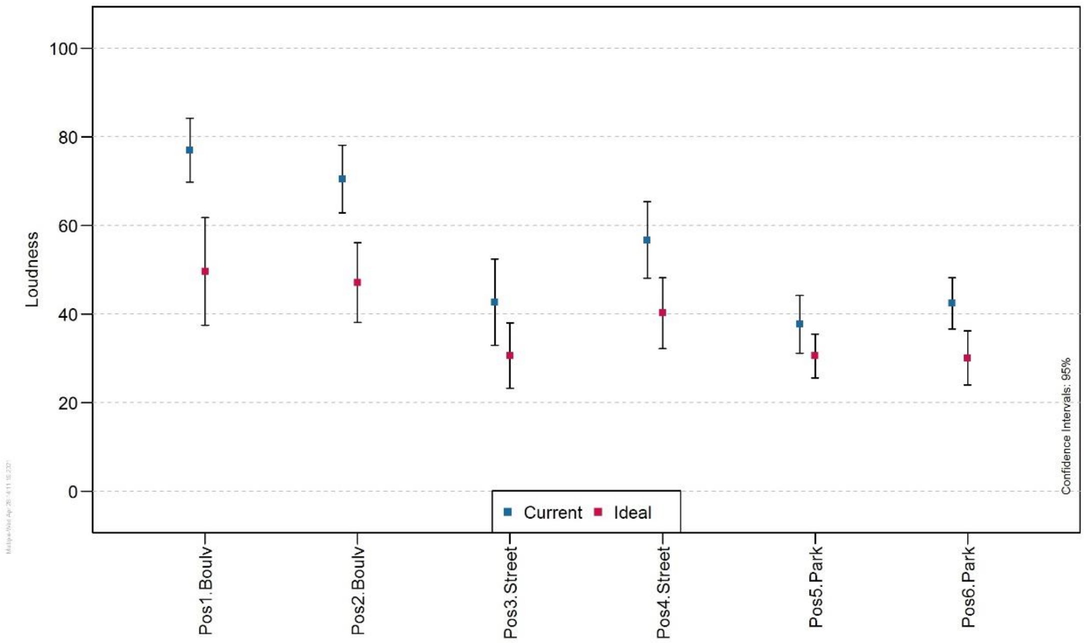


Figure 12 *Loudness. The perceived loudness. The mean assessments and 95 % confidence intervals in each position.*

From Figure 12 it is seen that position 1 and 2 are perceived as the loudest and that position 4 is perceived louder than positions 3, 5 and 6. In all positions less loudness is preferred (the ideal), this is most pronounced in positions 1, 2 and 4. The same tendencies are seen for traffic noise in Figure 13.

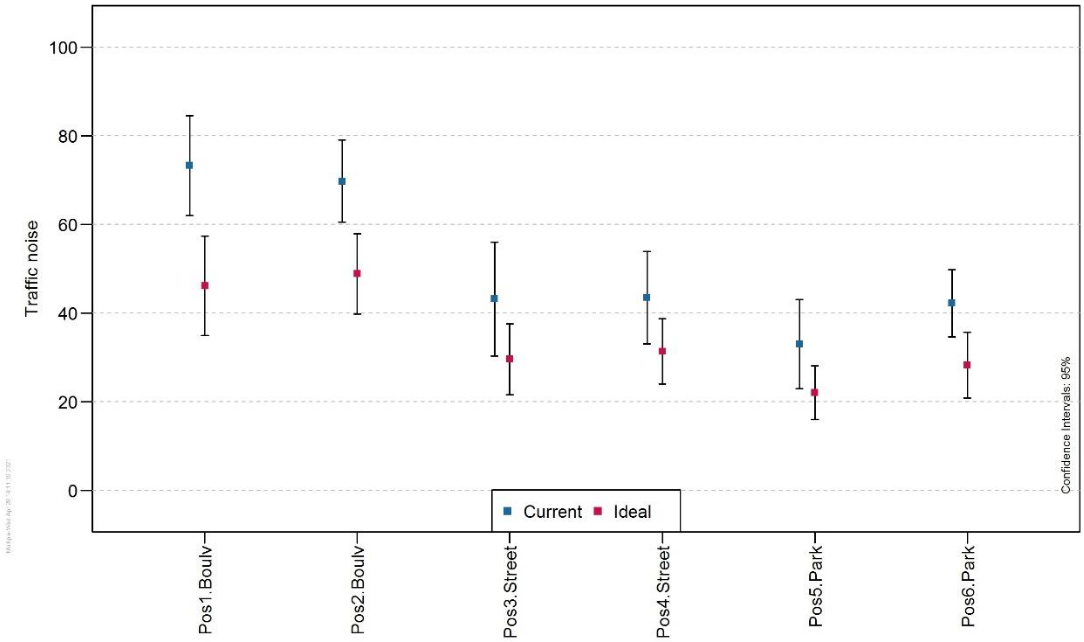


Figure 13 *Traffic noise. To what extent do you hear noise both from local traffic and from more distant roads? The mean assessments and 95 % confidence intervals in each position.*

The pattern from Loudness and Traffic noise is also seen for Stressful and annoyance in Figure 14 and Figure 15 and also for Intrusive in Figure 16.

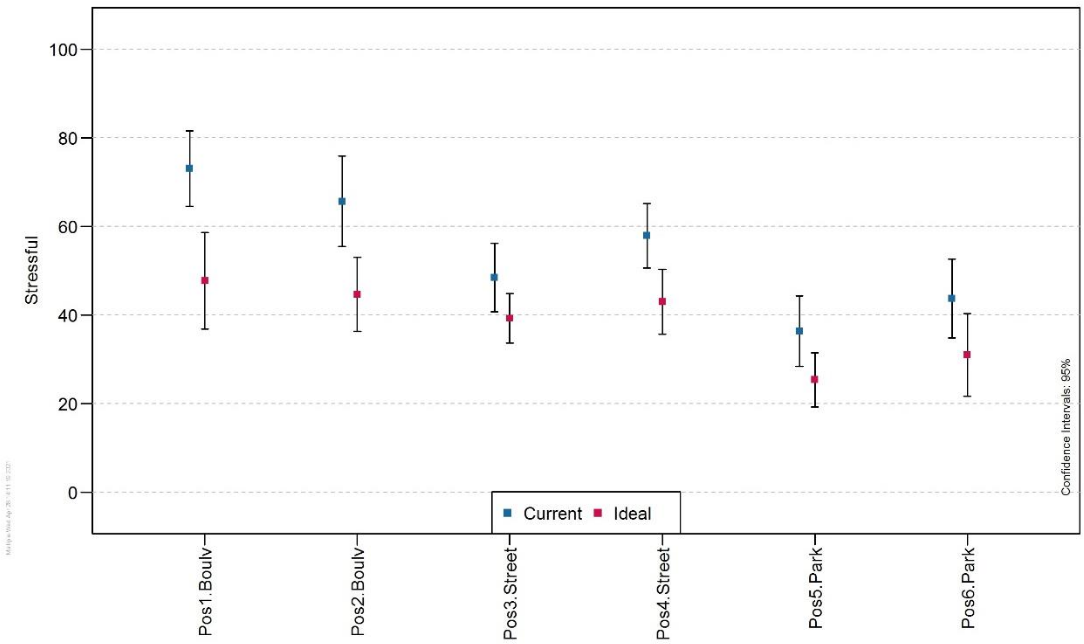


Figure 14 *Stressful. State how you perceive the sound as a whole. Stressful: Causes tension. Soothing: Make yourself relaxed, safe, peaceful; provides peace of mind. The mean assessments and 95 % confidence intervals in each position.*

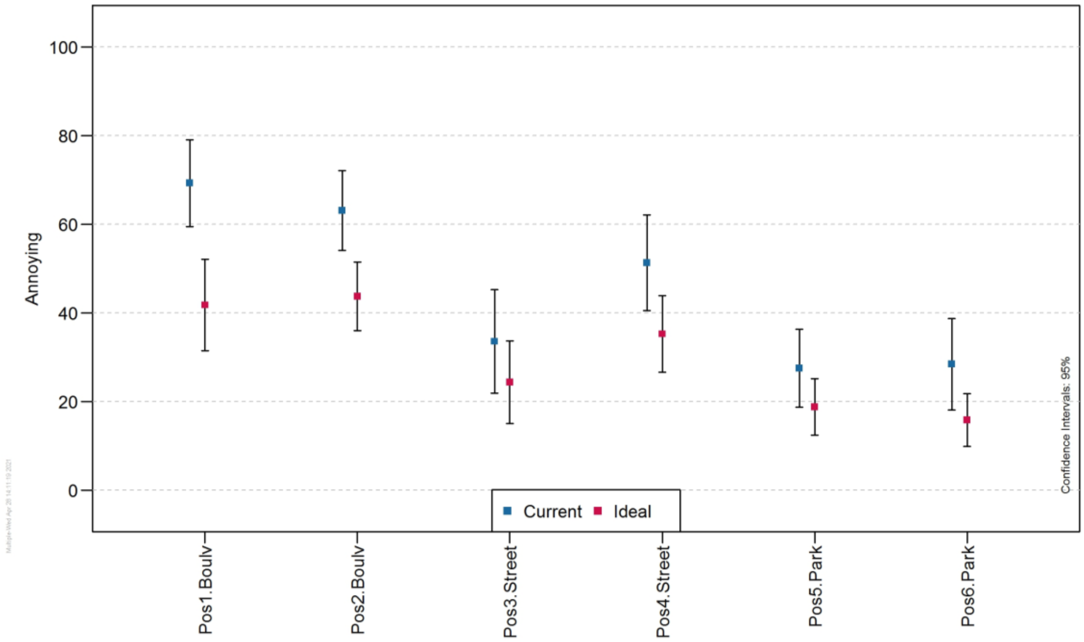


Figure 15 *Annoyance. Indicate how annoying you perceive the sound as a whole. Annoying: Is the sound annoying or bothering? The mean assessments and 95 % confidence intervals in each position.*

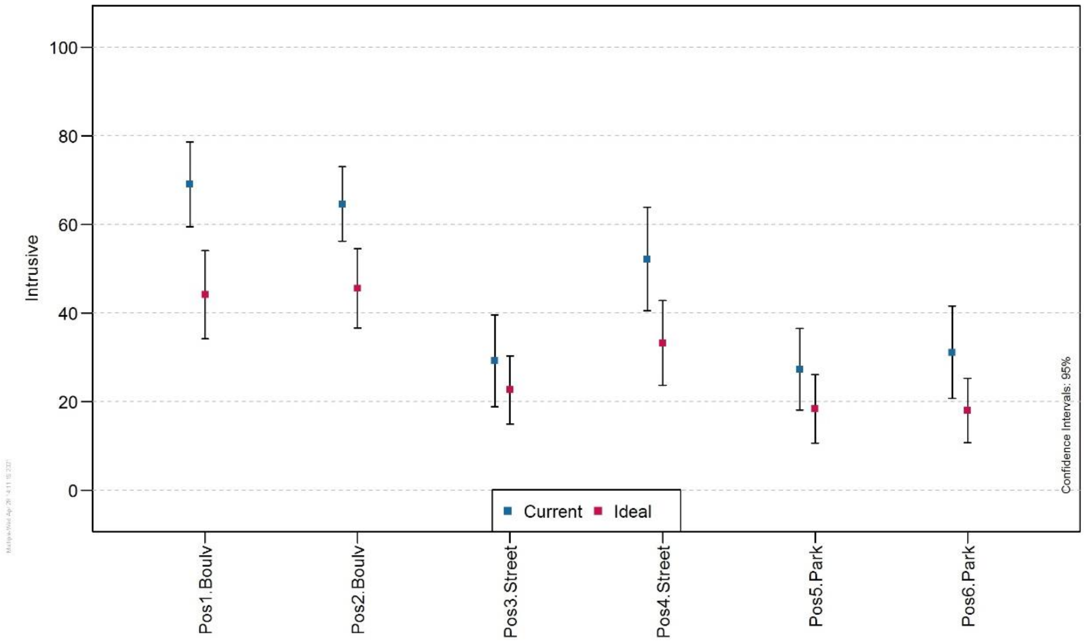


Figure 16 *Intrusive. Indicate how intrusive you perceive the sound as a whole. Intrusive: Which presses on the consciousness; which strongly affects the sound perception. The mean assessments and 95 % confidence intervals in each position.*

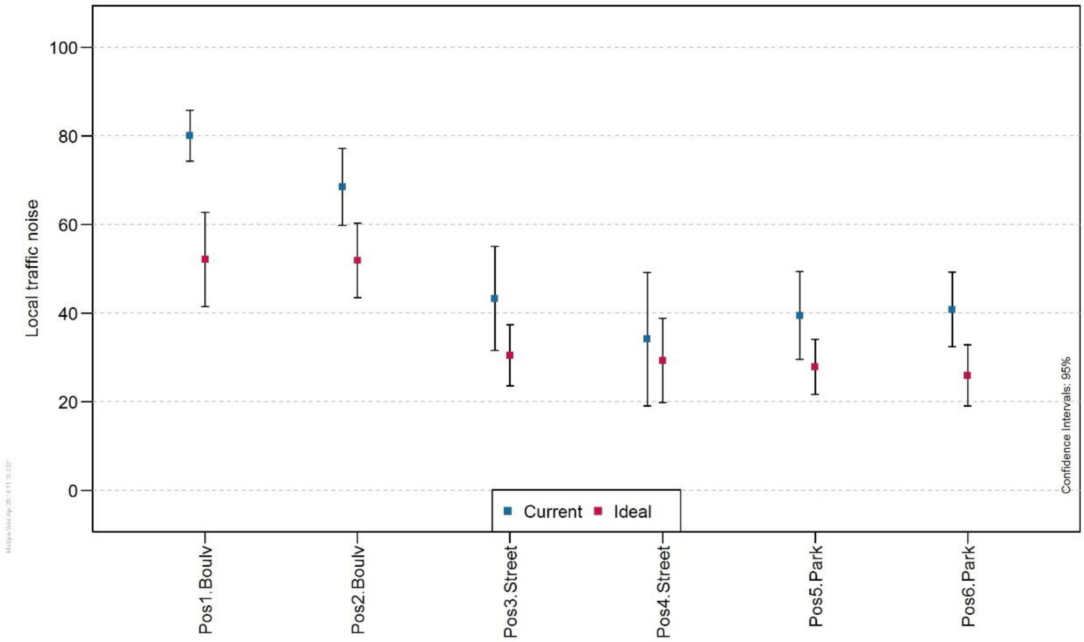


Figure 17 *Local traffic noise. To what extent do you hear noise from local traffic on this/the nearest road? The mean assessments and 95 % confidence intervals in each position.*

In Figure 17 it is seen that in position 3 the perception of the actual Local traffic noise is almost the same as the actual.

