New Methods and Proposals for Evaluating Soundscape Designs and Interventions

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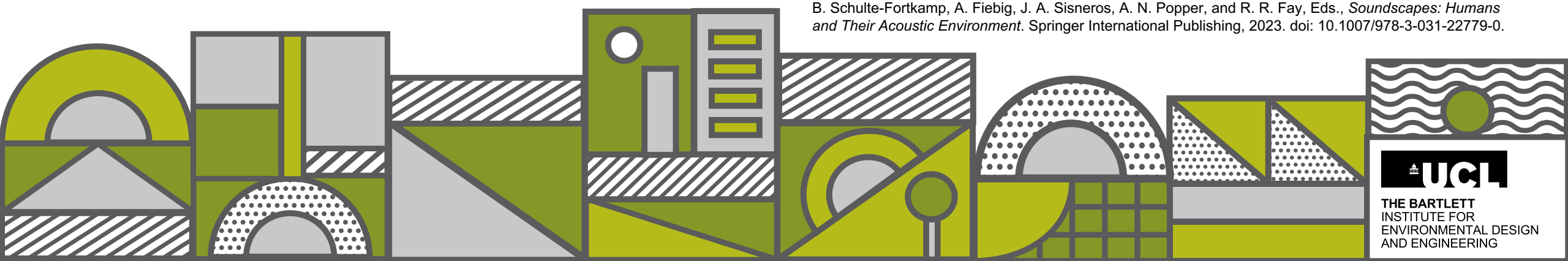
The Soundscape Approach

- The concept of soundscape integrates individuals into the process of assessing and changing acoustic environments **based on the perceptions and responses of affected individuals.**
- It is increasingly apparent that a sound level-oriented perspective cannot capture several relevant aspects of noise and its perception in specific concepts.
- Thus, methods have been developed to **measure and analyze human perception of sound in context.**

B. Schulte-Fortkamp, A. Fiebig, J. A. Sisneros, A. N. Popper, and R. R. Fay, Eds., *Soundscapes: Humans and Their Acoustic Environment*. Springer International Publishing, 2023. doi: 10.1007/978-3-031-22779-0.



“In practice, noise abatement is a reactive approach to sound. […] This makes noise abatement comparable to waste management. Sound is deemed a harmful waste product of human activity that must be removed.”

-- Östen Axelsson (2020)

Axelsson, Ö. (2020, August). Soundscape revisited. *Journal of Urban Design, 25*(5), 551-555. doi: 10.1080/13574809.2020.1810006

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Introduction – what is (a) soundscape?

Soundscape is normatively defined by ISO 12913-1:2014 as:

an acoustic environment as perceived or experienced and/or understood by a person or people, in context

It is important to make sure we are all talking about the same thing when we call something a soundscape

Three key definitions

ISO 12913-1 - Soundscape:

The acoustic environment as perceived or experienced, by a person or people, in context

ISO 12913-1 – Acoustic Environment:

sound at the receiver from all sound sources as modified by the environment

Note: Acoustic environment can be actual or simulated, outdoor or indoor, as experienced or in memory

Soundscape Ecology:

All sounds, those of biophony, geophony, and anthrophony, emanating from a landscape to create unique acoustical patterns across a variety of spatial and temporal scales

Pijanowski, B. C., et. al. (2011). Soundscape Ecology: The Science of Sound in the Landscape. *BioScience*, *61*(3), 203–216.

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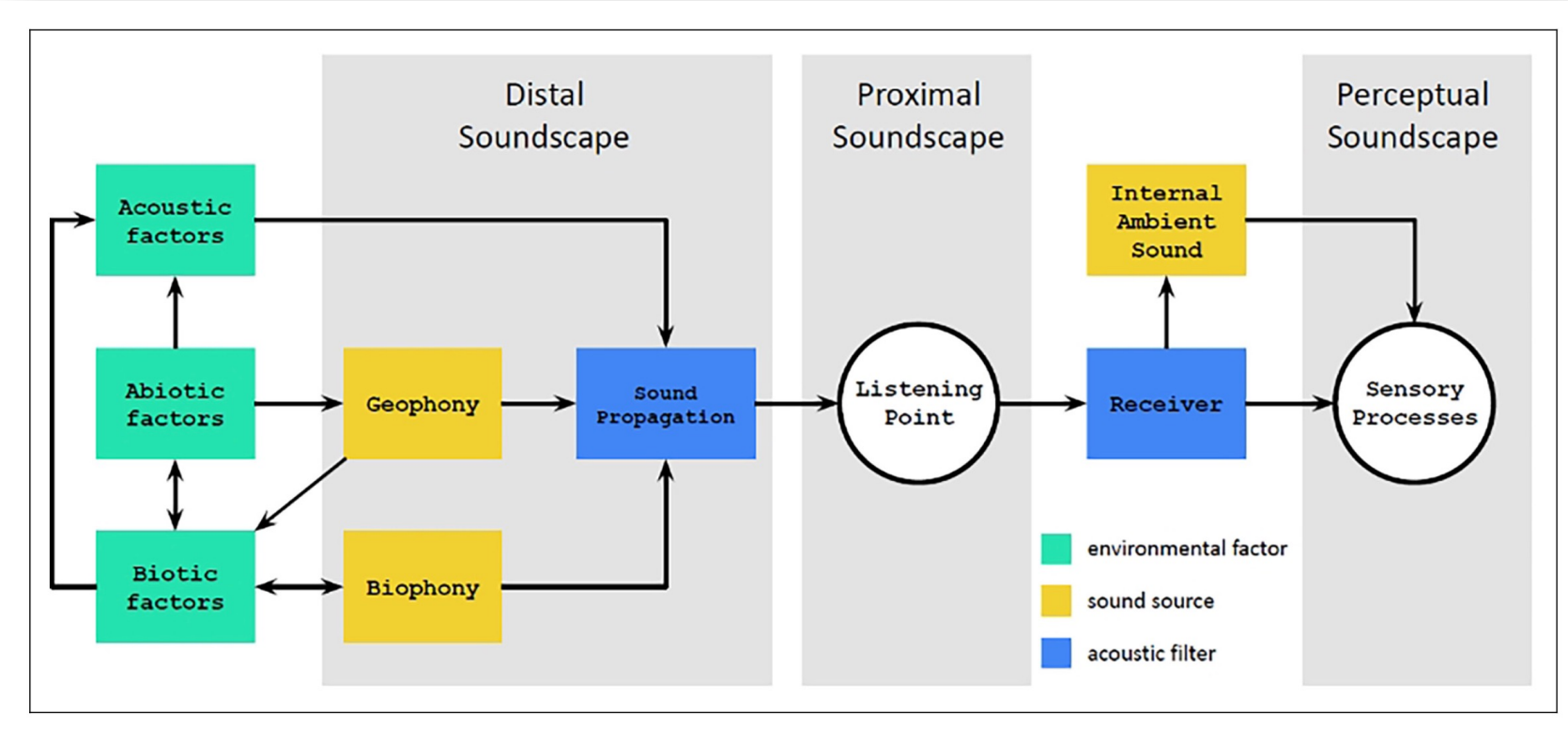
Distal, Proximal, and Perceptual

Many of these conceptions of soundscape can actually be organized into different **types of soundscapes:**

Distal, Proximal, and Perceptual Soundscapes as defined by Grinfeder et al. (2022)

Grinfeder, Elie, Christian Lorenzi, Sylvain Haupert, and Jérôme Sueur. 2022. “What Do We Mean by "Soundscape"? A Functional Description.” *Frontiers in Ecology and Evolution* 10 (June). https://doi.org/10.3389/fevo.2022.894232.

Distal, Proximal, and Perceptual



Distal: "the spatial and temporal distribution of sounds in a prespecified area"; a theoretical construct which encompasses all the sound signals which arise within a given area.

Soundscape Ecology: All sounds emanating from a landscape

Lorenzi, Christian, Frédéric Apoux, Elie Grinfeder, Bernie Krause, Nicole Miller-Viacava, and Jérôme Sueur. 2023. "Human Auditory Ecology: Extending Hearing Research to the Perception of Natural Soundscapes by Humans in Rapidly Changing Environments." *Trends in Hearing* 27 (January). https://doi.org/10.1177/23312165231212032.

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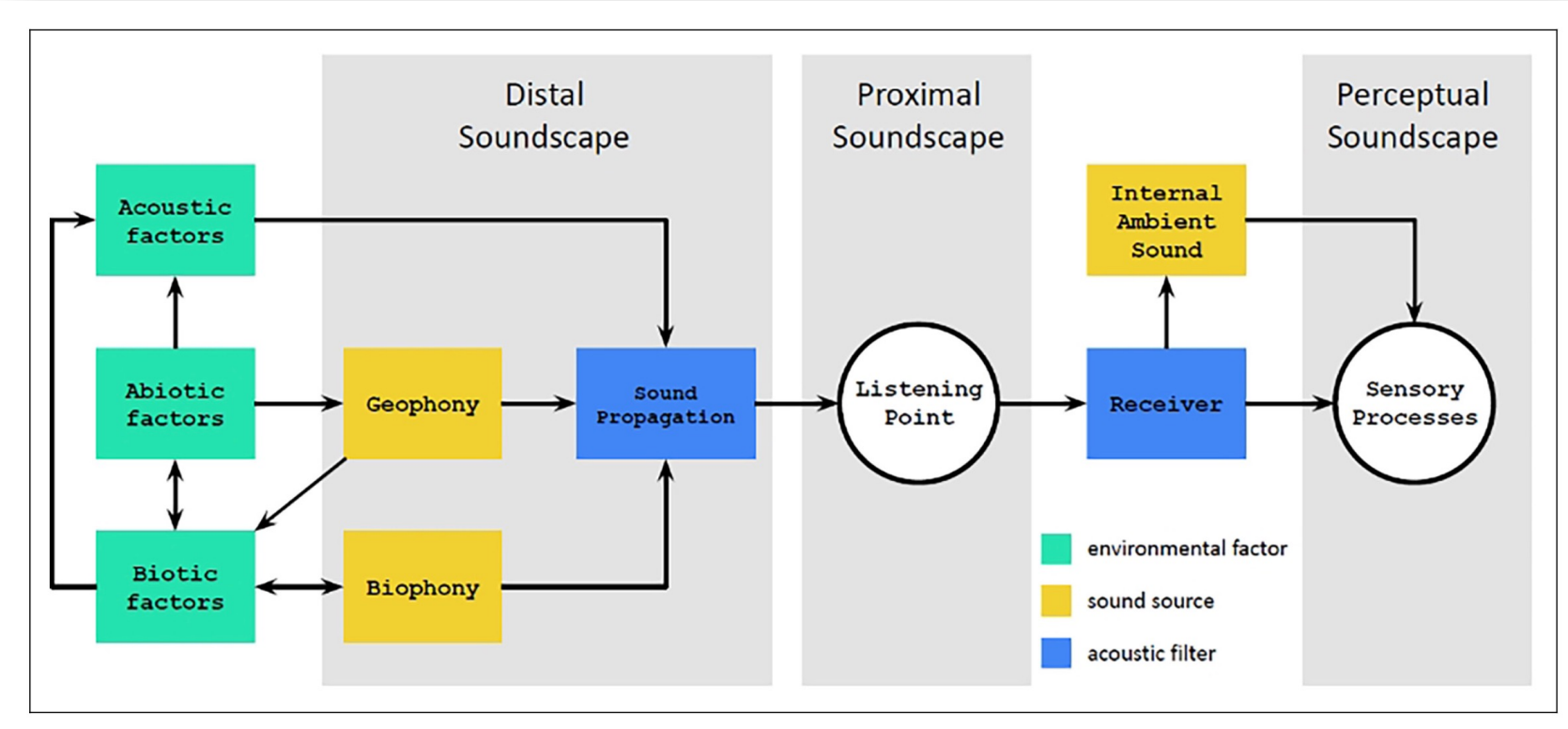

Proximal: the collection of sound signals at a particular receiver, after propagating throughout the environment

Acoustic Environment: Sound at the receiver

Lorenzi, Christian, Frédéric Apoux, Elie Grinfeder, Bernie Krause, Nicole Miller-Viacava, and Jérôme Sueur. 2023. "Human Auditory Ecology: Extending Hearing Research to the Perception of Natural Soundscapes by Humans in Rapidly Changing Environments." *Trends in Hearing* 27 (January). https://doi.org/10.1177/23312165231212032.

