Quiet Area Investigation - A Soundscape Assessment of the People's Park, 17th October 2024

Simon Jennings, Environment and Climate Action Section, Limerick City and County Council
simon.jennings@limerick.ie

Quote:
"The final question will be: is the soundscape of the world an indeterminate composition over which we have no control, or are we its composers and performers, responsible for giving it form and beauty?"
— R. Murray Schafer, The Soundscape: Our Sonic Environment and the Tuning of the World.

Abstract

The sound environment in many cities is not healthy for its citizens, mainly due to transportation noise. Green spaces and areas of public realm that the public use and congregate are potential quiet areas away from environmental noise. These quiet areas provide opportunities for physical activity, social connection and mental relief. Studies have shown that exposure to green space is good for our health and well-being and improves cognitive development and brain function[1,2]. Limerick City and County Council is investigating the acoustic characteristics of public green spaces that contribute to tranquillity as part of noise action planning and the investigation of potential Quiet Areas, for designation under the Environmental Noise Regulations[3]. This report outlines an investigation of the People's Park on 17th October 2024 and the advantage of involving the public in the assessment of our acoustic environment. Public engagement offers the potential to take account of citizens perceptions and preferences, highlight the benefits of Quiet Areas to health and well-being, target improvements in green spaces (e.g. parks, greenways) and urban design.

Introduction

Noise pollution is the second largest urban environmental stress factor affecting people's health according to the World Health Organization[4] and is a major environmental problem in cities around the world. The European Environment Agency published a report showing that 20% of Europe's population (approximately 113 million people) is exposed to noise levels that are harmful to their health[5]. Long-term exposure to noise produces a variety of health effects including annoyance, dis-improved mental health, hearing impairment, cognitive impairment in children, sleep disturbance, and negative effects on the cardiovascular and metabolic system. The 7th Environment Action Program's objective of reducing noise pollution in Europe by 2020 was not achieved[6]. The Zero Pollution Action Plan for 2030 sets a new goal: to reduce the number of people chronically disturbed by transport noise by 30% compared to 2017[7]. The Environmental Noise Directive (END) 2002/49/EC is the main European legislative framework for the management of environmental noise[8], which was first transposed into Irish legislation under the Environmental Noise Regulations in 2006. Much of the focus of the implementation of the regulations by local authorities has focussed on mitigation (reducing the number of persons harmfully affected by environmental noise) which is a reactive response, environmental noise management. However, another key objective of the regulations (and as important) is the designation of Quiet Areas. Designation does not provide statutory protection to prevent environmental noise in Quiet Areas but is an opportunity to highlight the benefit of those spaces for citizens health and well-being. They are of particular significance for citizens exposed to the harmful effects of high levels of environmental noise where they live and need access to a healthy sound environment in close proximity (e.g. green areas such as parks). Green spaces also have multi-functional benefits which need consideration and are also important to improve air quality, intercept rainfall and reduce temperatures, and enhance the aesthetic appeal of cities[9].

Soundscape Assessments

Limerick City and County Council is taking a soundscape approach to investigate publicly accessible green spaces. The concept of soundscape has been adopted to provide a holistic approach to the acoustic environment (beyond noise - or unwanted sound) and its effects on quality of life[10]. Soundscape investigations intend to assess all sounds perceived in an environment in all their complexity and use a variety of data collection methods related to human perception, the acoustic environment and their context. The assessment of publicly accessible open spaces offers the opportunity to inform local authorities of citizens preferences which can help highlight the benefit of those spaces and understand correlations between measurements and visitor experiences. That understanding can allow the extrapolation of measurements to determine how an acoustic environment is expected to be perceived where visitor experience data is limited or not available. In that respect soundscape assessments can aid in the auditing and design of green spaces (e.g. parks) and also our wider public realm.

People's Park Investigation

On 17th October 2024 between 2.30 p.m. and 4.00 p.m. fourteen interested delegates of the 2024 National Public Participation Network (PPN) Conference undertook a guided soundwalk (listening walk) in the People's Park, Limerick, to experience the Council's soundscape approach to investigating green spaces. A route through the park was followed with four listening stops (**Figure 1**). At the stops the group focussed on actively listening for two minutes, in silence. Two types of data were collected to assess the soundscape at each of the stops: quantitative assessments made by the fourteen participants and binaural measurements (using an artificial head and torso system) (**Figure 2**). The quantitative assessments were undertaken after listening to the acoustic environment by means of a questionnaire that was completed, which included descriptive statistics to describe and summarise participants sonic experience in the park. The artificial head and torso system collected acoustic measurements that relate to the way humans perceive the acoustic environment. Both methods of data collection took account of the international standard ISO 12913-2:2018 (Data Collection and Reporting Requirements)[11].

