Sound Art in the Time of Crisis:
Climate Data Sonification for Exploration, Understanding, and Aesthetic Renewal

PerMagnus Lindborg, PhD, City University of Hong Kong

Communication University of China, Beijing, 27 November 2023

LOVE IN THE TIME OF CHOLERA

Gabriel García Márquez

Associate Professor

LINDBORG, PerMagnus 林博培

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KEYWORDS

Sound Art **Music Composition** **Perception** **Psychoacoustics** **Sonification**

Multimedia **Soundscape**

BACKGROUND

PerMagnus Lindborg, PhD, is a composer, sound artist, and researcher in sound perception. The first author of more than 150 scholarly publications, compositions, and media artworks.

He is a Fellow with *The Arctic Circle* (2023), *SCM Team Research* (2020-25), and *TBA The Current* (2016), and Principal Investigator for *Multi-Modal Hong Kong* (GRF 2023-25).. He was commissioned by or selected for *Asian Composers League* (New Zealand 2022), *ArtScience Museum* (Singapore 2021), *Osage* (Hong Kong 2021),

PerMagnus Lindborg, PhD

interactive   **multimedia**   **installation**

*1968   1989   1995   1999   2003   2007   2010   2015   2018   2020
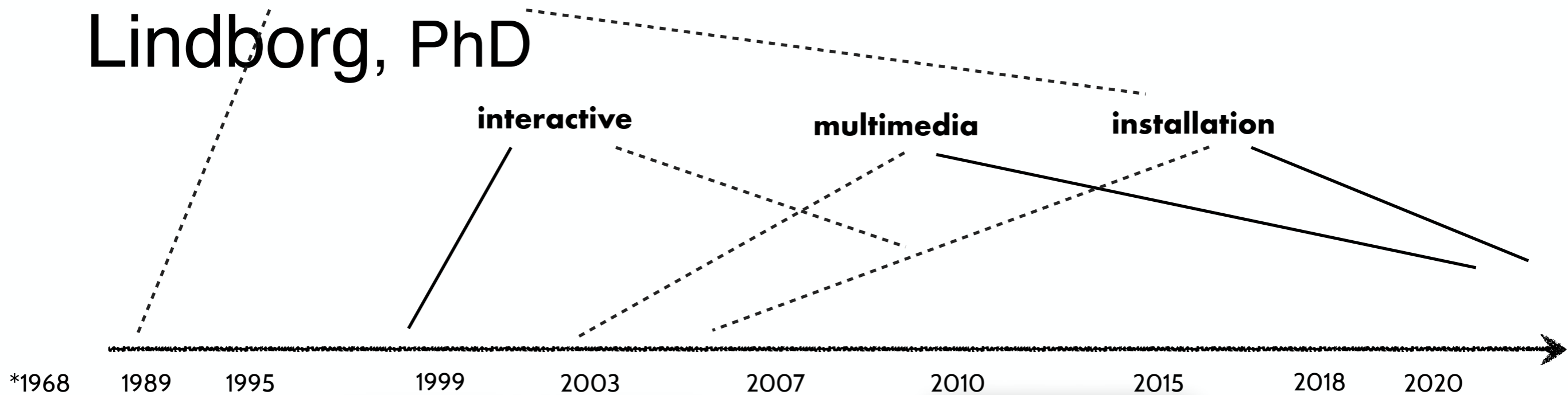
BMus Composition
(Academy of Music, Oslo)

PgDip
Music Computing
(IRCAM, Paris)

MPhil
20thC Musicology
(Sorbonne, Paris)

PhD (techn.)
Sound & Music Computing
(KTH Royal Institute of
Technology, Stockholm)

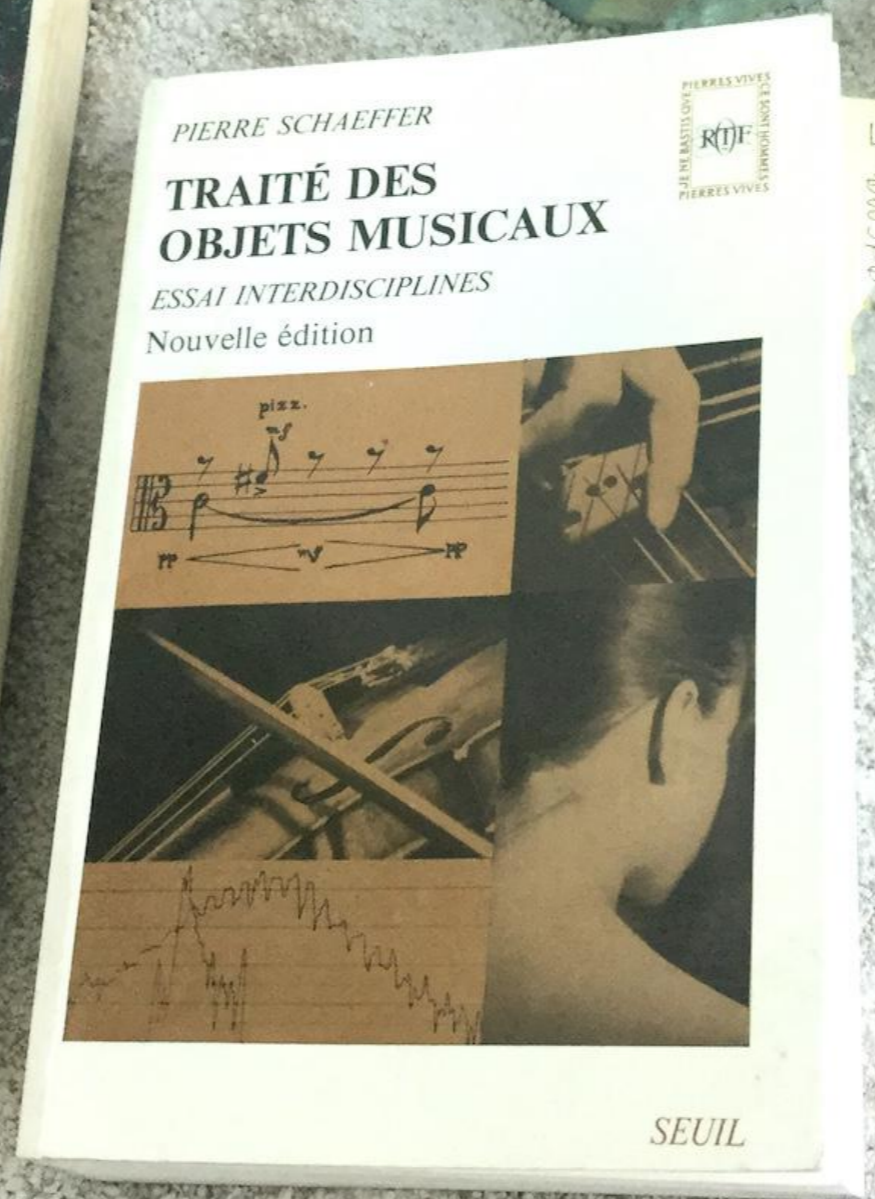*Sweden*   *Norway*

*(Holland,
Canada,
Japan)*

France

ENM

Singapore

LaSalle, NTU/ADM

Korea   *Hong Kong*

SNU   CityU

OUR SONIC ENVIRONMENT AND

THE SOUNDSCAPE

the Tuning of the World

R. MURRAY SCHAFER

PIERRE SCHAEFFER

TRAITÉ DES OBJETS MUSICAUX

ESSAI INTERDISCIPLINES

Nouvelle édition

R(T)F
PIERRES VIVES

SEUIL
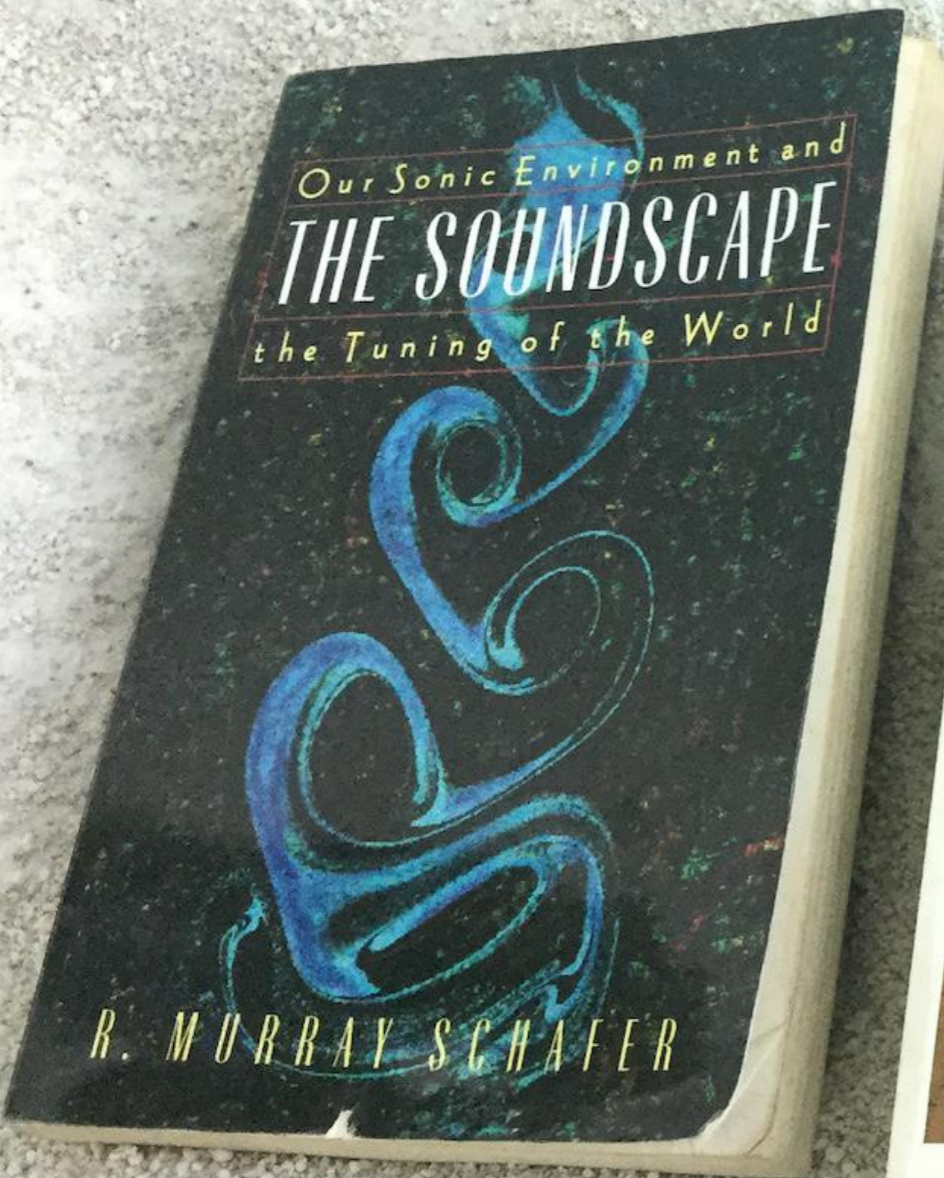
November 2022

香港城市大學
City University of Hong Kong

Less Glitz, more Grit: Towards Sustainable Sound Art Practices
PerMagnus Lindborg, PhD

In lecture series Sound, Ecology and Climate Changing. Curated by Zhang Qian, Music and Recording Art School, Communication University of China (Beijing)

15 November 2022

CLIMATE CONTROL PROJECTS
12 Tweets

CLIMATE CONTROL PROJECTS
@ClimateControlP

Joined April 2020

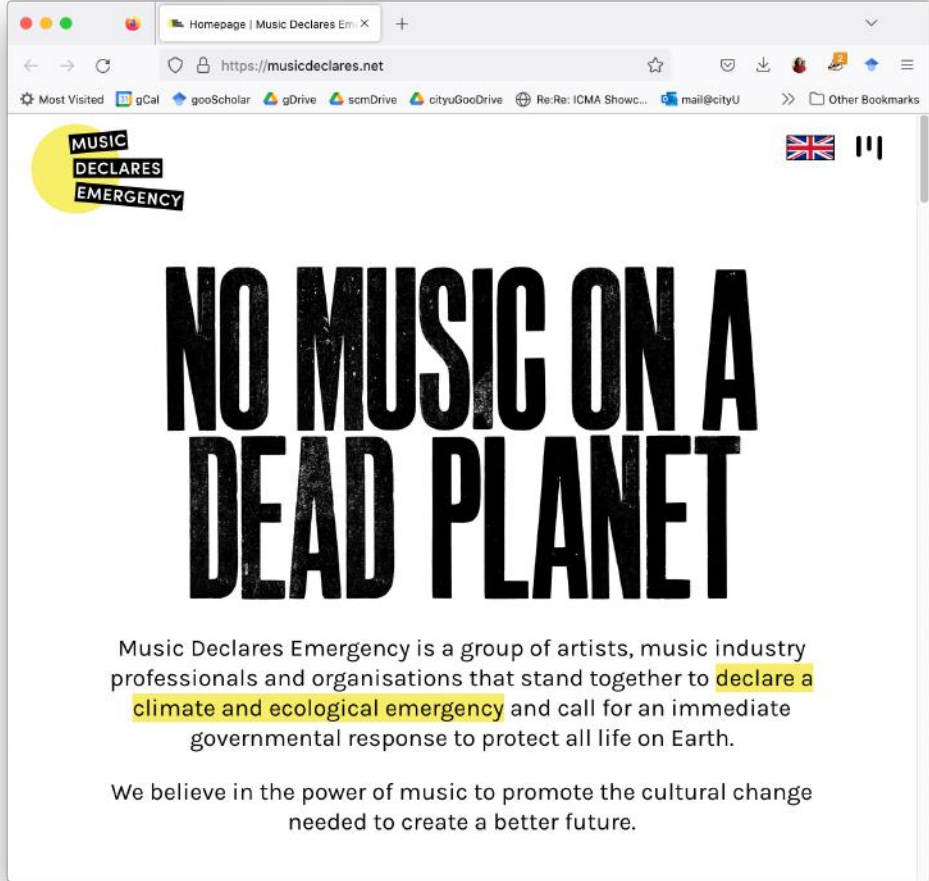6 Following   22 Followers

Tweets   Tweets & replies   Media   Likes

CLIMATE CONTROL PROJECTS @ClimateControlP · Apr 18
The time is now. #ClimateCrisis

Just Stop Oil @JustStop_Oil · Apr 18
The time to #JustStopOil is now

Fossil Fuels
AND WHAT THEY'RE DOING:

Oil is killing people now and will destroy
our future. Every drop of oil we burn
matters. It means more air pollution, more
and hotter heatwaves, more frequent and

https://musicdeclares.net

https://accessaa.co.uk

LIVE GREEN

GEI
SUMMER EDITION

INDUSTRY'S LIVE GREEN DECLARATION TO
BE LAUNCHED AT GEI CONFERENCE

CHRISTOPHER BARRETT · SEPTEMBER 1, 2021

Senior figures from companies including AEG Europe, Live
Nation and Kilimanjaro Live are lined up to speak at
sustainability organisation A Greener Festival's (...