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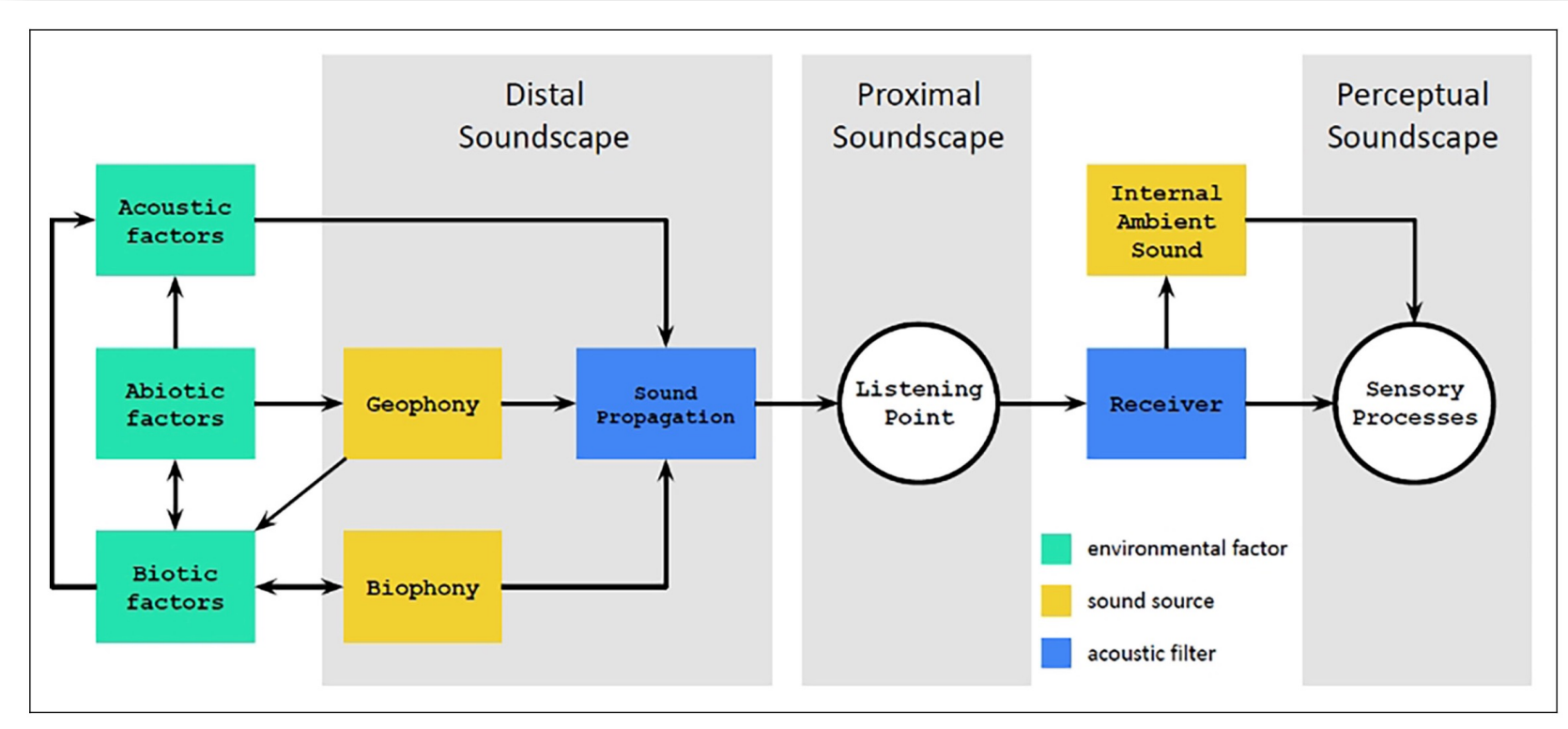

Perceptual: the individual subjective interpretation of a proximal soundscape

ISO Soundscape: Acoustic Environment as perceived

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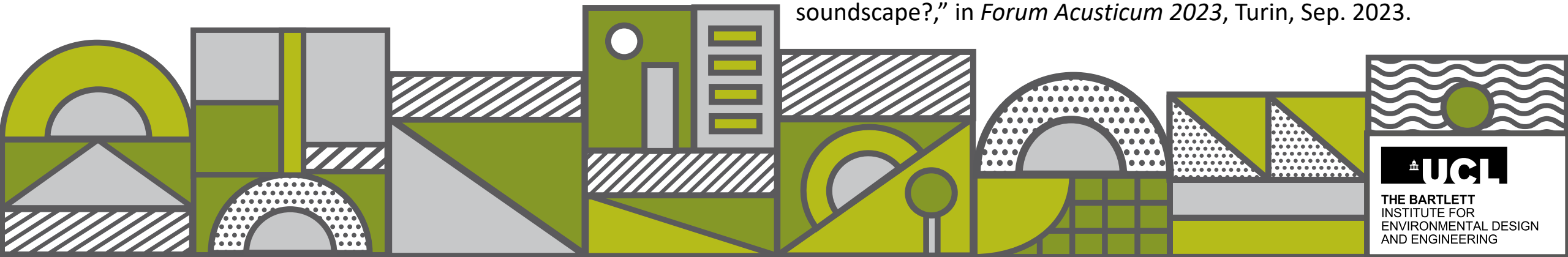
A novel definition of soundscape:

A soundscape is the sonic environment **of a place, setting, or community,** whose character is the result of the interaction with non-auditory and/or contextual factors.

A. Mitchell, F. Aletta, T. Oberman, and J. Kang, “How do we define soundscape?,” in *Forum Acusticum 2023*, Turin, Sep. 2023.



How do we bring a soundscape approach into engineering practice?

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Engineering Practice

- The ability to affect change at large scales and in a wide range of projects will require that familiar engineering tools and approaches can be applied to soundscape design.
- If we want to improve on the dB, soundscape needs methods which can take its place and be used in similar ways.
- Current soundscape assessment methods are generally limited to a post-hoc assessment of the existing environment.
- Best practice soundscape design such as co-design or participatory methods are great, but they are typically only applied in dedicated research or high-budget projects.
- A predictive model of user's perceptual response to the soundscape is necessary to make the soundscape approach more widely applicable.

Applications in Design and Mapping

The soundscape approach faces several challenges in practical engineering applications which are unaddressed by current assessment methods, but which may be solved through the development of a predictive modelling framework.

1. Predicting how a change in an existing sound environment will be reflected in the soundscape perception – this relates strongly to the idea of soundscape interventions

2. Retrospective methods struggle to capture the dynamics of the soundscape in a space.

3. Survey methods make city-scale mapping of soundscape perception difficult and work-intensive.

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Components of a Predictive Soundscape Model

- Soundscape **descriptors** are measures of how people perceive the acoustic environment – e.g. perceptual attributes
- Soundscape **indicators** are measures used to predict the value of a soundscape descriptor – e.g. *LAeq, Loudness,* etc.
- Soundscape **Indices** are single value scales derived from either descriptors or indicators that allow for comparison across soundscapes.

Aletta, F., Kang, J., Axelsson, Ö. (2016, July). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning.* 149:65-74.

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Conceptual Model of Soundscape Perception

Soundscape Indicators

Sonic Features

(Psycho)acoustic
- Loudness
- Spectral content
- Temporal pattern
- etc.

Sound source
- Semantic meaning
- Frequency of Occurrence
- etc.

Space Characteristics

Landscape and Land use
- Designed use-case
- Openness
- Monumental
- etc.

Longterm Sound Environment
- $L_{Aeq,30min}$
- LDEN
- etc.

Environmental
- Temperature
- Humidity
- Air Quality
- etc.

Visual
- Brightness
- Greenness
- Blueness
- Crowdedness
- etc.

Perceptual Mapping

A **statistical model** aims to approximate this perceptual mapping

Input weighting

Individual weighting

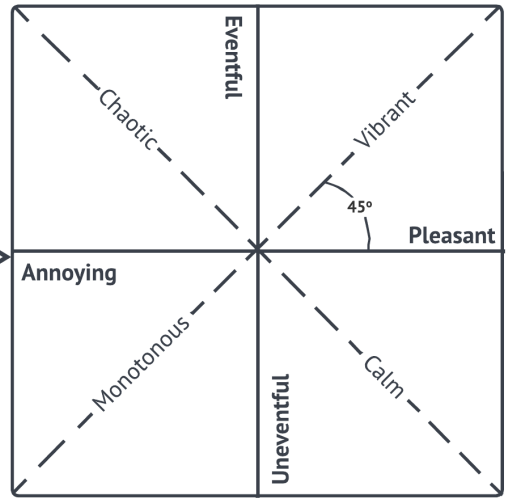
The space characteristics weight the sonic features as they are processed by the listener

Listener arrives at the space with an initial PM based on their personal characteristics

Personal / Demographic
- Age/Gender
- Psychological Well-being
- Hearing problems
- Past experiences
- Home environment
- Intended activity
- etc.

Soundscape Descriptors

Soundscape Circumplex



Soundscape descriptors are the expressed perception. In order to arrive at a descriptor, the input must be processed by the individual's PM, then expressed by them.

Here, the circumplex is given as one example of descriptors as an outcome, others could also be used.