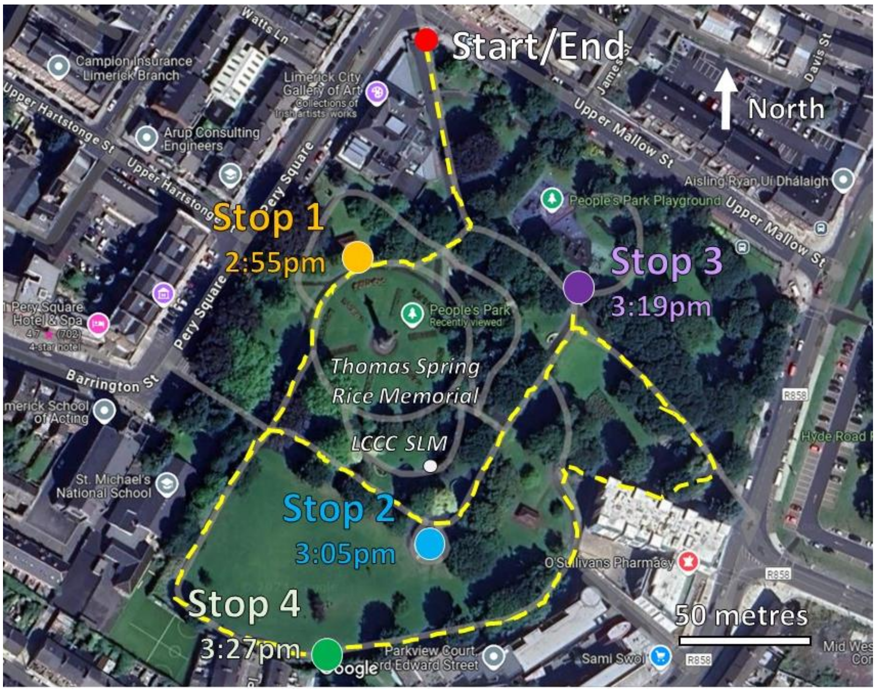

Figure 1. Route of the soundwalk with the four listening stops (map courtesy of Google Maps) – ***LCCC SLM is the location of the Council's sound level monitor*****.**

Figure 2. Delegates of the 2024 National PPN Conference participating in the soundwalk with the head and torso unit, People's Park.

Listening Stops

Four listening stops (**Figure 3**) were selected based on a presumption they might represent different acoustic environments in the park. Stop 1 was at one of the gazebos in the park, approximately 35 metres from a road (Pery Square) and the same distance to the Thomas Spring Rice Memorial, a focal point in the park. Tree cover was in close proximity to the location. Stop 2 was at the bandstand, approximately 40 metres from residential houses and an apartment block, and just over 100 metres from roads bounding the park to the east and west. The area is in close proximity to trees and along a path that is slightly elevated above the surrounding open space. Stop 3 at the ornate fountain was adjacent to a childrens playground, with the nearest road being approximately 50 metres distance (Upper Mallow Street) and trees in close proximity. Stop 4 was beside the walled boundary of the site, adjacent to housing and facing open green space with few trees in close proximity. The nearest road to Stop 4 was Pery Square, approximately 110 metres away. Stop 4 was in a topographic depression approximately 1 to 2 metres below the path that led to Stop 2. The head and shoulder unit was pointed face front towards the memorial for each of the measurement stops.

Figure 3. Listening stops 1 to 4 in the People's Park, 17th October 2024 (see Figure 1 for locations).

Quantitative Assessment - Questionnaires

The collected responses via the questionnaire were assigned scale values from 1 to 5 (using the *likert scale*) to four questions:

- the identification of the sound source for noise (e.g. traffic, industry), human activity (e.g. conversation, walking) and nature (e.g. birdsong, wind blowing vegetation);
- the perceived response to a variety of emotional indicators (e.g. pleasant, chaotic, vibrant etc.);
- an assessment of the surrounding sound environment;
- and an assessment of the appropriateness of the surrounding sound to the place.

The results in **Table 1** present the median values from all participants as the measure of central tendency at each of the four stops. The results for Questions 1 and 2 in **Table 1** are more easily visualised in graph form (**Figures 4** and **5**).

Traffic noise was dominant at Stops 1 and 3, those stops being nearer to the roads at the park boundary. Natural sounds became more noticeable further from the roads, but most noticeable at the band stand. Social signals were more noticeable at Stops 1 and 3 (people talking, footsteps), also with the sound of children playing at the playground at Stop 3.

Stops 1, 2 and 4 were generally considered most pleasant, being furthest from the more heavily trafficked roads and away from the playground. Stop 3 had an acoustic environment that was considered most chaotic and also eventful, probably due to the proximity of the playground. Natural sounds (rustling vegetation, birdcall) were more dominant to rear of park away from roads. Stops 2 and 4 were considered most calm while Stops 1 and 3 were more annoying.