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MUSIC
DECLARES
EMERGENCY

NO MUSIC ON A
DEAD PLANET

Music Declares Emergency is a group of artists, music industry
professionals and organisations that stand together to declare a
climate and ecological emergency and call for an immediate
governmental response to protect all life on Earth.

We believe in the power of music to promote the cultural change
needed to create a better future.

Check for updates

The Multi-hub Academic Conference: Global, Inclusive, Culturally Diverse, Creative, Sustainable

Richard Parncutt[1]*, PerMagnus Lindborg[2], Nils Meyer-Kahlen[3] and Renee Timmers[4]

[1]Centre for Systematic Musicology, University of Graz, Graz, Austria, [2]School of Creative Media, City University of Hong Kong, Hong Kong, China, [3]Department of Signal Processing and Acoustics, Aalto University, Espoo, Finland, [4]Department of Music, University of Sheffield, Sheffield, United Kingdom

New conference formats are emerging in response to COVID-19 and climate change. *Virtual conferences* are sustainable and inclusive regardless of participant mobility (financial means, caring commitments, disability), but lack face-to-face contact. *Hybrid conferences* (physical meetings with additional virtual presentations) tend to discriminate against non-fliers and encourage unsustainable flying. *Multi-hub conferences* mix real and virtual interactions during talks and social breaks and are distributed across nominally equal hubs. We propose a global multi-hub solution in which all hubs interact daily in real time with all other hubs in parallel sessions by internet videoconferencing. Conference sessions are confined to three equally-spaced 4-h UTC timeslots. Local programs comprise morning and afternoon/evening sessions (recordings from night sessions can be watched later). Three *reference hubs* are located exactly 8 h apart; additional hubs are within 2 h and their programs are aligned with the closest reference hub. The conference experience at each hub depends on the number of local participants and the time difference to the nearest reference. Participants are motivated to travel to the nearest hub. Mobility-based discrimination is minimized. Lower costs facilitate diversity, equity, and inclusion. Academic quality, creativity, enjoyment, and low-carbon sustainability are simultaneously promoted.

Keywords: conference, multi-hub, semi-virtual, hybrid, emissions, inclusion, climate change
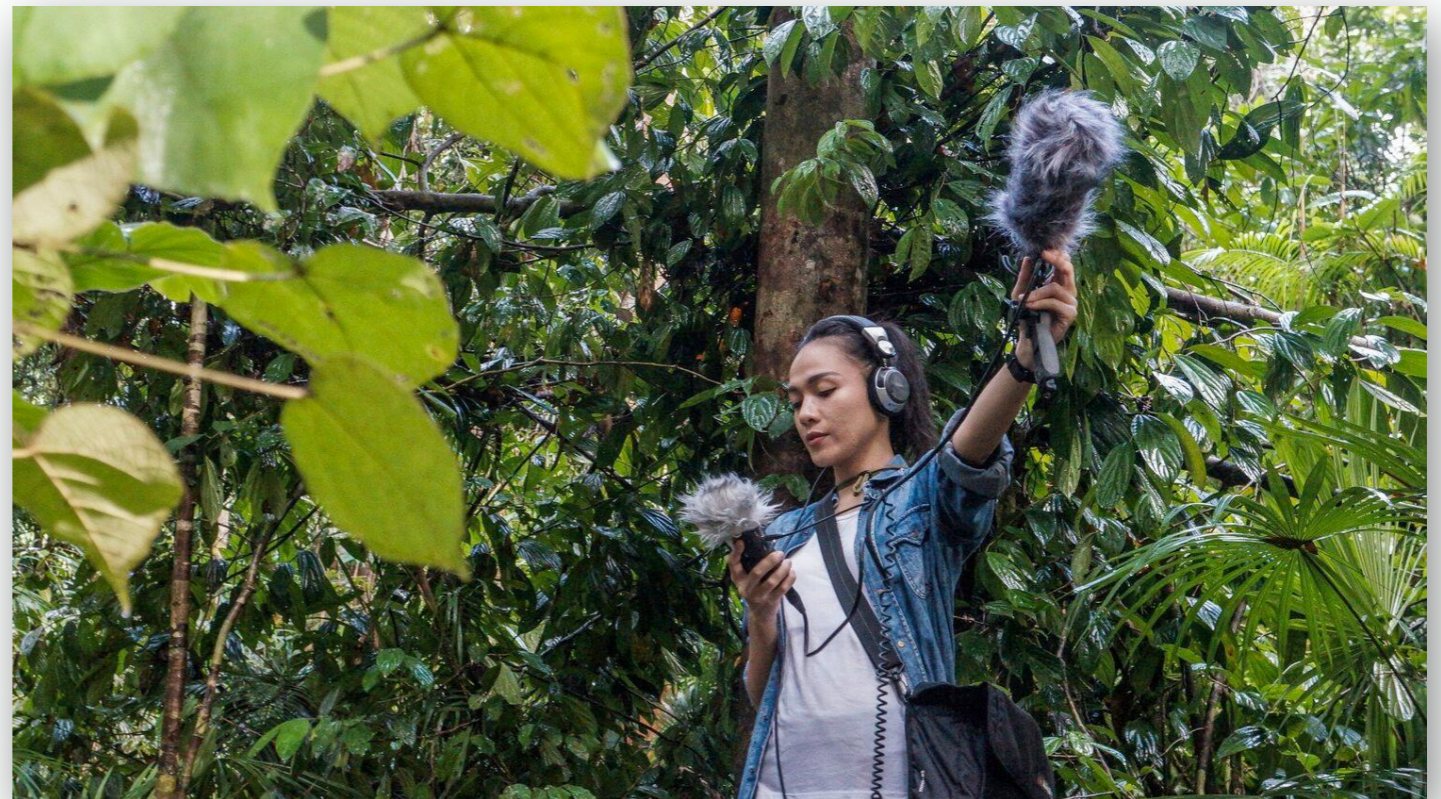
School of Creative Media

Three (3) courses out of 123 mention either "sustainability" or "climate"

One course has this as its focus

DJs for Climate Action

"HOW DO WE WANT OUR FUTURE TO SOUND?"

https://www.djs4ca.com/climate-sample-pack

DATA ART FOR CLIMATE ACTION

:: dual-hub conference :: Hong Kong + Graz + Internet :: 12-15 January 2022 ::

CONFERENCE ⌄   PEOPLE ⌄   CALLS & DATES ⌄   INFORMATION ⌄

ANNOUNCEMENT · 📌

Lina Simon, DACA Exhibition Co-

ANNOUNCEMENT · 📌

Meet Lillian Song Zijing :: DACA Best Student Paper Award

2021-11-18 · BY PERMAGNUSORG

Follow Zijing's research via the DACA proceedings and Frontiers

RECENT POSTS

Lina Simon, DACA Exhibition Co-Curator

CLIMATE FICTION FOR SOCIAL PURPOSE

Meet Lillian Song Zijing :: DACA Best Student Paper Award

Data Art for Climate Action Conference 2022: Student Workshop

Radio podcast for COP26

DACA

sonification / visualisation of climate data with a purpose of exploration, awareness, education, and action...
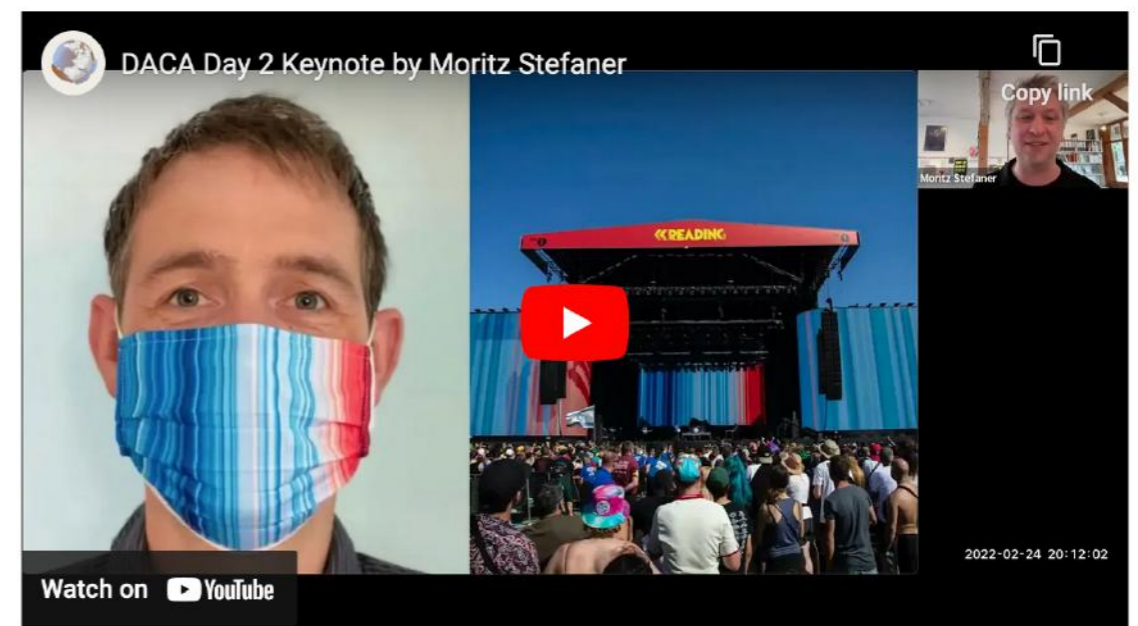
a focal point for researchers, academics, and students in arts, computer science, media, journalism, and environmental studies

http://dataclimate.org/
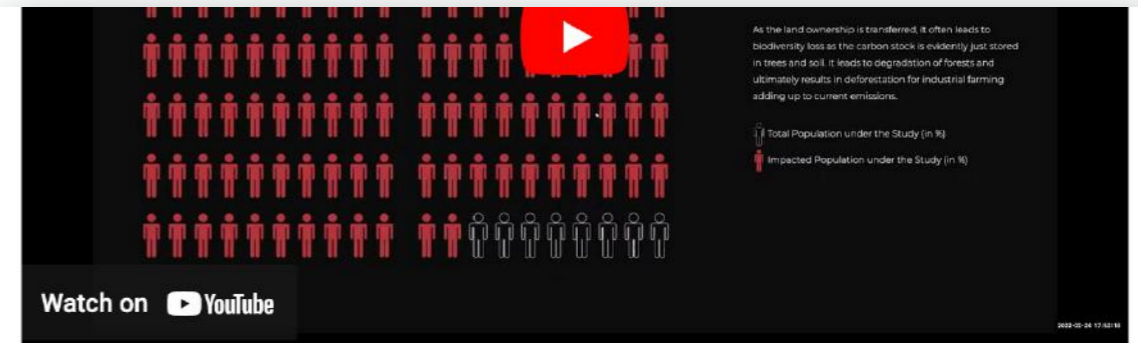
20:00 (60) Keynote :: Moritz Stefaner

- Moritz **Stefaner** :: Visual Rhetorics

21:00 (40) Audiovisual event #2

- Enrico **Dorigatti** :: A Multimedia Representation of the increase of Global Warming from 1940 to 2016 (p. 74)
- Duncan **Geere** & Miriam Quick :: The Natural Lottery: turning climate data into techno music (p. 77)
- Longman **Luk** :: Hong Kong Damp Cold: Really Cold

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Data Perceptualization for Climate Science Communication

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Research Topic

Data Perceptualization for Climate Science Communication

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About this Research Topic

In 2017, the Secretary-General of the United Nations António Guterres stated unequivocally that climate change is an unprecedented and growing threat, and that the arguments for action are clear. Notwithstanding, it has proven a hard challenge to present complex science so that laymen and non-specialists are convinced. Without developing a deeper affinity towards and trust of science, climate denialism will remain prevalent. To date, climate science is most commonly communicated using texts and still images. Might we gain a deeper understanding and richer appreciation of the data that scientists use to describe large-scale climate change through other means?

Sonification and visualization are processes of data perceptualization that may have either an aesthetic or a utilitarian purpose, or both. Data art is the study, interpretation, and representation of scientific measurements in ways that excite and surprise. As in all human-computer interaction design, it is essential to involve evaluation of output in an iterative process. Multimodal perceptualization hinges on understanding sensory processing, cognitive load, and cross-modal correspondences. While science speaks through words, numbers, and diagrams, art communicates through movement, images, sound, and sculpture. While there is a lot of potential merging the two

Topic Editors

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Shauhrat S Chopra
School of Energy and Environment, City University of Hong Kong
Kowloon, Hong Kong,   Follow

Data Sonification Archive (DSA; https://sonification.design)

Sonification *:: Perception and Design*

Sonification makes data *audible*

 — a set of techniques and an aesthetic, navigating ars musica and ars informatica