A. Mitchell, "Predictive Modelling of Complex Urban Soundscapes: Enabling an engineering approach to soundscape design," PhD Thesis, University College London, 2022. doi: 10.13140/RG.2.2.15590.50245.

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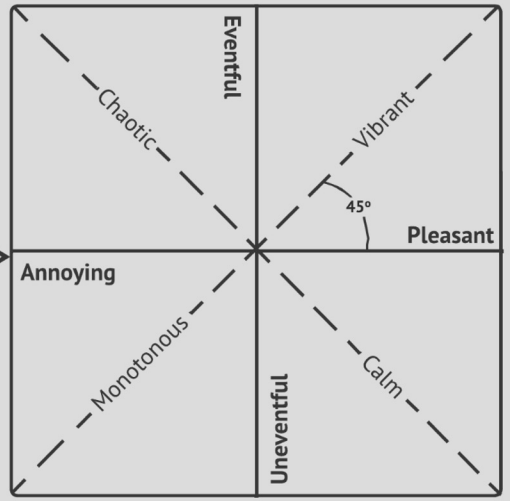

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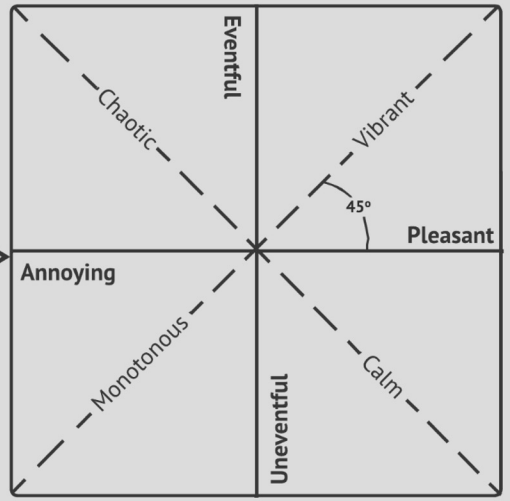

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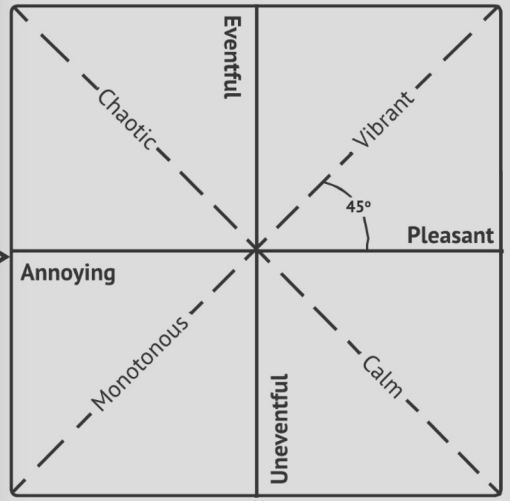

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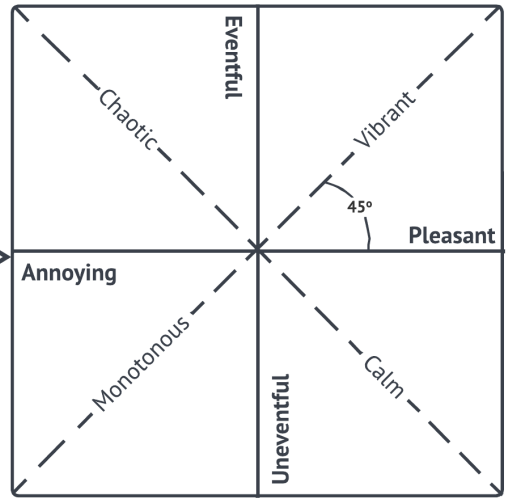

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Measuring and Representing Soundscape Perception Data

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The International Soundscape Database (ISD)

To demonstrate the methods we'll be talking about, we'll use the ISD as an example

An initial version of the ISD has already been published on Zenodo. This version contains survey and acoustic data from 13 locations in London and Venice

For more detailed information, see:

Mitchell, A.; Oberman, T.; et al.. **The Soundscape Indices (SSID) Protocol: A Method for Urban Soundscape Surveys—Questionnaires with Acoustical and Contextual Information**. Appl. Sci. 2020, 10, 2397.

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Perceived Affective Quality (PAQs)

For each of the 8 scales below, to what extent do you agree or disagree that the present surrounding sound environment is...

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Pleasant	○	○	○	○	○
Chaotic	○	○	○	○	○
Vibrant	○	○	○	○	○
Uneventful	○	○	○	○	○
Calm	○	○	○	○	○
Annoying	○	○	○	○	○
Eventful	○	○	○	○	○
Monotonous	○	○	○	○	○

Sound Sources

To what extent do you presently hear the following four types of sounds?

	Not at all	A little	Moderately	A lot	Dominates completely
Traffic noise (e.g. cars, buses, trains, airplanes)	○	○	○	○	○
Other noise (e.g. sirens, construction, industry, loading of goods)	○	○	○	○	○
Sounds from human beings (e.g. conversation, laughter, children at play, footsteps)	○	○	○	○	○
Natural sounds (e.g. singing birds, flowing water, wind in vegetation)	○	○	○	○	○

Overall soundscape

Overall, how would you describe the present surrounding sound environment?

○ Very good
○ Good
○ Neither bad nor good
○ Bad
○ Very bad

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

○ Not at all
○ Slightly
○ Moderately
○ Very
○ Perfectly

How loud would you say the sound environment is?

○ Not at all
○ Slightly
○ Moderately
○ Very
○ Extremely

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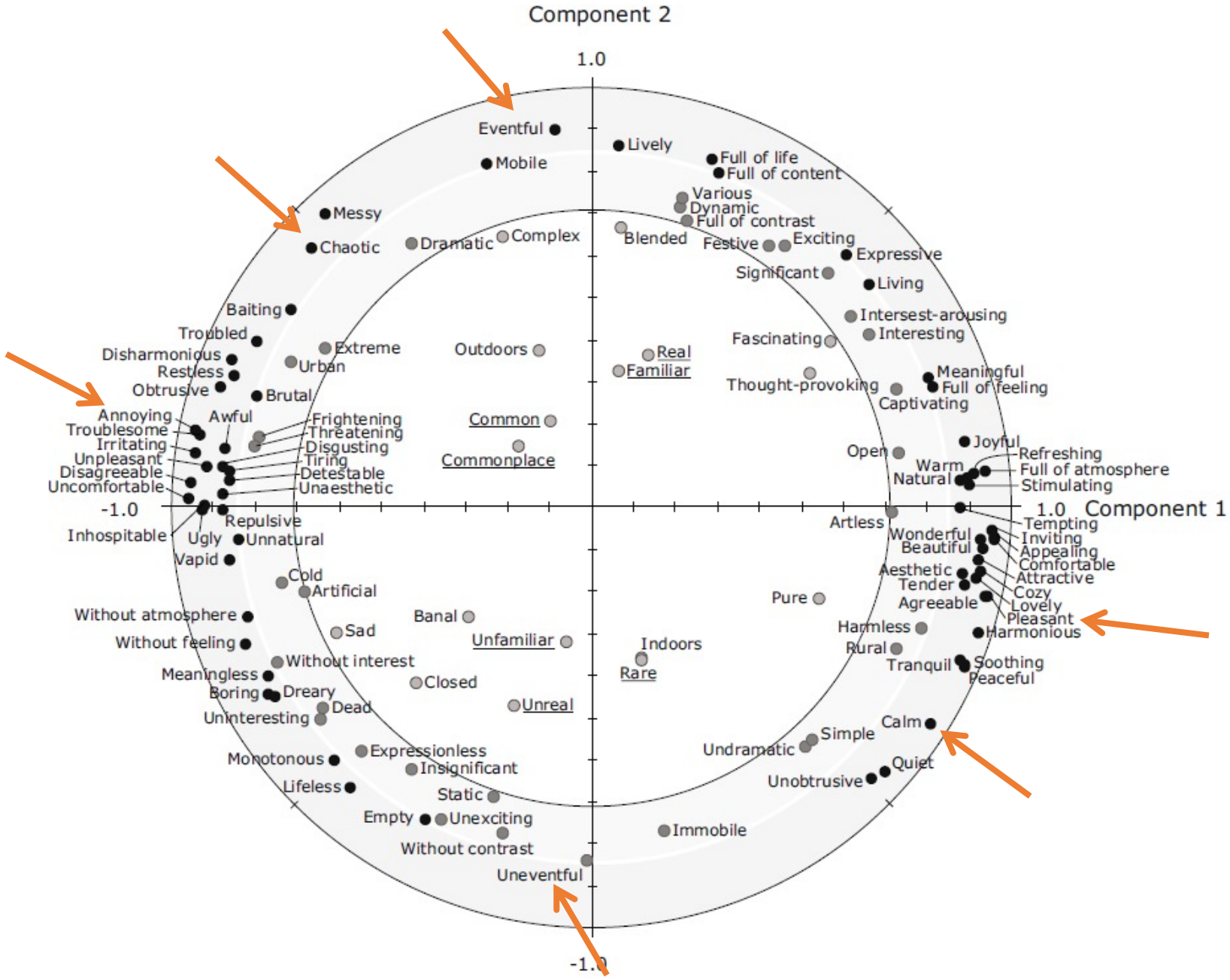
The Circumplex Model of Soundscape Perception



Axelsson, O., Nilsson, M.E., & Berglund, B. (2010). A principal components model of soundscape perception. *The Journal of the Acoustical Society of America, 128*(5), 2836-2846. doi.org/10.1121/1.3493436