The responses overall were neutral as to whether the sounds were uneventful or vibrant. However, in general at all the stops they were considered more pleasant and eventful rather than annoying, monotonous and uneventful.

Table 1. Results of the questionnaires.

Location	*Stop 1*	*Stop 2*	*Stop 3*	*Stop 4*
Question 1 - Sound Source Identification?				
Type	***Median Value***	***Median Value***	***Median Value***	***Median Value***
Noise	*Moderately [3]*	*A little [2]*	*Moderately [3]*	*A little [2]*
Humans	*A lot [4]*	*A little [2]*	*A lot [4]*	*Moderately [3]*
Natural	*A little [2]*	*A lot [4]*	*A little [2]*	*Moderately [3]*
Question 2 - Perceived Affective Quality?				
Pleasant	*Agree [4]*	*Agree [4]*	*Neutral [3]*	*Agree [4]*
Chaotic	*Disagree [2]*	*Disagree [2]*	*Agree [4]*	*Disagree [2]*
Vibrant	*Neutral [3]*	*Neutral [3]*	*Neutral [3]*	*Neutral [3]*
Uneventful	*Disagree - Neutral [2.5]*	*Disagree - Neutral [2.5]*	*Disagree [2]*	*Disagree - Neutral [2.5]*
Calm	*Neutral [3]*	*Agree [4]*	*Disagree [2]*	*Agree [4]*
Annoying	*Neutral [3]*	*Disagree [2]*	*Disagree - Neutral [2.5]*	*Disagree [2]*
Eventful	*Neutral [3]*	*Neutral [3]*	*Agree [4]*	*Neutral [3]*
Monotonous	*Disagree [2]*	*Disagree [2]*	*Disagree [2]*	*Disagree [2]*
Question 3 - Assessment of surrounding sound environment?	*Neither good or bad [3]*	*Good [4]*	*Neither good or bad [3]*	*Good [4]*
Question 4 - Assessment of appropriateness of sound environment?	*Moderately - Very appropriate [3.5]*	*Very appropriate [4]*	*Moderately - Very appropriate [3.5]*	*Very appropriate [4]*

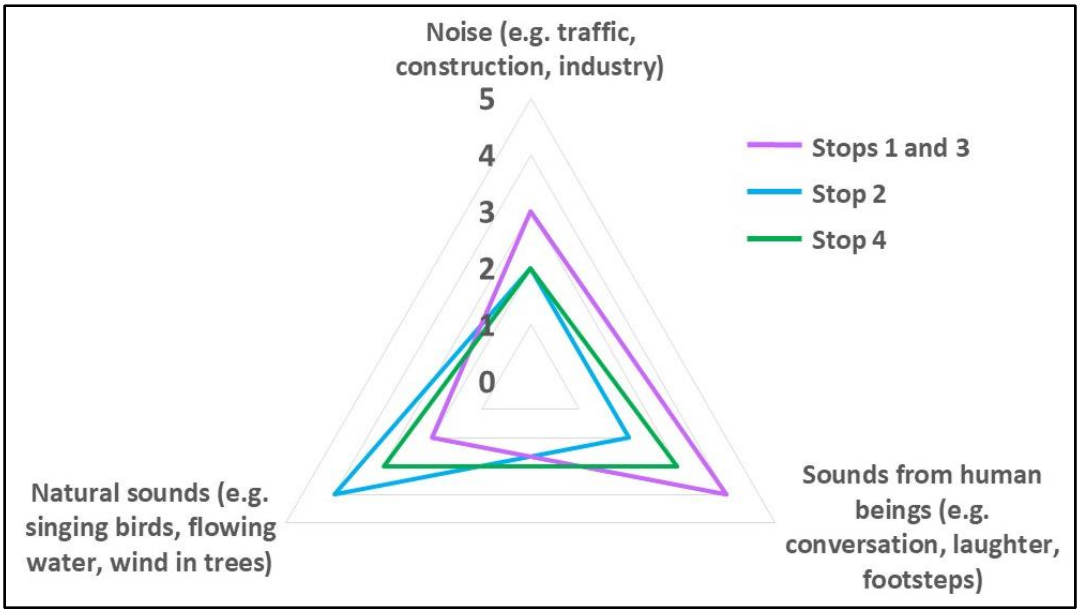

Figure 4. Median responses at the four stops in the People's Park to Question 1 – Sound Source Identification?

