Towards Multisensory Cartography

A Review of the Auditory & Haptic Communication of Space & Place in Interactive Applications

By NTUA

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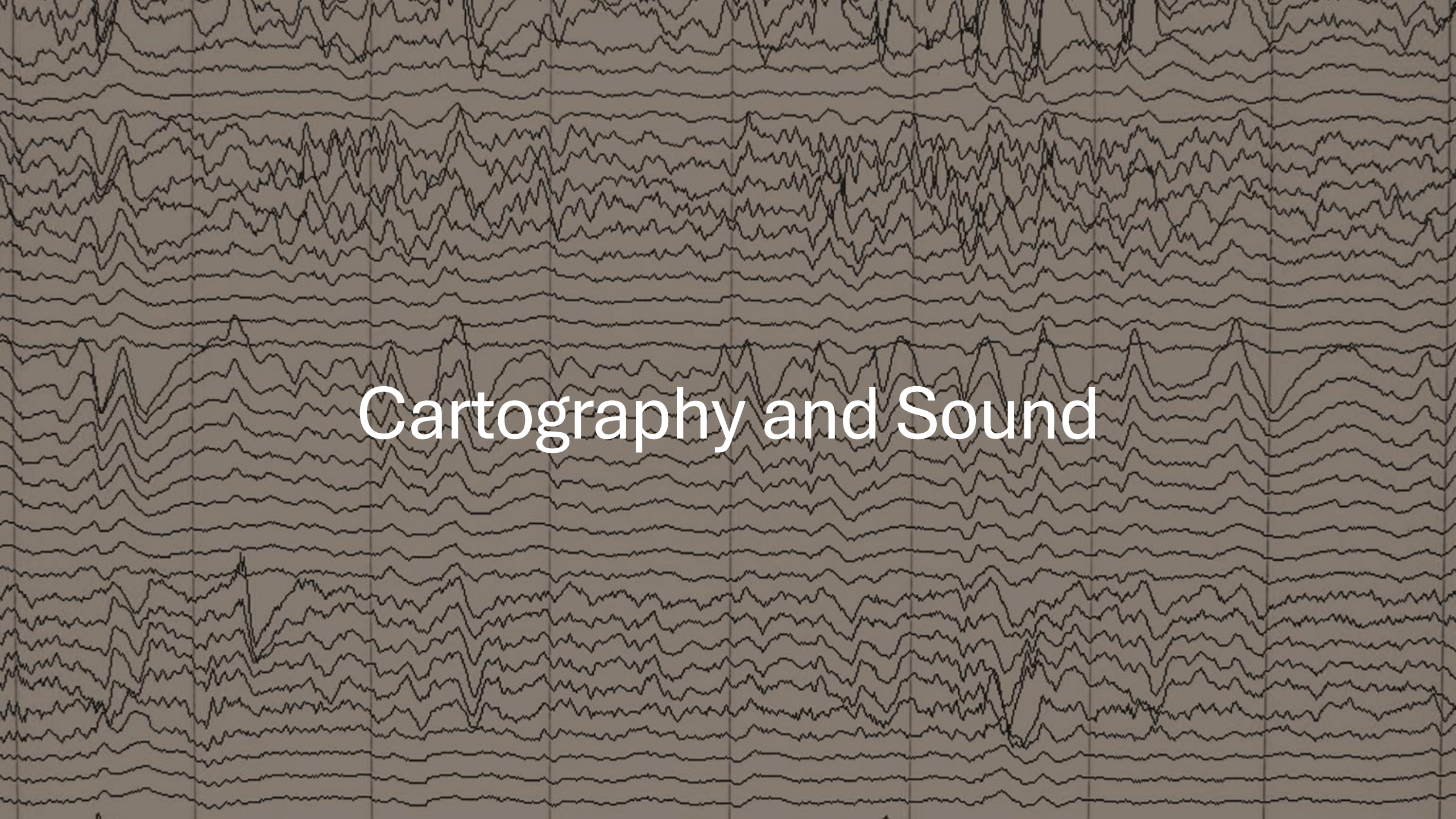

Cartography and Sound

The Auditory Dimension in Cartography

Sound variables - cartographic sonification
Cybercartography
The broader sensory turn, & mapping the “Soundscape”
Recent advances in Audiovisual Cartography
Narrative Cartography

Krygier (1994)

- **Proposed the use of sound in geographic visualization**, to better utilize human perceptual and cognitive abilities and offer more representation options.