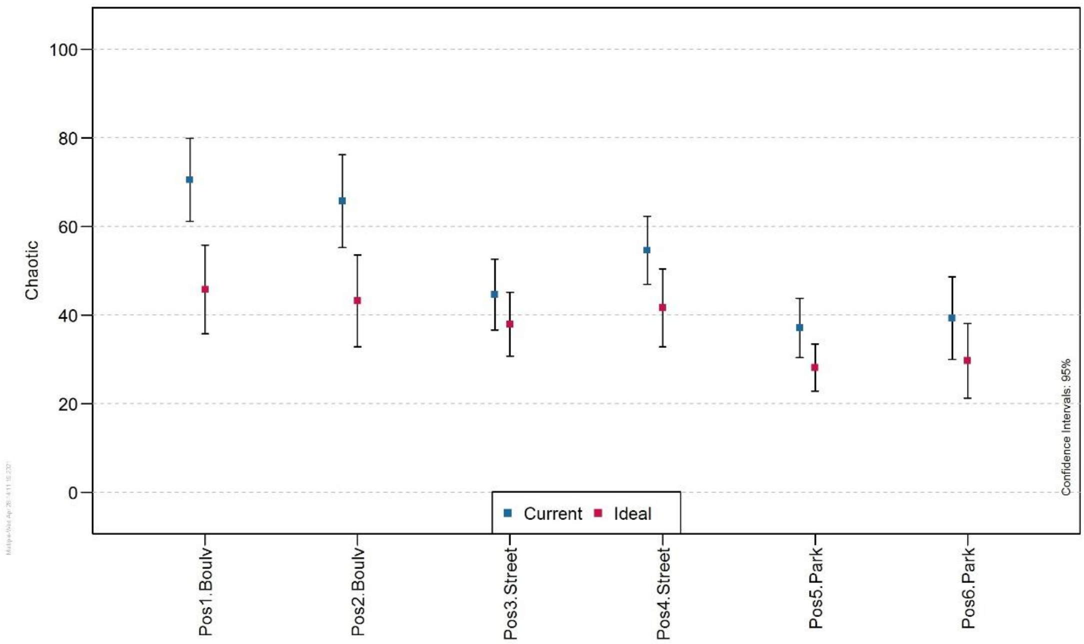


Figure 18 *Chaotic. State how you perceive the sound as a whole. Chaotic: Characterized by disorder or confusion. Calm: Free from disturbances, characterized by calm and regularity. The mean assessments and 95 % confidence intervals in each position.*

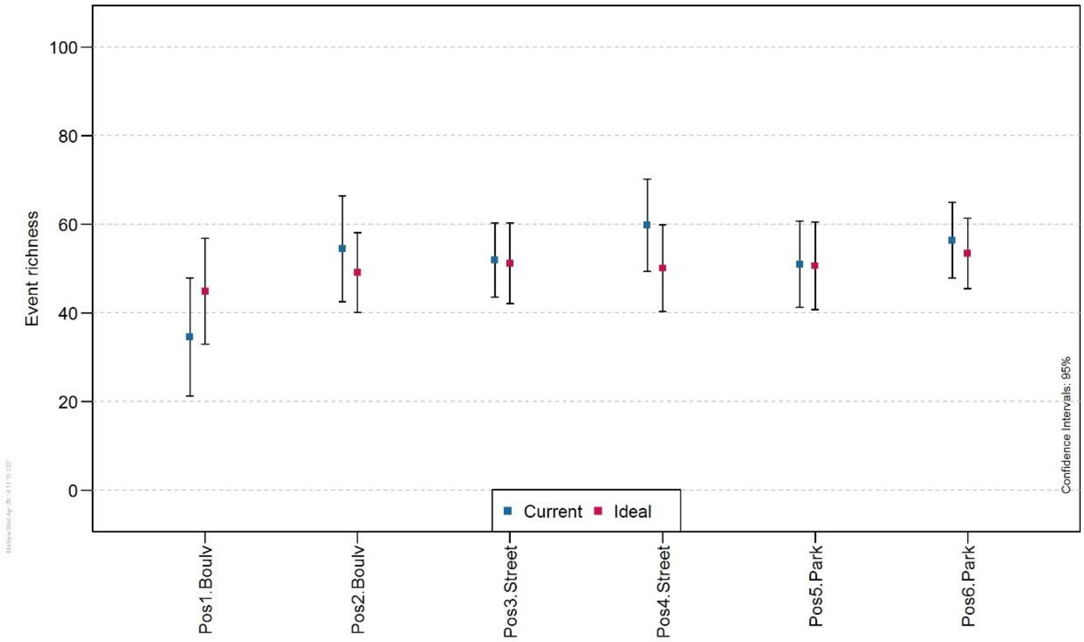


Figure 19 *Event richness. State how you perceive the sound as a whole. Event-rich: Characterized by variety and exciting or interesting events. Event-poor: Monotonous and without exciting or interesting events or any other kind of variation. The mean assessments and 95 % confidence intervals in each position.*

In Figure 19 it is seen that almost all assessments of actual and ideal Event richness are in the middle of the scale. Only position 1 is lower and position 4 is higher.

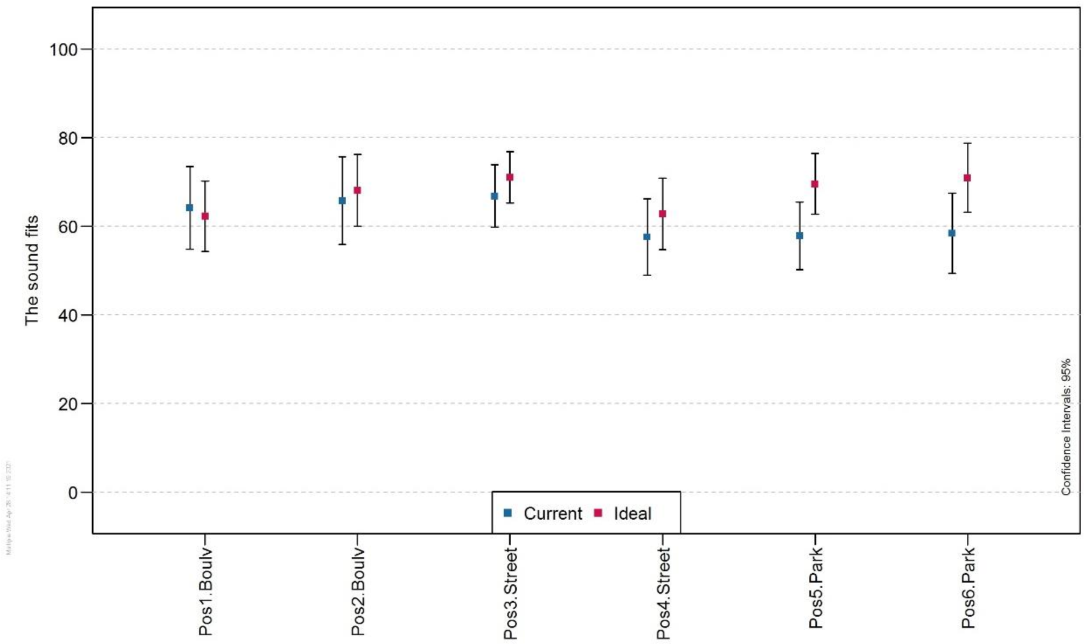


Figure 20 *The sound fits the location. State how you think the sound as a whole fits the place. Appropriate: Look around. Does the sound fit what you see and the possible activities that could take place here? The mean assessments and 95 % confidence intervals in each position.*

The assessments of the sound fits the location in Figure 20 seem to say that it sounds as expected. The ideal point is a bit hard to interpret for this attribute.

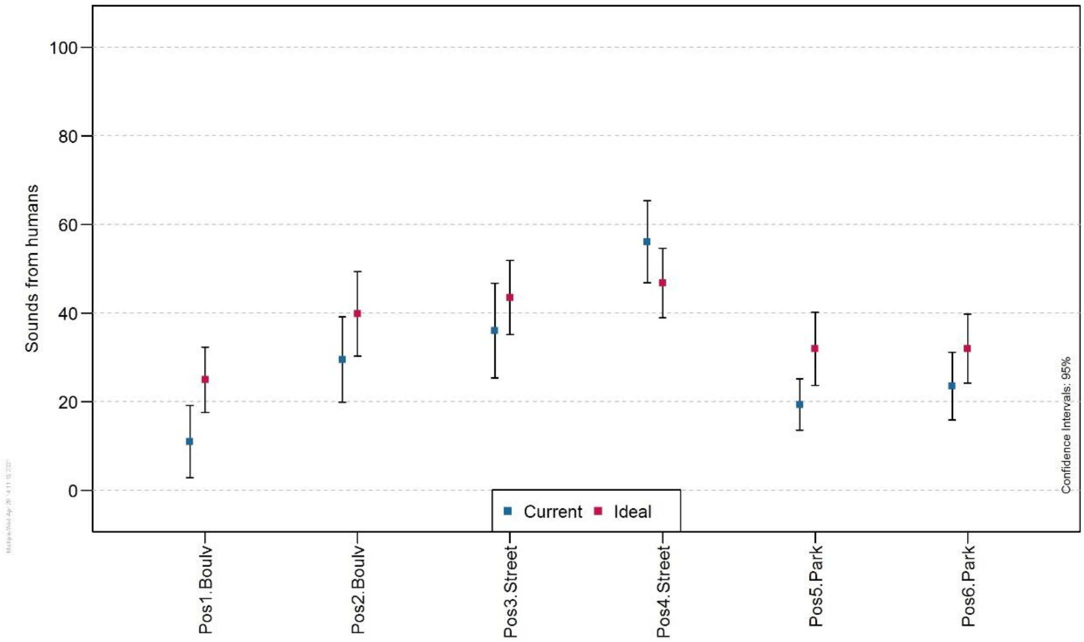


Figure 21 *Sounds from humans. To what extent do you hear sounds from people? (speech, laughter, children, footsteps…). The mean assessments and 95 % confidence intervals in each position.*

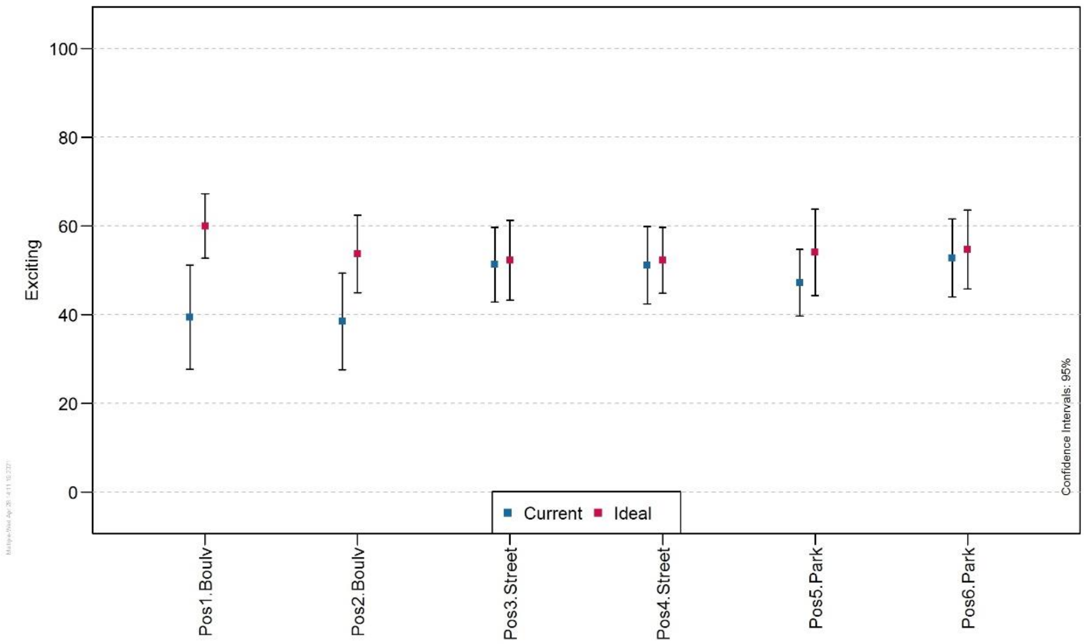


Figure 22 *Exciting. State how you perceive the sound as a whole. Exciting: Fascinating, attractive or interesting. Boring: Without invigorating or interesting elements. The mean assessments and 95 % confidence intervals in each position.*

From Figure 21 it is seen that Sounds from humans are most pronounced in position 4, where the ideal point is below the assessment of the actual sound. For the other positions more sounds from humans are wanted.

Except for positions 1 and 2 all assessments and ideal points of Exciting are in the middle of the scale. The sound in positions 1 and 2 should be more exciting according to the ideal points.

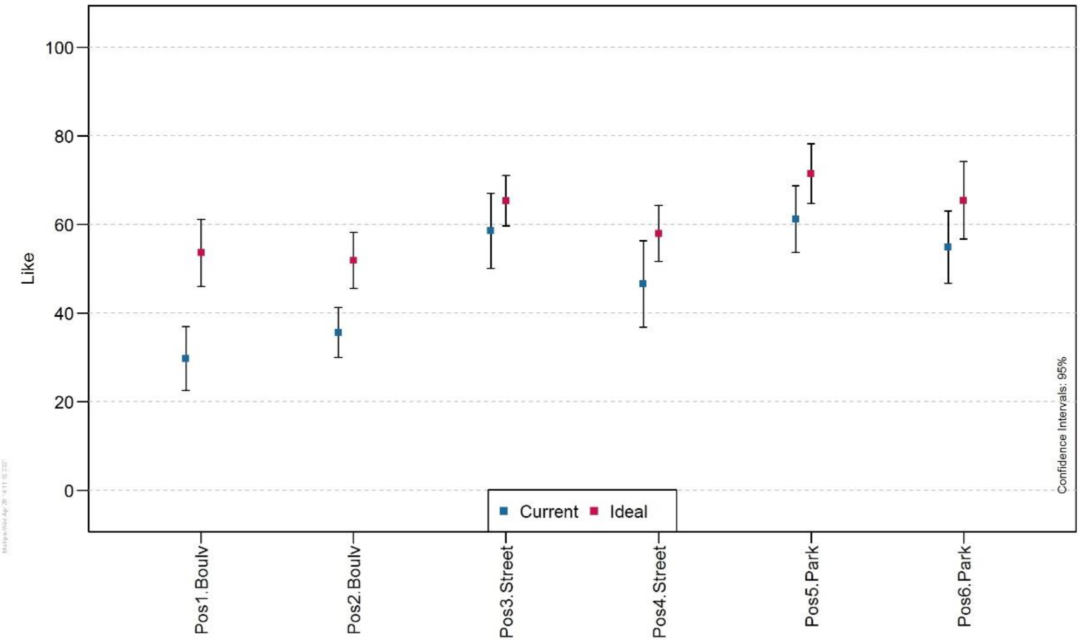


Figure 23 *Like. State how you like the sound as a whole. Like: Do you like what you hear? The mean assessments and 95% confidence intervals in each position.*

From Figure 23 it is seen that the best liked soundscapes are the ones in positions 3, 5 and 6. The same holds for Pleasantness in Figure 24.