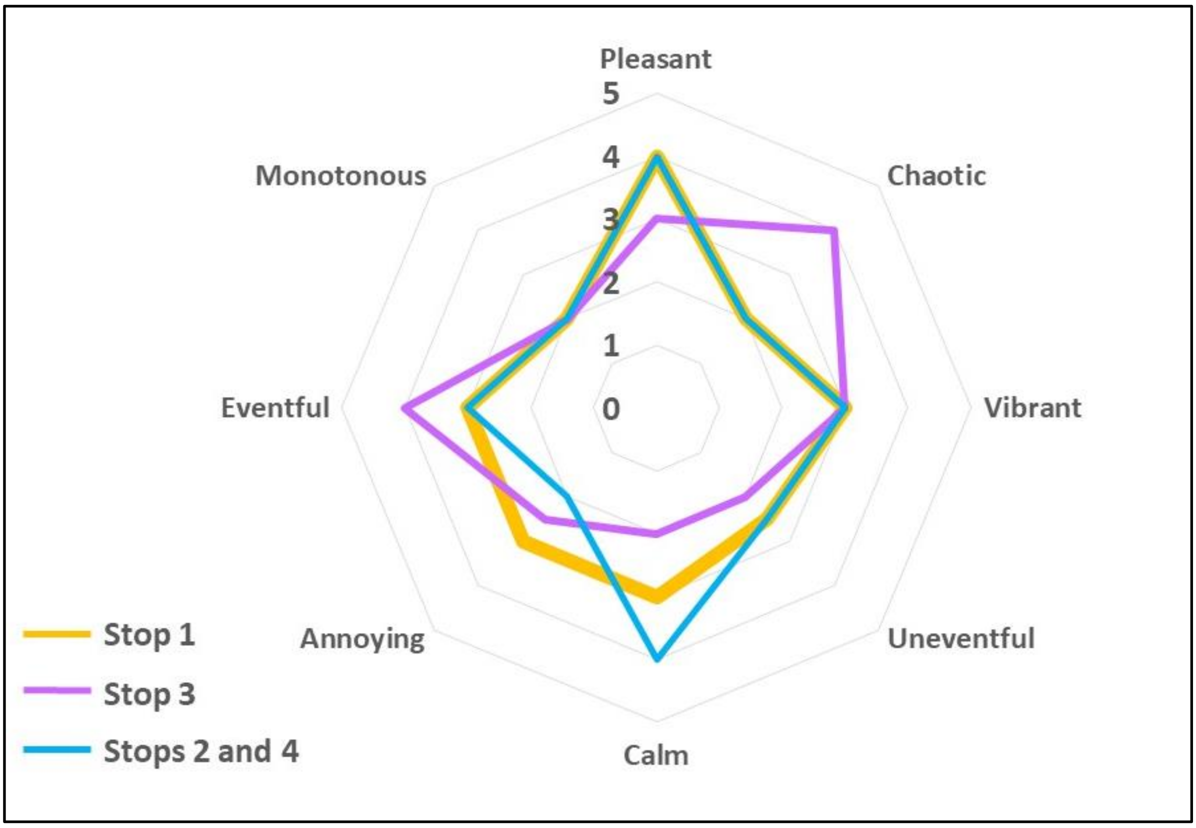

Figure 5. Median responses at the four stops in the People's Park to Question 1 – Perceived Affective Quality?

Environmental psychologists have established that the responses to Question 2 (**Table 1** and **Figure 5**) can be represented in a 2D-model where the main dimension is related to how pleasant or unpleasant the environment was judged, and therefore noted as pleasantness (ISO 12913-3)[12]. The second dimension is related to the amount of human and other activity. This is represented by how eventful or uneventful the acoustic environment is perceived to be, and therefore noted as eventfulness. If pleasantness and eventfulness axes are taken as perpendicular further labelling corresponds to two axes rotated at 45^{o} representing environments that are chaotic and stressful versus calm and those that are monotonous (boring) versus vibrant (loud and resonant).

The coordinates for pleasantness and eventfulness based on the responses to Question 2 in Table 1 are calculated based on equations in ISO 12913-3. Scatter and density plots are presented in **Figure 6**.

The results indicate that generally the perceived acoustic environment was pleasant at Stops 1, 2 and 4. There was slightly more annoyance associated with Stop 1 and there was a tendency towards it being considered vibrant. The perceived acoustic environment at Stop 2 was perceived to be calm and vibrant (as well as being pleasant) and Stop 4 was considered most calm. Of the three stops, Stop 1 had most traffic noise associated with the acoustic environment, correlating with some participants considering it to be annoying. Stops 2 and 4 were perceived to have more sound relating to nature and social signals and were considered most pleasant.

There was mixed reaction whether the acoustic environment at Stop 3 was perceived to be pleasant. Stop 3 was considered chaotic with some participants considering it annoying, although there was a tendency towards the sound being considered vibrant by some participants. The sound from the playground combined with traffic probably accounts for the more chaotic and annoying association with the acoustic environment. However, it is noted that through discussion with the group after the soundwalk there was an indication of the sound from the playground being perceived by some participants as being vibrant which may account for the mixed reactions observed for Stop 3 in Figure 6.