CONCRETE

CONCRETE SONIFICATION

MUSIQUE CONCRÈTE

INFORMATICAL ◄──────────► MUSICAL

ABSTRACT SONIFICATION

ABSTRACT MUSIC

ABSTRACT

Aesthetic Perspective Space
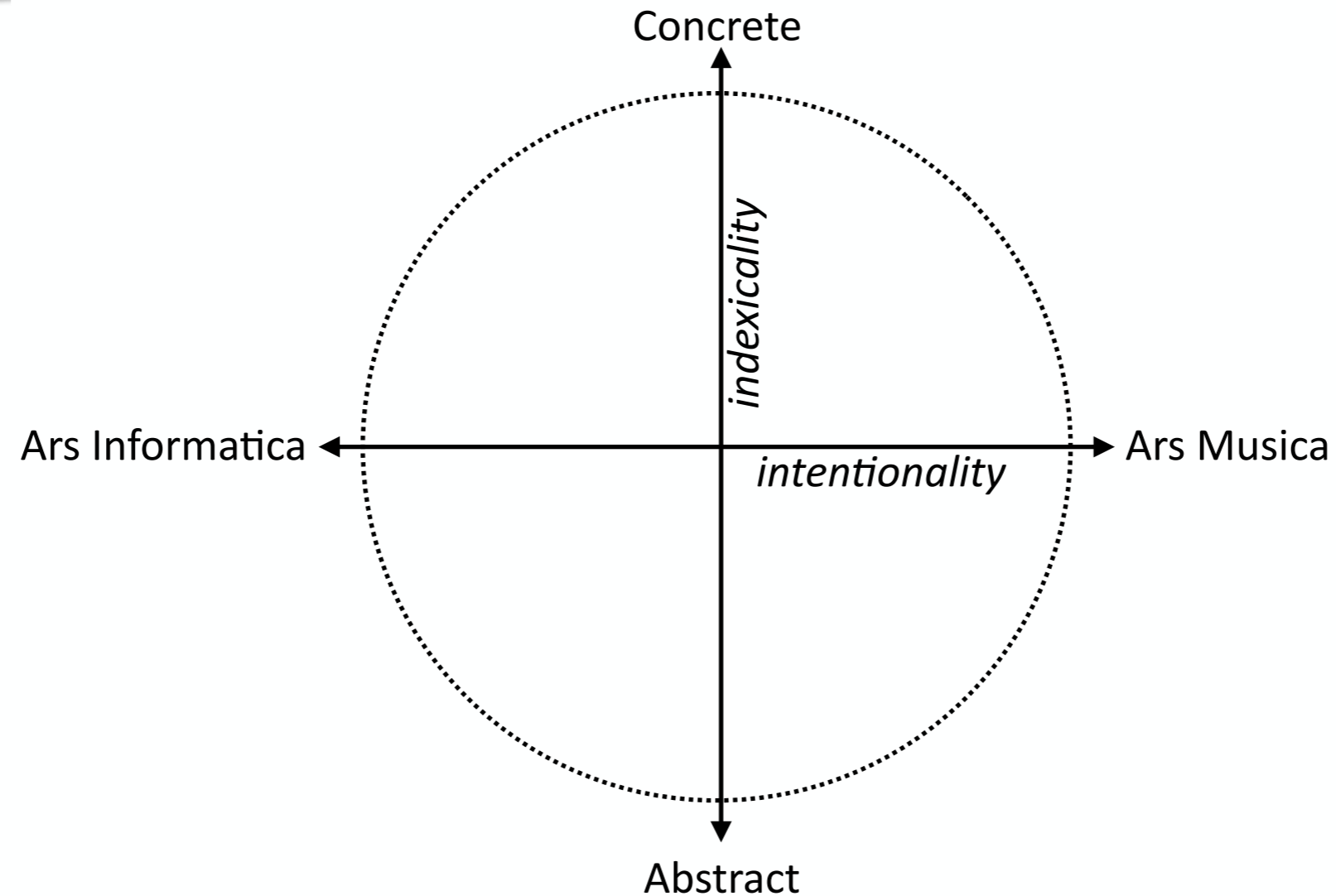(*Vickers & Hogg 2006*)
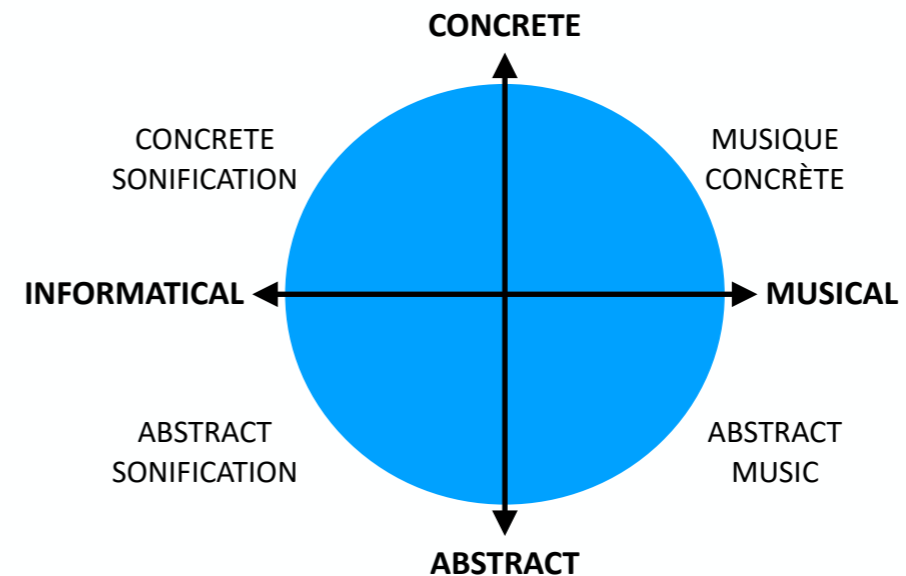
Sonification is a *design process*

"any technique that translates data into sound with a systematic, describable, and reproducible method, in order to reveal or facilitate communication, interpretation, or discovery of meaning that is latent in the data, having a practical, artistic, or scientific purpose." (Liew & Lindborg 2020; cf. Kramer 1994; Grinstein & Smith 1990; Pollack & Ficks 1954)

data

heuristics + machine learning

listening + evaluating
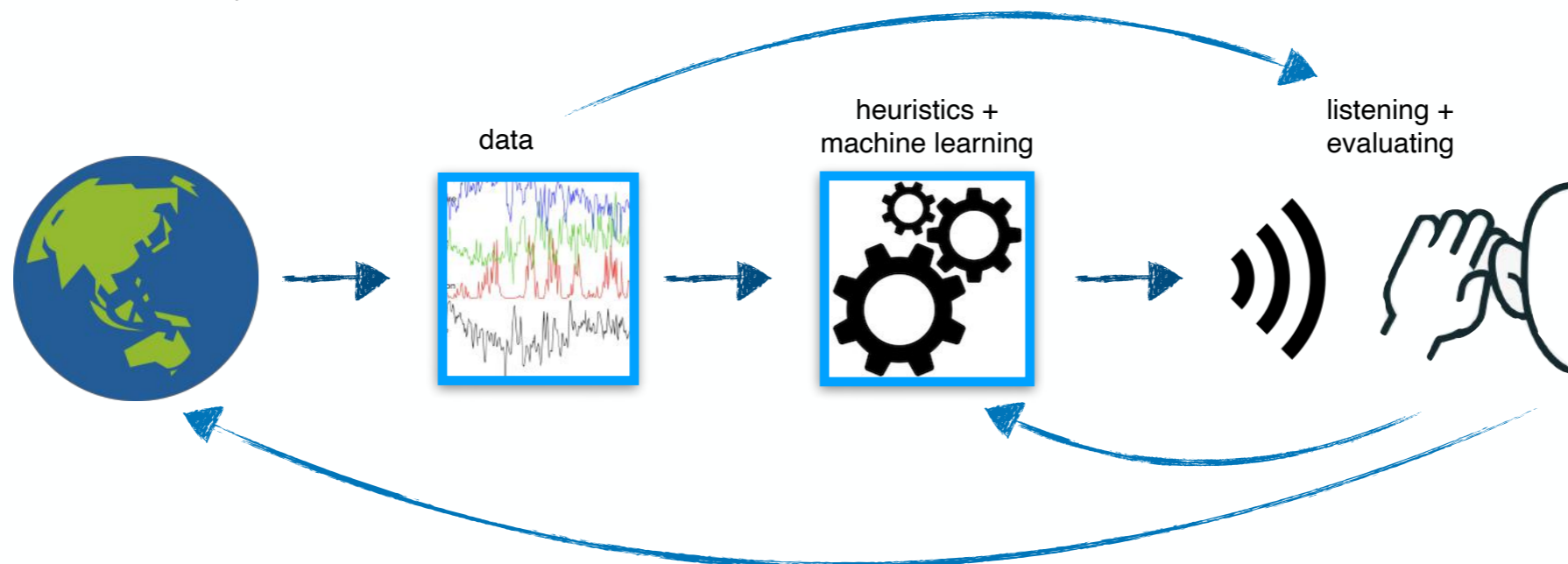
Sonification is to *music* as visualisation is to visual art: **a *strategy* for explaining.**

Sound design is to *composition* as graphic design is to visual imagination: **a *method* for making**

Aesthetic Perspective Space

Vickers & Hoggs 2006; Vickers 2017

Sonification *:: How is it perceived?*

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SYSTEMATIC REVIEW article

This article is part of the Research Topic
Data Perceptualization for Climate Science Communication
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Climate data sonification and visualization: An analysis of topics, aesthetics, and characteristics in 32 recent projects

PerMagnus Lindborg[1*]   Sara Lenzi[2]   Manni Chen[1]

[1] SoundLab, School of Creative Media, City University of Hong Kong, Kowloon, Hong Kong SAR, China
[2] Critical Alarms Laboratory, Faculty of Industrial Design Engineering, Delft University of Technology, Delft, Netherlands

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Introduction: It has proven a hard challenge to stimulate climate action with climate data. While scientists communicate through words, numbers, and diagrams, artists use movement, images, and sound. Sonification, the translation of data into sound, and visualization, offer techniques for representing climate data with often innovative and exciting results. The concept of sonification was initially defined in terms of engineering, and while this view remains dominant, researchers increasingly make use of knowledge from electroacoustic music (EAM) to make sonifications more convincing.

Methods: The Aesthetic Perspective Space (APS) is a two-dimensional model that bridges utilitarian-oriented sonification and music. We

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Royal Institute of Technology, Sweden

19

https://www.frontiersin.org/articles/10.3389/fpsyg.2022.1020102/full

Sara Lenzi
Manni Chen
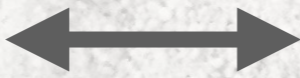
Aesthetic Perspective ⟷ Characteristics

Background

DACA conference - dataclimate.org

Frontiers RT - https://www.frontiersin.org/research-topics/20827/data-perceptualization-for-climate-science-communication#articles

Data Sonification Archive (DSA; https://sonification.design)

Methods & Materials

PRISMA framework (Preferred Reporting Items for Systematic
Reviews and Meta-Analyses, https://www.prisma-statement.org/)

Corpus

TABLE 1 Overview of the 32 climate data projects included in the study.