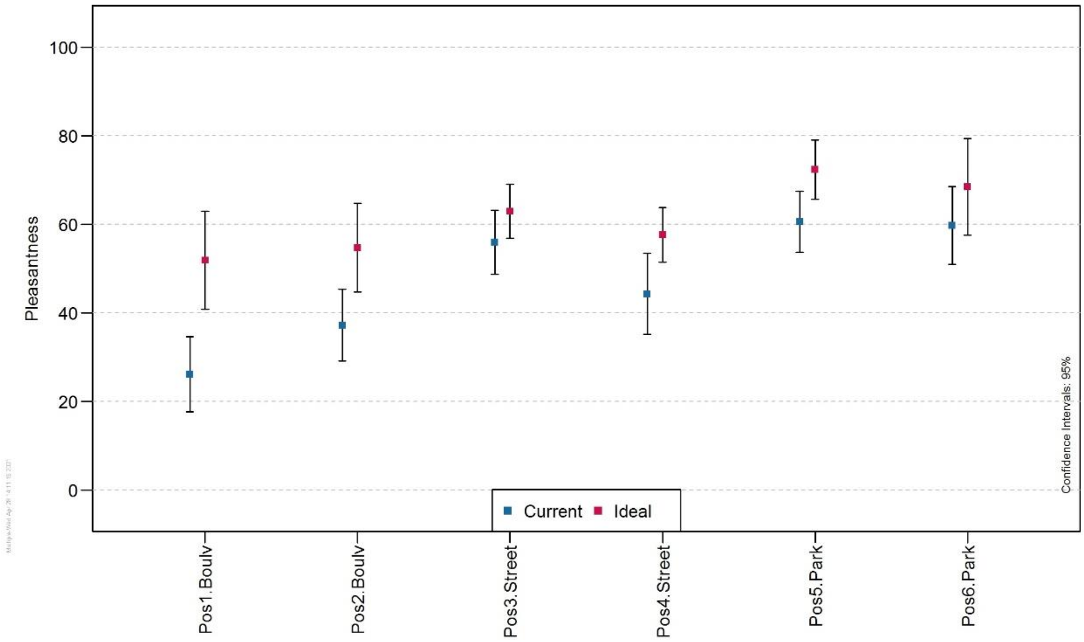


Figure 24 *Pleasantness. State how you perceive the sound as a whole. Pleasant: Gives satisfaction, joy or well-being. Unpleasant: Gives dissatisfaction, unwillingness or reluctance. The mean assessments and 95% confidence intervals in each position.*

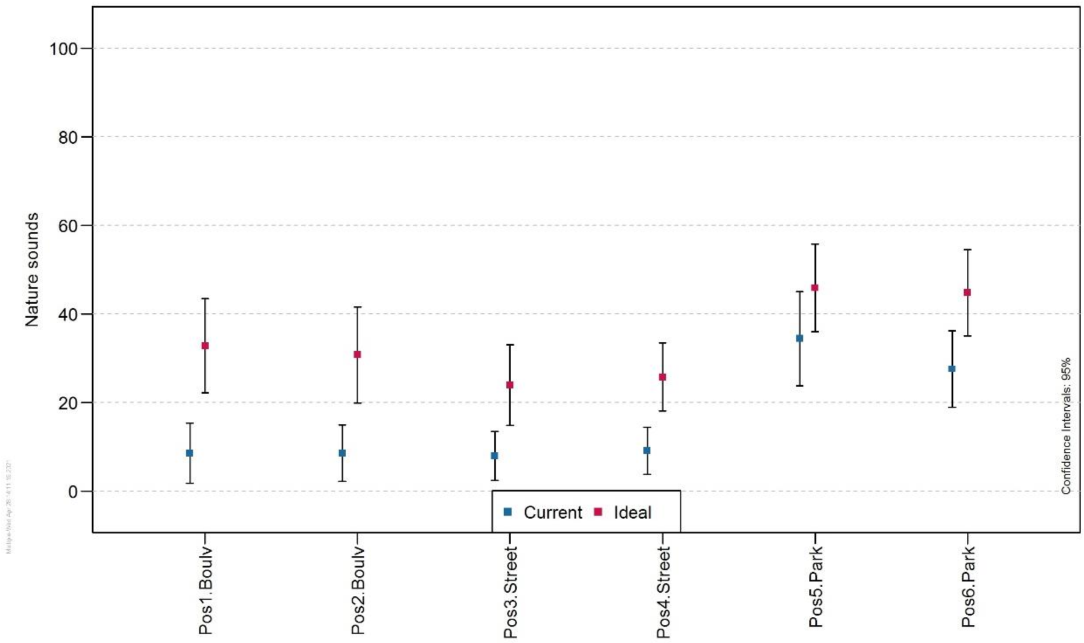


Figure 25 *Nature sounds. To what extent do you hear sounds of nature? (birds, animals…, water ..., wind in the trees…)The mean assessments and 95 % confidence intervals in each position.*

The pattern for the assessments of Nature sounds in Figure 25 deviates from other assessments. The assessments are very low for positions 1-4 and essentially and significantly lower that the ideal points in these positions.

Although a correlation analysis[3] has not been made, it is easily seen from the graphs above that there is a high correlation among attributes with negative connotations (like Annoying, Stressful, Intrusive…) and a high correlation among attributes with positive connotations (like Pleasantness, Nature sounds and Like).

From the graphs in Figure 12 to Figure 25 it can be concluded (the remarks shall be seen as trends as they are not all statistically significant):

- For position 1 compared to position 2: It is seen that the assessments of Loudness, Traffic noise, Stressful, Annoying and Intrusive are slightly less in position 2. The assessments of "The sound fits" and the ideal points are equal for the two positions, so the sounds seem to be as one could expect at such locations.
- For position 3 compared to position 4: The assessments of Loudness, Stressful, Annoying, Intrusive and Chaotic are higher in position 4 although the Traffic noise is assessed equal. The assessments of "The sound fits" and the ideal points are equal for the two positions, so the sounds seem to be as one could expect for the activities seen at these locations. The ideal point for the Event richness is the same as the assessment in position 3 but is higher than the assessment in position 4. Less activity seems to be preferred in position 4.
- For position 5 compared to position 6: The assessments of Loudness, Traffic noise, Stressful, Intrusive and Chaotic are slightly higher in position 6 although the Annoyance is assessed almost equal. For "The sound fits" the ideal points seem to deviate significantly from the assessments in both these positions. This is not the case for positions 1-4. This could be interpreted as there are more traffic noise than expected in a green park where the traffic is only partly or not visible at all.

The differences between the assessments of the actual and the ideal situations are summarised in the soundscape index, see Figure 28.

5.4 Principal component analysis

While the 14 attributes have been found to contribute with valuable information in general, some might contribute with similar information in one particular sound walk. This makes it of interest to understand the relationship between ratings of the attributes, which may also help understand the mechanisms of how to improve the soundscapes investigated.

A principal component analysis, PCA, is a tool to get an overview over the many assessments of the attributes for the actual situation. PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets by transforming a large set of variables into a smaller one that still contains most of the information in the large set. The idea of the PCA is to reduce the number of mathematical dimensions. Basically, all the results from the test can be thought of as a multidimensional space spanned out by the 14 attributes. The data will form a cloud of points. Think of only three dimensions and fly around this cloud until you find the direction where the cloud has the largest dimension, we could call it the length (Dimension 1). Next find the direction perpendicular to the length where the cloud has the largest dimension, we could call it the width (Dimension 2). We don't know if these dimensions have any meaning (yet), but they are the directions with the largest variations in the data. This also means that they are the most important dimensions in relation to explaining the variations we see.

If all attribute ratings were completely independent (uncorrelated) we would have 14 perpendicular dimensions, but due to correlations between some and others that are rated the same across all listening positions, the number of mathematical important independent dimensions are always smaller.

[3] Correlation is a term for the relationship between two quantitative variables. This is when one variable increases while the other increases and vice versa.

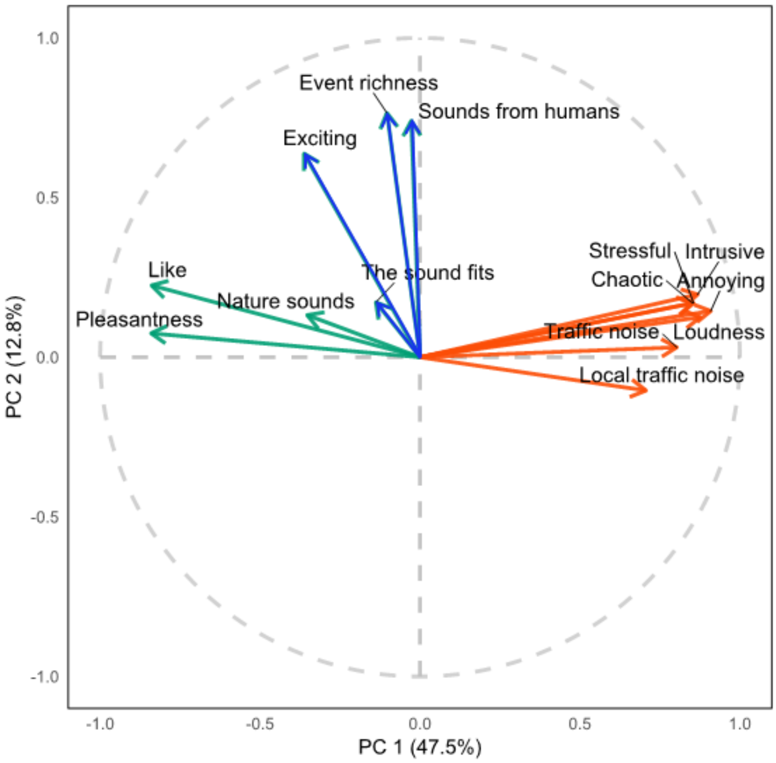


Figure 26 *PCA loadings from a principal component analysis (PCA) of the actual situation that indicates the relationship between the various attributes.*

A result from the PCA is the "loadings" of the attributes shown in Figure 26. It shows the correlation of the attributes in the plane of dimension 1 and 2. If the vectors representing the attributes are close together, then the attributes are correlated (e.g. Loudness and Annoying). If a vector is long (e.g. Annoying), its variation is explained mainly by these two first dimensions. If a vector is short (e.g. The sound fits), it's mainly explained by a third or other dimension.

It is seen that the attributes Pleasantness, Nature sounds and Like (green arrows) are in the same direction. In the opposite direction is Loudness, Traffic noise, Stressful, Annoyance, Intrusive, Local traffic noise and Chaotic (orange arrows). It is quite meaningful that these two groups are in opposite directions. We can conclude that dimension 1 is related to Annoyance with the largest annoyance to the right and the least (Liking) to the left. The attributes Event richness, The sound fits, Sounds from humans and Exciting (blue arrows) have a special meaning as they are more or less perpendicular to the direction of the two first mentioned groups, dimension 1. Dimension 2 is related to how exiting the sound is in terms of Event richness and Sounds from humans. Dimension 1 explains 47.5 % of the variation in data, dimension 2 explains 12.8 %. In total the two dimensions explain 60.3 % of the variation in the data.

The PCA loadings plot may also suggest that increasing the audibility of nature sounds may increase pleasantness and reduced annoyance.

5.5 Relations between the positions

From the assessments of the attributes some information about the six positions can be deduced.

From a principal component analysis, PCA analysis, of the attributes a systems factor map is shown in Figure 27. To understand this figure, you can imagine seeing the beforementioned cloud of points from a direction where you see the maximum length (dimension 1 on the x-axis) and the maximum width (dimension 2 on the y-axis). The Blue square is then the position of the mean value for all points belonging to position 1 and the blue ellipse is indicating the 95% confidence area of this mean value and so forth for the other five positions.

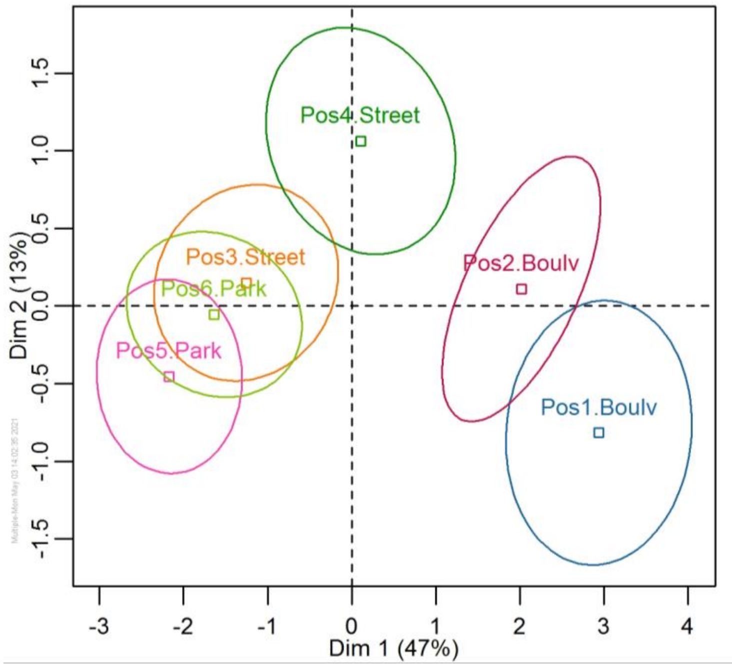


Figure 27 *A systems factor map from a principal component analysis (PCA) that shows the mean values and confidence ellipses for the measuring positions in the first two dimensions of the space consisting of the attribute assessments.*

When dimension 1 is related to annoyance, and dimension 2 is related to Event richness and Sounds from humans, Figure 27 can be interpreted as follows: Position 1 by the road with high traffic volume is the most annoying, position 5 in the park is the least annoying. As position 6 is included in the confidence ellipse of position 5, the two park positions are probably not significantly different. Positions 1 and 5 have the least Event richness and Sounds from humans while position 4 is clearly the one with the maximum of these attributes.