The combined scatter and density plot for all of the stops indicates that overall the acoustic environment was generally perceived by the participants to be pleasant, calm and vibrant (**Figure 7**).

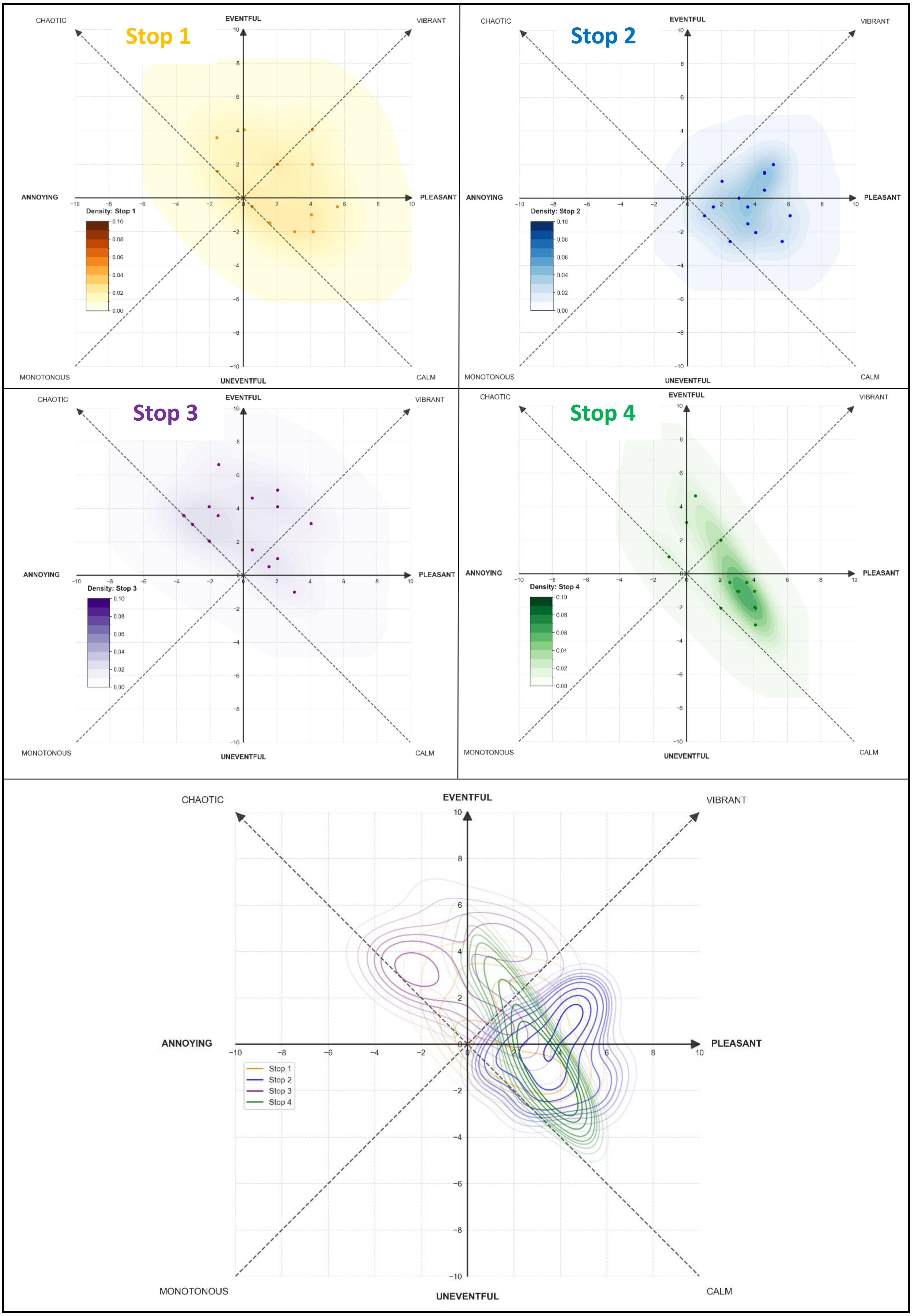

Figure 6. Scatter and density plots of the participants results to Question 2 (Table 1) as per the equations in ISO 12913-3 for Stops 1 to 4 (*n= 14 at each of the stops - to note: some of the points plot over each other*).

