Soundscape Design: Going Beyond Quieteness

Jooyoung Hong
Assistant Professor
Architecture and Substantiable Design
Singapore University of Technology and Design
Five Questions on Soundscape

Q1: What is soundscape?

Q2: Why soundscape is important?

Q3: How can we measure soundscapes?

Q4: How can we design soundscapes?

Q5: What are the challenges of soundscape research?
Q1: What is soundscape?
ISO 12913-1

“Acoustic environment as perceived or experienced and/or understood by a person or people, in context.”
Q2: Why soundscape is important?
Conventional Environmental Noise Management

- European Environmental Noise Directive (END, 2002)

The Directive requires Member States to prepare and publish, every 5 years, noise maps and noise management action plans for:

- Agglomerations with more than 100,000 inhabitants
- Major roads (more than 3 million vehicles a year)
- Major railways (more than 30,000 trains a year)
- Major airports (more than 50,000 movements a year, including small aircrafts and helicopters)
Current management of the acoustic environment is predominantly focused on sound levels and noise mitigation. Consequently, its objective is to reduce sound pressure levels below an acceptable guideline value (cf. WHO, 2000).

https://www.mewr.gov.sg/topic/noise-pollution
Is Sound Pressure Level (dB) Enough?

- Acoustic Comfort vs. Sound Pressure Levels (Yang and Kang, 2005)

No significant relationship between SPL and acoustic comfort. (50-65 dBA)

From Noise Control to Soundscape

- **Acoustic environment**: Physical phenomenon
- **Soundscape**: Perceptual construct

ISO 12913-1: Conceptual framework of soundscape
Acoustic environment as perceived or experienced and/or understood by a person or people, in context.

- Paradigm shift from **Noise Control** into **Soundscape Design**
- Subsequently **Global policy of Urban Sound Management** in the future
### Scientific Production of the last 20 years

#### Soundscape-related studies

- **International Research Projects (EU)**
  - Soundscape of European cities and landscapes (2009-2013)
    - Soundscape research through international and interdisciplinary efforts
  - HOSANNA (2010-2013)
    - Exploring practical approaches using recycled materials and vegetation towards better soundscape design
    - [http://noiseabatementsociety.com/](http://noiseabatementsociety.com/)
  - The Urban Sound Planner SONORUS (2012-2016)
    - Education and research for urban sound planner project to develop a new, holistic soundscape design approach.

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Noise Control Approach vs. Soundscape Approach

Annoying Sounds (Negative) — Design Elements — Pleasant Sounds (Positive)

Waste (Reduce) — Resource (Increase)
Q3: How can we measure soundscapes?
Soundscape Descriptors and Indicators

- Noise annoyance
- Pleasantness
- Tranquillity
- Music-likeness
- Perceived affective quality
- Soundscape quality
- Appropriateness

- Acoustical indices
- Psycho-physiological indices
- Context indices
- Design or remedial indices

Triangulation Model of Soundscape Assessment

Soundscape

Questionnaire Surveys
- Social survey
- Soundwalks
- Lab experiments

Acoustic Analysis
- SPL indices
- Psychoacoustic indices

Narrative Interview
- Grounded theory
- Focus group interview
ISO 12913-2 Data Collection and Reporting Requirements

Section
1 Scope
2 Normative reference
3 Terms and definitions
4 Descriptors and indicators
5 Data collection
   • Soundwalk
   • Questionnaire
   • Guided interview
   • Sound source taxonomy
   • Binaural measurement
6 Reporting requirement

Annexes
Annex A (normative): Minimum reporting requirements
   • Participants
   • Acoustic environment
   • Data collection

Annex B (informative): Psychoacoustic indicators

Annex C (informative): Data collection methods

Annex D (normative): Binaural measurement methods

Annex E (informative): Good practice in reporting a soundscape study

ISO 12913-2 Annex C: Data Collection Methods

Quantitative approach

Method A: Structured questionnaire
- Sound source identification
- Perceived affective quality
  - Pleasantness
  - Eventfulness
- Overall soundscape quality
- Appropriateness of soundscape

Qualitative approach

Method B: Structured + open-ended questionnaire
- Sound source recognition and ranking
- Assessment of the sound environment
  - Perceived loudness
  - Unpleasantness (Annoyance)
  - Appropriateness of soundscape
  - Frequency of visit
- Open-ended comments

Method C: Narrative interview
- Narrative interview on contexts
- Interview guidelines
Pleasantness-Eventfulness Model (Method A)