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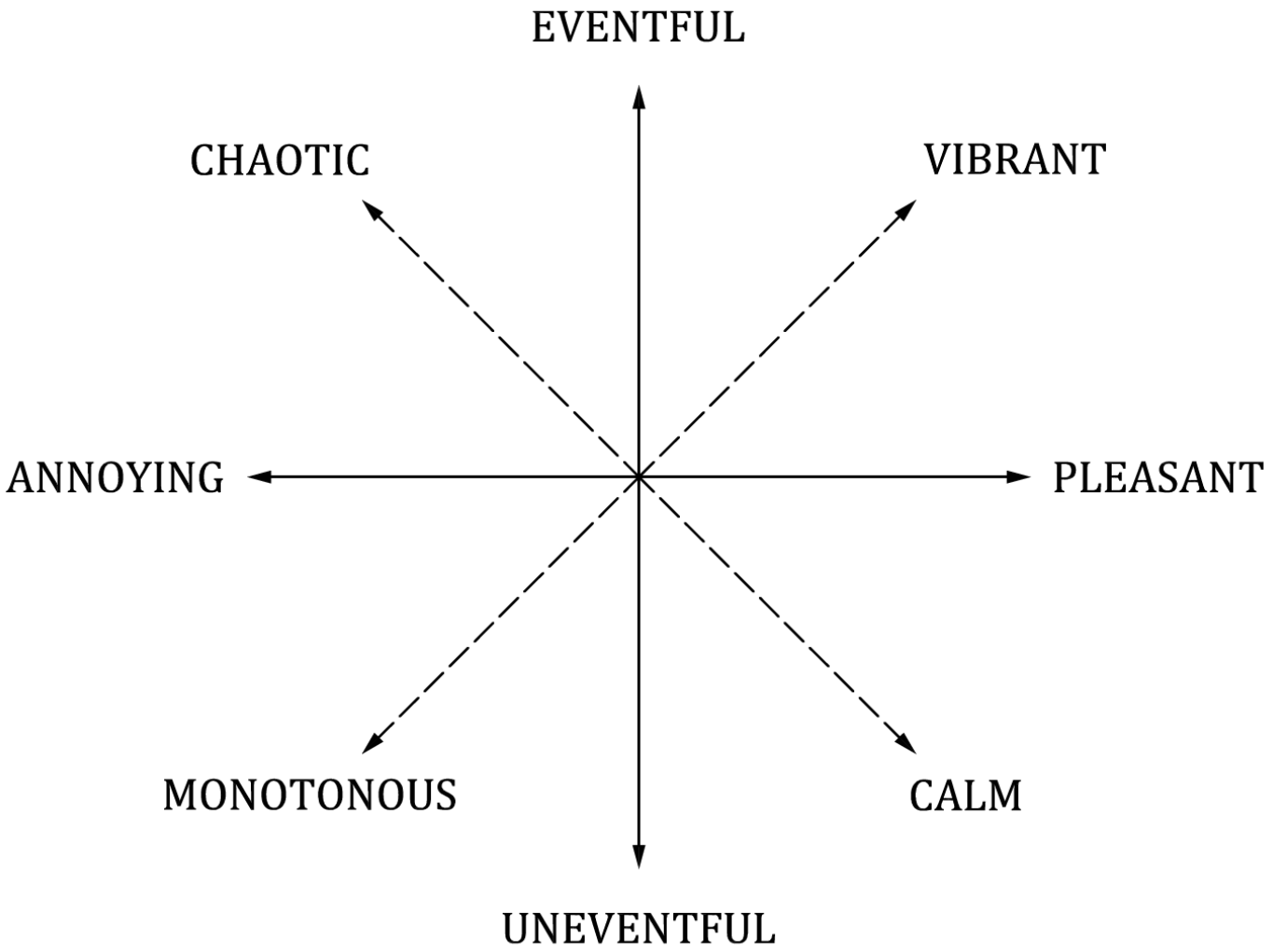

ISO/*TS 12913-3:2019 Acoustics - Soundscape - Part 3: Data analysis*

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From PAQs to Circumplex Coordinates

- We can convert the 8 PAQ scales into a **two-dimensional coordinate point**.
- This is done through a trigonometric projection of the 8 PAQs on to the x- and y-axes, according to their theoretical relationships in the circumplex
- Once this projection is done, **the coordinates represent the overall pleasantness and eventfulness** expressed by the PAQs.
- We call these the **ISOPleasant** and **ISOEventful** values:

$$ISOPleasant = \begin{bmatrix} (pleasant\ -annoying) + \\ \cos 45° * (calm - chaotic) \\ +\cos 45° * (vibrant - monotonous) \end{bmatrix} * 1/(4 + \sqrt{32})$$

$$ISOEventful = \begin{bmatrix} (eventful\ -uneventful) + \\ \cos 45° * (chaotic - calm) \\ +\cos 45° * (vibrant - monotonous) \end{bmatrix} * 1/(4 + \sqrt{32})$$

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How to describe the diversity of perceptions in a group?

- In order to **characterise the soundscape of a particular space or time**, perceptual responses from multiple people must be collected and subsequently summarised to describe the **general soundscape** of the location
- The soundscape survey methods and the ISO were originally developed for **characterising the perception of an individual.**
- No location, setting, or even single sound will have an identical, single perception across a population. This should be reflected in our representation of soundscape perception.
- However, the soundscape of a place could be more accurately described as a **collective perception**.
- By definition, this collective perception should consider the **diversity of people's perception.**

A. Mitchell, F. Aletta, and J. Kang, "How to analyse and represent quantitative soundscape data," *JASA Express Letters*, vol. 2, no. 3, p. 37201, 2022, doi: 10.1121/10.0009794.

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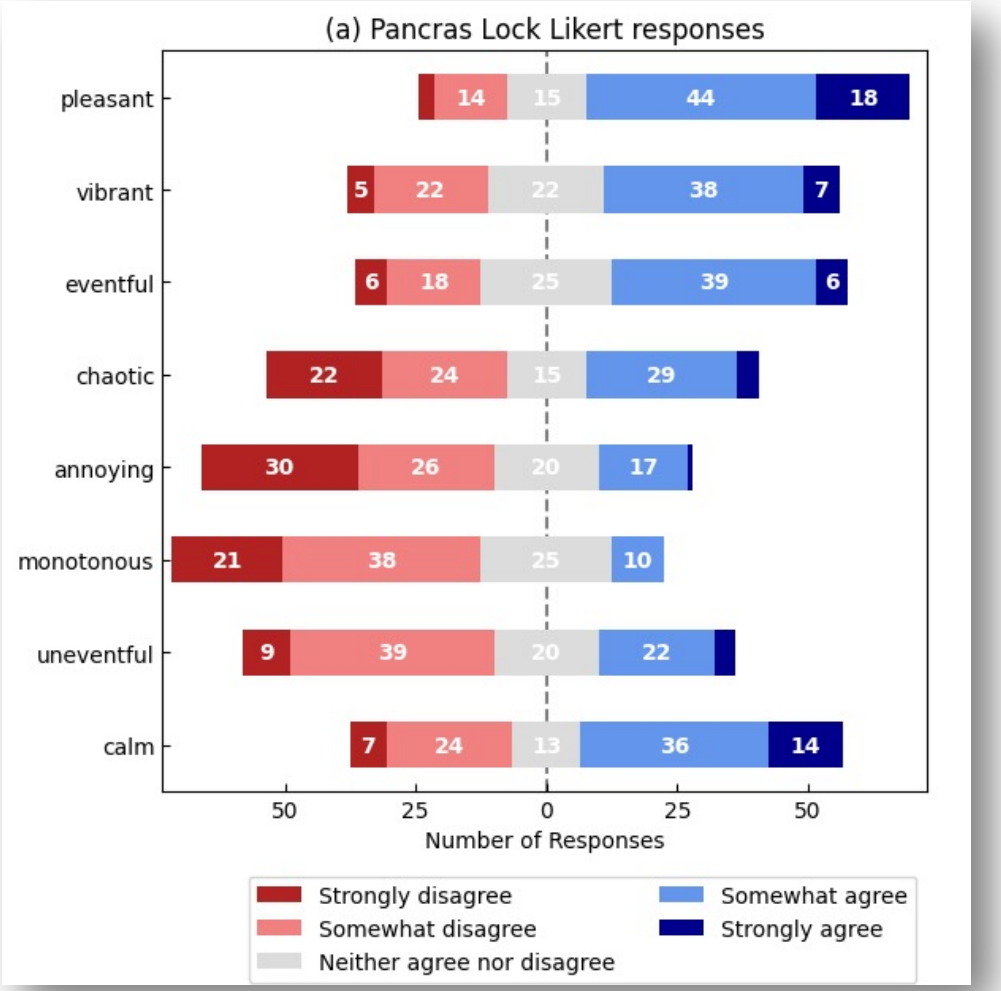
Soundscape Density Plots

First: Calculate the coordinates of each individual response



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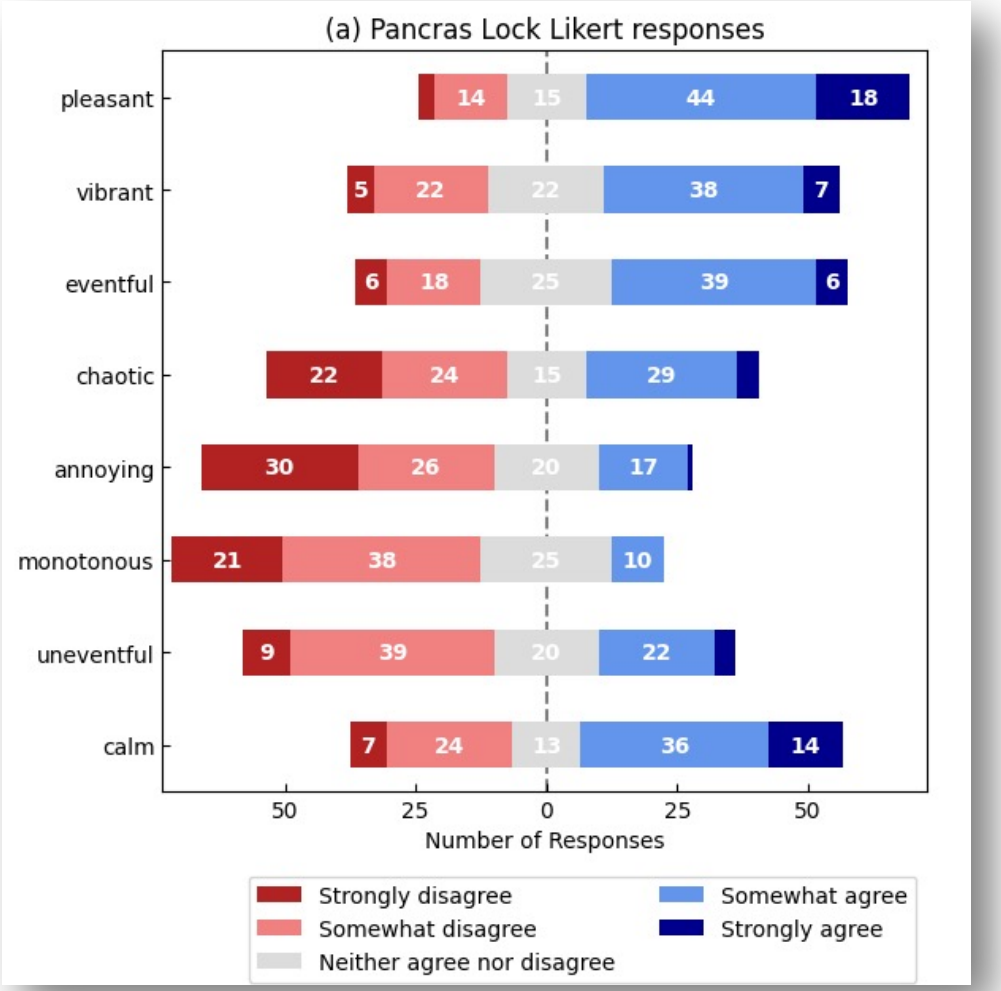
Soundscape Density Plots