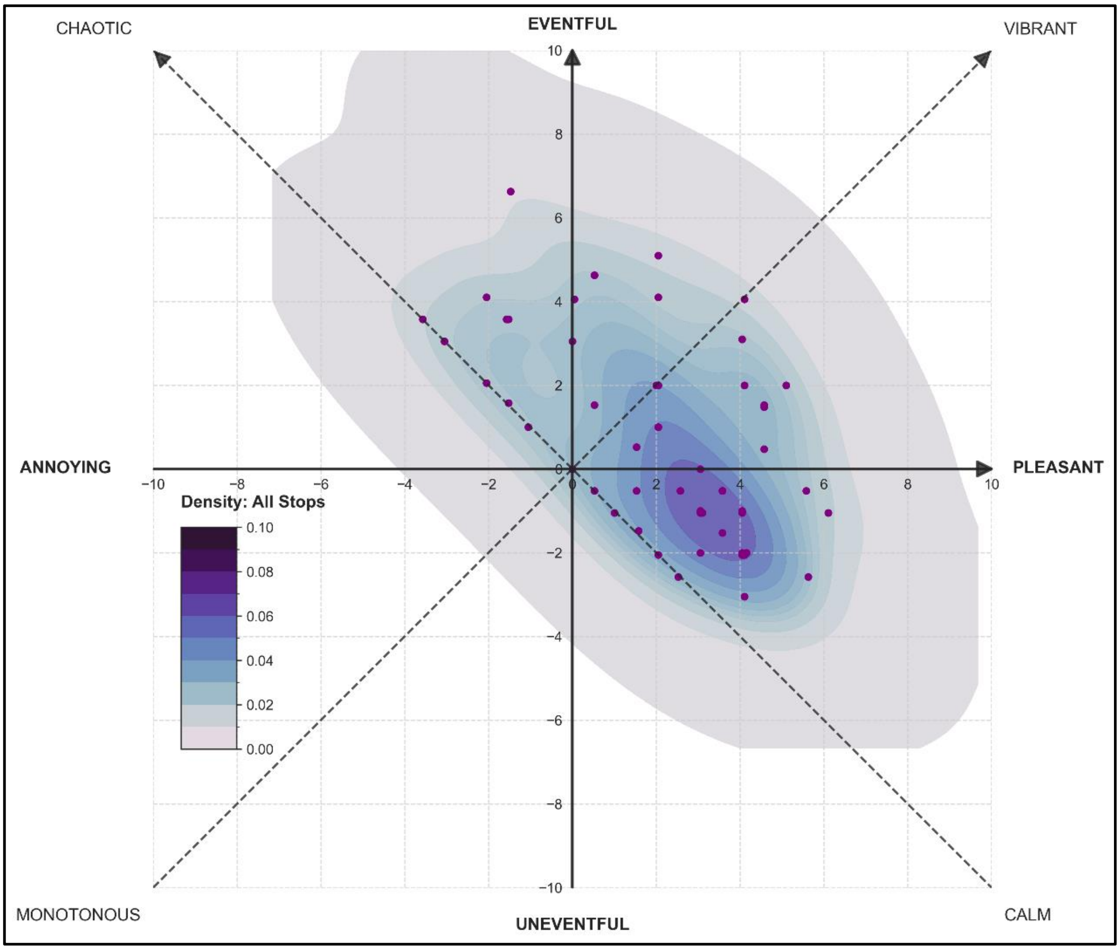

Figure 7. Combined scatter and density plot of the participants results to Question 2 (Table 1) as per the equations in ISO 12913-3 for all stops (*n= 56 - to note: some of the points plot over each other*).

Binaural analysis

The analysis of the binaural data enables the characterisation of the acoustic environment and identification of auditory sensations. The intended purpose of measurements is that they can be helpful to correlate with and support the perceived affective responses.

Since binaural measurements provide two signals representing the left and right ear of a human listener, acoustic parameters are calculated for both ears separately. The maximum measurements for either the left or right ear recorded by the artificial head are provided in **Table 2** for selected parameters.

Table 2. Binaural measurements for each of the listening periods (2 minutes logging).

Location	*Stop 1*	*Stop 2*	*Stop 3*	*Stop 4*
Sound Pressure Level (LAeq,2min), dB	*53*	*56*	*61*	*54*
Sound Pressure Level, (LCeq,2min), dB	*64*	*63*	*66*	*59*
LCeq,2min - LAeq,2min, dB	*11*	*7*	*5*	*5*
Tonality, tuHMS	*0.211*	*0.091*	*0.283*	*0.167*
Loudness, sone	*8.62*	*9.18*	*12.80*	*8.61*
Loudness, N5 (5th Percentile), sone	*10.40*	*10.40*	*15.20*	*9.73*
Roughness, asper	*0.151*	*0.127*	*0.192*	*0.134*
Sharpness, acum	*1.20*	*1.48*	*1.19*	*1.38*

Traditionally, average A-weighted sound pressure levels[i] (*LAeq* over a period of time, T) are used for the assessment of quiet areas in Ireland, and also more widely across Europe. The long-term *Lden* (a 24-hour measure average sound pressure levels based on *LAeq*, with penalties for evening- and night-time which the Environmental Protection Agency

[i] A-weighting is an adjustment applied to sound measurements to reflect how sound is perceived by the human ear.