Soundscape Data Collection

Soundwalk  Questionnaire  Audio-Visual Measurement

Data Collection and Analysis (Method A)

Case study (Millenia Walk) by ASD SUTD students

Sound source identification

Perceived affective quality

1. Escalators Area
   - 59 dBA
   - 60 dBA

2. Linkway / Bridge

3. C-Shaped Seatings Area
   - 69 dBA

4. Triangle Green & Water Feature
   - 71 dBA

60 dBA

2020 Sustainable Design Option Studio
PUBLIC SOUNDSCAPE: REIMAGINING PUBLIC LIFE IN POST-COVID WORLD

69 dBA

59 dBA
Q4: How can we design soundscapes?
Soundscape Design Elements

Sound sources
- Sound pressure level
- Spectrum
- Temporal conditions
- Location
- Source movement
- Psychological/social characteristics

Effect of the space
- Reverberation
- Reflection pattern and/or echogram
- General background sound
- Sounds around space

Social-cultural aspects
- Social/demographic characteristics of the users
- Acoustic conditions at users’ home and work, experience etc.

Other sensory aspects
- Temperature, humidity, lighting, etc.
- Visual, landscape, and architectural characteristics

- Variation (hour, day, season)
- Duration
- Impulsive characteristics
- Meaning
- Natural or artificial sound
- Relation to activities
- Soundmark
- Descriptive or holistic

Soundscape Intervention by Adding Pleasant Sounds

Perceived loudness of noise

Soundscape quality

Attract users’ attention

Using Pleasant Natural Sounds as Design Elements

Noisy Urban Public Spaces

Urban noise

Conventional Noise Control Approach

Soundscape Design Approach
Soundscape Design Precedent #1

Sheaf Square in Sheffield, UK
The waterfalls and metal sculpture acting as a physical barrier as well as providing a pleasant water sound in the square.
Soundscape Design Precedent #2

Nauener Park, Berlin, Germany
Speakers embedded in park street furniture to generate bird songs and water sounds to mask loud traffic noise.

VR-AR Soundscape Design Tools

Virtual Reality (VR) laboratory test
- Controlled environment
- Systemically exploring masking effects

Augmented Reality (AR) in-situ test
- Real environment
- Testing the masking effects with high-ecological validity

3D Audio Tech.

Immersive Experience
Developed VR-AR Soundscape Tool

- Ambisonic Microphone
- Spherical Panoramic Camera (VR)
- Augmented sound object
- Adjusting Masker Level
- Binaural Mic.
- AR HoloLens
- Portable Audio-Recorder
Effect of Natural Sounds on Soundscape in a Laboratory

**participants:** 68 (Singaporean / Permanent resident)

**Noise**
- Traffic

**Noise with Masker**
- Bird
- Stream

**dB**
- Noise Level (dB)
- Masker-to-Noise Ratio (dB)
- Total Level (dB)

**Subjective test**
- Perceived Loudness of Noise
- Overall Soundscape quality
Reduction of Perceived Loudness of Noise (PLN) by Natural Sounds

- Introducing natural sounds can reduce ~ 20 - 30% of the PLN.
- Masker levels do not need to be louder than the traffic noise levels.
Enhancement of Soundscape Quality by Natural Sounds

- Introducing natural sounds significantly increased soundscape quality by ~20-36%.
- When traffic noise level became 75 dB, lower masker levels were preferred.

<table>
<thead>
<tr>
<th>Masker-to-Noise Ratio [dB]</th>
<th>Noise only</th>
<th>Baseline</th>
<th>Masker</th>
<th>None</th>
<th>Bird</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>55 dB</td>
<td>+36.8%</td>
<td>+36.8%</td>
<td>+31.8%</td>
<td>+31.8%</td>
<td>+18.5%</td>
<td>+18.5%</td>
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<tr>
<td>65 dB</td>
<td>+31.8%</td>
<td>+31.8%</td>
<td>+31.8%</td>
<td>+31.8%</td>
<td>+18.5%</td>
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<tr>
<td>75 dB</td>
<td>+18.5%</td>
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Effects of Natural Sounds In-situ Environment

- What is the most preferred natural sound level corresponding to ambient noise levels?