From Table 1 it can be seen that position 3 has almost the same L_{Aeq} as position 4. Anyway, the impression of position 3 is that it is a silent street with a few cars passing by now and then. In that sense it is more in line with positions 5 and 6 as the figure shows while there was a lot of activity in position 4 (schools and some building activity).

5.6 The soundscape index

FORCE Technology has constructed a soundscape index which can be calculated from the differences between the assessments of the actual and the ideal situation for each attribute evaluated.

An overview of the results is given in Figure 28. Each curve shows the deviation from the ideal point for all attributes for a measuring position. The assessment of the ideal has been given the value 0 and is here marked as a black line. What you want less of is above 0, and what you want more of is below 0.

The deviations from the ideal must be seen in the light of the fact that the uncertainty (95 % confidence intervals) is on average around 10 units on the y-axis.

Based on the total deviations, a sound landscape index has been calculated which is shown in Figure 28. It is a number between 0 and 10 that indicates the quality of the soundscape. 0 is lowest and 10 is highest quality.

The soundscape index SI is calculated as:

$$SI = \frac{100 - 1{,}5 * M}{10}$$

Where M is the average deviation from the ideal point for all attributes.

The soundscape index SI can be seen as an overall expression of the quality of the soundscape at a specific location based on the evaluation of 14 different attributes related to soundscape (see Table 2). The soundscape index SI can be used to compare the soundscape quality at different locations.

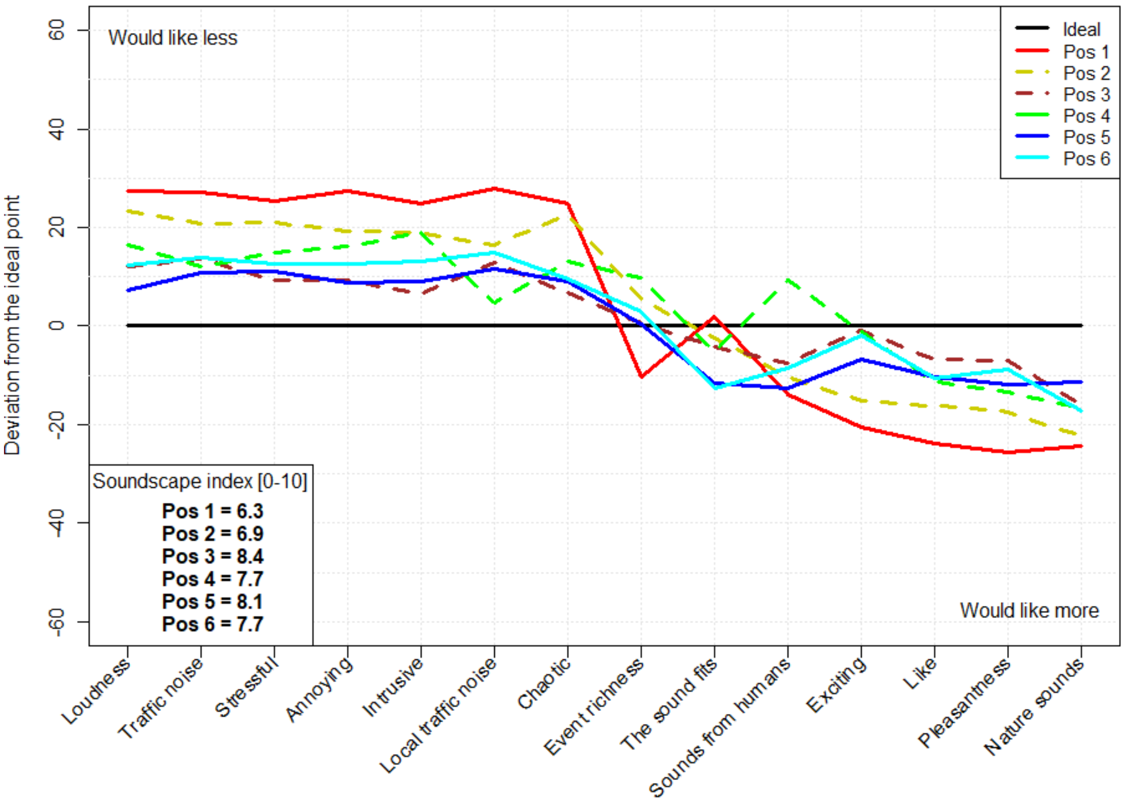


Figure 28 *Soundscape index for each of the 6 measurement positions. Each curve shows the deviation from the ideal point for all attributes for a measuring position. The ideal point is marked with the black line. The soundscape index for each position is shown in the lower left corner of the graph.*

It is seen that positions 1 and 2 have the lowest soundscape index indicating that these positions are the most unpleasant to be situated in. On the other hand, positions 3 and 5 have the highest ratings soundscape index indicating that these positions are the most pleasant to be situated in. It is remarkable that position 3 is rated higher than positions 5 and 6 in the park. The explanation may be that the traffic noise was more prominent than one would expect in the park while position 3 was perceived as a rather silent street.

6. Models for annoyance – dose-response curves

The relation between the annoyance reaction and the noise exposure can be described with dose-response curves. Most often these curves represent the annoyance response as function of the noise exposure, L_{den} where the annoyance responses are averaged over all context, social and personal variables.

The responses are normally obtained from socio-acoustic surveys where hundreds to thousands of respondents are asked to assess the annoyance within the last year when they are at home (see as an example [4]). The annoyance assessment is meant to be the average over time and over the many situations where the annoyance is felt at home.

Although the annoyance measured during the sound walks uses the same annoyance scale, the situation is quite different. It is a short time assessment where the traffic is present and where the focus is at the traffic and the annoyance felt in the actual situation "answering questions on a sound walk".

Nevertheless, there may be similarities between the dose-response reactions and the non-acoustic factors that modify the dose response curves.

With the purpose of finding the dose-response curves for the annoyance from traffic noise during sound walks, models of the annoyance measured as a variable in the sound walks as function of the corresponding L_{Aeq} levels have been tested. The curve in Figure 29 shows a model with a logistic fit to the measured data.

It should be noted that normally the results from socio-acoustic surveys are given as curves showing the percentage of highly annoyed. For the sound walks we have chosen to show the results for the annoyance in each position as the average annoyance response for all participants on the 0-10 scale.

A logistic function is often used to describe the relation between noise exposure and the perceived annoyance, see e.g. [4]. The curve in Figure 29 can be described by the logistic function given by:

$$A = \frac{u}{1 + e^{-s(E-f)}}$$

where

- *A* is a measure for the annoyance response
- *u* is the **u**pper limit of *A (10 for the annoyance score, 100 for the percentage annoyed)*
- *s* is the **s**lope of the inverse logit function
- *E* is a measure for the noise **E**xposure e.g. L_{den} or L_{Aeq}
- *f* is the value of E for a **f**ifty percent annoyance response

It is seen that the curve is defined by only two constants, the slope, s, and the fifty percent value of the exposure, f.

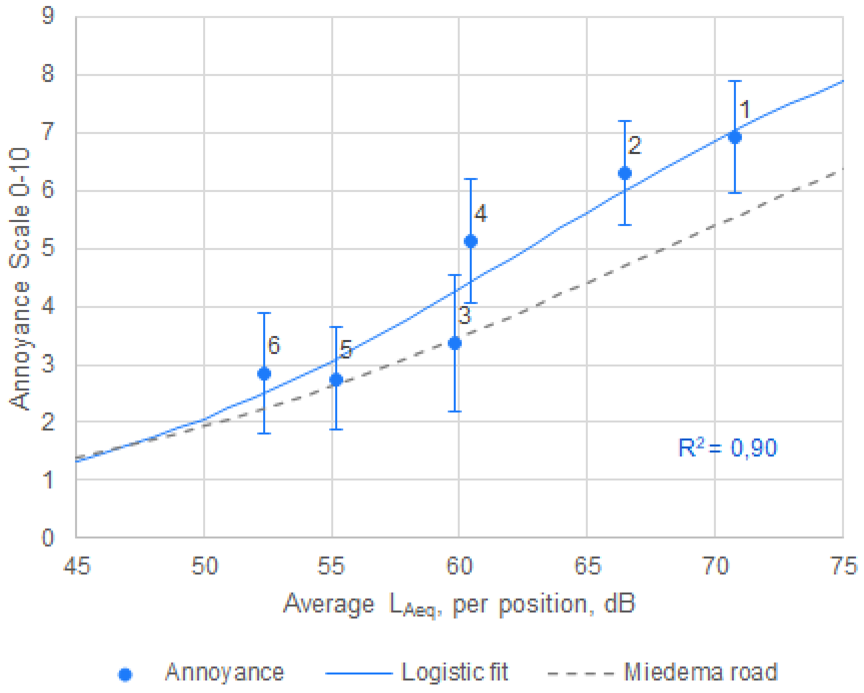


Figure 29 *Average annoyance response during the sound walks in each of the measuring positions 1-6. The vertical bars represent the 95 % confidence intervals for each measurement position. The blue curve can be described by s = 0,1064 and f = 62,7, see the text. The grey dotted curve here called "Miedema road") (s = 0,0795, f = 70,4) is the average annoyance score deduced from [5] according to [6]. For this curve L_{den} is converted to L_{day} (~ L_{Aeq}) by adding 2,4 dB according to [7].*

The model in Figure 29 gives good fit (R^2 = 0,9) to the data. So, it can be concluded that it is possible to find a dose-response curve from a sound walk when there is sufficient variation in the noise levels, in this case a 20 dB range of L_{Aeq} values from 52-71 dB.

The "official" EU curve (here called the Miedema curve) is also shown. (The curve is corrected from L_{den} to L_{Aeq}). Compared to the corresponding curve from the Miedema data (showing the annoyance score and not highly annoyed as usually used), it is seen that the annoyance response is higher from the sound walks and with a steeper slope. This is to be expected because the Miedema survey data is the average over all situations at home where the focus is not at the traffic noise as in the sound walks.

The next relevant topic is to see if the influence of non-acoustic factors can be modelled. In this case it was planned to model the influence of greenery and the visibility of the traffic.

The input data for this (L_{Aeq}, amount of greenery and visibility of the traffic) is found in Table 1 and a logistic regression is made with a model including L_{Aeq}, % greenery and % traffic visible (the dotted red curves in Figure 30).

In the analysis it turns out that only the influence of L_{Aeq} is statistically significant. Anyway, for illustration purposes only the tendency for the effect of greenery on the dose-response curves is shown in Figure 30. The annoyance equivalent change in L_{Aeq} for 0-100 % greenery is seen to be approx. 3 dB. Meaning that in a situation with 100 % greenery, the annoyance response is lower than in a similar situation but without greenery. The reduced annoyance corresponds to 3 dB.

The non-significant effect of the visibility of the traffic is of the same magnitude.

As the confidence intervals for the size of both effects include both positive and negative changes, no reliable data for the influence of these moderators can be deduced from the sound walk results.

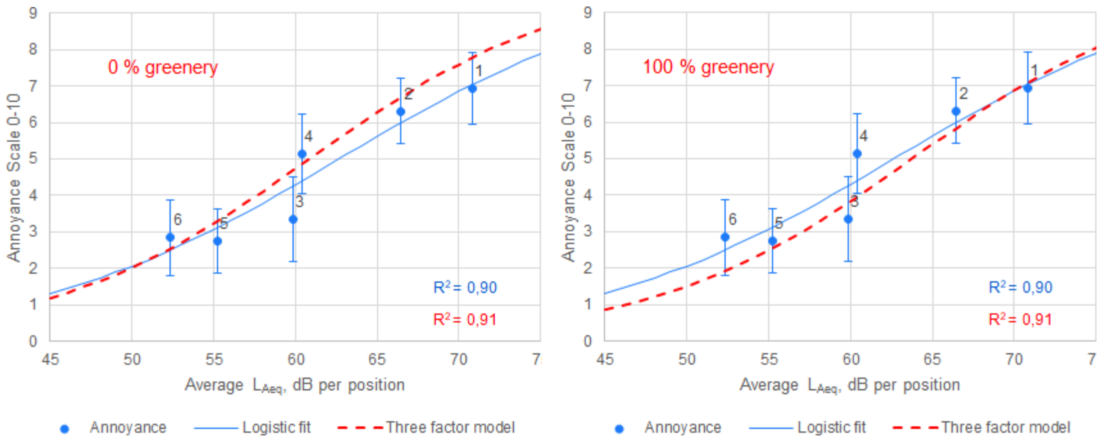


Figure 30 *The (non-significant) effect of greenery on the dose response curve. The dotted red line represents 0 % greenery in the left graph and 100 % greenery in the right. The blue curves show the average annoyance response during the sound walks in each of the measuring positions 1-6 as seen in Figure 29.*

It may be a bit disappointing that the effect of greenery and visible traffic is not significant in this investigation. But on the other hand, the input data in Table 1 shows little variation in the moderator greenery and the high values correlate with low noise levels so there is not much left for this variable to explain. The same holds for traffic visibility where the two data points without 100 % visibility have the lowest noise levels.

It may be possible to investigate the effect of the variable's greenery and visible traffic by the means of sound walks. In that case more measuring points would be needed and with more and independent variations of the variables L_{Aeq}, greenery and visible traffic.

7. Conclusions

The sound walks were successful in the sense that they gave a good representation of the sound sources in a sound source hierarchy (sound source taxonomy). The diversity of sound sources was dominated by sounds from human activity, especially traffic noise. According to the participants bad sounds were dominating except in the two positions in the park. Results with acceptable uncertainty (95 % confidence intervals) were obtained for the 14 soundscape attributes (soundscape descriptors) used to describe the soundscape and the annoyance. The results gave detailed characteristics of the six measuring positions. A principal component analysis revealed that the results could mainly be represented in an annoyance-like dimension and a dimension describing Event richness and Sounds from humans. From these results a "systems factor map" could be constructed, which gave a clear picture of the relations between the six measuring positions, and why they differed.

