Psychoacoustic Assessment of the Castletroy Greenway Dawn Chorus Walk - 18th May 2024

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.

Introduction
The concept of soundscape has been adopted to provide a holistic approach to the acoustic environment, beyond noise, and its effects on the quality of life. Soundscape investigations intend to assess all sounds perceived in an environment in all its complexity and use a variety of data collection methods related to human perception, the acoustic environment and the context.

On 18th May 2024 at 05.40 a.m. during the Castletroy Greenway Dawn Chorus Walk we stopped along the walk and collected two types of data that have been used to assess the soundscape: quantitative data and a binaural recording (using an artificial head measurement system, **Figure 1**). The quantitative data was collected after listening to the acoustic environment by means of the questionnaire that we filled out, which included descriptive statistics to describe and summarise our experience of the dawn chorus. The artificial head collected psychoacoustic measurements that relate to the way human beings perceive the acoustic environment. Both methods of data collection were in accordance with an international standard – *ISO 12913-2 Soundscape Data Collection*.

Figure 1. Binaural artificial head measurement system.

Quantitative analysis
The collected responses via the questionnaire were assigned scale values from 1 to 5 (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. birdsongl, 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 as the measure of central tendency.

Table 1. Results of the questionnaires.

1 Sound Source Identification	
Type	***Median Value***
Noise	*Moderately [3]*
Humans	*Not at all [1]*
Natural	*A lot [4]*
2 Perceived Affective Quality	
Pleasant	*Strongly Agree [5]*
Chaotic	*Disagree [2]*
Vibrant	*Agree [4]*
Uneventful	*Neutral [3]*
Calm	*Agree [4]*
Annoying	*Strongly disagree [1]*
Eventful	*Agree [4]*
Monotonous	*Disagree [2]*
3 Assessment of surrounding sound environment	*Good [4]*
4 Assessment of appropriateness	*Very appropriate [4]*

Environmental psychologists have established that these responses 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. 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 (e.g. a busy city centre). If pleasantness and eventfulness axes are taken as perpendicular further labelling corresponds to two axes rotated at 45° representing environments that are chaotic and stressful versus calm and those that are monotonous (dull) versus vibrant (exciting).

The coordinates for pleasantness and eventfulness are calculated based on equations in the international standard *ISO 12913-3 Soundscape Data Analysis* which use the responses. The results from the dawn chorus for each of the participants are plotted in **Figure 2**.

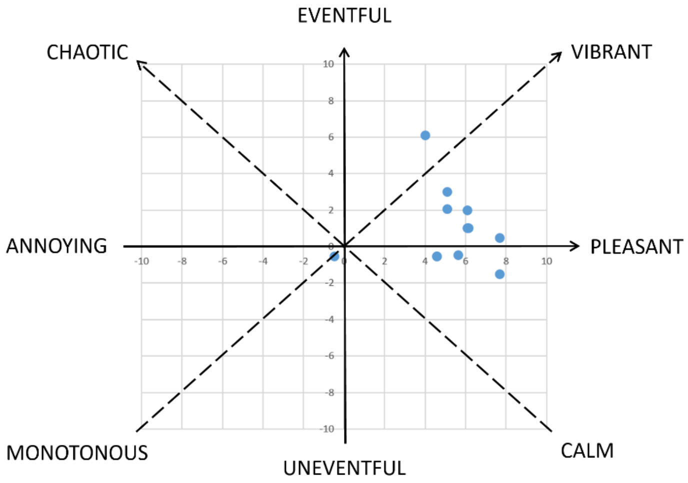

Figure 2. Results of the perceived affective responses.

The results indicate that in general the perceived acoustic environment was pleasant, vibrant and calm - the sound environment being good (there was audible noise/unwanted sound) and the sound being appropriate to the place. For one person the acoustic environment was marginally chaotic and for another their experience was generally neutral.

Binaural analysis

The analysis of the binaural data enables the characterisation of the acoustic environment and identification of auditory sensations. The intended purpose of the psychoacoustic indicators can be helpful to correlate the data collected to the human responses.

Because binaural measurements provide two signals representing the left and right ear of a human listener, acoustic parameters are calculated for both ears separately. The basic measurements recorded by the artificial head are provided in **Table 2** - sound pressure level, tonality and loudness, variance of loudness over the measurement period (the loudness exceeded 5 % of the time, N5; and the loudness exceeded 95 % of the time, N95). The analysis period used has been clipped to two minutes from the start of the recordings even though the recordings are slightly longer.

The average sound pressure levels over the listening period in both ears were at and just below 50 dBA (*Leq*), a level that would be expected for quiet conversation (where the measurement of sound has been weighted to reflect human hearing - A-weighted).