First: Calculate the coordinates of each individual response

Second: Treat these results as a vector of ISOPleasant, ISOEventful values which are continuous variables from -1 to +1 and can be analysed statistically



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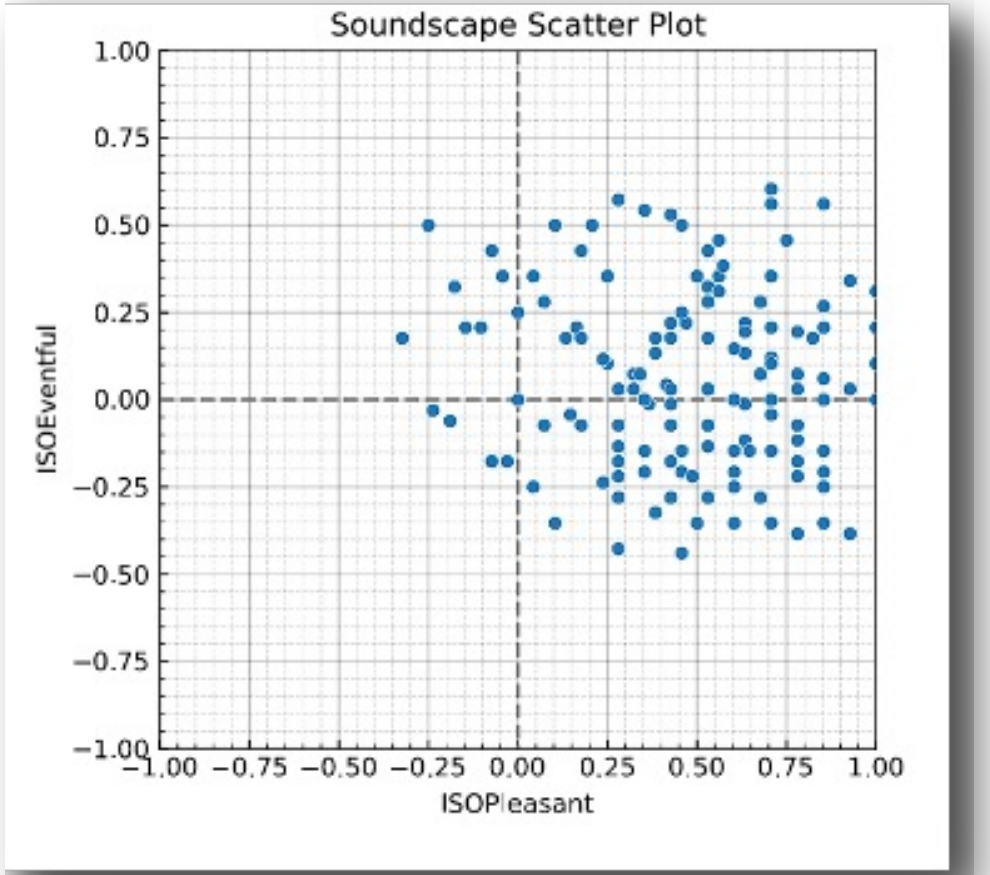
Third: Plot these coordinates as a scatter plot



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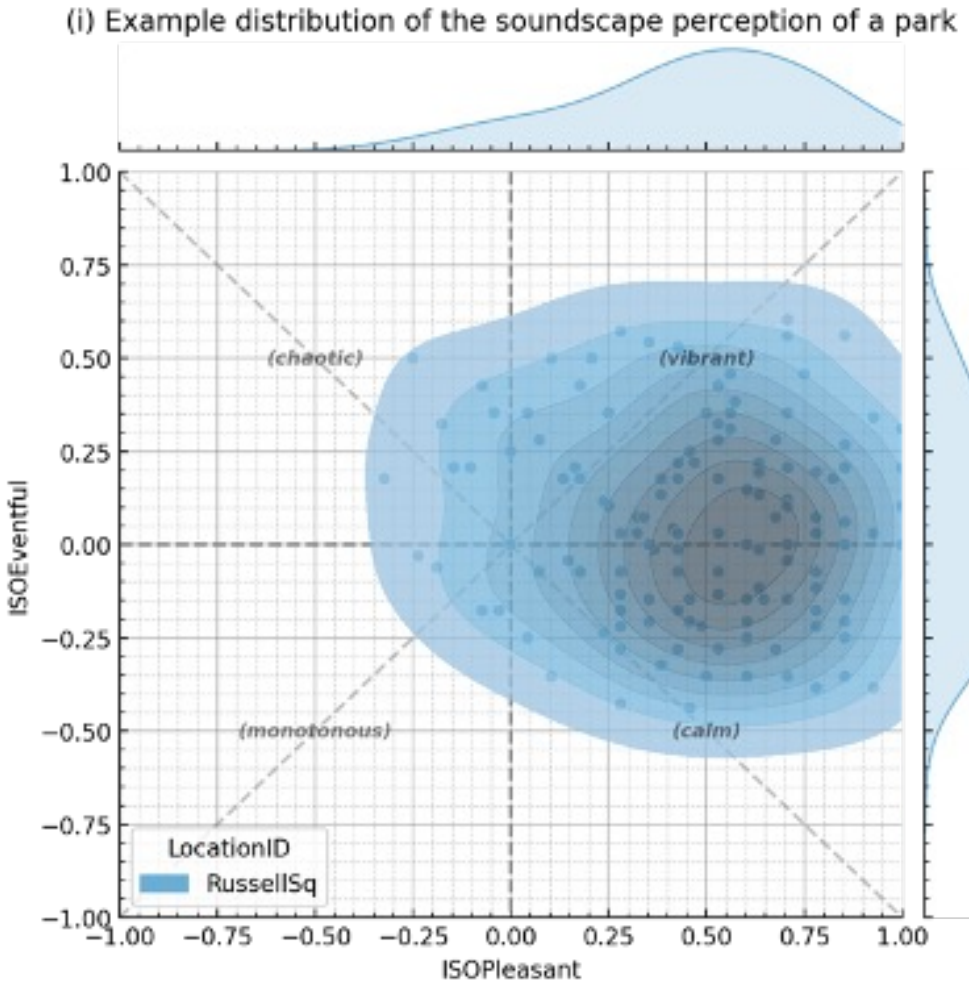
Finally: Overlay a density heatmap and marginal distribution plots to examine the shape and distribution of the location



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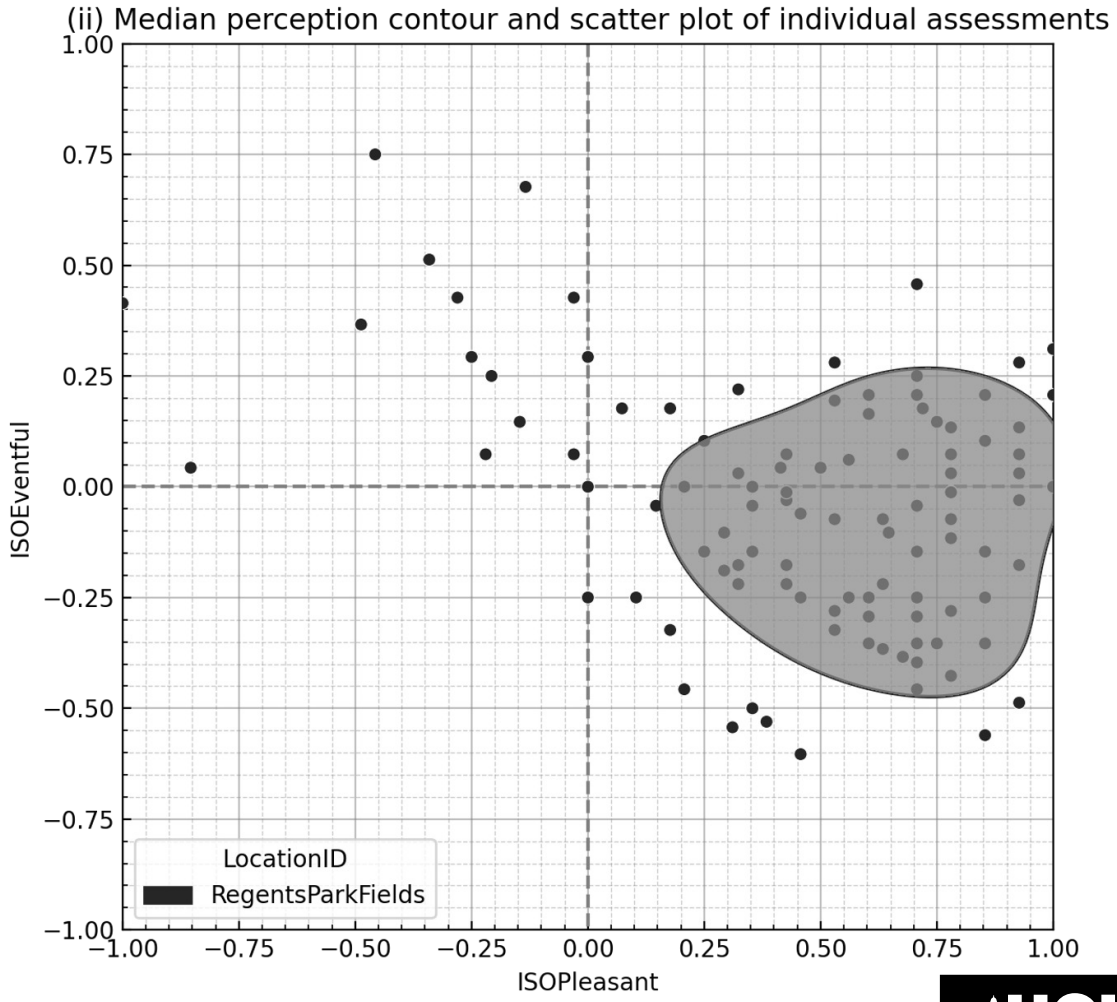
Simplified distribution for comparisons

While the decile heatmap provides a lot of detailed information, the detail can make further analysis difficult.

We propose using a simplified version which only plots the 50th percentile contour.