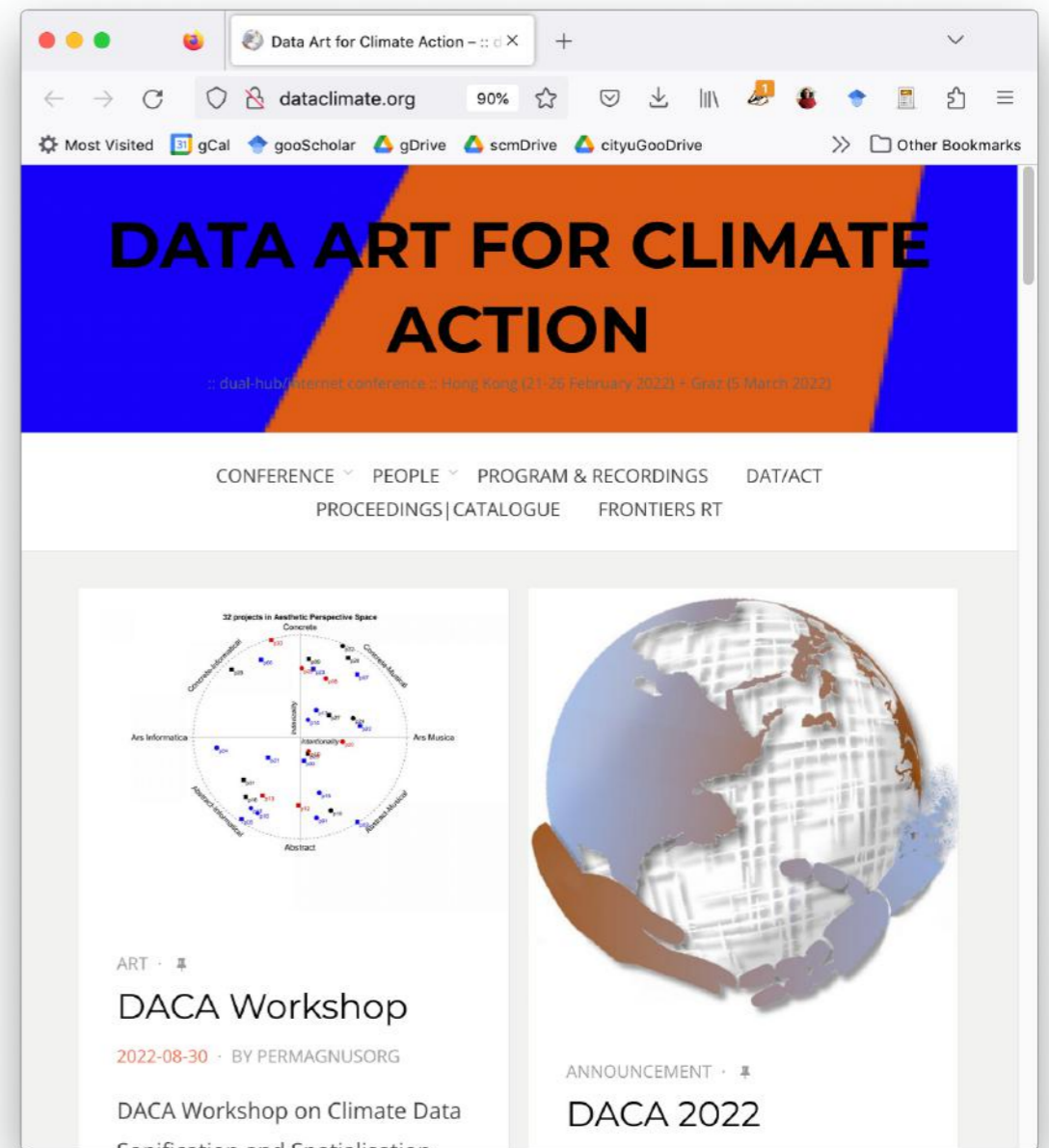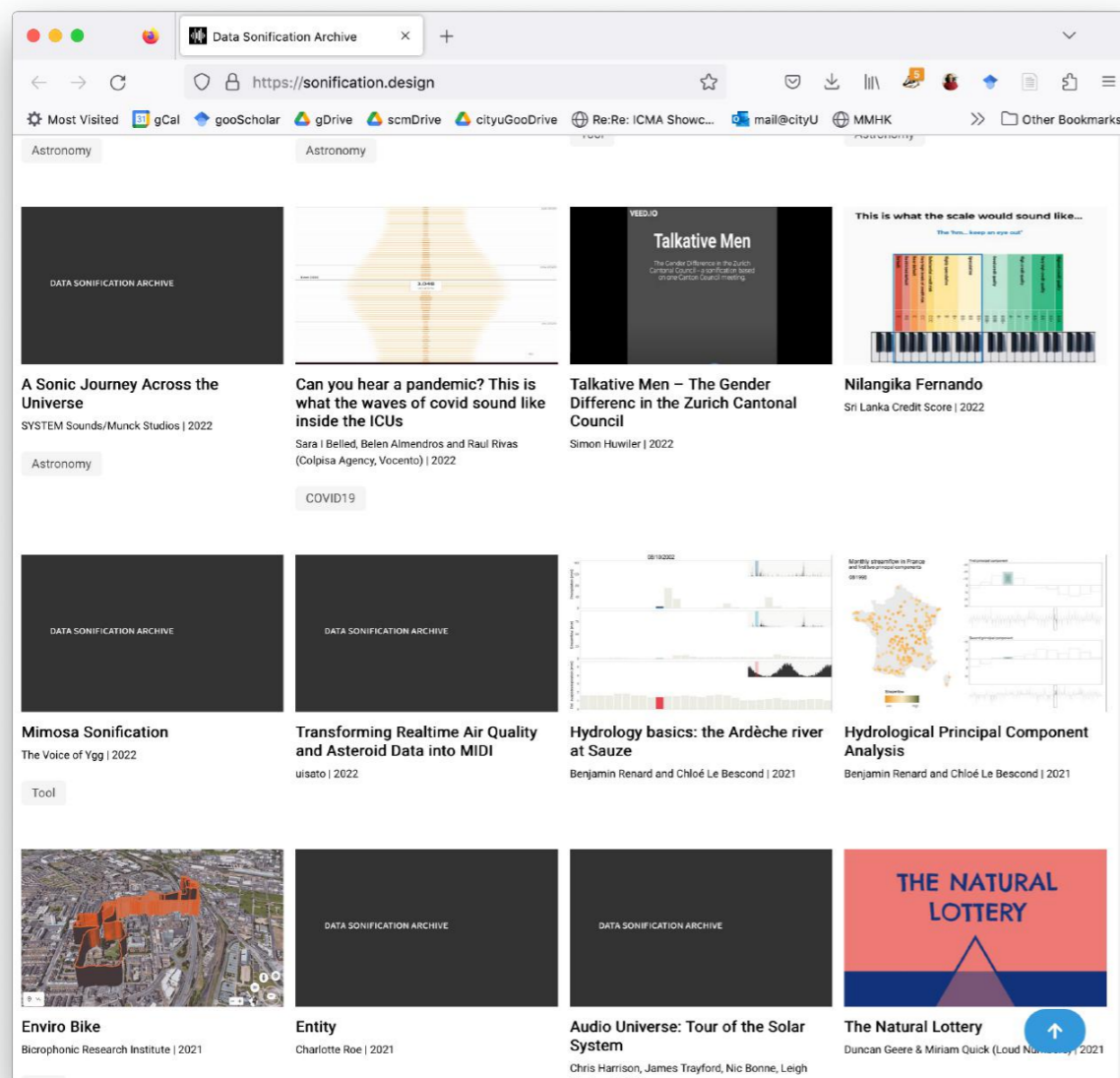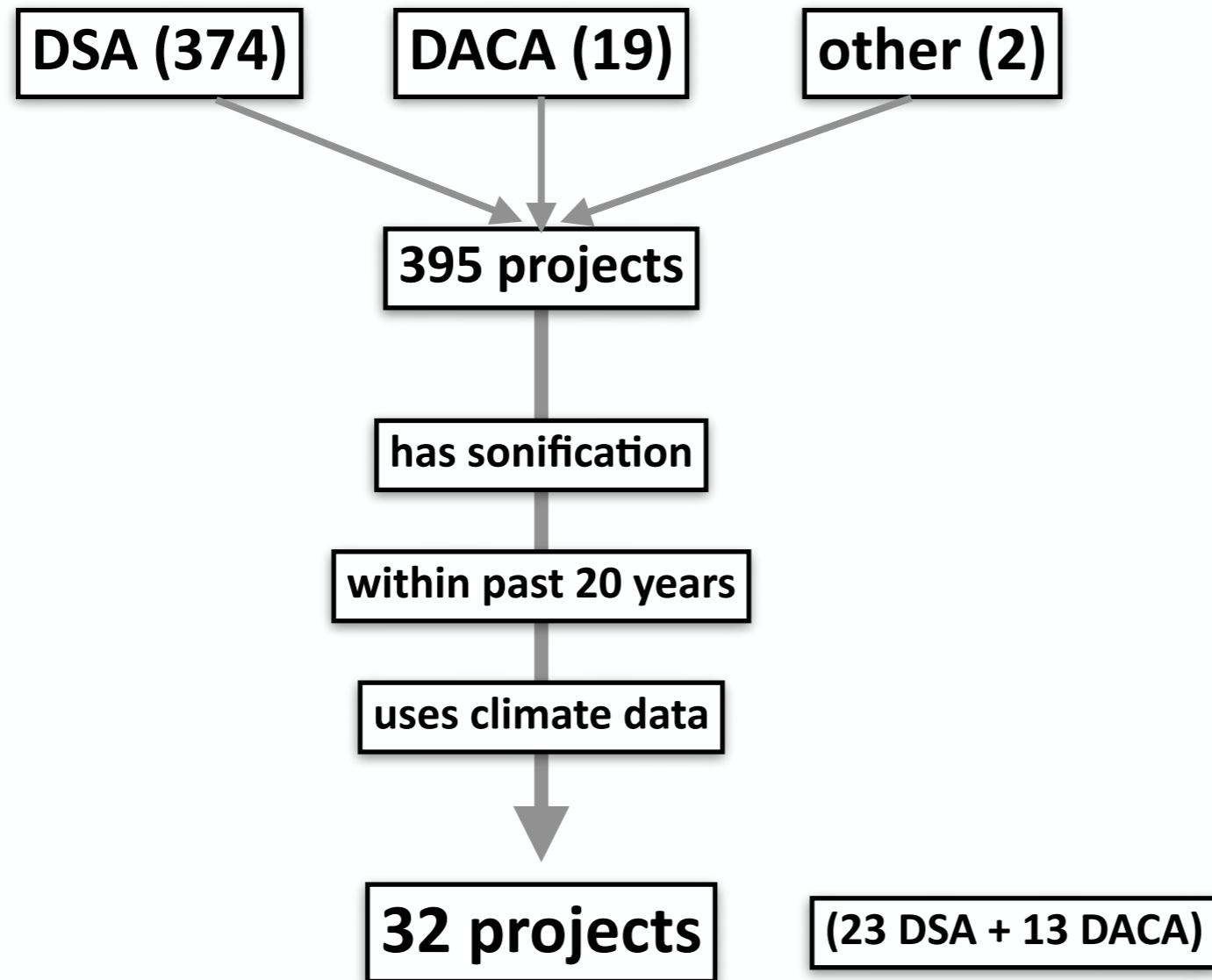| Project	Author(s)	Title	Year
p01	Aedes Aegypti	Sonification of atmospheric carbon dioxide in PPM (1958–2008)	2022
p02	Renick Bell and Moon Hung	HKO_hot_temp_rain_sea_1884-2021_20220225	2022
p03	Jon Bellona	#Carbonfeed	2022
p04	András Blazsek	Extreme weather in three movements	2021
p05	Chris Chafe	Hear climate data turned into music	2021
p06	Daniel Crawford and Scott S. George	A song of our warming planet	2021
p07	Enrico Dorigatti	76	2021
p08	Frank Ekeberg	Ingenmannsland	2021
p09	Brian Foo	Too blue	2020
p10	Duncan Geere and Miriam Quick	The natural lottery	2020
p11	Nelson Guda	Treshold	2019
p12	Band of Weeds (Kalle Hamm, Olli Aarni, Lauri Ainala, and Hermanni Keko)	Waiting for the extinction :-(	2019
p13	Band of Weeds (Kalle Hamm, Olli Aarni, Lauri Ainal, and Hermanni Keko)	The weep of trees	2019
p14	Sara Lenzi	While I was not there	2019
p15	PerMagnus Lindborg	Locust wrath	2013
p16	PerMagnus Lindborg	LW24	2015
p17	PerMagnus Lindborg	Stairway to Helheim	2021
p18	Levy Lorenzo	Song of the tides	2018
p19	Duncan Geere, Miriam Quick (Anders Pape Møller)	The end of the road	2017
p20	Falk Morawitz	On the extinction of a species	2017
p21	Hiromi Okumura, Valerie Williams, Jenn Kirby, Thomas B. Jobson, and Joseph Vaughan	Atmos actions	2016
p22	Jamie Perera	Flatline	2016
p23	Jamie Perera	Anthropocene in C major	2015
p24	Jamie Perera	If the oceans could speak	2015
p25	Marty Quinn	The climate symphony	2015
p26	Benjamin Renard	Major flood events	2015
p27	Benjamin Renard and Chloé Le Bescond	Hydrological principal component analysis	2014
p28	Neil Rolnick	Oceans eat cities	2013
p29	Nik Sawe and Lauren Oakes	Sonification of Alaskan forest changes	2013
p30	Katja Striedelmeyer	Shifting apple blossom in bremen—data sonification with a music box	2013
p31	Marco Tedesco and Polar Seeds Group	Polar seeds	2010
p32	Judy Twet	Piano piece	2007

Methods

Duration (seconds, logarithmic)

Lexical Diversity :: MTLD-MA (Measure of Textual Lexical Diversity, McCarthy & Jarvis 2010)

Topics :: author's description, website, article

provenance (focus) of data

source data type

media (e.g. sonification, visualisation, artefact…)

goal

Corpus

Topic,
content
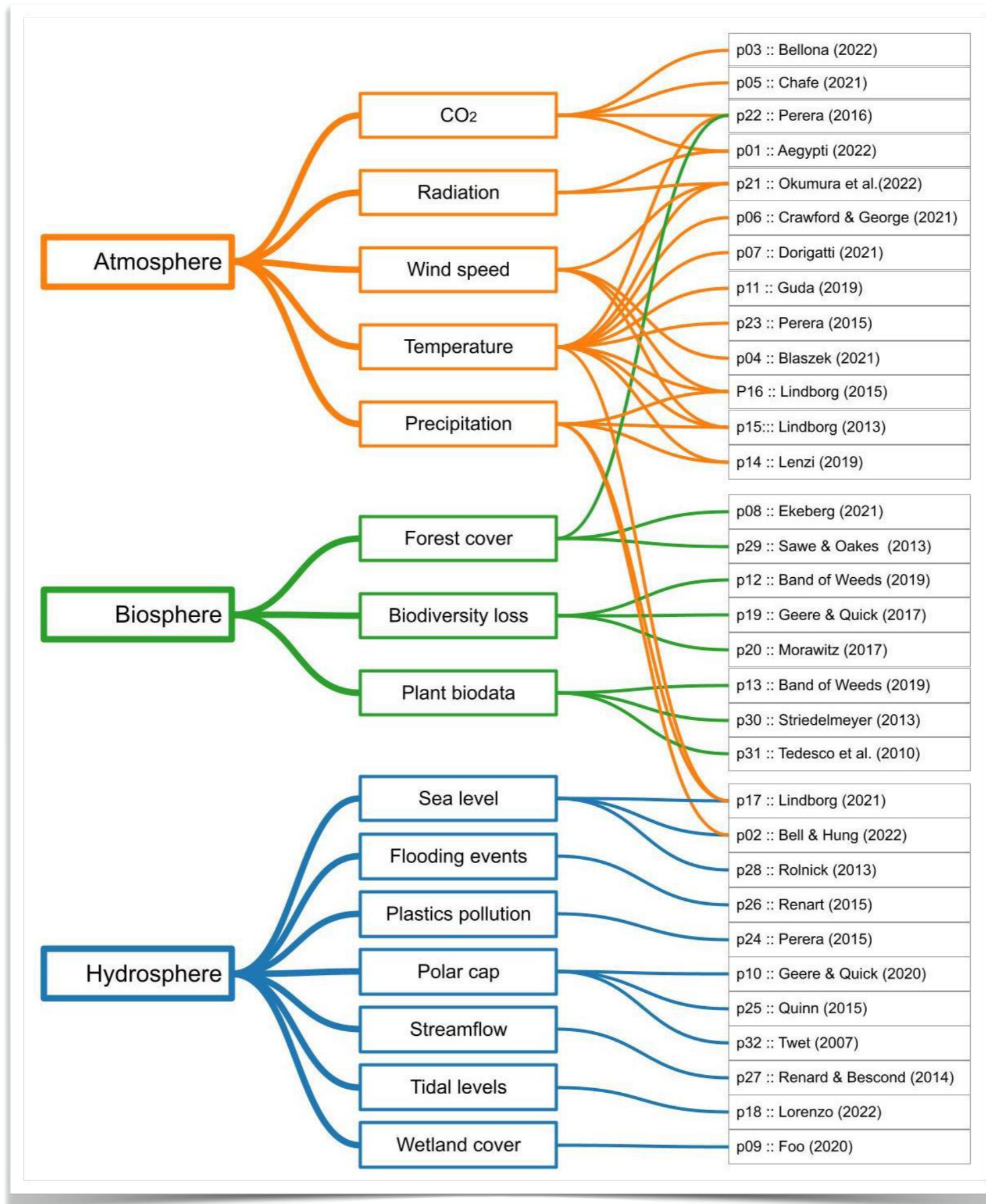
Methods

Aesthetic Perspective

Concrete

indexicality

Ars Informatica ← → Ars Musica

intentionality

Abstract

This sonification consists of concrete sounds that are recognisable as recordings of things and actions in the physical world. [Concrete]

I hear acoustic instruments/vocalisations/objects that give meaningful information. [Concrete-Informatic]

I hear acoustic instruments/vocalisations/objects and they form a body-engaging music. [Concrete-Musical]

This sonification is information-like, and understood through attentive listening. [Ars Informatica]

This sonification is music-like, and experienced through embodied listening. [Ars Musica]

I hear beeps/synthesisers/drum-machines that give meaningful information. [Abstract-Informatic]

I hear beeps/synthesisers/drum-machines, and they form a body-engaging music. [Abstract-Musical]

This sonification consists of abstract sounds that are recognisable as generated by digital computer synthesis. [Abstract]