«(…) *as vocal narration,*
a mimetic symbol,
a redundant variable,
a means of detecting anomalies,
a means of reducing visual distraction,
a cue to reordered data,
an alternative to visual patterns,
an alarm or monitor,
a means of adding non-visual data dimensions to interactive visual displays
and for representing locations in a sound space».

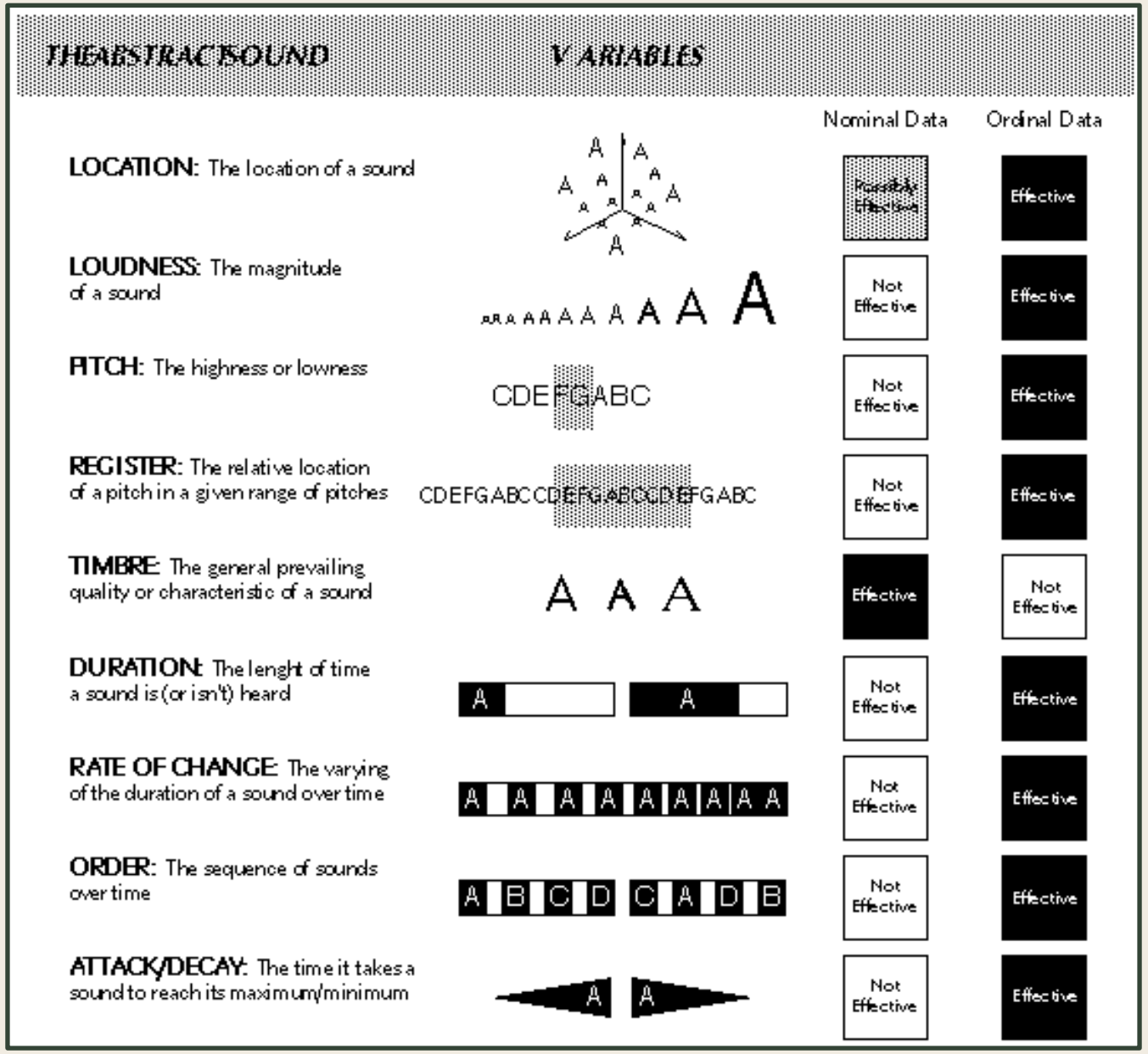
Uses of sound

- **Realistic**: vocal narration, "*mimetic sound icons, or 'earcons'*''*
- **Abstract**: can direct the attention of users or can be mapped to actual data.