Furthermore, it was possible to calculate the soundscape indices for the six positions which gave a clear discrimination between the positions in terms of soundscape quality.

Sound level measurements were made during the sound walks and annotated level recordings helped the understanding of the soundscape assessments.

By combining the assessments of annoyance from the sound walks with the measured noise levels it was possible to make a model (dose-response curve) for the annoyance as function of the noise level (L_{Aeq}) with a good fit ($R^2 = 0,9$).

The influence of greenery and the visibility of the traffic was also sought to be modelled. Due to insufficient variations and correlation with the traffic noise levels, the modelled influence of these moderators was not significant. A trend was found that the effect of presence of greenery reduced the annoyance equivalent level with around 3 dB, but the uncertainty was large.

The investigation has showed that sound walks can give valuable and quantifiable information about the soundscapes in the various positions.

The results also suggest that soundscape measurements may be a useful tool for investigating the annoyance from traffic noise and the effect of non-acoustic variables, e.g. greenery and visible traffic. For this to be successful the following should be considered:

- As the holistic situations at the places of interest may differ for other reasons than the differences in the variables under investigation a higher number of positions is needed so unwanted bias can be corrected for or averaged out. Alternatively, special care should be taken that the main differences only or primarily are caused by differences in the variables of interest.
- There shall be sufficient and independent variation in the variables under investigation in the chosen measuring positions. As an example: Greenery may be related to lower noise levels e.g. if measurements are made in a park away from the traffic. If so, both other "green" positions with high noise levels should be found and also no-green positions with low noise levels.
- Based on the sparse experience from this investigation: As a rule of thumb we would recommend having four times as many measuring positions as the number of variables of interest. So, if we want to investigate the influence of noise level, greenery, and the visibility of the traffic, this means 12 measuring positions. For construction of a dose-response curve we will recommend at least 6 measuring positions where the main variable is the noise level of the traffic with a level range of 15-20 dB or more.
- At least 20 persons (e.g. in groups of 5-7 persons) shall make the assessments. If not the same group of persons is assessing all positions, more persons and some experimental design is needed to ensure that differences in results are caused by the positions and not the difference between the groups of assessors. With the current questionnaire the assessment time is 5-10 minutes in each position.

8. References

[1] Truls Gjestland, “Non-acoustic factors that affect the annoyance response,” Deliverable 1.2 Preliminary prioritized list of modifiers, Report from he FAMOS project, 2020.

[2] ISO, *DS/ISO 12913-1 Akustik - Soundscape - Del 1: Definitions- og begrebsramme. Definition and conceptual framework.* 2014, p. 14.

[3] ISO, *ISO CD 12913-2 Acoustics — Soundscape — Part 2: Data collection*, vol. 7. 2016, p. 41.

[4] J. Fryd, L. N. Michelsen, H. Bendtsen, L. M. Iversen, and T. H. Petersen, “Noise annoyance from urban roads and motorways - Vejdirektoratet Report 565,” 2016.

[5] European Commission, *Position paper on dose response relationships between transportation noise and annoyance*. 2002.

[6] T. Pedersen, “The ‘Genlyd’ Noise Annoyance Model: Dose-Response Relationships Modelled by Logistic Functions,” *DELTA Acoust. Electron. Hørsholm, Denmark*, pp. 1–121, 2007.

[7] M. Brink, B. Schäffer, R. Pieren, and J. M. Wunderli, “Conversion between noise exposure indicators Leq24h, LDay, LEvening, LNight, Ldn and Lden: Principles and practical guidance,” *Int. J. Hyg. Environ. Health*, vol. 221, no. 1, pp. 54–63, 2018.

Appendix 1 Sound measurements and recordings

In each position and for every sound walk recordings were made with a stereo setup of measuring microphones and with a dummy head (Head and Torso Simulator, HATS, Brüel & Kjær type 4100).

The recordings were analysed with the analysis software, NoiseLab. The analyses were for all positions the positions made for the same periods as the assessments. The results are shown in Table 5 and the succeeding graphs.

Positions and sound walks	L_{Aeq}	L_{A50}	L_{A95}
Pos1 SW1	71,0	70,2	65,4
Pos1 SW2	70,1	69,7	64,4
Pos1 SW3	71,5	70,9	66,5
Pos1 SW4	70,5	70,3	64,5
Pos2 SW1	67,7	67,5	59,8
Pos2 SW2	65,1	64,3	57,2
Pos2 SW3	66,8	65,9	58,8
Pos2 SW4	66,4	65,7	58,9
Pos3 SW1	61,5	53,4	48,0
Pos3 SW2	57,1	51,9	45,8
Pos3 SW3	61,5	54,9	50,5
Pos3 SW4	59,3	57,1	49,2
Pos4 SW1	59,3	55,6	49,6
Pos4 SW2	58,6	54,8	47,7
Pos4 SW3	61,3	57,7	51,4
Pos4 SW4	62,5	61,7	60,2
Pos5 SW1	52,2	49,8	44,6
Pos5 SW2	56,8	50,6	44,8
Pos5 SW3	58,9	55,9	49,9
Pos5 SW4	52,9	50,8	45,8
Pos6 SW1	52,8	51,3	46,3
Pos6 SW2	52,2	51,4	46,3
Pos6 SW3	52,4	51,8	48,5
Pos6 SW4	52,1	51,6	48,8
Pos 1 avg	70,8	70,3	65,2
Pos 2 avg	66,5	65,8	58,7
Pos 3 avg	59,8	54,3	48,4
Pos 4 avg	60,4	57,5	52,2
Pos 5 avg	55,2	51,8	46,3
Pos 6 avg	52,4	51,5	47,5

Table 5 *The results of the noise measurements for each position and for each of the sound walks (SW) and the average values (avg) for each position.*

Figure 31 to Figure 42 show the A-weighted time history of the recordings. Special events are noted on the graphs.

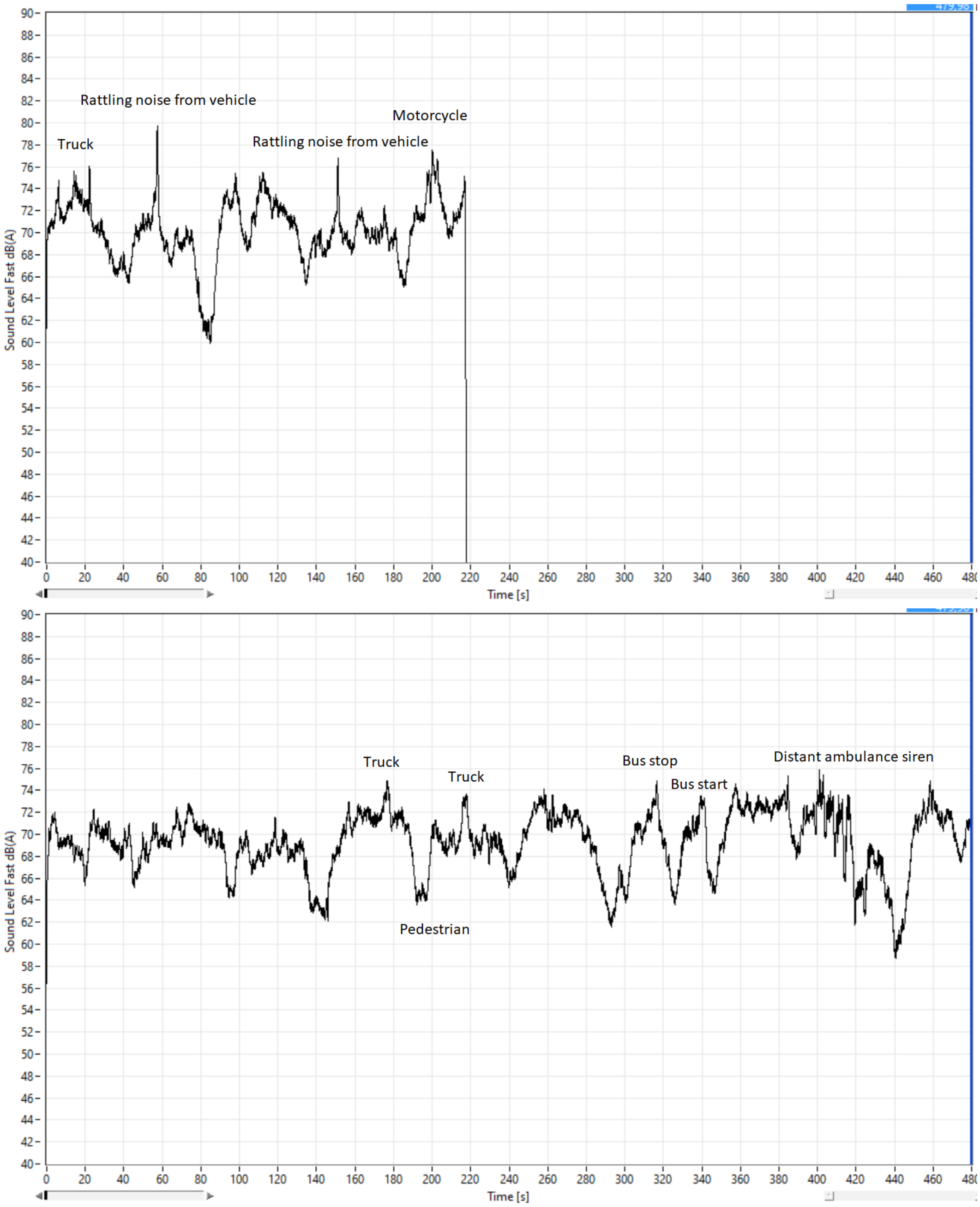
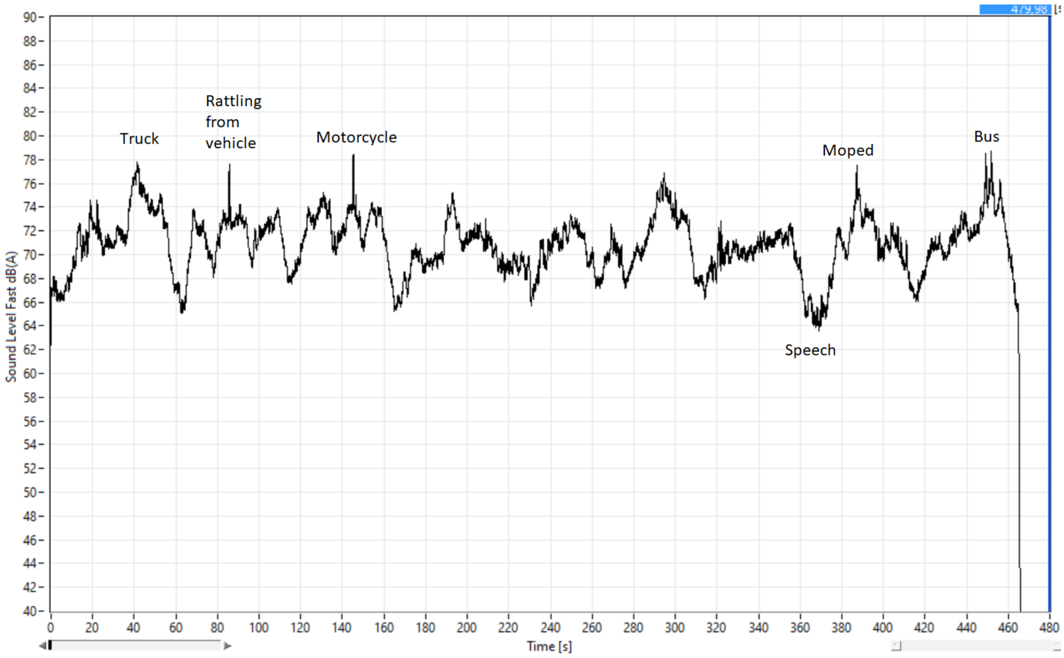


Figure 31 *Position 1. Level recordings (A-weighted, F).*
Upper: Sound walk no. 1. Lower: Sound walk no. 2.



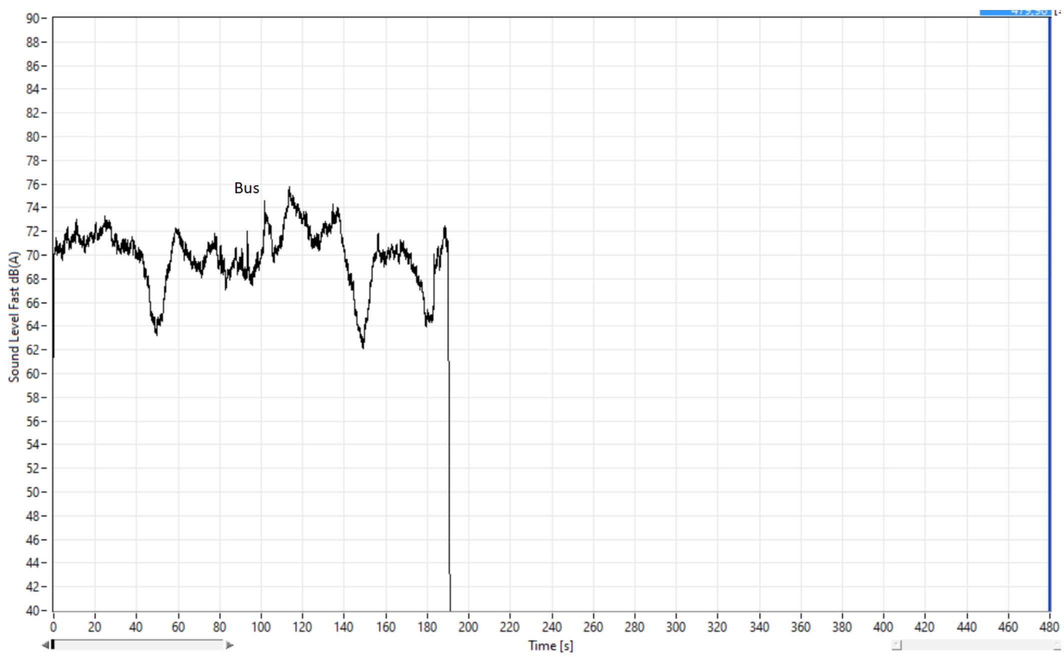


Figure 32 *Position 1. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3. Lower: Sound walk no. 4.