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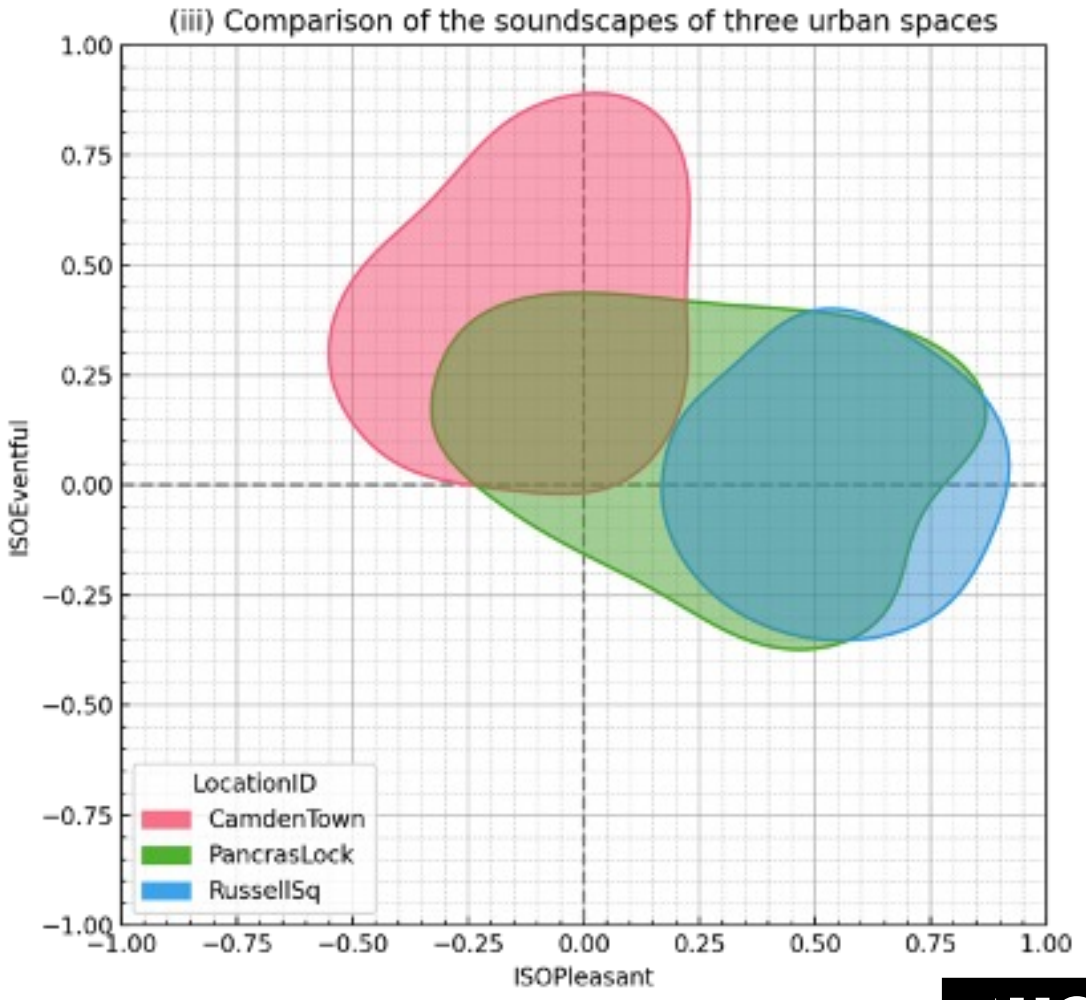
Simplified distribution for comparisons

The greatest benefit of this is seen when **comparing multiple locations**



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Proposals

Towards Soundscape Engineering

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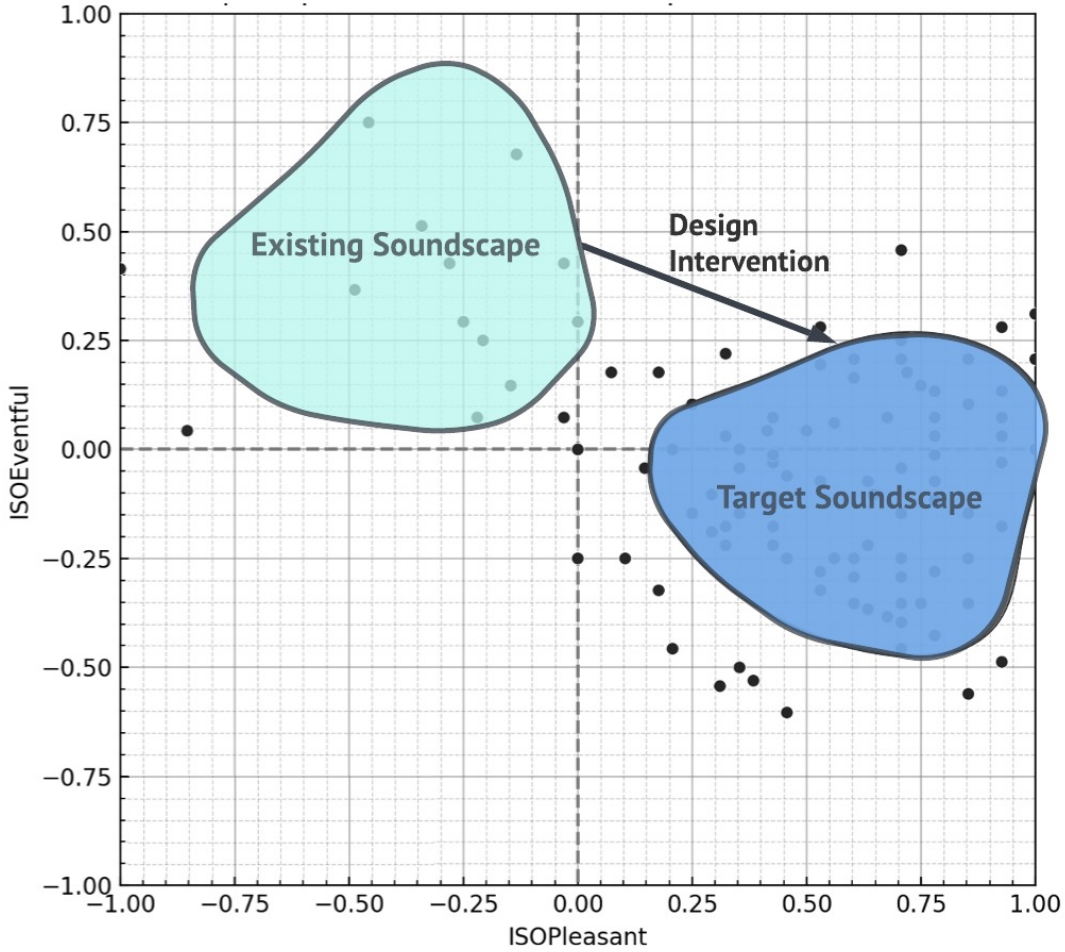
Making use of the predictions in design

- Once the existing soundscape distribution is established (through prediction or surveys) the designer then defines their goal or target soundscape.
- By creating design proposals and running them through a PSM, the success of the proposal for achieving the target can be assessed.
- With a PSM which meets the defined goals & constraints, we can trial various designs to optimize and assess their success.



Adapted from Cain, R., Jennings, P., & Poxon, J. (2013, Feb.). The development and application of the emotional dimensions of a soundscape. *Applied Acoustics*, 74(2):232-239.

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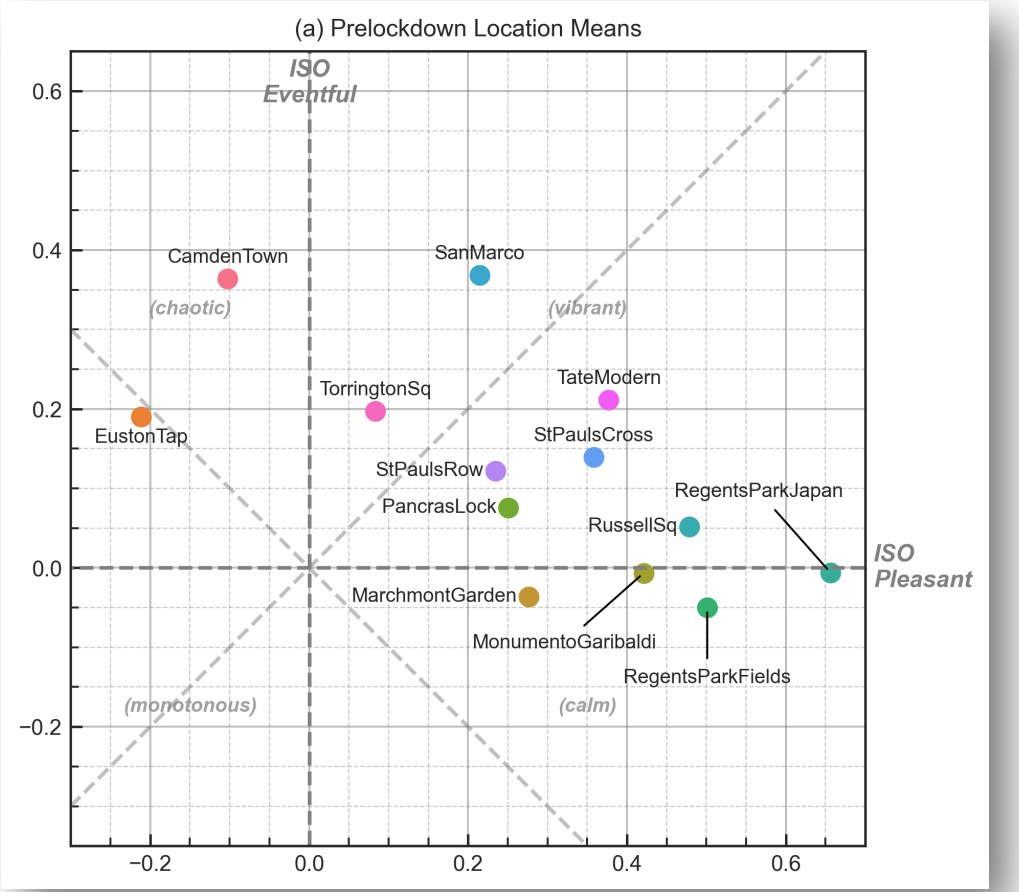
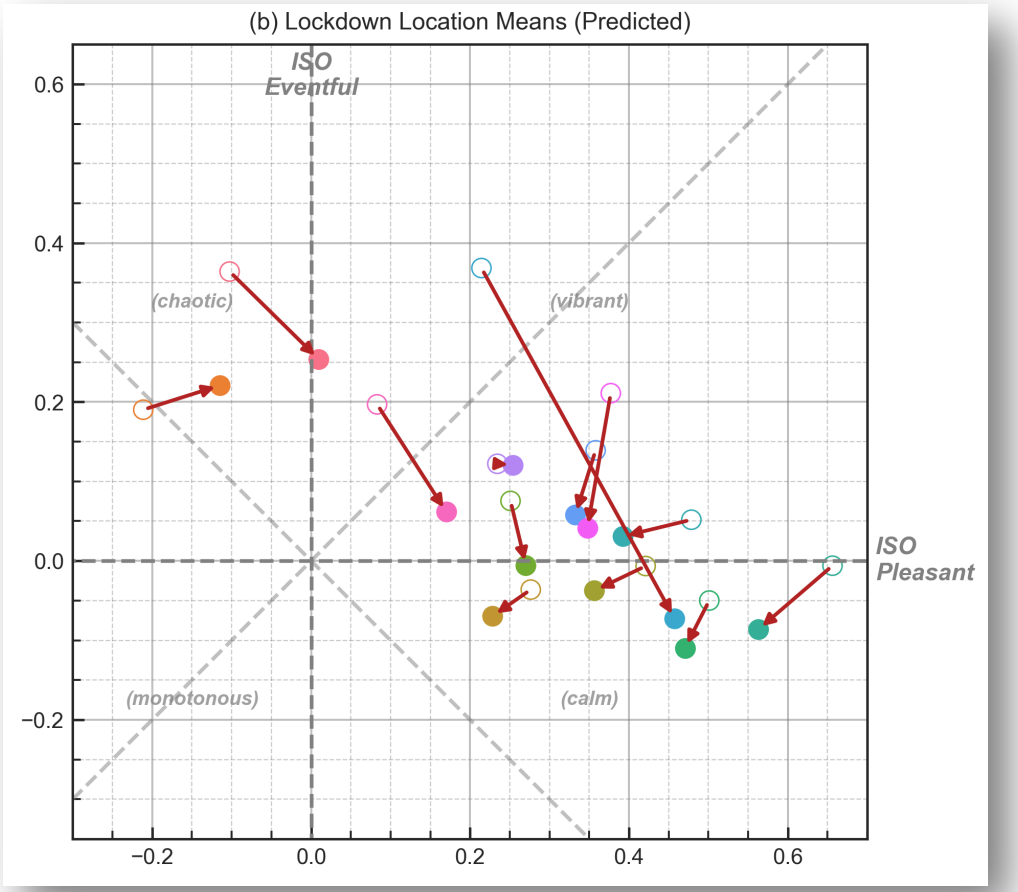
An application case study – COVID-19 Lockdown