Result

32 projects in Aesthetic Perspective Space

Methods

Qualitative characteristics

Rating scales to probe salient aspects
of **content, methods, and context**

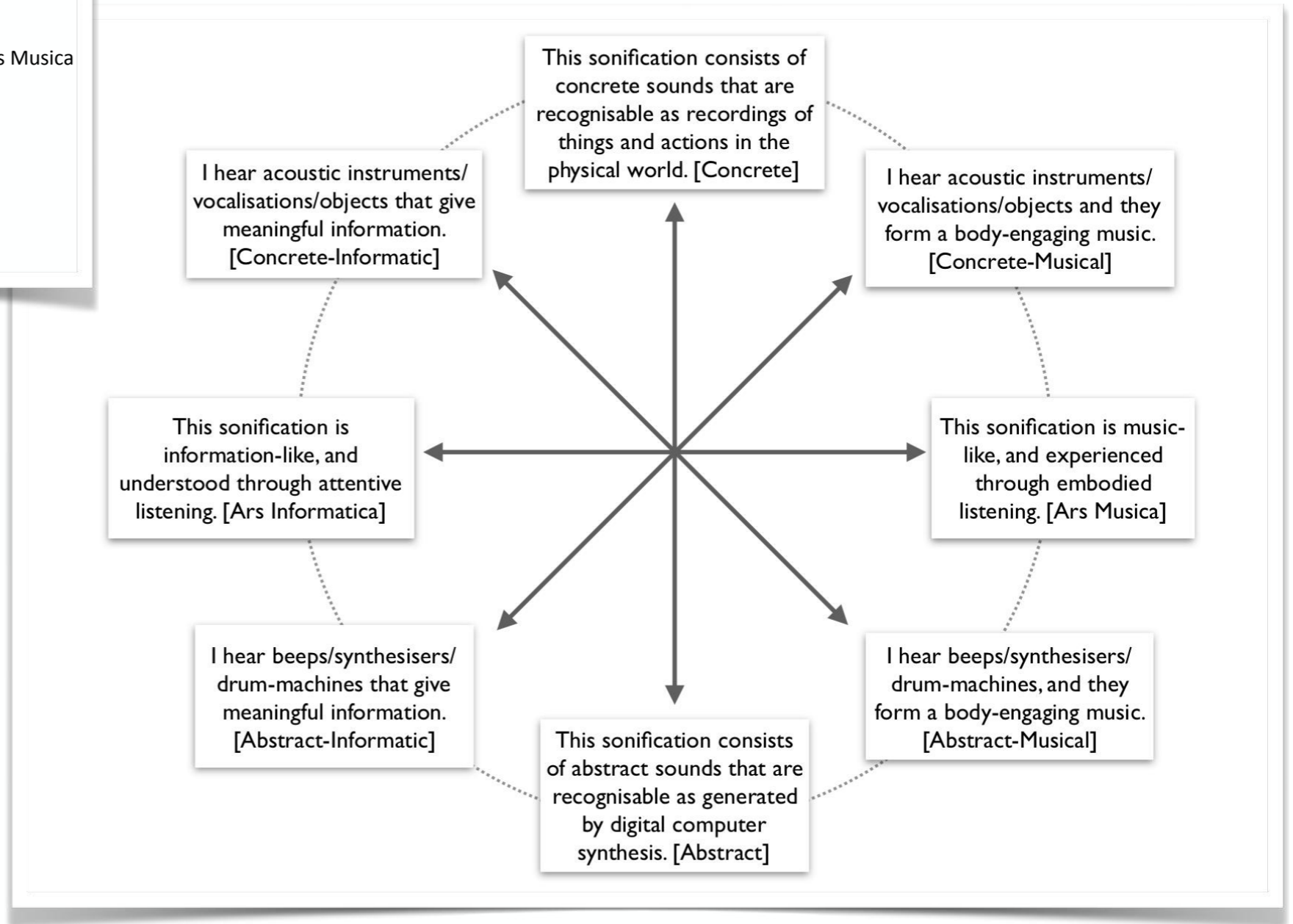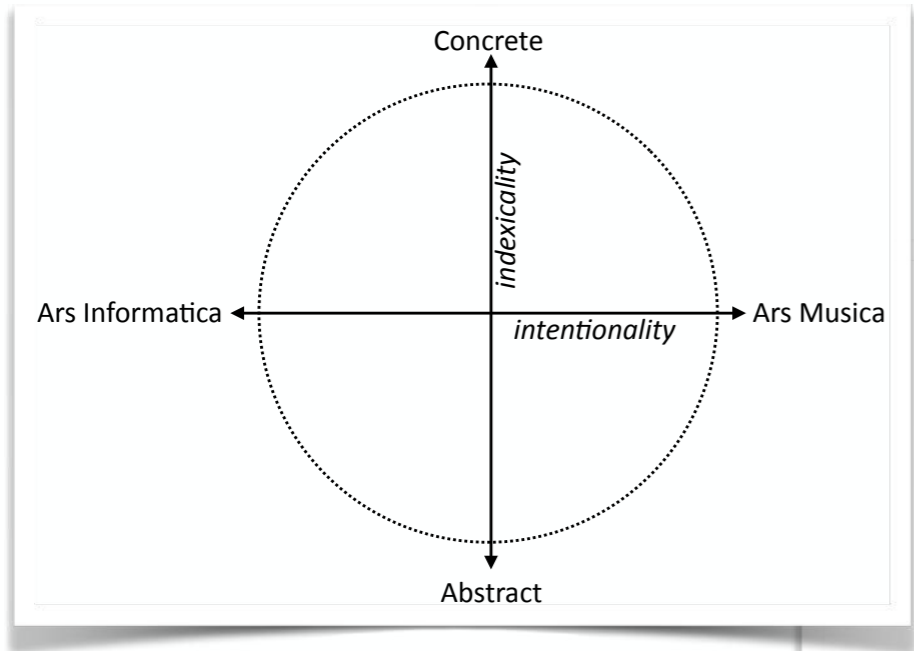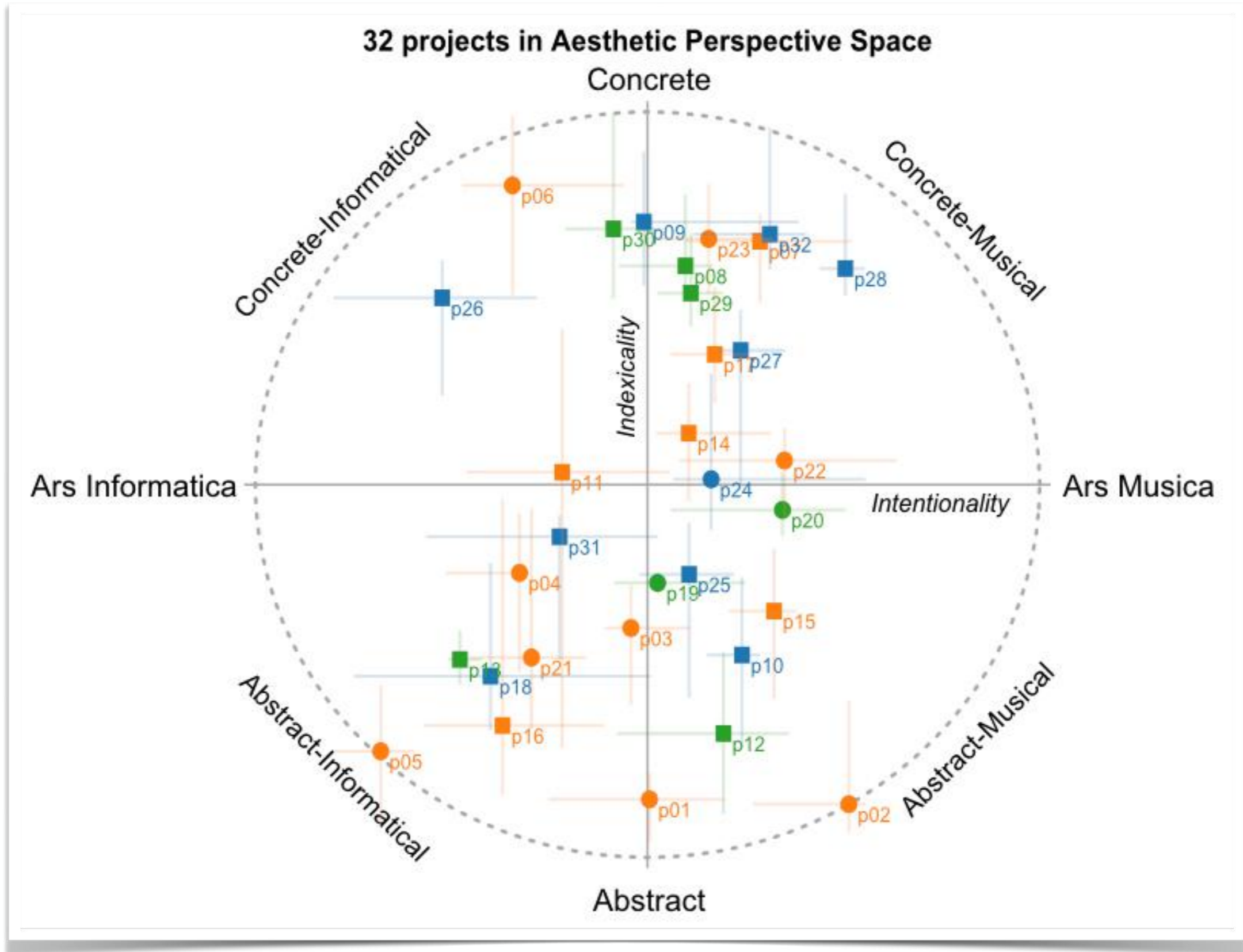| 9	Char20	Author	How much of the text/description is about the author(s) themselves (as opposed to the work itself)?
10	Char20	Motivation	How much is the text/description about the author's general motivation?
11	Char20	Background	How much background detail does text/description give about the specific project?
12	Char20	SourceData	How specific is the information about the source data?
13	Char20	Context	How detailed is the explanation of creative context (such as commissioning body or location of presentation)?
14	Char20	Impact	How detailed is the recount of impact (such as associated publications audience testimonies and visitor numbers)?
15	Char20	Subjective	How subjective (personal) is the content of the project?
16	Char20	Objective	How objective (distanced) is the content of the project?
17	Char20	Fruition	How detailed is the information on the original context of fruition (live performance multimedia product installation website,…)?
18	Char20	Methods	How detailed is the technical information about the methods of data translation?
19	Char20	EngageDegree	What degree of active engagement with the media is called for?
20	Char20	EngageHow	How specific are the instructions for how to engage with the media?
21	Char20	Legend	How extensive/complete is the legend for understanding how data are represented?
22	Char20	MatchOrig	How closely does the media representation match the original phenomenon described by the data?
23	Char20	Convincing	How convincing is the project in terms of climate science communication?
24	Char20	Crisis	How overtly does the project address the climate crisis?
25	Char20	SciCom	To what degree is it the author‚Äôs stated intention for the project to contribute to climate science communication?
26	Char20	Awareness	How much does the project raise awareness of the climate crisis?
27	Char20	Behaviours	How much does the project push for concerted action and adaptation of individual behaviours (e.g. travel lifestyle choices)?
28	Char20	Action	How successful is the project in arousing climate action?
29	SonVis	VisImpo	How important is visualisation to the project as a whole?
30	SonVis	SonImpo	How important is sonification to the project as a whole?
31	SonVis	Son2Vis	In the development of the project how much did sonification methods drive (initiate) visualisation methods?
32	SonVis	Vis2Son	In the development of the project how much did visualisation methods drive (initiate) sonification methods?
33	SonVis	SonVisConcur	To what degree do visualisation and sonification represent the same content?

Analysis

Qualitative characteristics

Exploratory Factor Analysis (EFA)

32 projects x 6 raters

| 20 scales | $\longrightarrow$ | 4 latent factors |

Action, Technical, Perspective, Context

variance explained = 56%

18 projects x 6 raters

| 5 scales | $\longrightarrow$ | 1 latent factor |

Visualisation

variance explained = 39%

Results

Multivariate Analysis of Variance (MANOVA)

Linear Regression modelling (linreg)

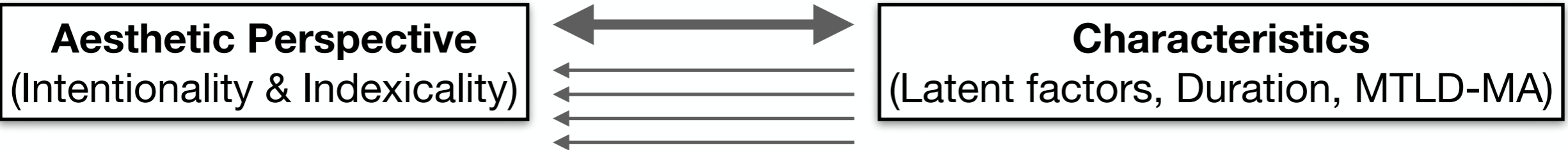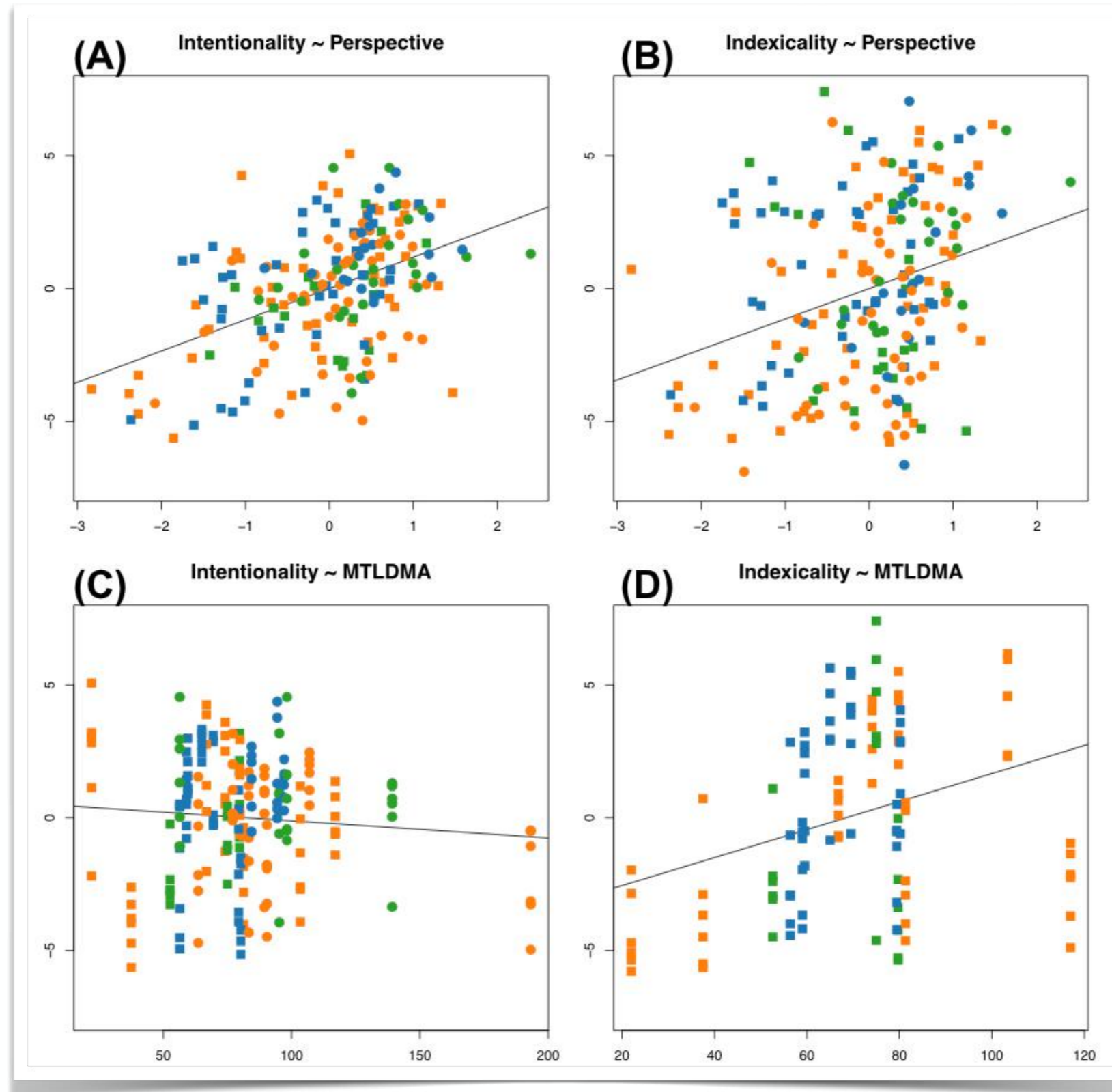| Aesthetic Perspective (Intentionality & Indexicality) | ⟷ | Characteristics (Latent factors, Duration, MTLD-MA) |

TABLE 4 Statistics for regression models predicting Intentionality and Indexicality from rated characteristics, duration, and lexical diversity, in all 32 projects and a subset of 18 projects integrating visualization.