Equipment settings for in-situ soundscape experiments

- Binaural microphone (B&K, Type 4101-B)
- Bluetooth keyboard (Logitech K380)
- Portable acoustic data acquisition instrument (HEAD acoustics, SQobold)
- AR HMD (Microsoft HoloLens)
- Augmented audio-visual object
- Adjusting Masker Level
Effects of Natural Sounds In-situ Environment

Augmented Reality Soundscape Experiment Procedure

Nanyang Technological University
Effects of Natural Sounds on Soundscape In situ

- **Reduction in Perceived Loudness of Noise**

- **Enhancement of Overall Soundscape Quality**

- Mean ambient traffic noise level (3-min)
  - Location A: 67.6 dBA
  - Location B: 73.6 dBA
Relationship between preferred MNRs and ambient traffic noise levels

\[ MNR = L_{\text{Aeq,3–min, Natural}} - L_{\text{Aeq,3–min, Traffic}} \]

\[ MNR_{\text{bird}} = -0.78 L_{\text{Aeq,3–min, traffic}} + 59.5 \]

\[ R^2 = 0.25, p < 0.001 \]

\[ MNR_{\text{water}} = -0.77 L_{\text{Aeq,3–min, traffic}} + 54.8 \]

\[ R^2 = 0.42, p < 0.001 \]
Q5: What are the challenges of soundscape research?
# Challenges in Soundscape Research

<table>
<thead>
<tr>
<th>Theme</th>
<th>Sub-Themes</th>
<th>Perceived Priorities (Challenges)</th>
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<tbody>
<tr>
<td><strong>Academia–Practice gap</strong></td>
<td>• Normative context</td>
<td>To bridge soundscape research and practice (architecture, urban planning, landscape design, etc.)</td>
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<td></td>
<td>• Design and planning guidelines</td>
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<td>• Education and training for soundscape professionals</td>
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<td><strong>Applicability of the soundscape framework</strong></td>
<td>• Indoor environments</td>
<td>To explore how to adapt the current (urban) soundscape frameworks for other contexts/disciplines.</td>
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<td>• Quiet areas</td>
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<td>• Scale of intervention</td>
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<td></td>
<td>• Common language to communicate</td>
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<td></td>
<td>• Techniques for representation</td>
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<td></td>
<td>• Operational tools (methods)</td>
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<td><strong>Multisensory interactions in soundscapes</strong></td>
<td>• Sound-visual</td>
<td>To identify impacts of other sensory inputs for soundscape appraisal.</td>
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<td>• Sound-smell</td>
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<td>• Sound-haptic</td>
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<tr>
<td><strong>Relationships between soundscape, behaviors, and physiology</strong></td>
<td>• Antisocial behaviours Use of spaces</td>
<td>To understand how people react to different types of sounds, behaviourally and psychologically, in specific contexts.</td>
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<td>• Crowd’s movements/flows</td>
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<td><strong>Technology for soundscapes</strong></td>
<td>• Sensors and apps</td>
<td>To analyse data collected from emerging technologies, archives, and platforms in an ecologically valid way.</td>
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<tr>
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<td>• Virtual/Augmented Reality tools</td>
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<td>• Data archives and platforms</td>
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<td>• Repositories of soundscape studies/interventions</td>
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Augmenting Urban Soundscape (AUS) Phase 2

AUS: Adaptive Soundscape Enhancement System and Evaluation of the Urban Sound Environment

Thrust 1: Development AUS Algorithm via AR-VR

Thrust 2: AUS Design, Development, Deployment

- Virtualize Actual AUS
- Testbed for Psycho-Physical-Behavioral Impact
- Aid in Designing AUS
- Aid in Assessing Sound Masking Effects
- Psycho-Physiological Assessment

Thrust 3: Psycho-Physiological-Behavioral Study

- Examine AUS through Psycho-Physiological-Behavioral studies
- Community Feedback
Significance and Impact of AUS System

AUS system can be deployed in Urban Public Spaces Where Exposed to Heavy Traffic Noise

01 Perception-Driven Design and Display Tools

02 Integrated Solution for Soundscape Design in Smart Cities

03 Improve Utilization of Urban Public Spaces and Health
Towards Sustainable Urban Soundscape

Psycho-Physiology-Behavior

The home territory of soundscape studies will be the middle ground between science, society and the arts.

R. M. Schafer

Integrated solution for sustainable urban sound design

Masking sound to mitigate urban noise

Vehicle Noise

Water Sounds

Urban Planning & Architecture

Acoustic Sensing Tech

Bird/Insect Sounds
Thank you for your attention!

jooyoung_hong@sutd.edu.sg  https://qrgo.page.link/dkbnZ

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