From Mitchell et al. (2021). Investigating urban soundscapes of the COVID-19 lockdown: A predictive soundscape modelling approach. *The Journal of the Acoustical Society of America*, 150(6):4474-4488.

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Developing New Predictive Models

Conferences > ICASSP 2022 - 2022 IEEE Inter...

Probably Pleasant? A Neural-Probabilistic Approach to Automatic Masker Selection for Urban Soundscape Augmentation

Publisher: IEEE

Kenneth Ooi ; Karn N. Watch

2 Cites in Papers

367 Full Text Views

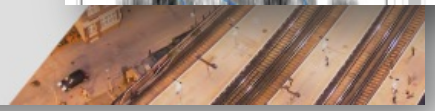
The Alan Turing Institute

Data Study Group Final Report:

IEDE Acoustics Group, University College London

Deep Learning Techniques for noise annoyance detection (DeLTA)

12-16 December 2022



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Volume 154, Issue 5

November 2023

NOVEMBER 15 2023

AI-based soundscape analysis: Jointly identifying sound sources and predicting annoyance[a)]

Yuanbo Hou ; Qiaoqiao Ren ; Huizhong Zhang; Andrew Mitchell ; Francesco Aletta ; Jian Kang ; Dick Botteldooren

Check for updates

+ Author & Article Information

J. Acoust. Soc. Am. 154, 3145–3157 (2023)

https://doi.org/10.1121/10.0022408 **Article history**

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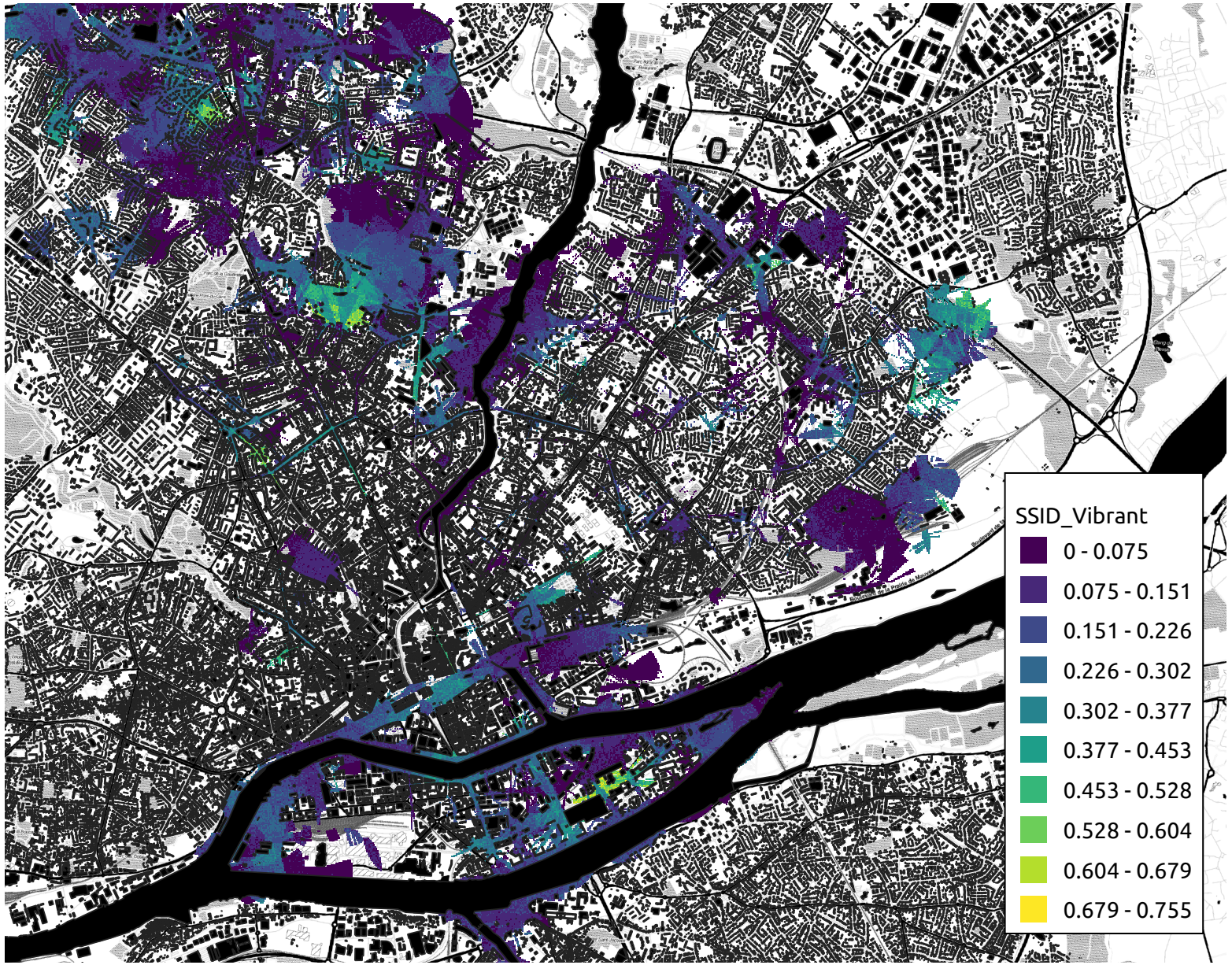
Soundscape Indices for Mapping & Monitoring



- A preliminary example of soundscape index (SSID) mapping.
- Mapping soundscape vibrancy based on PAQs from surveys collected in Nantes.
- The survey collection is extremely labour-intensive and results in low spatial resolution. A PSM would allow these responses to be predicted from sensor recordings.

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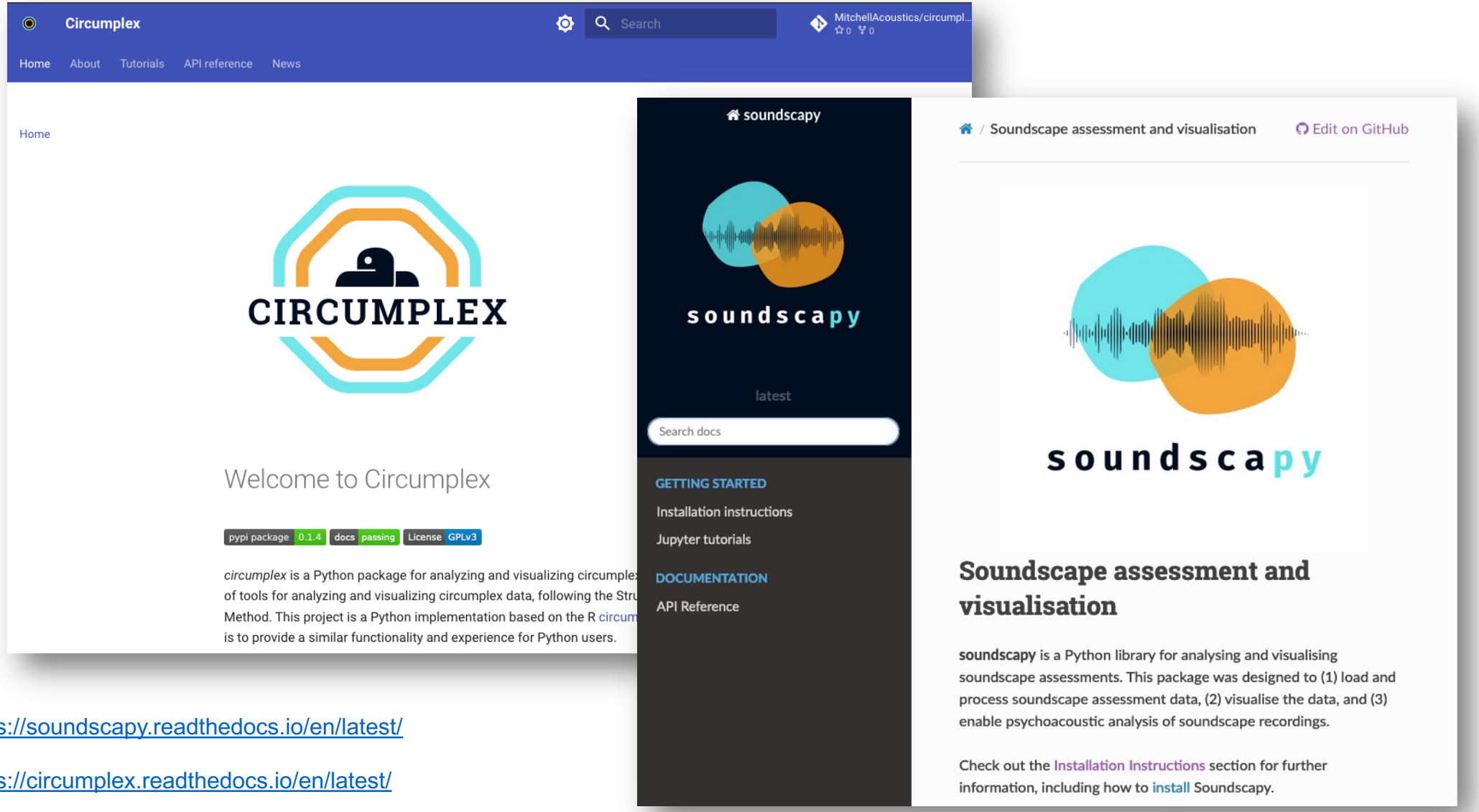
Open Source Packages



https://soundscapy.readthedocs.io/en/latest/

https://circumplex.readthedocs.io/en/latest/

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Open Source Packages

Soundscapy:

Psychoacoustic and Eco-acoustic Analysis

- In addition to making it simpler to work with soundscape survey data, Soundscapy makes it easier to perform **bulk analysis of binaural recordings.**
- By providing a streamlined and repeatable frontend to analysis libraries such as MoSQito, scikit-maad, and python-acoustics, we make it possible to calculate a wide range of metrics from **psychoacoustics, eco-acoustics, and environmental acoustics with consistent settings**
- Calculation settings can be saved and shared in a JSON file.
- **Parallel calculations** drastically speed up bulk processing.

```
from soundscapy import Binaural
b = Binaural.from_wav("example.wav")
b.mosqito_metric('loudness_zwtv', statistics=(5,50,'avg', 'max'), as_df=True, parallel=True
```

```
- Calculating MoSQITo metric: loudness_zwtv
```

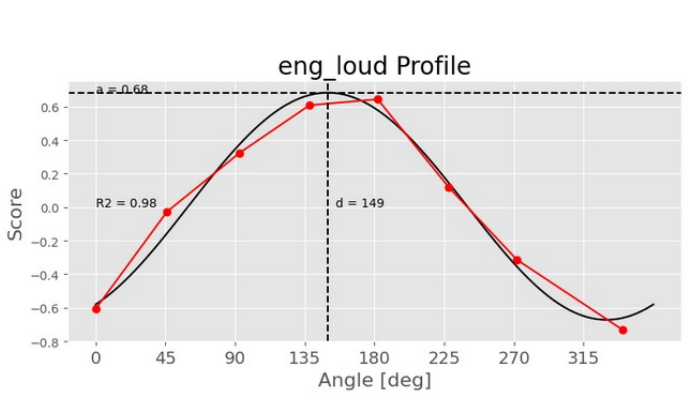
[11]:

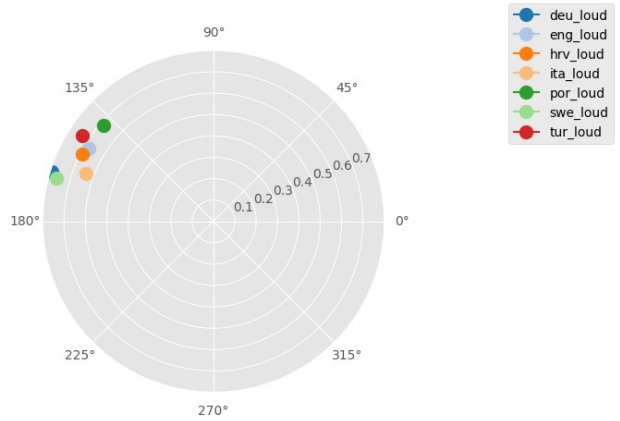
Recording	Channel	N_5	N_50	N_avg	N_max
CT101	Left	28.834482	23.164299	22.669519	36.160815
	Right	30.834215	23.939352	23.774119	37.762344

Circumplex:

Advanced circumplex analysis

- Implements the **Structural Summary Method (SSM)** of circumplex analysis.
- This enables more detailed analysis of circumplex items, **correlation with external variables, and validation of the circumplex structure of responses.**
- Extended to any circumplex survey instrument





Putting it all together

Free and Open Source

soundscapy

Modular and Adaptable

Audio analysis

Psychoacoustics, environmental acoustics, bioacoustics, etc.

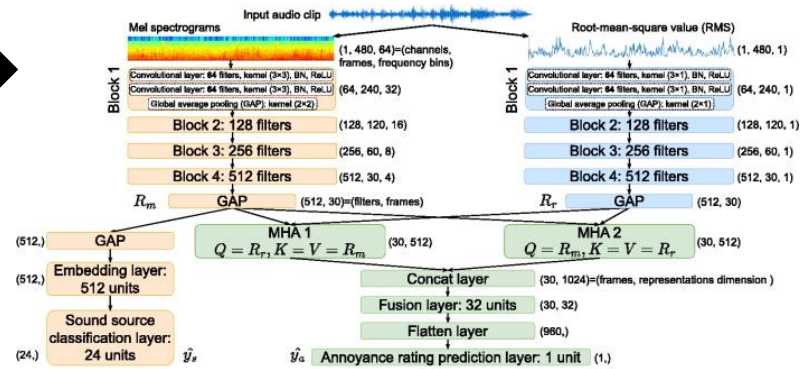
```
metric = "loudness_zwtv"
stats = (5, 50, 'avg', 'max')
func_args = {
    'field_type': 'free'
}

b.mosqito_metric(metric, statistics=stats, as_df=True
```

```
- Calculating MoSQITo metric: loudness_zwtv
```

Recording	Channel	N_5	N_50	N_avg	N_m
CT101	Left	28.834482	23.164299	22.669519	36.1608
	Right	30.834215	23.939352	23.774119	37.7623

Predictive Modelling

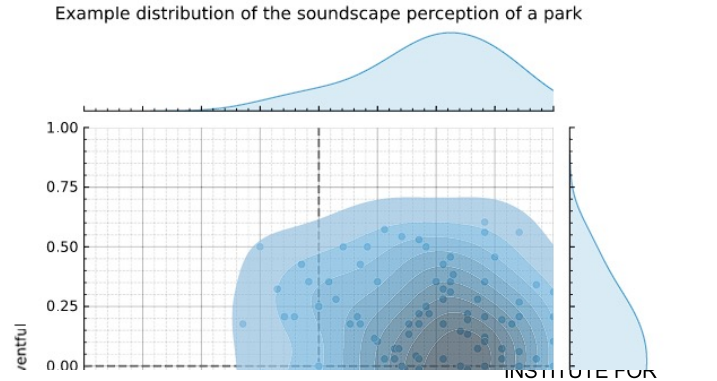
Multi-level Linear Regression
Probabilistic Predictions
Joint Source-Perception Modelling



Visualisation & Scoring

Soundscape Density Plots
Soundscape Indices

```
jo = ssid.isd.filter_location_ids(['RussellSq']).isd.circumplex_jointplot_density(
    title='Example distribution of the soundscape perception of a park',
    marginal_kind = 'kde', hue = 'LocationID', legend = True, alpha=0.75, incl_scatter = True, joint_kwargs={'s': 30})
```



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Thank you for listening

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For more on me and my work, visit:

Website: https://drandrewmitchell.com

And my software packages:

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References

Schulte-Fortkamp, B., Fiebig, A., Sisneros, J. A., Popper, A. N., & Fay, R. R. (2023). *Soundscapes: Humans and Their Acoustic Environment*. Springer International Publishing. https://doi.org/10.1007/978-3-031-22779-0

Axelsson, Ö. (2020). Soundscape revisited. *Journal of Urban Design*, *25*(5), 551–555. https://doi.org/10.1080/13574809.2020.1810006

Pijanowski, B. C., Villanueva-Rivera, L. J., Dumyahn, S. L., Farina, A., Krause, B. L., Napoletano, B. M., Gage, S. H., & Pieretti, N. (2011). Soundscape Ecology: The Science of Sound in the Landscape. *BioScience*, *61*(3), 203–216. https://doi.org/10.1525/bio.2011.61.3.6

Aletta, F., Kang, J., & Axelsson, Ö. (2016). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning*, *149*, 65–74. https://doi.org/10.1016/j.landurbplan.2016.02.001

Axelsson, Ö., Nilsson, M. E., & Berglund, B. (2010). A principal components model of soundscape perception. *The Journal of the Acoustical Society of America*, *128*(5), 2836–2846. https://doi.org/10.1121/1.3493436

Cain, R., Jennings, P., & Poxon, J. (2013). The development and application of the emotional dimensions of a soundscape. *Applied Acoustics*, *74*(2), 232–239. https://doi.org/10.1016/j.apacoust.2011.11.006

Ooi, K., Watcharasupat, K. N., Lam, B., Ong, Z.-T., & Gan, W.-S. (2022, May). Probably Pleasant? A Neural-Probabilistic Approach to Automatic Masker Selection for Urban Soundscape Augmentation. *ICASSP 2022 - 2022 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. https://doi.org/10.1109/icassp43922.2022.9746897

Mitchell, A., Aletta, F., Oberman, T., & Kang, J. (2023, September). How do we define soundscape? *Forum Acusticum 2023*.

Mitchell, A., Aletta, F., Oberman, T., Erfanian, M., & Kang, J. (2023, August). A conceptual framework for the practical use of predictive models and Soundscape Indices: Goals, constraints, and applications. *INTER-NOISE 2023 Conference*.

Mitchell, A., Oberman, T., Aletta, F., Erfanian, M., Kachlicka, M., Lionello, M., & Kang, J. (2020). The Soundscape Indices (SSID) Protocol: A Method for Urban Soundscape Surveys–Questionnaires with Acoustical and Contextual Information. *Applied Sciences*, *10*(7), 2397. https://doi.org/10.3390/app10072397

Mitchell, A., Oberman, T., Aletta, F., Erfanian, M., Kachlicka, M., Lionello, M., & Kang, J. (2021). *The International Soundscape Database: An integrated multimedia database of urban soundscape surveys – questionnaires with acoustical and contextual information*. Zenodo. https://doi.org/10.5281/zenodo.5578572

Mitchell, A., Aletta, F., & Kang, J. (2022). How to analyse and represent quantitative soundscape data. *JASA Express Letters*, *2*(3), 37201. https://doi.org/10.1121/10.0009794

Mitchell, A., Oberman, T., Aletta, F., Kachlicka, M., Lionello, M., Erfanian, M., & Kang, J. (2021). Investigating urban soundscapes of the COVID-19 lockdown: A predictive soundscape modeling approach. *The Journal of the Acoustical Society of America*, *150*(6), 4474–4488. https://doi.org/10.1121/10.0008928

Hou, Y., Ren, Q., Zhang, H., Mitchell, A., Aletta, F., Kang, J., & Botteldooren, D. (2023). AI-based soundscape analysis: Jointly identifying sound sources and predicting annoyancea). *The Journal of the Acoustical Society of America*, *154*(5), 3145–3157. https://doi.org/10.1121/10.0022408

Data Study Group Team. (2023). *Data Study Group Final Report: IEDE Acoustics Group, University College London Deep Learning Techniques for noise annoyance detection (DeLTA)* [Resreport]. The Alan Turing Institute. https://doi.org/10.5281/ZENODO.10090651

Moshona, C. C., Aletta, F., Henze, H., Chen, X., Mitchell, A., Oberman, T., Tong, H., Fiebig, A., Kang, J., & Schulte-Fortkamp, B. (2022). What is a soundscape intervention? Exploring definitions and identifi-cation criteria and a platform to gather real-world examples. *51st International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2022)*.