* But note that:
- **Auditory icons**: "auditory equivalent of visual icons" (Brazil & Fernström, 2011).
- **Earcons:** "short structured musical phrases that can be parameterized to communicate information in an Auditory display" (McGookin & Brewster, 2011)

Krygier (1994)

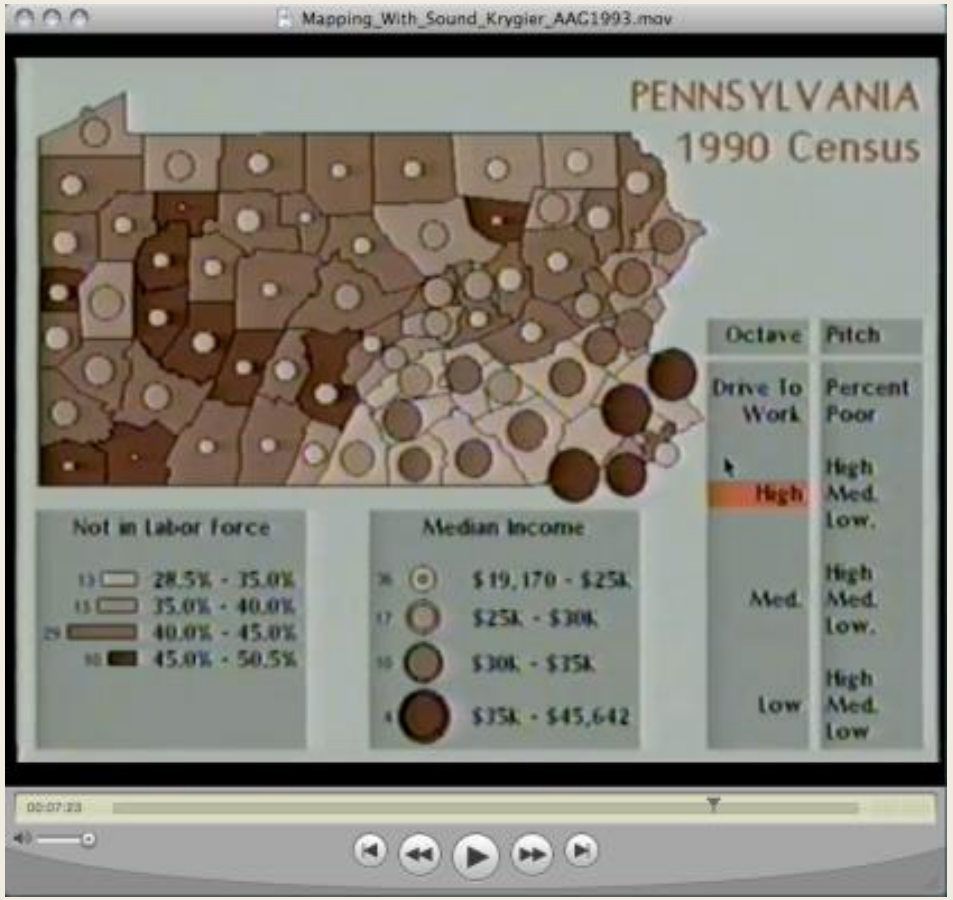
- Proposed a non-exhaustive set of **abstract sound variables** for geographic visualization, in analogy to the visual variables by Bertin.
  - ▶ Not fully separable.
  - ▶ Sound introduces a temporal dimension.



Abstract sound variables (Krygier, 1994)

Downloaded from https://krygier.owu.edu/krygier_html/krysound.html

Early examples of sonification



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Krygier

Map animation & interactive multimedia

e.g. Interactive map of **census data** (left):

- 2 variables visually (choropleth/ graduated circles)
- 2 variables sonically (register/pitch), **on mouse click**

Fisher (1994)

- Sonic map overlays for **pixel reliability in classified remotely sensed image**.
- Several variables, e.g. pitch, “duration and silence”, “complex sounds” like modulation (a constant drone for Min/Max values for reference, over which the pitch for each pixel would be heard).
- **Mouse or automatic traversal** to get a sense of reliability patterns
- Applicable to **continuous data** ancillary to categorical maps; supported by anecdotal evidence.