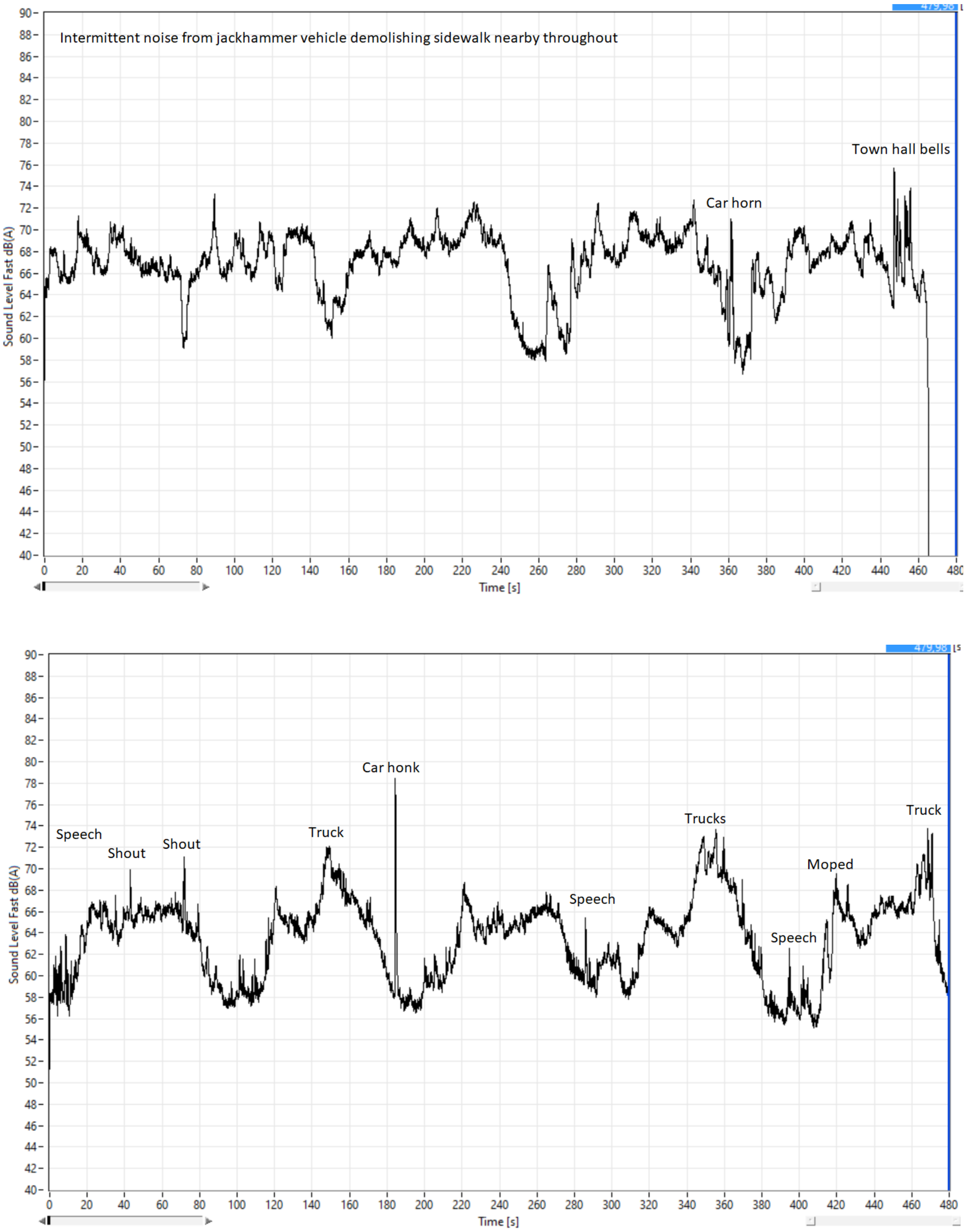
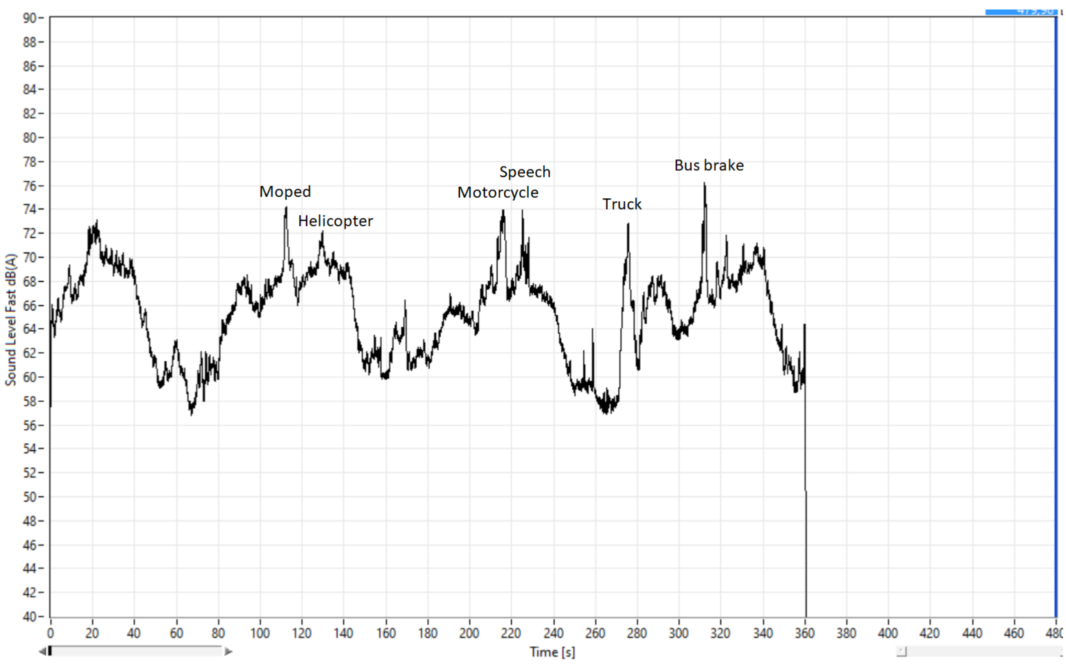


Figure 33 *Position 2. Level recordings (A-weighted, F).*
Upper: Sound walk no. 1. Lower: Sound walk no. 2.



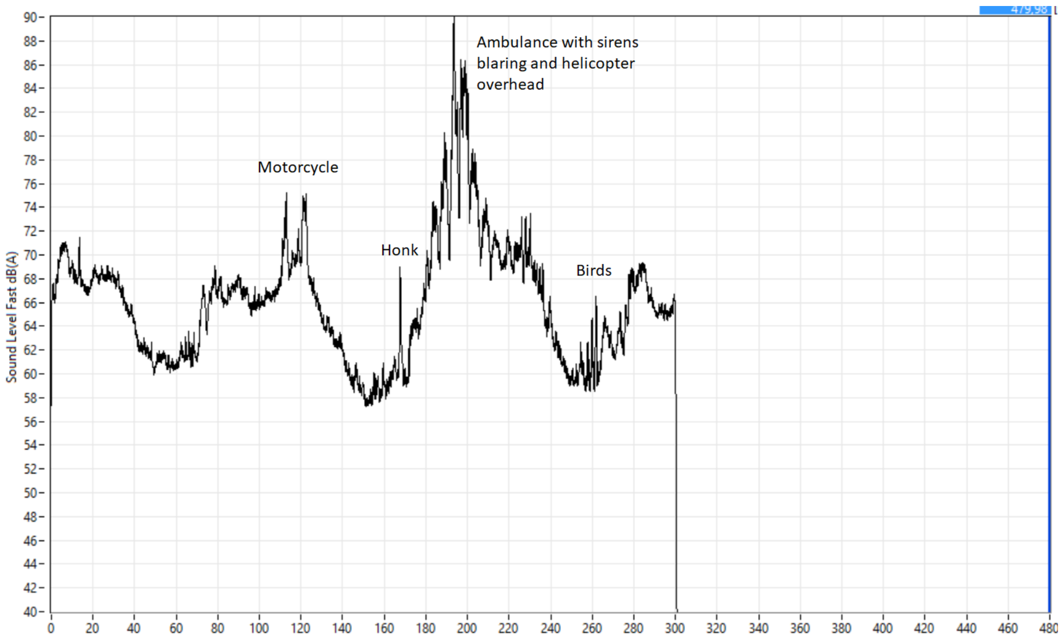


Figure 34 *Position 2. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3.
Lower: Sound walk no. 4, 160-260 s excluded from analysis.

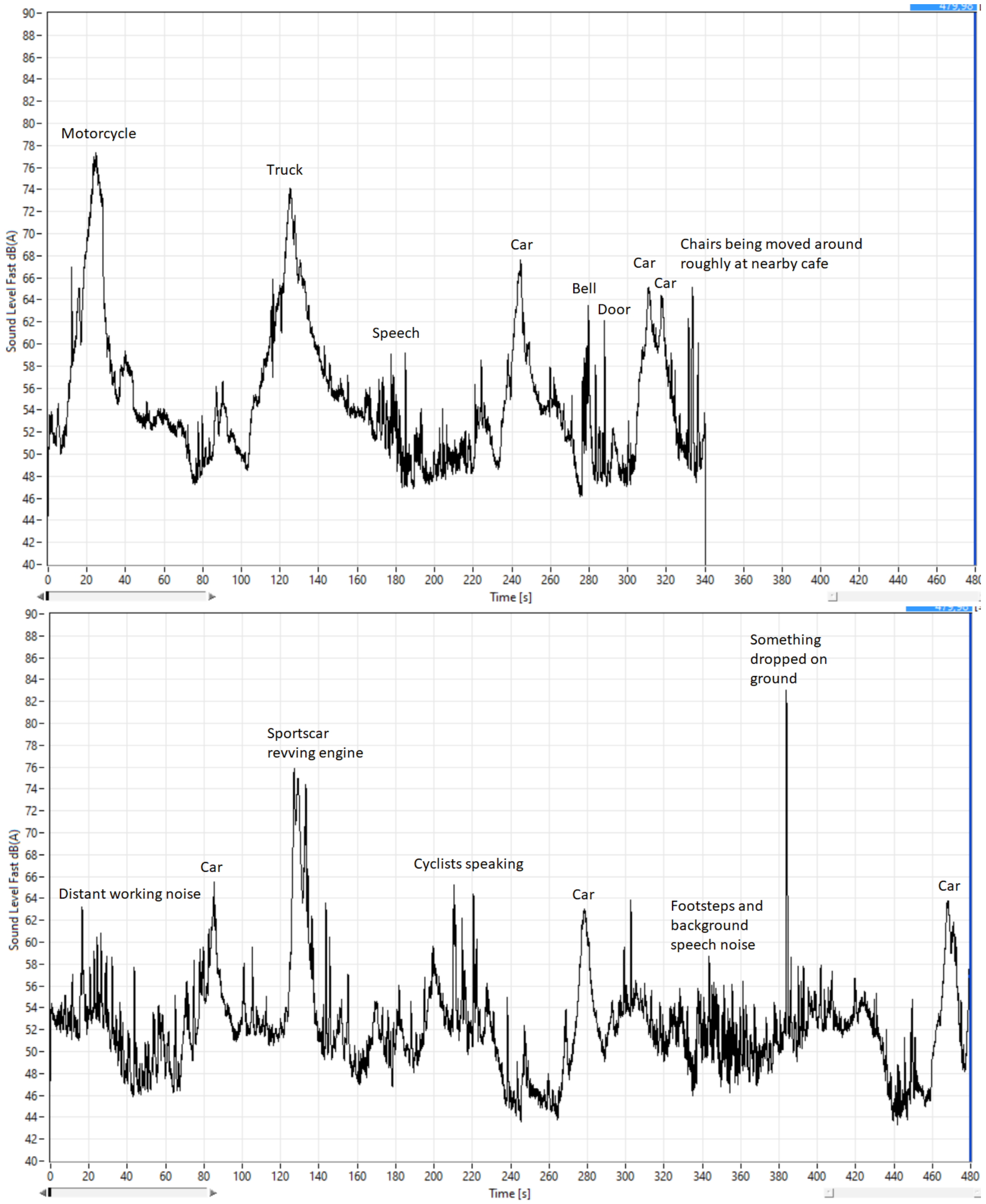


Figure 35 *Position 3. Level recordings (A-weighted, F).*
Upper: Sound walk no. 1. Lower: Sound walk no. 2.

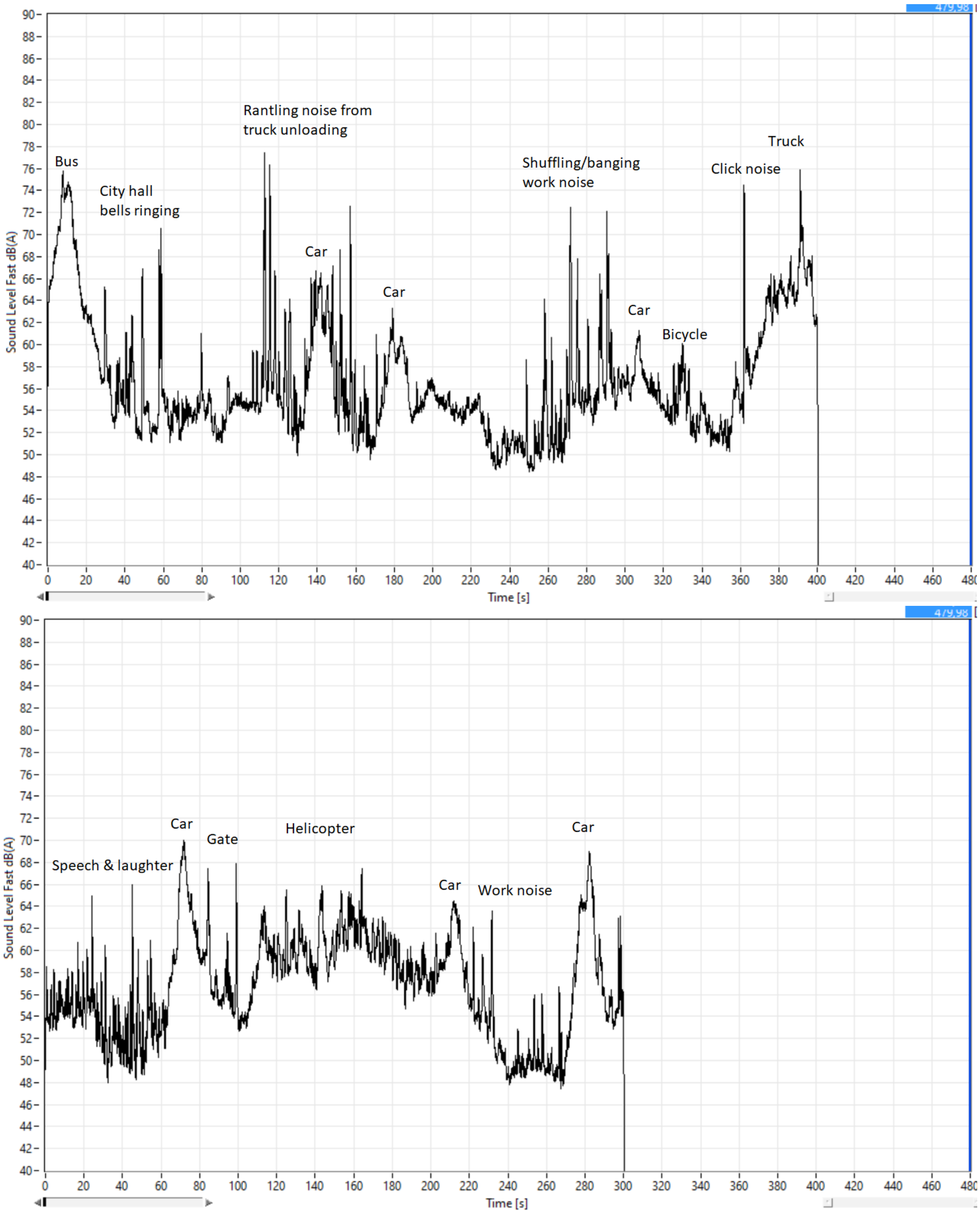


Figure 36 *Position 3. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3. Lower: Sound walk no. 4.