Table 2. Binaural data for 2 minutes at 05:41 a.m..

Parameter	*Value (left ear)*	*Value (right ear)*
Sound pressure level	*46.7 dBA*	*50.4 dBA*
Tonality	*0.151 tuHMS*	*0.162 tuHMS*
Loudness (Average)	*5.85 sone*	*6.95 sone*
Loudness (Percentile N5)	*6.19 sone*	*7.13 sone*
Loudness (Percentile N95)	*2.69 sone*	*2.56 sone*

If we look at the frequency versus time during the listening period (**Figure 3**) we can see that the dominant/highest sound pressure levels occurred at high frequencies between 2,000 Hz and 10,000 Hz (the yellow patches), being birdsong. There were also a strong component of sound at frequencies between 150 Hz and 1,000 Hz towards the end of the listening period which was when aircraft noise became audible.

Sounds that we hear and are dominant at one frequency might be considered tonal and strong tones would be expected to have a tonality exceeding approximately 0.3 tuHMS. The average sound that was heard over the listening period was not particularly tonal (0.151 to 0.162 tuHMS) but when viewing the a graph of the tonality versus time (**Figure 4**) it can be seen that intermittently when birds were singing there was strong tonality at frequencies between 2,000 Hz and 10,000 Hz (pink colours, around 0.6 tuHMS).

A weakness of using the sound pressure level metric is that sounds with the same value of dBA are perceived to have different loudness to the human ear at different frequencies (e.g. a sound at 50 dBA at 1,000 Hz is perceived louder by a human than a sound at 50 dBA at 100 Hz). Using the sone metric (a loudness metric) takes away that perceived difference, 1 sone is heard at an equal loudness across all

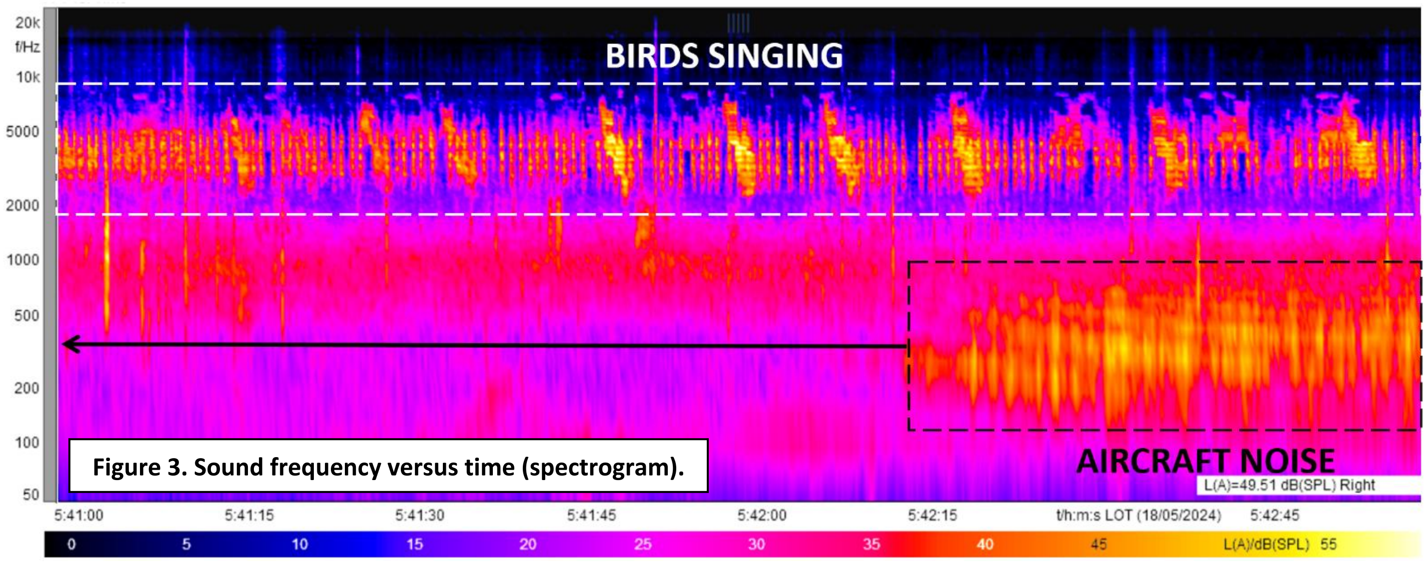

Figure 3. Sound frequency versus time (spectrogram).