Cybercartography

A **new cartographic paradigm** proposed in 1997 by Taylor, in response to the technological and conceptual challenges of the information age

Cybercartography:

«(…) *the organisation, presentation, analysis and communication of spatially referenced information on a wide variety of topics of interest and use to society in an interactive, dynamic, multimedia, multi-sensory format with the use of multimedia and multimodal interfaces*».

- Uses the worldwide web
- Interacts with the user in new ways
- Is part of an information package rather than a standalone product
- Is developed through interdisciplinary collaboration and new research partnerships (Taylor, 2003, in Taylor & Pyne, 2010).

Cybercartography

Trbovich et al. (2005)

Potential of **multimodal interfaces** for cartography; strengths, weaknesses, applications, cognitive load of different modalities

Théberge (2005)

Strategic integration of sound in cartographic design, considering the **cultural** dimension of sound

Brauen (2006)

Sound is **underused** in cartography; **different types of sound** - narration, music, sound effects, ambient or environmental sounds - **may serve different purposes** (aid intepretation, immersion, emotional engagement, offer alternative perspectives, additional information).
e.g. Modulated volume of recorded speeches to increase dimensionality of map of election results

Cybercartography

Brauen & Taylor (2008)

Focused on **linked audio representation** to explore approaches that retain the structure of music and recognizable sounds in abstract representation

Caquard et al. (2008)

Sound as an opportunity to approach spatial dimensions of **emotions, culture, memory**

Sound in the Cybercartographic Atlas of Antarctica:

- cinematic narrative of phases of Antarctic exploration
- contrapuntal use of simultaneous voices when mouse hovered over contested land
- recurring aural elements for consistent audio identity of the atlas

Benefits/challenges of mapping sound on the web, user participation

Cybercartography

Taylor & Laurialt (2007)

Opportunities for multimedia cartography: new technologies, entertainment market, experience economy

Need for **high-quality content, understanding the user, engaging all senses, archiving and preserving multimedia cartographic products**.

Main challenge: re-integrating qualitative, artistic, and emotional elements into digital cartography to enhance engagement and effectiveness, while maintaining a scientific framework

Also: Touch (de Almeida & Tsuji, 2005), smell (Lauriault & Lindgaard, 2006)

Context: A broader sensory turn in science

Sui (2000)

Late 20th century: Shift in geographic discourse from visuality toward aurality

Howes (2022)

Geographic manifestations of the sensory turn in scholarship centered on the mediating role of the senses in shaping our relationship to space and cultivating a sense of place

Southworth (1969)
Schafer (1977)
Truax (1978) ...

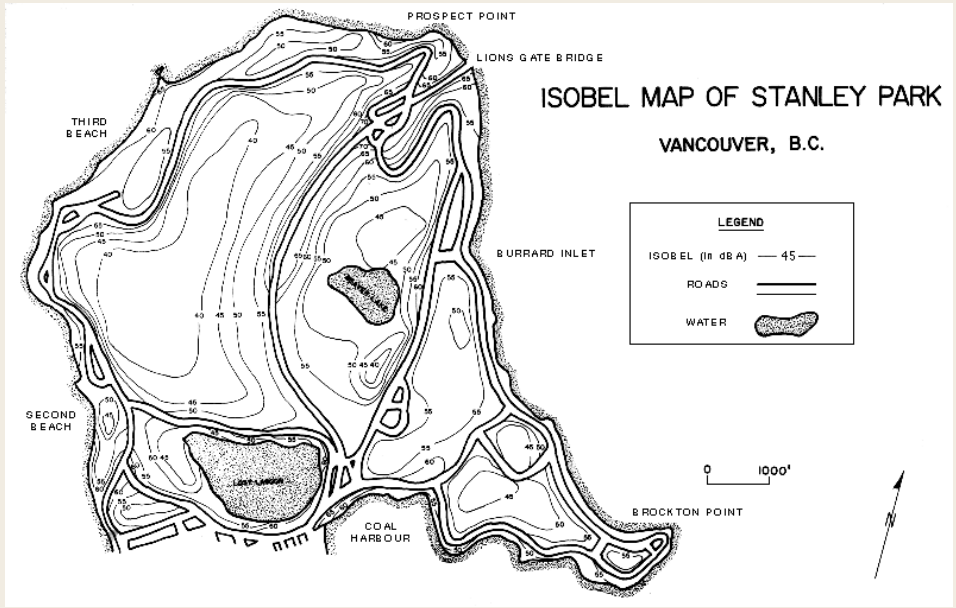
The "Soundscape"