recommended to be used under the last round of noise action planning) for 2023 at the Council's monitoring location (**Figure 1**) is 58 dB. However, average sound pressure levels alone do not provide context to sound observed by visitors. Natural sounds and social signals can have high sound pressure levels. For example, on a windy day the movement of branches and leaves rustling in a wooded area might produce a high level of sound even though the location might be considered by a person to be tranquil and preferred. In **Table 2** the *LAeq* at Stops 1, 2 and 4 are very similar, ranging between 53 dB and 56 dB (a 3 dB difference in levels is just noticeable by a person and 5 dB is expected to be noticeable) and so A-weighted sound pressure levels alone are not necessarily useful to correlate between the listening stops and the participants perceived affective responses.

Average C-weighted sound pressure levels[ii] (*LCeq* over a period of time, T) are a better representation of how humans perceive low frequency sounds. Higher C-weighted sound pressure levels indicate a higher low frequency sound content. The *LCeq* levels were similar at Stops 1, 2 and 3, most likely due to the traffic noise. The relatively low difference between the *LCeq* and *LAeq* levels at Stop 3 (5 dB – lower than at Stops 1 and 2) was probably due to the relatively high level of sound from children in the playground i.e. low frequency traffic noise was less dominant than at Stops 1 and 2. The lowest *LCeq* level was at Stop 4 which was the furthest distance from traffic. The relatively low *LCeq* level may also have been partly a result of Stop 4 being located in a topographic depression in the park, the surrounding high ground may mitigate some traffic noise.

The roughness of sound (asper) is a complex effect which quantifies the subjective perception of rapid amplitude modulation (or fluctuation) of a sound within low to medium frequencies (15-300 Hz). Sound measured near traffic has a higher roughness than sound measured further away and this is identified at the People's Park (**Figure 8**). Stops 1 and 3, close to roads have higher roughness values than Stops 2 and 4, further from roads. The roughness at Stop 3 is most likely to be highest because it is adjacent to the more heavily trafficked roads (R858 and Upper Mallow Street).

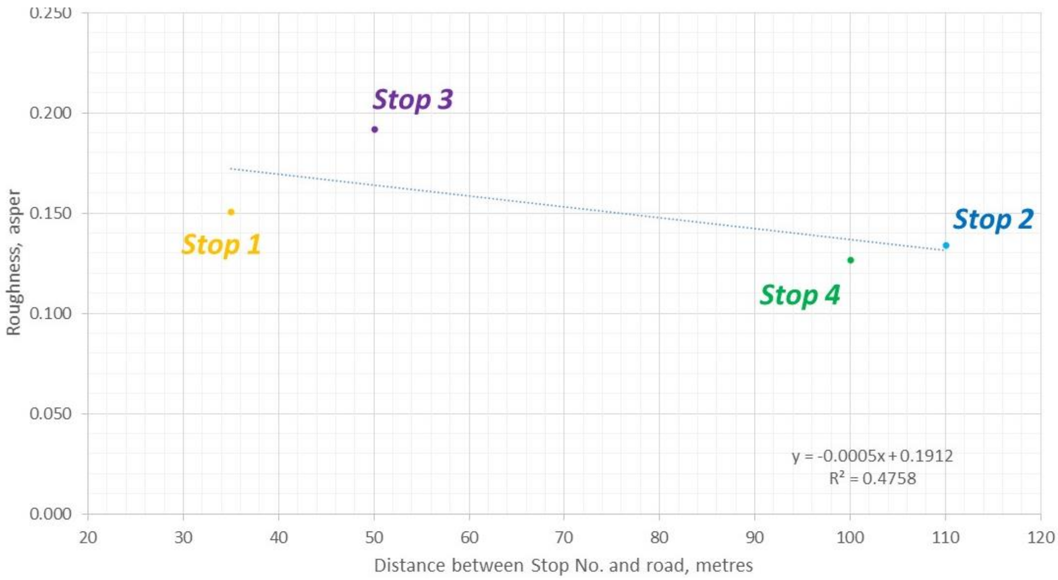

Figure 8. Measured roughness (asper) at the listening stops in the People's Park. ***To note: this is a trend observed at other green spaces in Limerick as well.***

The measurement of loudness (sone) has an advantage over sound pressure levels because it is measured on a linear scale, rather than sound pressure which is measured on a logarithmic scale. It is easier to compare the perceived increase in loudness between one stop and another. The 5th percentile loudness (N5, the loudness exceeded for 5 % of the time) is considered to be a good indication of annoyance[13]. The loudness results at Stops 1, 2 and 4 were similar. The loudness at Stop 3 would have been perceived as being approximately 30 % higher than the other listening stops which correlates with the sound environment being perceived as more annoying.