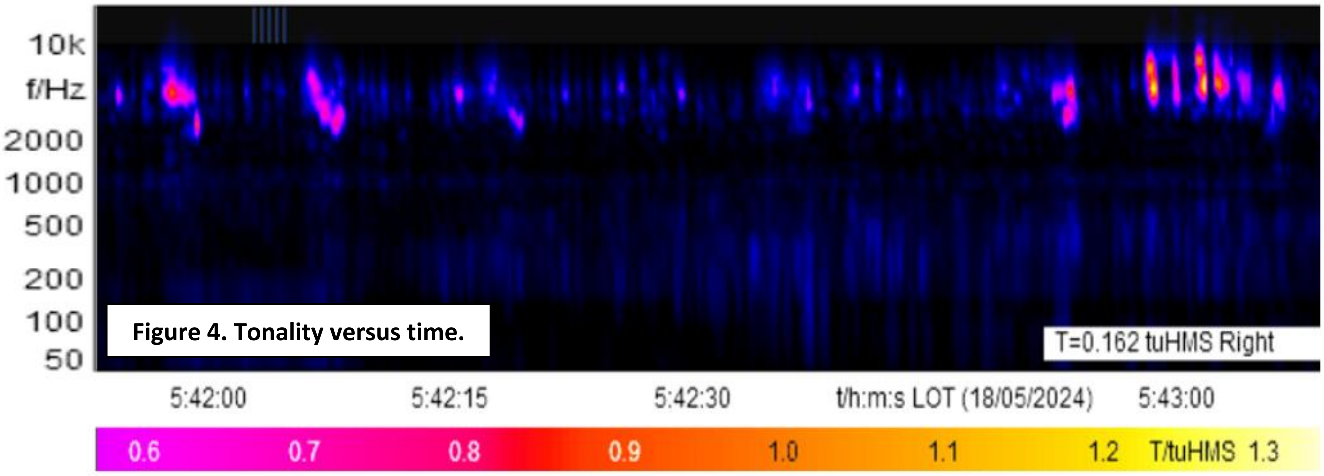

Figure 4. Tonality versus time.

frequencies. The advantage of the sone as well is that a doubling of a sone equates to a doubling of the perceived loudness i.e. 2 sone is twice as loud as 1 sone (it is a linear scale). The results during the listening period indicate that there was over a doubling of loudness of the sound at the quietest times (N95) compared to the loudest times (N5).

A recording of the dawn chorus was also taken at a similar location on the greenway before the dawn chorus walk began at approximately 4.50 a.m. (**Table 3**). The results indicate that while there wasn't much difference in the sound pressure level there was a significant reduction in the loudness at the earlier time (over a halving of the loudness in the right ear and similar in the left ear) and the tonality of the sound was stronger (0.228 tuHMS in the left ear and 0.199 tu HMS in the right). While it was relatively quiet at both times it was less loud at the earlier time with birdsong being dominant. The loudness increased at the later time as environmental noise became more noticeable.

Table 3. Binaural data for 2 minutes at 04:49 a.m..

Parameter	*Value (left ear)*	*Value (right ear)*
Sound pressure level	*43.8 dBA*	*40.5 dBA*
Tonality	*0.228 tuHMS*	*0.199 tuHMS*
Loudness (Average)	*3.82 sone*	*3.03 sone*
Loudness (Percentile N5)	*4.20 sone*	*3.41 sone*
Loudness (Percentile N95)	*2.27 sone*	*2.21 sone*

Conclusions

Overall the soundscape for participants was pleasant, being vibrant and calm which was possibly what would have been expected given the nature of the experience (people came to hear the dawn chorus which didn't disappoint). Birdsong dominated the sound environment at 05:40 a.m., there being intermittent tonality. However, it was almost twice as loud at that time than earlier in the morning at 04:49 a.m. due to an increase in environmental noise. Birdsong at the earlier time was more prominent, with stronger tonality.

Acoustic data such as this can be subject to clustering analyses to audit inside our publically accessible open spaces and compare them against each other (e.g. parks and green spaces) to establish their benefit to our quality of life, improve them where possible, and aid in the improvement, design and planning of new open spaces.

Identified birds

The birds that were heard or seen along the greenway during the dawn chorus walk were (those in ***bold type*** were identified by sound):

Hooded Crow, Rook, **Jackdaw, Magpie, Goldfinch, Chaffinch, Dunnock**, Stonechat, **Willow Warbler**, Meadow Pipit, Pied Wagtail, **Wren, Blackbird, Song Thrush,** Wood Pigeon, Lesser Black-backed Gull, Starling, **Swallow, House Martin, House Sparrow, Great Tit, Robin**, Feral Pigeon**.**

Acknowledgements

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Simon Jennings

Comhairle Cathrach & Contae **Luimnigh**

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GO GREEN ROUTES