ISO 12913-1:2014 definition: "the acoustic environment as perceived, experienced, and/or understood by a person or people, in context"

Feld (1992)

Acoustemology: Sound as a way of knowing and existing in the world

Mapping the Sonic Environment – Examples



Isobel map of Stanley Park, Vancouver, B.C.

(from The Vancouver Soundscape, No. 2, Music of the Environment series, World Soundscape Project, 1974). *Retrieved from:* https://www.sfu.ca/sonic-studio-webdav/handbook/Isobel.html

- **Granö:** Hatched maps of sensory phenomena on the island of Valosaari, Finland (1920s)
- Early graphic maps of **urban noise**, e.g. Map of Loudness for Charlottenburg (Meister,1956)
- **World Soundscape Project** (since late 60s): used multiple media to map the soundscape and raise awareness on noise pollution
- ***Your Favourite London Sounds*** (Cusack, 1998): participatory recordings, positive acoustic identity
- **European Environmental Noise Directive** 2002/49/EG: stimulated the production of visual maps of noise, according to mandatory guidelines
- **Soundcities** (Stanza, c. 2004) – possibly the first online open-source global audiovisual sound map and database – several online "soundmaps" followed

Recent advances

Brauen (2014) Survey of **web** maps which use audiovisual interfaces

Sonification

Schiewe (2014) **Reviewed the sound variables** and extended them for encoding **quantitative data** for a single point in time and for time series

Brittell (2018) **Reviewed parameter mapping sonification** of geospatial data, including implementations addressing BVI users

- Highlighted implications of mapping-translating conceptual data categories in the different dimensions of the geographic data cube (attributes, time, location)

Recent advances

Animated maps

- Several cartographers (e.g. Krygier, 2004; Harrower, 2007; Lucjan, 2016) have **proposed benefits of sound**, e.g. reducing cognitive load, directing attention and improving learning
  - However, these benefits have not been empirically verified (Hall et al., 2015).
- Cybulski (2016): 38% of animated maps on the internet included sound, most often using narration as a substitute for a legend.

Recent advances

Lammert-Siepmann et al. (2017), Siepmann et al. (2020)

Empirical studies:

- Users of topographic maps recall the name and the position of map objects better when they not only see, but also listen to the object names, as speech recordings.
- Monaural directional communication of the object names (i.e. sound from the left if the visual stimulus is on the left half of the map, and conversely) additionally improves spatial memory performance.

Edler et al. (2019)

4 main **variants** of cartographic sound:

1. Abstract sounds
2. Speech
3. Music
4. Audiorealistic recordings/simulations of the ‘soundscape’

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Recent advances

New technologies & directions

Edler & Vetter (2019)	Audiovisual web cartography using JavaScript
Hruby (2019)	Technical and cognitive potential of audiovisual representation of geospatial phenomena in virtual environments, contribution of sound to spatial presence
Signorelli (2017)	Need to align visual and auditory LOD for soundscape representations to support planning
Edler et al. (2019)	3D representation of the soundscape in 3D virtual environments using game engines
Siepman et al. (2021)	2D/3D representations of individual and social constructions of the landscape

Recent advances

References to sound in narrative cartography

Caquard & Cartwright (2014)	Discussed relationships of maps & narratives: 1. Maps representing spatiotemporal structures of stories 2. Maps as narratives that critically address cartographic process Limited capacity of maps to convey emotions
Caquard et al. (2019)	Memories do not follow Euclidean structure of maps Complementarity of different approaches
Roth (2021)	Cartographic design as visual storytelling: narrative elements, genres, tropes
Bodenhammer et al. (2015) – and others	Deep mapping approaches: emphasize narratives that combine geospatial, historical and cultural information, toward deeper understandings of place