	Intentionality ($R^2 = 0.27$, adjusted $= 0.25$)				Indexicality ($R^2 = 0.17$, adjusted $= 0.14$)			
In 32 projects	est.	t	p	ß	est.	t	p	ß
Action	0.38	2.48	0.014**	0.16	0.09	0.36	0.72	0.02
Technical	−0.33	−1.87	0.062.	−0.13	0.33	1.18	0.24	0.09
Perspective	1.19	6.32	0.000***	0.48	1.44	4.86	0.000***	0.39
Context	0.18	1.00	0.32	0.07	0.24	0.83	0.41	0.06
logDuration	0.02	0.22	0.83	0.02	−0.62	−3.84	0.000***	−0.29
MTLD-MA	−0.01	−2.68	0.008***	−0.19	0.00	−0.44	0.66	−0.03
	Intentionality ($R^2 = 0.12$, adjusted $= 0.10$)				Indexicality ($R^2 = 0.15$, adjusted $= 0.12$)			
In 18 projects	est.	t	p	ß	est.	t	p	ß
Visualization	0.49	1.84	0.068.	0.20	0.41	1.10	0.28	0.11
logDuration	0.66	3.82	0.000***	0.42	−0.34	−1.39	0.17	−0.15
MTLD-MA	0.01	0.64	0.52	0.065	0.04	2.85	0.005***	0.28

All intercepts were non-significant and have been removed for clarity. R2, amount of total variance explained; adj., R2 adjusted for the number of predictors; est., estimated coefficient for the variable. t, coefficient divided by its standard error; p, probability value, with asterisk codes for degree of significance: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; ß, standardized beta coefficient.

Results

Linear Regression modelling

Sonification *:: How is it designed?*

Manuscript Number:	
Article Type:	Special Issue
Section/Category:	Special Issue on Sonification
Manuscript Classifications:	170: Auditory display; 170.10: Sonification
Keywords:	data sonification, data representation, multi-modal data experience
Corresponding Author:	PerMagnus Lindborg, PhD City University of Hong Kong HONG KONG
First Author:	PerMagnus Lindborg
Order of Authors:	PerMagnus Lindborg
	Manni Chen
	Valentina Caiola
	Paolo Ciuccarelli
	Sara Lenzi
Abstract:	This systematic meta-analysis focuses on a corpus of 445 sonification projects currently available in the Data Sonification Archive. The DSA was created in a collaborative process involving researchers and creative communities, and is online since early 2021. Projects are heuristically classified according to a theoretical framework, the Sonification Canvas, which is being developed in parallel. The classifications specify projects by several aspects, in particular their intended purpose, targeted users, subject matter, sonification method, and combination of media. In the present study, we introduce two computational classification methods, respectively based on k-means clustering of music information retrieval of sonification audio, and topic modelling of the descriptive texts accompanying projects. Correlation analysis between the six curatorial classifications and the two computational classifications, correspondingly sized, showed that the text-based automatic methods we employed might be more powerful than the audio-based methods we had access to. We also explored further aspects, including author gender, measures for textual lexical diversity

How do sonification and visualisation relate?

Quantitative on (partly) qualitative CA data

The whole Data Sonification Archive (445 projects, August 2023) were analysed by comparing **curatorial categories** (qualitative CA) against music information retrieval (**MIR**) clustering and topic models (**LDA**) of textual descriptions.

Manuscript Number:	
Article Type:	Special Issue
Section/Category:	Special Issue on Sonification
Manuscript Classifications:	170: Auditory display; 170.10: Sonification
Keywords:	data sonification, data representation, multi-modal data experience
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Abstract:	This systematic meta-analysis focuses on a corpus of 445 sonification projects currently available in the Data Sonification Archive. The DSA was created in a collaborative process involving researchers and creative communities, and is online since early 2021. Projects are heuristically classified according to a theoretical framework, the Sonification Canvas, which is being developed in parallel. The classifications specify projects by several aspects, in particular their intended purpose, targeted users, subject matter, sonification method, and combination of media. In the

A State-of-the-Art Report on the Combination of Sonification and Visualization

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1. Introduction

In our daily lives, we as humans perceive our surroundings in an inherently multimodal way. We see, we hear, we taste, smell, and touch. Nevertheless, the vast majority of data analysis idioms are exclusively visual, not using the apparent potential of combined designs. Inspired by the capabilities of the human auditory system, this state-of-the-art report will cover academic contributions from both the visualization and the sonification communities, that blend sonification and visualization within the context of data exploration and data presentation. A STAR on combined designs will help both visualization and sonification researchers understand the potential of such combinations but also give insights into the respective other research area.

The group of authors consists of members of both the visualization and the sonification communities and is experienced with respect to working on surveys and meta-analyses in the visualization field [AMST11, AMA*16, RWA*13, WFL*15, CLR22]. The authors are part of the audio-visual analytics community (AVAC, https://audio-visual-analytics.github.io/), a group of researchers explicitly interested in the combination of sonification and visualization. Recent contributions to the field of audio-visual analytics, authored by our team are [ERI*23, RIA18, ERI*22, AEI*22, EE22, CLR22, LLC23, EEBR21, EBL*23, Rön19, RF22]

This state-of-the-art report will (1) provide an overview of the

known in the sonification community is the "sonification archive" (sonification.design), a curated collection of sonification designs, often related to other modes of representation, such as visualization.

Caiola et al. [CLR22] recently presented an analysis of visual and auditory channels commonly used in combined designs. Their survey includes combined idioms that map data attributes redundantly to both a visual channel (like position) and an auditory channel (like pitch). Analyzed work stems from (1) the curated sonification archive and (2) from a Google keyword search exclusively using sonification-related terms.

Originating from the visualization literature, we were not able to find any STAR or survey covering the combination of sonification and visualization. We also scanned the survey of surveys [ML17] and could not identify any related contributions. Therefore, to the best of our knowledge, this is the first systematic State-of-the-Art report covering academic combinations of sonification and visualization for exploratory and presentational purposes.

3. Survey Methods

We review academic publications about audio-visual data analysis idioms that combine visualization and sonification of data.

Inclusion Criteria:

SOUNDLAB

High Spatial Resolution Audio :: Sound Art, Design and Perception Research

All Ears, All Eyes

Design Strategies for Concurrent Sonification-Visualisation of Geodata

- PI :: PerMagnus Lindborg, PhD, Associate Professor, School of Creative Media, City University of Hong Kong
- Co-I :: Sara Lenzi, PhD, Ikerbasque Research Fellow, University of Deusto, Spain
- Co-I :: Paolo Ciuccarelli, Professor of Design, Northeastern University, Boston, USA

About

Sonification is the translation of data into sound. Inherently interdisciplinary, the field has seen tremendous development characterised by 1) expanding the definition to embrace aesthetics, via electroacoustic music composition; 2) professionalisation of terminology, techniques, and community-building; and 3) increased attention to visualisation. Time is ripe to focus efforts on the third point. We employ knowledge from dynamic data visualisation to improve on sonification techniques, to generate a cross-modal perception informed theoretical framework, and to determine practicable strategies for concurrent sonification-visualisation design. Project targets are: 1) a set of design guidelines, and 2) a proof-of-concept software system applied to geodata with real-life importance, such as rain and wind, pollution and traffic, forest fires and landslides. People seek to understand their physical environment. Accurate and
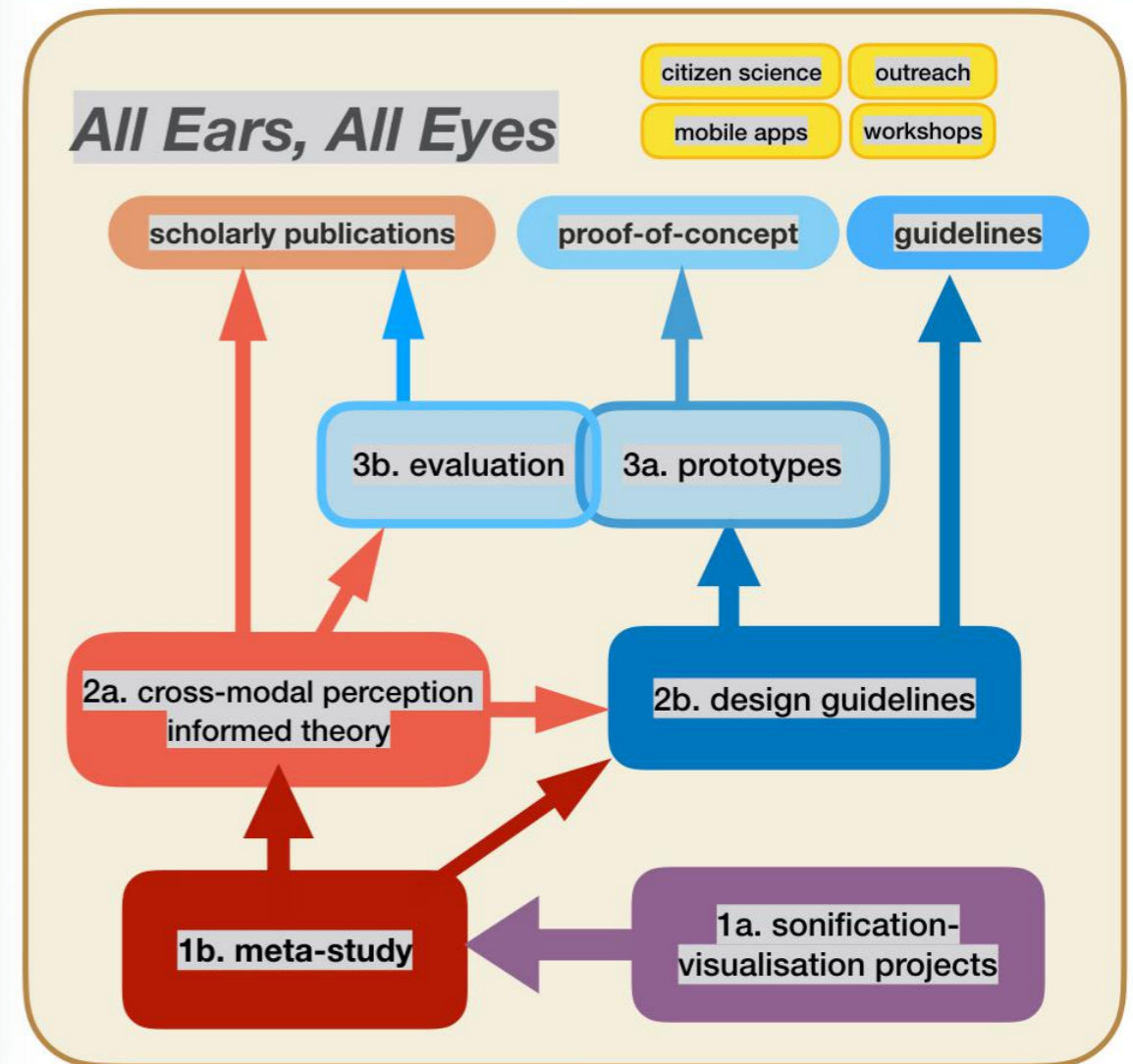
Figure 1. Flowscheme of project components and objectives.

Sonification :: *Examples*

Loki's pain

Loki's pain

from the installation at Banga Gallery, Hong Kong, can be adapted

LOKI structure suspended above subwoofer. Note the equipment platform in the grid, above to the left.

The equipment platform conceals playback devices, pre-amplifiers, amplifiers, and cables

A ladder is essential during the installation!

XLR cable runs between subwoofer and equipment platform

Loki's Pain (2020)
a sculptural sound installation for
[live] sonification of earthquake data

Internet

http://www.iris.washington.edu/
seismon/eventlist/index.phtml
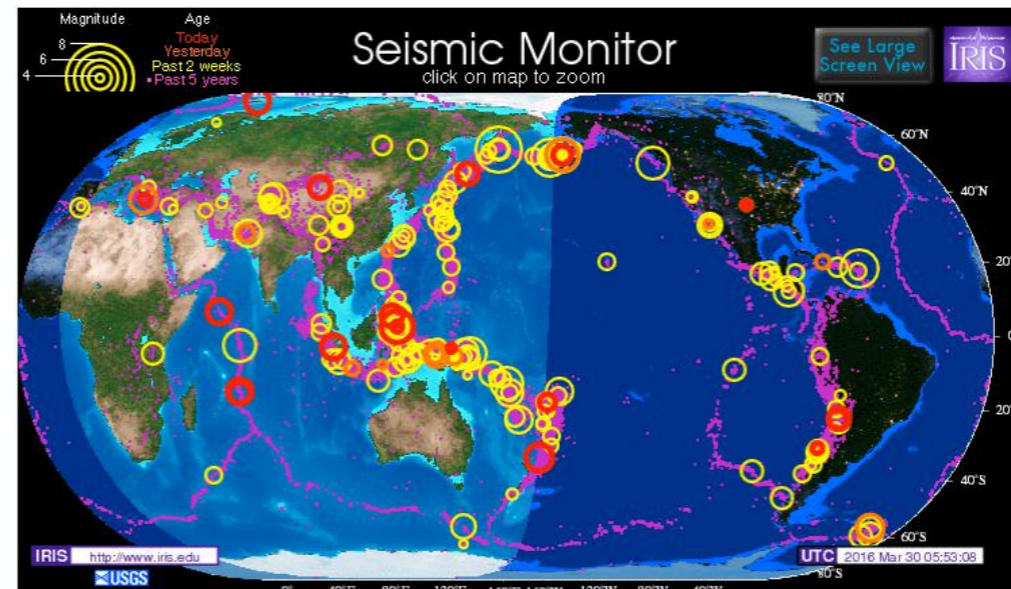
data parsing

parameter
mapping

visualisation

sonification

spatialisation

Loki's pain

LOKI'S PAIN

Evaluation protocol for participant: _____ (name or nickname)

Setup: Installation_structure / Headphones (circle one). **Time** First / Second (circle one)

Instructions. Immediately after listening to the whole piece (10 minutes) in one of the setups, please evaluate your impressions, individually and without speaking with your group mates. For each topic below, indicate what the listening experience was like by <u>circling one response.</u>

Visual imagery	*How strongly did mental images of landscapes, places, smells come to you?*	**Very strong imagery**	Quite strongly	Neutral	Somewhat weakly	**Very weak imagery**
Sound spatialization	*How clearly were individual sounds distributed around you?*	**Very clear distribution**	Quite clear	Neutral	Somewhat muddy	**Very muddy distribution**
Social experience	*While listening, what did you think of the body presence of others close to you?*	**Very positive**	Quite positive	Neutral	Somewhat negative	**Very negative**
Mind wandering	*How often did your mind wander off to other matters, rather than listening?*	**Wandering off very often**	Quite focused	Neutral	Somewhat unfocussed	**Wandered off very rarely**
Immersivity	*To what degree did you feel immersed or enveloped by the sounds?*	**I felt very immersed**	Quite immersed	Neutral	Somewhat immersed	**I didn't feel immersed at all**
Evoked emotion	*How strongly did you feel that the experience affected you?*	**Very strongly affected**	Quite affected	Neutral	Somewhat affected	**Not much affected at all**
Audio quality	*How good or bad were the individual sounds or instruments?*	**Very high quality**	Quite high	Neutral	Somewhat low	**Very low quality**
Aesthetic judgement	*As a whole, how much did you like the listening experience?*	**Overall, it was very likable**	Quite likable	Neutral	Somewhat not likable	**Overall, it was not very likable**