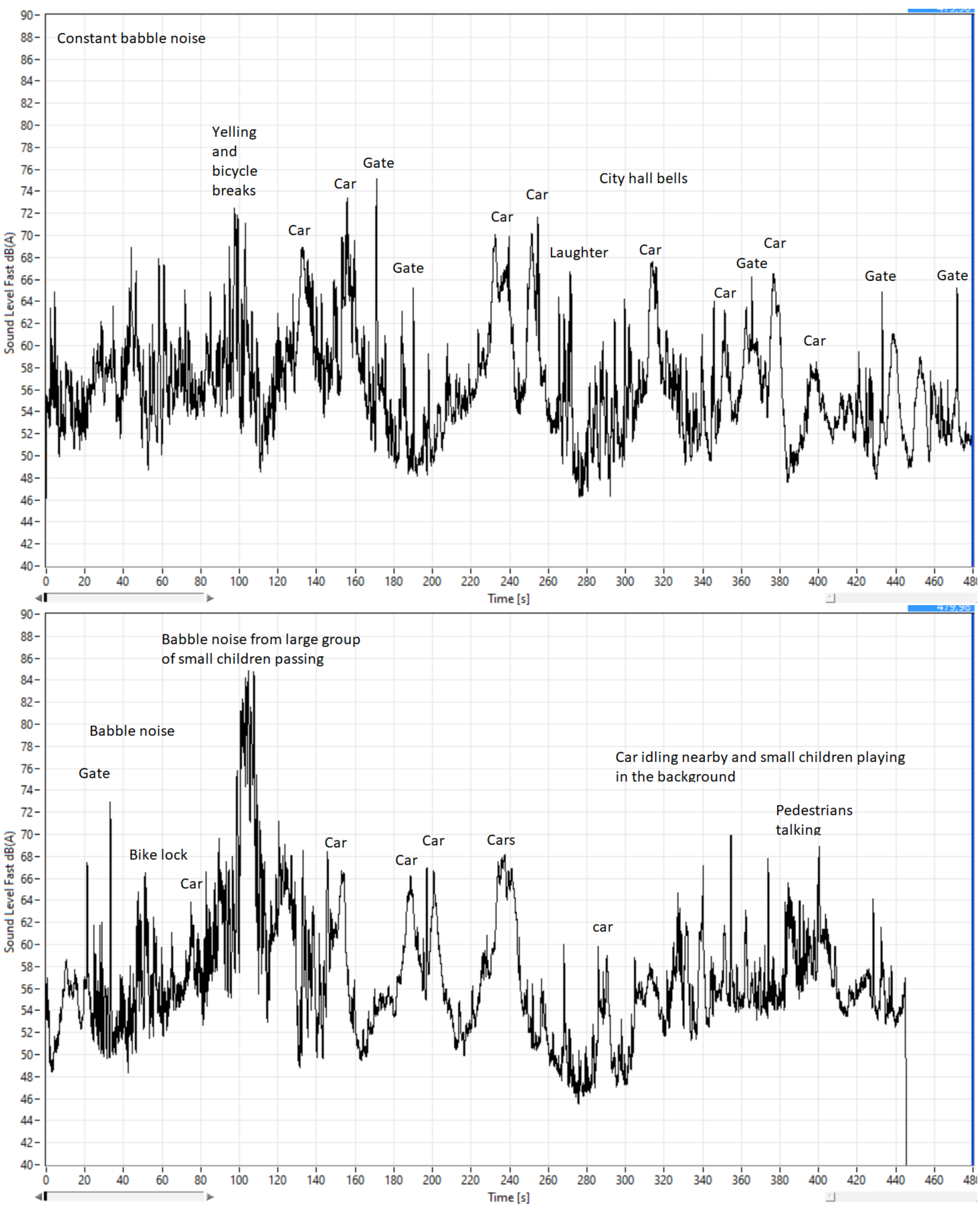


Figure 37 *Position 4. Level recordings (A-weighted, F).*
Upper: Sound walk no. 1. Lower: Sound walk no. 2, only 140-350 s analysed.

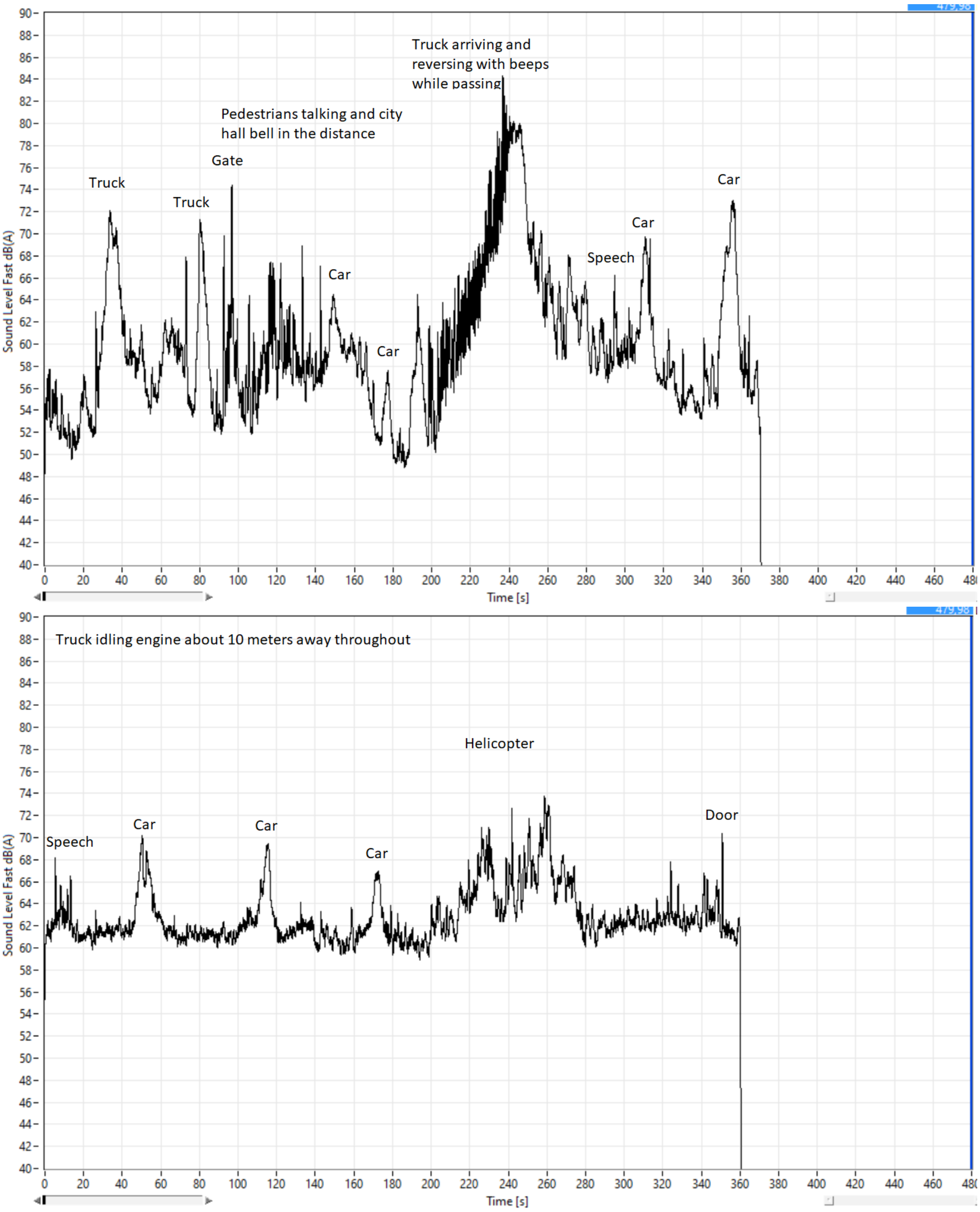
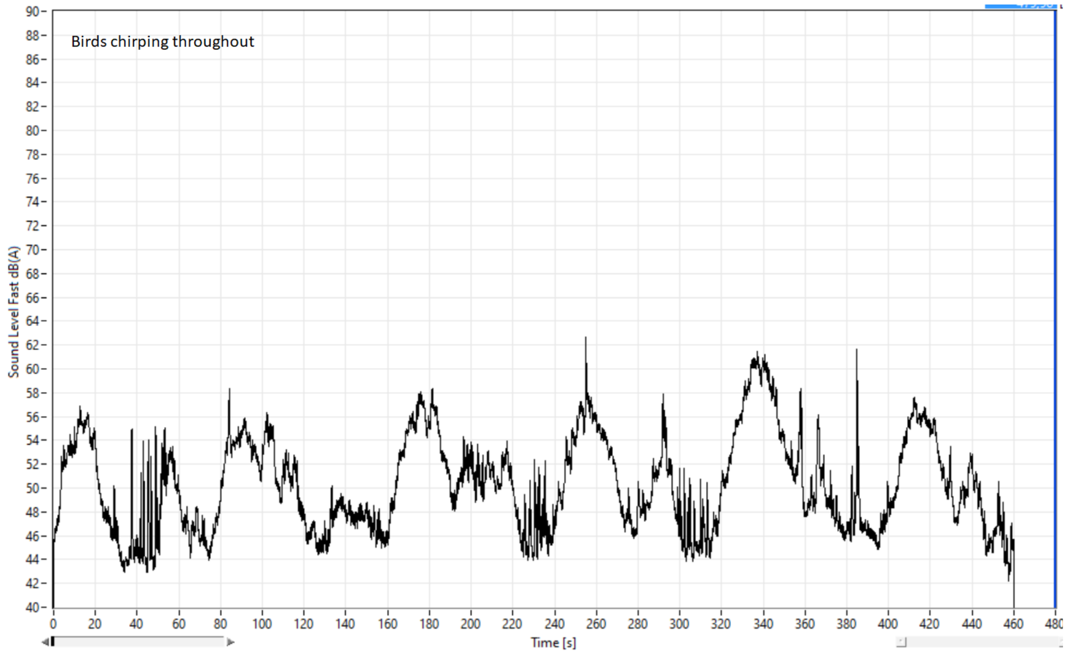


Figure 38 *Position 4. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3, 195-285 s excluded from analysis.
Lower: Sound walk no. 4, 210-280 s excluded from analysis.



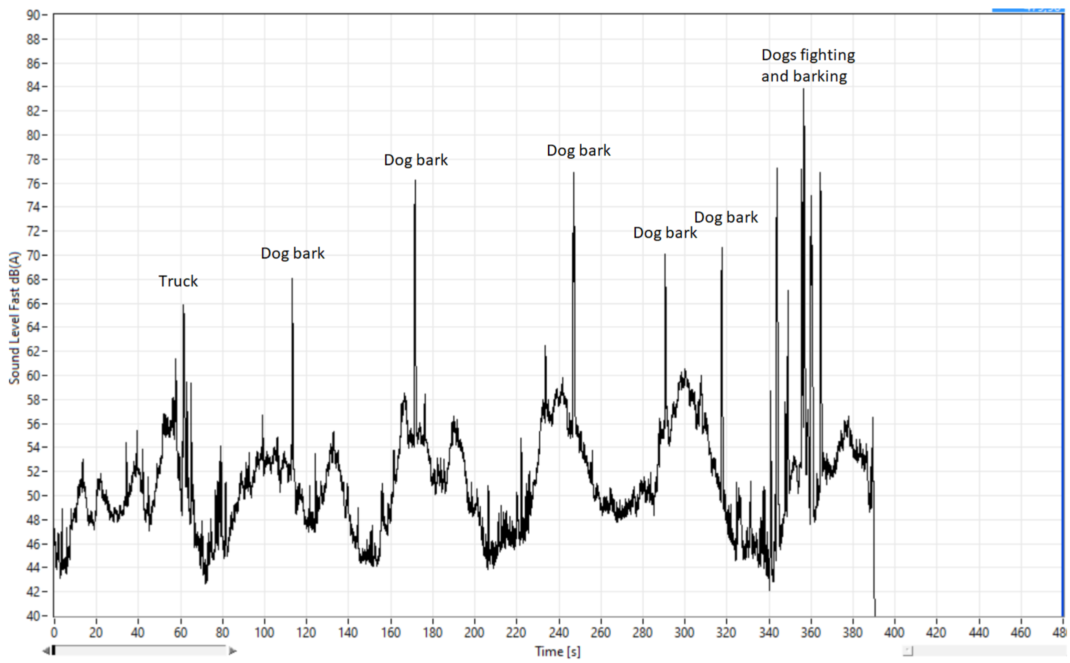
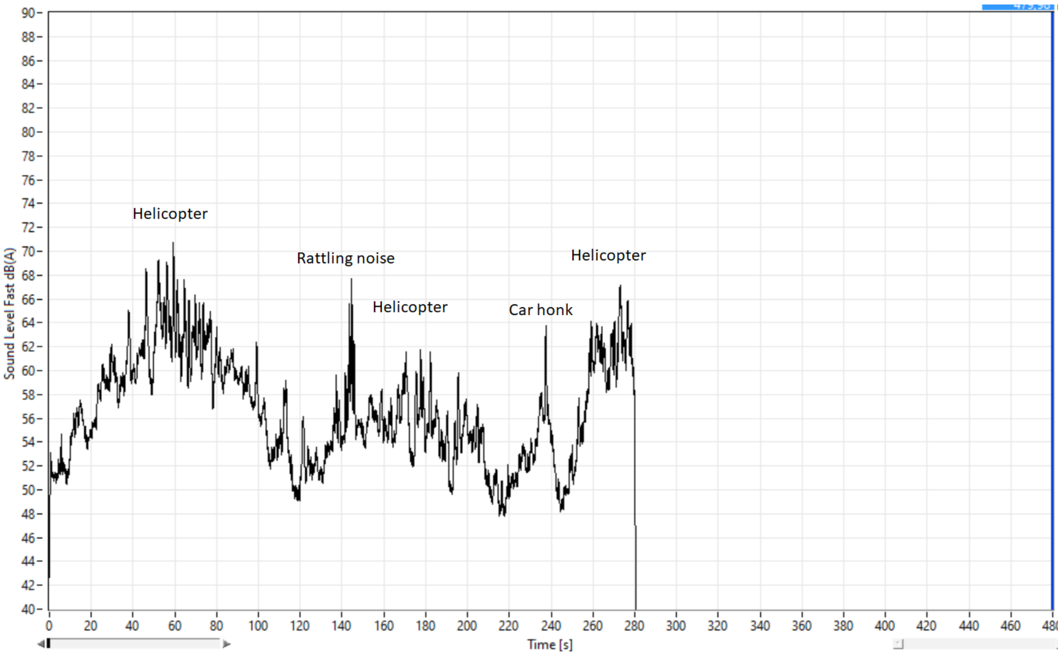


Figure 39 *Position 5. Level recordings (A-weighted, F).*
Upper: Sound walk no. 1. Lower: Sound walk no. 2.