Tonality (a measure of the strength of tones – the sound of a single frequency, tuHMS) is also considered to be a good indicator for annoyance where it is related to environmental noise[13]. Tonality was lowest at Stops 2and 4 which correlates well with those stops being considered the most calm and pleasant (**Figure 6**).

[ii] C-weighting is an adjustment applied to sound measurements that provides more emphasis to low frequency sound.

Sharpness (acum) is a measure of the high frequency content of sound. For example, the rustling of leaves would be expected to have relatively high sharpness levels. Stops 2 and 4 had the highest sharpness levels, relating to the sound of moving vegetation (branches and leaves) which was more audible than at Stops 1 and 3, correlating well with the perceived responses in **Figure 4**.

Discussion

There is a need at a European policy level for guidance on how to integrate the subjective nature of urban quietness in our cities with the current environmental noise management approach, to support local authorities to be proactive in the assessment and protection of quiet areas. Quiet areas should be thought of as an urban commons i.e. they should be considered as natural resources accessible to everyone in society[14,15].

This report demonstrates the value of citizen engagement to understand and describe the soundscape when investigating the potential benefits of our green areas - citizens preferences are taken into account in the review of these areas and can be used in the decision-making process to make an application for designation as Quiet Areas. The binaural and quantitative assessments in this study of the People's Park complement each other well. Binaural measurements support the participants perceived affective responses. The binaural measurements can be used to describe the affective perceived responses that natural sounds were more audible at Stops 2 and 4, being more calm at Stop 4 and more vibrant at Stop 2, and that environmental noise caused some participants annoyance at Stop 3 due to traffic noise (based on roughness and tonality) although the L_{Ceq} and L_{Aeq} levels indicate that some participants may also have been annoyed by the sounds of children playing (while other participants found it eventful, vibrant and pleasant, **Figure 6**). The results also support the perception of a tendency towards annoyance at Stop 1 from traffic noise (relatively high roughness and tonality) while the acoustic environment was also considered calm (relatively low loudness) – an acoustic environment midway between Stops 2 and 4, and Stop 3 (even though it had the lowest measured L_{Aeq}). The combination of the assessment techniques allows an understanding to be gained regarding the magnitude of the sound source contributions (natural, environmental noise, human signals) and whether in combination they provide a tranquil environment, which is an advantage over considering A-weighted sound pressure levels alone. Results from studies such as this can also be used to understand how the public may perceive an acoustic environment (its pleasantness and eventfulness) where only binaural measurements are available.

The results of soundscape assessments can be used to identify where improvements can be made within green areas to increase sensory pleasantness. The least preferred acoustic environment in the People's Park arguably was Stop 3 and any recommendations for a soundscape intervention (if funding was to be available) might be targeted in this area of the park to make it more pleasant for citizens and visitors. Any reduction in traffic noise will be of limited benefit because even a 40 % reduction in traffic volume will only result in an approximate 2 dB sound pressure level reduction (just perceptible). Potentially it is more helpful to mask traffic noise and sound from the playground introducing sounds that might be preferable (e.g. by a water feature, audio island, seating with noise barrier protection, sound art etc.).

Soundscape assessments can also be subject to clustering analyses to audit our publicly accessible green areas and compare them against each other (e.g. parks and green spaces) to aid the identification of where investment should be focused. The auditing of sound in green areas could potentially be tied in with other environmental assessments as well such as the Green Flag Award criteria (auditing quality and functionality of green spaces), biodiversity and air quality. Soundscape assessments can also be used to gain a better understanding of citizens preferences of our acoustic environment in our wider public realm (our streets and public areas where people congregate). Learnings can be used in planning and design to reduce environmental noise exposure in urban areas.

Conclusions

A soundwalk in the People's Park was undertaken for interested delegates of the 2024 National PPN Conference to assess the soundscape of the park based on the ISO 12913 soundscape standard and to highlight the importance of citizen engagement in the investigation of acoustic environments in green areas for potential designation of Quiet Areas.

In general the participants found the soundscape in the park to be pleasant and eventful, being most calm, vibrant and least chaotic away from the roads bounding park with the acoustic environment in that area considered to be good and very appropriate, with natural sounds and social signals at Stops 1, 2 and 4 being preferred, correlating well with the binaural measurements. The acoustic environment towards the more heavily trafficked roads at Stop 3 (Upper Mallow Street and R858) and the playground (by some participants) was considered more annoying which also correlated well with the binaural measurements.

The binaural measurements and perceived affective responses support each other when gathering evidence for potential applications for the designation of Quiet Areas by local authorities under the Environmental Noise Regulations. The soundscape approach is a useful means to be proactive and integrate the subjective nature of urban quietness in our cities with the environmental noise management approach, including helping to identify opportunities for soundscape interventions (masking noise) and incorporating learnings in the design of green areas and the wider public realm.

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