In your own words, describe the listening experience: _____

_____   _____

Loki's pain
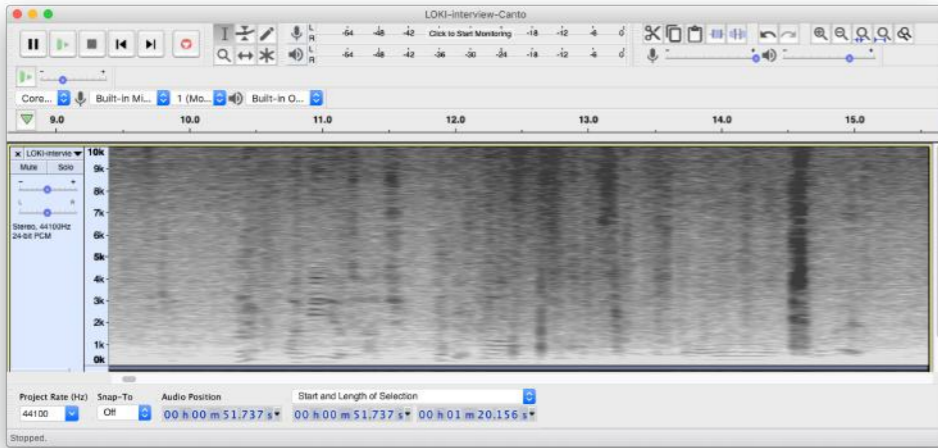
Loki's interview Cantonese -> English¶

¶

Abby: How was your experience using headphones?¶

Hin Nam: There was less spatialisation using headphones, as it was just left and right¶

Florence: For me the spatiality actually felt bigger than the installation¶

Hin Nam: But the installation has front, back, above¶

Florence: To me, using headphones made the sound more 3D, maybe because with the installation I was distracted by the visual elements and so my brain wasn't as focused on the sound. I was more focused on the sound when using headphones, which made the sounds more 3D.¶

	Installation	Headphones	Either/both
Focus vs. Distraction	"[speaker noise] interfered me [M3.VIII]", "[visuals & subwoofer] distracts our attentions [M4.IV]", "[speaker and other] noise is also the interference to immersion [M1.V]", "strong light shedding on my head [M3.V]", "I was distracted by the visual elements and so my brain wasn't as focused on the sound [C2.I]", "distracted visually by the structure and analysing the speaker set up [C2.V]"	"easier to focus and be evoked by headphone [M4.IV]", "[after loud sound] I stopped focusing on the sound [C3.VI]…my mind started wandering. It almost felt like I couldn't hear the sounds anymore because I was thinking about other things [C2.V]"	"As for the r as annoyed e distracted in
Emotion (positive)	"I felt like I was being purified [C1.II]", "I don't dislike that feeling [about the sounds] [C1.II]", "[prefer music in] installation [M1/3.VI]", "[prefer installation] because of the overall feelings [M1.VII]"	"Listening in headphones felt very peaceful [C2.VI]"	
Emotion (negative)	"knocking on my head [C3.II]", "my headache was more serious [M3.II]", "like meditation with sustain depression [M1.II]", "worst moment for my headache M3.III]", "very annoyed [M3.V]", "when I sit after a while, I wanted to escape from the installation [M3.X]", "felt like a headache [C2.II]", "knocking on my head [C3.II]", "[speaker noise] was a bit scary [C3.III]"	"I got headache [M3.II]", "after listening to the sounds with focus for the first few minutes I started to get bored with nothing to do [C2.V]", "It felt very passive [C1.VI]"	"always bad mind [M3.II uncomfortab [M3.II]
Expectation		"suddenly there was a moment with a loud part [C2.VI]"	"sometimes t finish, but in is like a puni middle part c
Immersivity (sonic)	"sound came from various directions… more immersive [M3.II]", "more immersive for me when siting in the installation [M1.III]", "[distractions] makes the music not that immersive [M4.IV]", "installation has front, back, above [C1.I]", installation [felt more immersive] [C1/3.IV]"	"better recognition of directions [M2.II]", "better sense of directions [M3.III]", "headphones made the sound more 3D…spatiality actually felt bigger [C2.I]", "less spatialisation using headphones [C1.I]"	"[both situati

International Conference on New Interfaces for Musical Expression
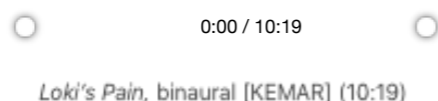
Loki's Pain

PerMagnus Lindborg

Loki's Pain [NIME Art Installation]

PerMagnus Lindborg, City University of Hong Kong, HKSAR

1. PROJECT DESCRIPTION

Loki's Pain (Lindborg 2020) is an immersive installation: a 16-channel 3D audio sonification of planetary seismological activity. Visitors take the place of Loki, who according to a Norse legend was "punished by the gods by being chained to three rocks in a cave using the entrails of his dead son, with a venomous serpent poised above his head. When the serpent's poison fell on Loki's head it caused him to shake uncontrollably, thereby unleashing an earthquake" (Allen 2020, p. 148-9). The installation is a physical structure, designed and built by the Author, in the shape of a hemi-dodecahedron. As show in Figure 1, the LOKI structure envelops the listener, and the immersive space may be shared by two visitors. In *Loki's Pain,* they sit on a lightly vibrating subwoofer while listening to the sound of virtual cymbals, created by physical modelling, spatialised according to the geographical location of seismological events, as if they found themselves at the centre of planet Earth.

The LOKI frame holds 15 custom-built loudspeakers mounted so as to produce a 3D immersive sonic environment. The structure is suspended from the ceiling rig, not touching the floor. Visitors band a little and step inside the installation space, and sit down on a subwoofer, which is lightly vibrating. They listen to a 10-minute sonification of the most recently retrieved earthquake data from the Internet. Seismological magnitude and epicentre depth are mapped onto the parameters of real-time physical modelling synthesis with Modalys (IRCAM). Data from IRIS is retrieved from the Internet and pre-processed in R (R Core Team), and then sonified in Max (Cycling'74) using virtual cymbals that are spatialised with Spat (IRCAM).

○　　　0:00 / 10:19　　　○

Loki's Pain, binaural [KEMAR] (10:19)

Loki's Pain grows out of the author's previous work with sonification of geodata (Lindborg 2017, 2018). The artwork aims to remind visitors of the fragility of the Earth's crust, and the reality faced by people exposed to the terrifying power of earthquakes and volcanic activity.

FEELING LOKI'S PAIN: DESIGNING AND EVALUATING A DIY 3D AUDITORY DISPLAY FOR GEODATA SONIFICATION

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ABSTRACT

Loki's Pain is an immersive 3D audio installation artwork, a sonification of seismic activity. Visitors take the place of Loki, who was punished by the gods and caused earthquakes. We designed an auditory display in the shape of a hemi-dodecahedron and built a prototype with a low-budget, DIY approach. Seismic data were retrieved from the Internet. Location, magnitude, and epicentre depth of hundreds of recent earthquakes were sonified with physical modelling synthesis into a 10-minute piece. The visitor experience was evaluated in a listening experiment (N = 7), comparing the installation with a version for headphones. Differences on eight semantic scales were small. A content analysis of focus group discussions nuanced the investigated topics, and qualitative interpretation strengthened the quantitative findings. Verbal expressions of immersivity were stronger in the installation, which stimulated longer and more detailed responses. Aspects such as audio quality, the structure's physical-visual shape, and multisensorial design evoked both positive and negative emotions, and elicited imagination and memory recall. However, the assumed capacity of the LOKI structure to stimulate a richer social experience than that of headphone listening was not supported by the responses in this study.

1. LOKI'S PAIN

Loki's Pain[a] is an immersive sound installation: a 16-channel 3D audio sonification of seismic activity [1]. Visitors take the place of Loki, who, according to a Norse legend, was "punished by the gods by being chained to three rocks in a cave using the entrails of his dead son, with a venomous serpent poised above his head. When the serpent's poison fell on Loki's head it caused him to shake uncontrollably, thereby unleashing an earthquake" [2]. The artwork aims to remind visitors of the fragility of the Earth's crust and the reality faced by people exposed to the terrifying power of earthquakes and volcanic activity.

To present *Loki's Pain*, we designed and built the 'LOKI structure'. It is a low-cost and relatively portable auditory display for 3D sonic artworks. The structure is suspended from the ceiling, does not touch the floor, and there are no obstructing cables. As shown in Figure 1, the structure envelops the listener and creates an immersive soundscape that may be shared by two visitors. In *Loki's Pain,* they sit on a lightly vibrating subwoofer while listening to the sound of virtual cymbals, created by physical modelling, spatialised

according to the geographical location of seismic events, as if they found themselves at the centre of planet Earth. *Loki's Pain* continues the author's work with geodata sonification and the LOKI structure builds on his previous designs of loudspeaker arrays [3], [4], [5], [6].

2. LOKI STRUCTURE

The LOKI structure is a hemi-dodecahedron and it was designed from scratch with inspiration from [7], [8]. The author and his assistant cut 30x aluminium profiles (T-slot Extrusion, 20 mm wide and 750 mm long), fabricated 160x laser-cut acrylic parts of three kinds, and assembled parts with 140x nuts/bolts and 40x cable ties. The final structure is ~220 cm wide, ~75 cm tall, and weighs ~25 kg. It has four ∩-fittings so as to be suspended from the ceiling grid with adjustable-length hooks and four 1.5 mm coated wires. The total cost of materials and a few special tools was ~4,500 HKD (~800 USD) and took an estimated ~80 man-hours to make.
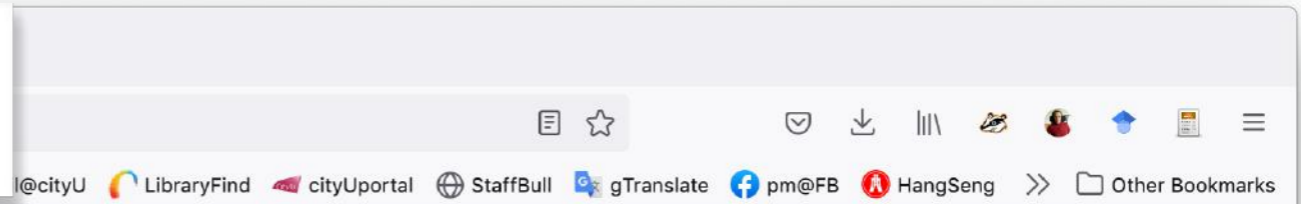
The structure was fitted with 15 custom-made 'bowl speakers' from a previous project [6]. Audio cables were run from the loudspeakers upwards, so as not to interfere with visitor movement, to a small platform concealed in the Gallery ceiling grid. The platform supports the audio playback system, consisting of two 8-channel fixed-media players (WavePlayer8), two 8-channel custom-built pre-amplifiers, two 4-channel power amplifiers (Pioneer GMX84), and a 12V DC power supply. The purchase cost of this equipment was ~1,600 USD. It took ~20 man-hours to assemble, install, and tune the piece on site. A single AC on/off switch was handled by the Gallery personnel every morning. More information and photos from the construction and installation are available on the project website (http://soundislands.com/2021/01/21/lokis-pain/).

3. GALLERY EXHIBITION

The LOKI structure playing *Loki's Pain* was exhibited at Indra and Harry Banga Gallery, Hong Kong, between 23 November 2020 and 31 May 2021, interrupted by a 10-week closure due to COVID-19 regulations. The installation was made in a dedicated, semi-secluded partition measuring ~450 cm x ~450 cm, with black carpet flooring and acoustic panels on four walls. A single spotlight gently illuminated the metal structure. In addition to the 15 'bowl speakers' mounted in the structure we placed a subwoofer on the floor at the centre of the LOKI structure. The amplification level and frequency response were adjusted so that visitors sitting on it could feel the vibration rather than hear it.

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[a] *Loki's Pain* was commissioned by Indra and Harry Banga Gallery, Hong Kong, and supported by the School of Creative Media, City University of Hong Kong.

Stairway to Helheim

SOUNDISLANDS
CONNECTING WAYS OF HEARING

INSTALLATION ▾   MUSIC ▾   FILM ▾   EVENTS ▾   PEDAGOGY ▾   ABOUT ▾

Eight-channel site-specific sound installation
PerMagnus Lindborg

STAIRWAY TO HELHEIM

STICKY   ON: 2021-11-10 | IN: 2021, EVENT, INSTALLATION

by PerMagnus Lindborg (2021). Eight-channel site-specific sound installation for Soundislands: Re:Sound at ArtScience Museum, Singapore. Stairway to Helheim is a sonification of meteorological data for Hong Kong covering 138 years, between January 1884 and September 2021, of daily rainfall and temperature, monthly 'hot nights' and 'hot days', as well as yearly sea level averages in Victoria Harbour. The data were calculated from files graciously provided by Hong Kong Observatory. A total of 1654 rows of