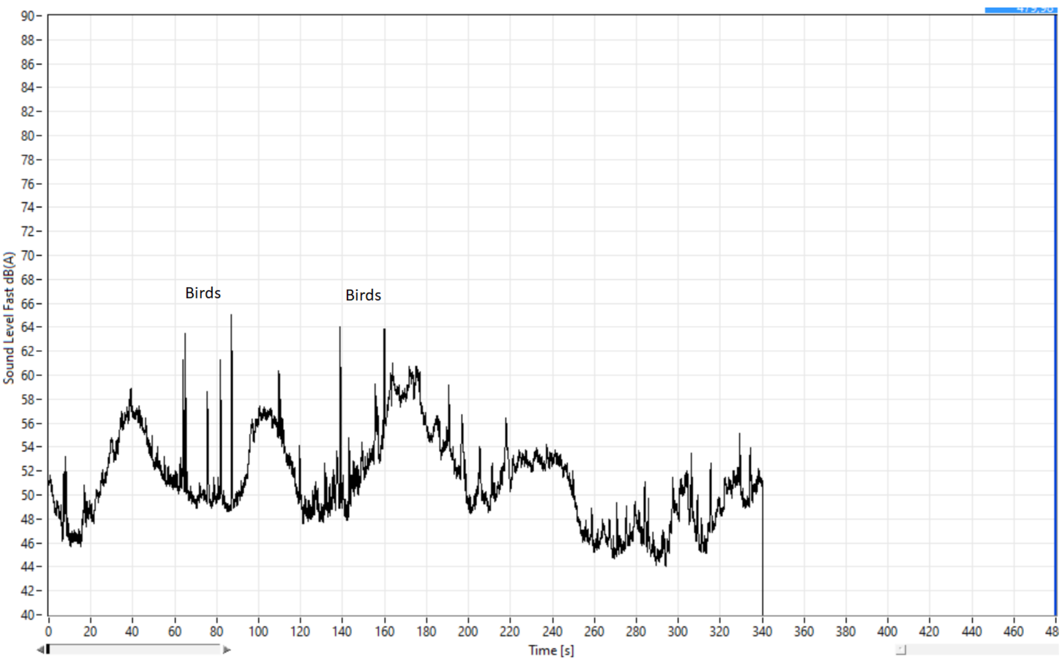
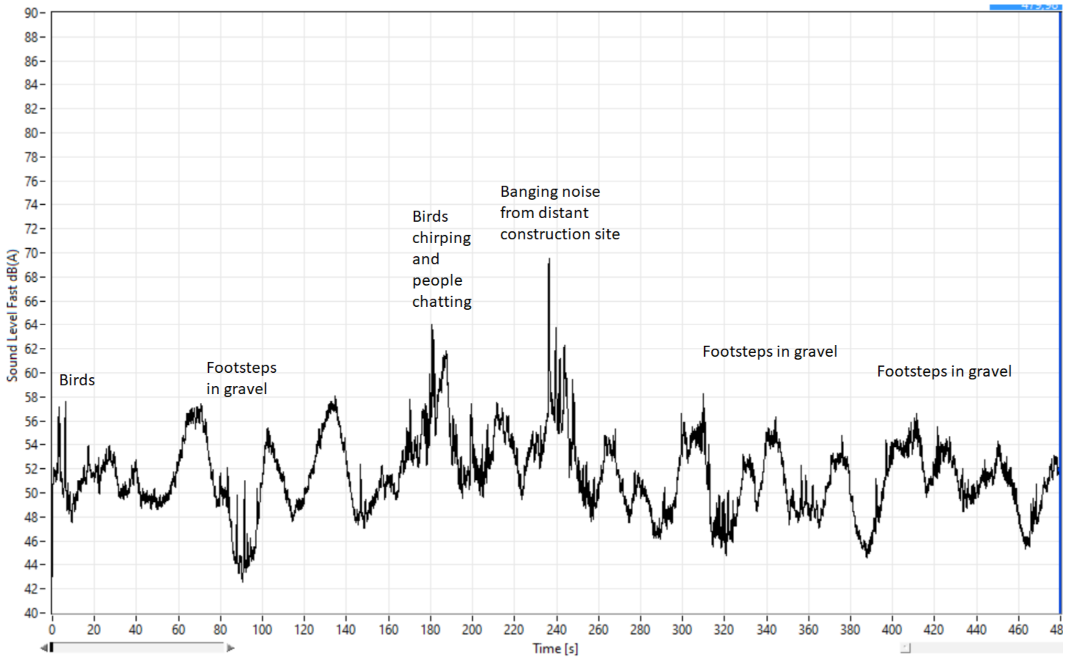


Figure 40 *Position 5. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3. Lower: Sound walk no. 4.



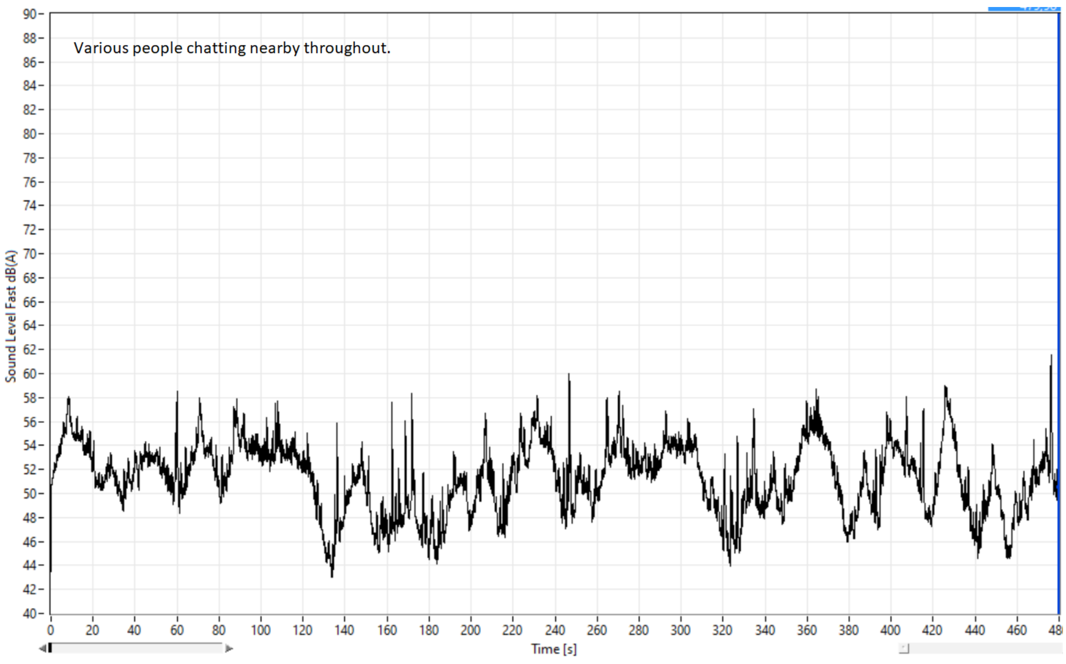
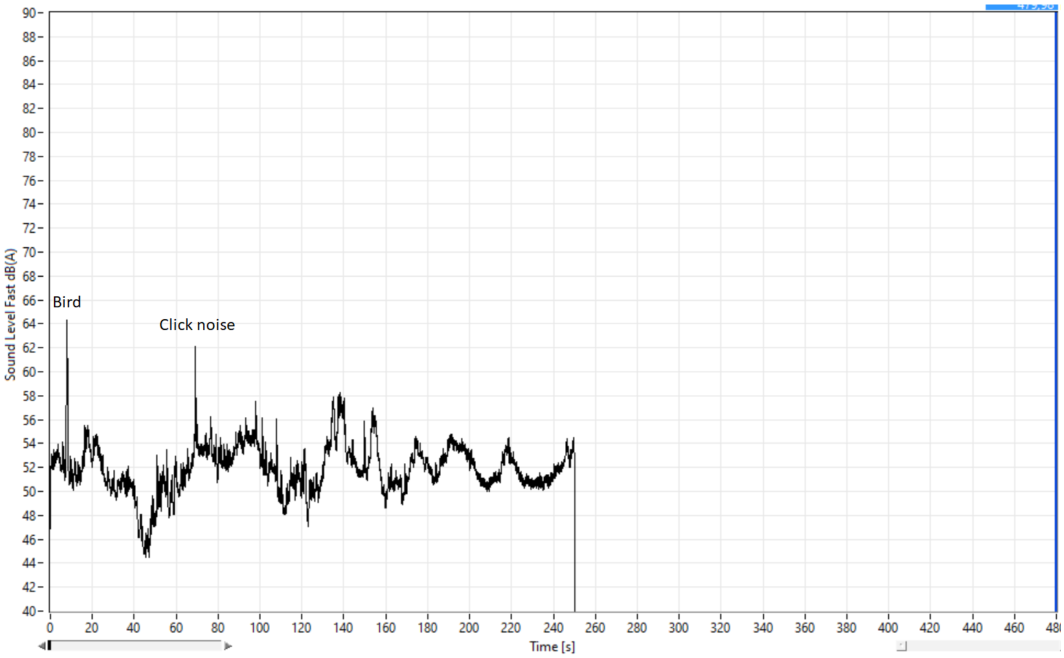


Figure 41 *Position 6. Level recordings (A-weighted, F). Upper: Sound walk no. 1. Lower: Sound walk no. 2.*



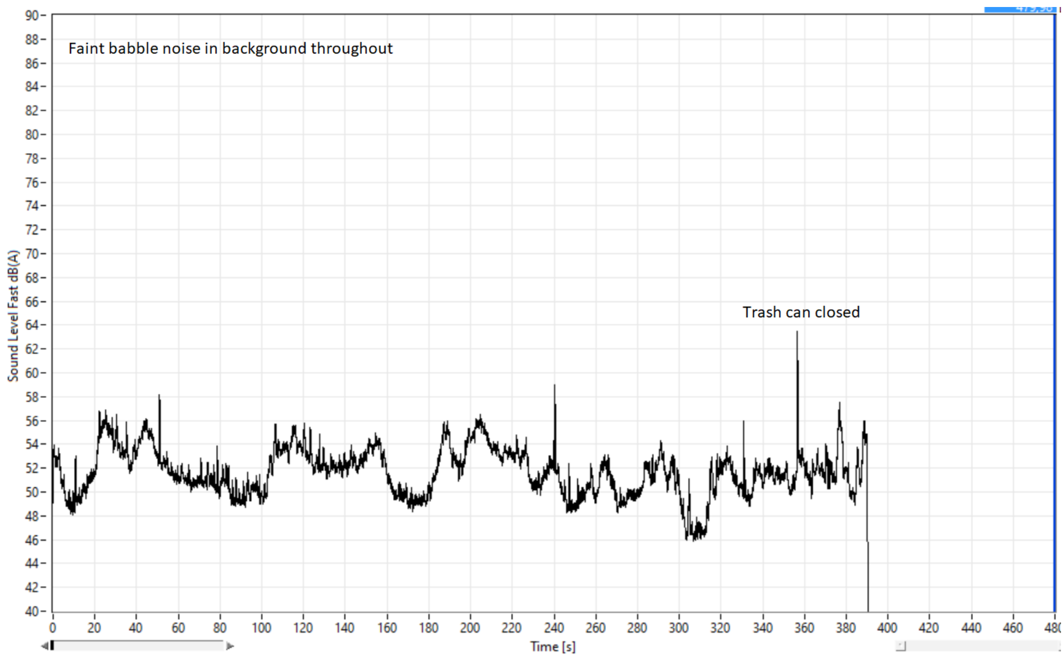


Figure 42 *Position 6. Level recordings (A-weighted, F).*
Upper: Sound walk no. 3. Lower: Sound walk no. 4.

Appendix 2 Questionaire on sound sources

For each measuring position the following should be noted:

- Note which sound sources are heard, in order of decreasing prominence.
- Only one sound on each row, and a total of up to the most 8 prominent.
- Fill the sounds in the tree columns: Bad Sounds, Neutral, Good Sounds

Lydvandrer LV:________________Posi-tion:_______________Navn___________________________

Mand ❑ Kvinde ❑ Alder:_____________

Notér hvilke lydkilder der høres, i rækkefølge efter aftagende tydelighed.

Kun en lyd på hver linje.

	Dårlige lyde	Neutral	Gode lyde
Tydeligst			
Næst tydeligst			
3. tydeligst			
4. tydeligst			
5. tydeligst			
6. tydeligst			
7. tydeligst			
8. tydeligst			