Soundislands Festival soundscape strings
text The Arts House theory

—

Select Category   ⇕

Stairway to Helheim

138 years of meteorological data
[Hong Kong Observatory]

pre-processing (R: Box-Cox transformations, scaling)

sonification
(Max)

sea water level —> tonality

temperature —> original–sawtooth cross-synth

219 samples —> 8
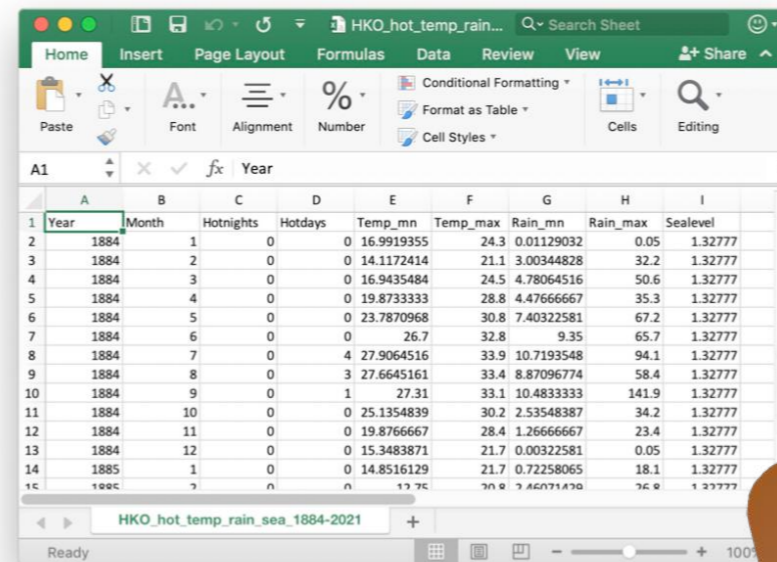categories —> 3
sonification layers
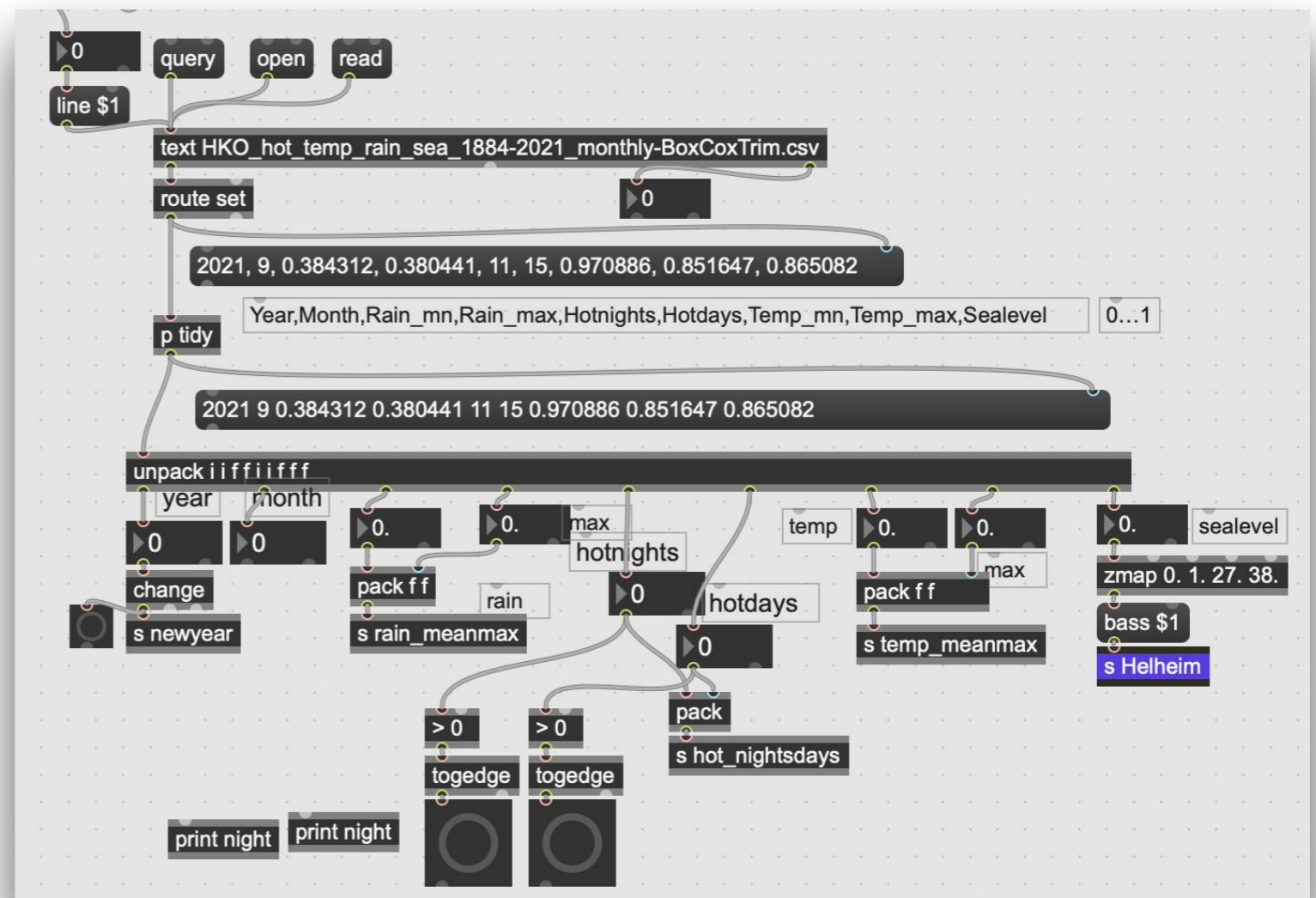
Stairway to Helheim

PerMagnus Lindborg

SoundLan, School of Creative Media, City University of Hong Kong

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Abstract

In Norse mythology, Helheim is the lowest part of the afterworld: the world of the dead. It is ruled by the goddess of death, Hel, a daughter of Loki. As visitors tread the steps of the central staircase of the Run Run Shaw Creative Media Centre, they are met with sonic objects falling onto them; cascading down the steps; obscenely bouncing like yoga balls, a hundred tennis balls, a thousand ping pong balls; splashing incessantly against their head as if they are crawling up a river; heavy objects crashing into invisible walls; objects sliding stealthily in the opposite direction…. The stream of sonic objects seemingly never-ending, the visitors will nevertheless eventually succeed to reach the highest floor. Released from the struggle, they float serenely into the calm of the top level – is Helheim a Parnassum, or is it Purgatory? Or is it another test altogether?

Sonification

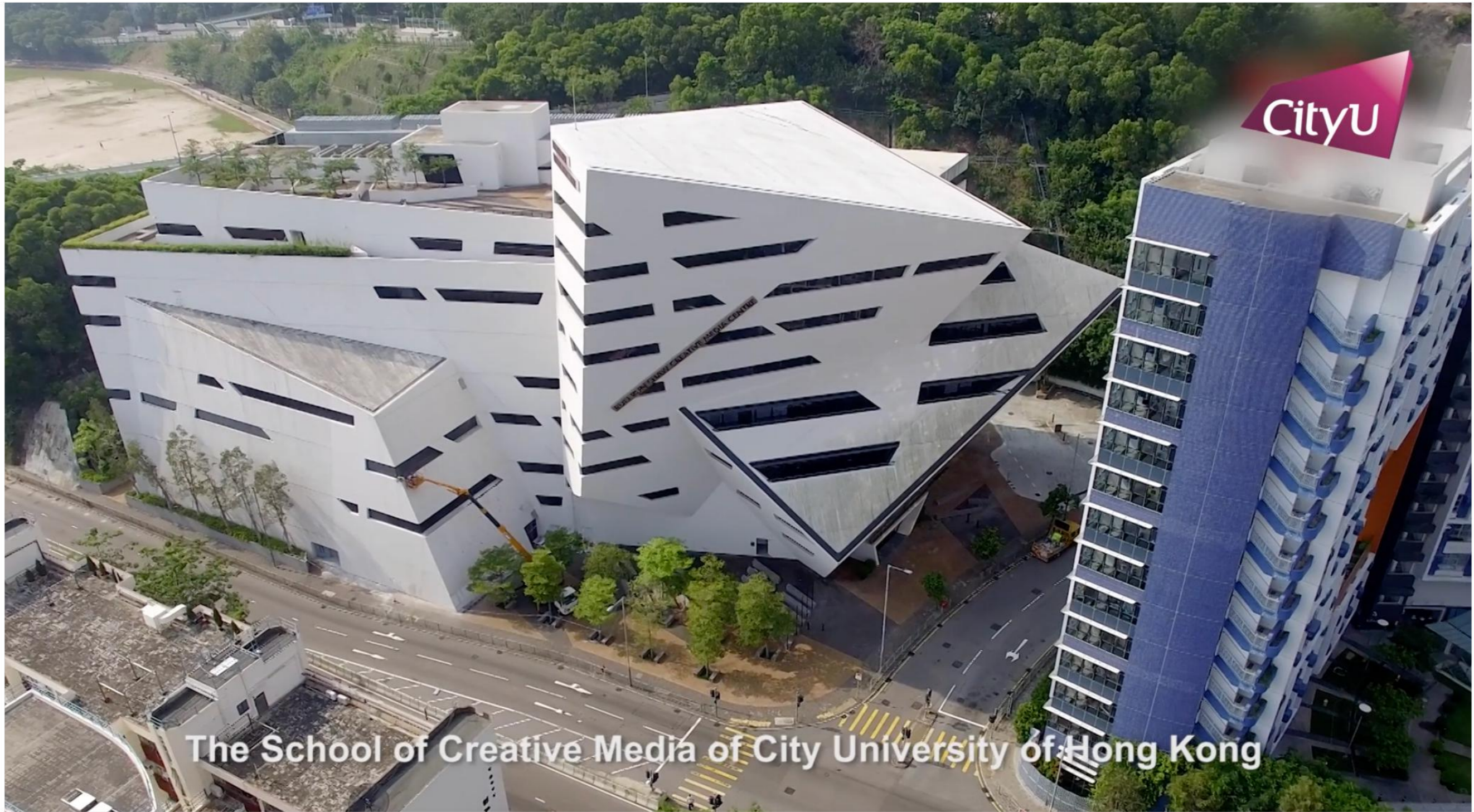Fig 1. Weather data in CSV format used for the signification.

Sonic material

The sonic material was based on action recordings of sound objects such as chairs, bottles, balls, and compact discs, made in October 2021 at [SoundLab](), City University of Hong Kong, by the

Opportunities :: *SoundLab*

The School of Creative Media of City University of Hong Kong

SOUNDLAB

High Spatial Resolution Audio :: Sound Art, Design and Perception Research
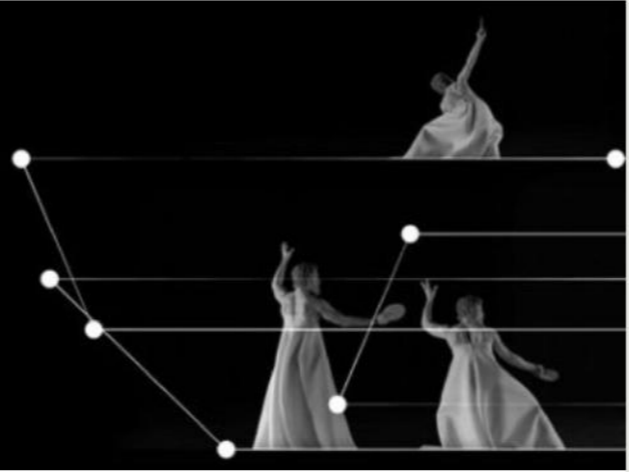
2023 · 📌

Abby Yuen, SoundLab alumna

31/10/2023 · BY PERMAGNUS

We congratulate Abby Yuen Hui Ching aka JustBee on her BAS degree (Bachelor of Art and Science 2023), achieved in July 2023. Here's

2023 · 📌

SoundLab presents :: Good Company Arts: Daniel and Donnine Belton

31/10/2023 · BY PERMAGNUS

Friday 3 November 2023, 11:00am – 12:30pm MultiMedia Theatre (MMT,

TAGS

ACIM / AI / alumna / alumni / Ambisonics / analysis / audiovisual / concert / conference / diaspora / electronics / EMSAN / ethnography / event / field recording / film / guest lecture / Huawei / ICMA / installation / listening / loudspeakers / Max / MIR / MMHK / multimodal / music / music production / OAT / Open Ambisonics Toolkit / opportunities / performance / PhD / power / RA / Research Assistant / SCM / sonic art / sonification / sound art / soundscape / spatial audio / streaming / VR / workshop /
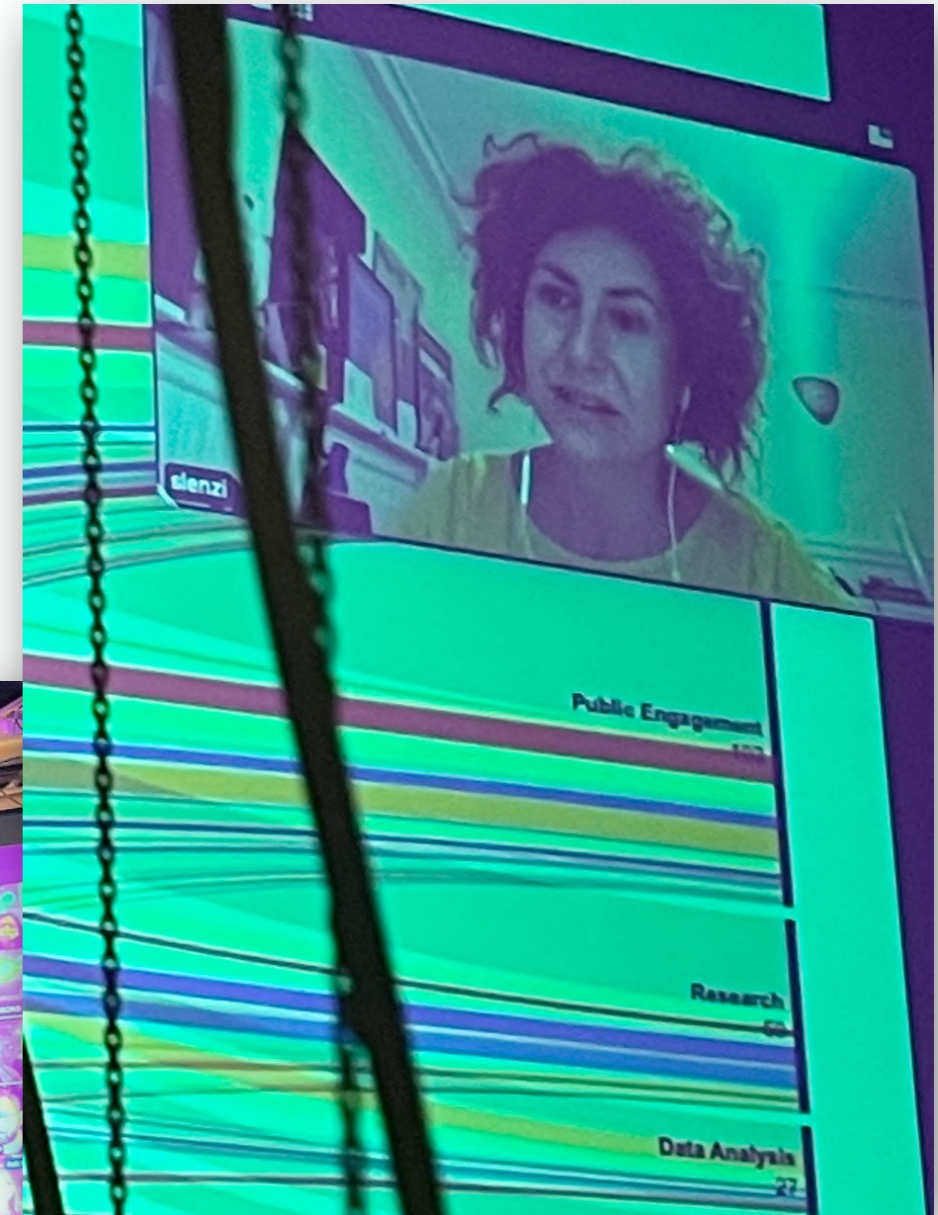
CATEGORIES

https://soundlab.scm.cityu.edu.hk/

Workshops on spatial audio, sonification, computer music...

SoundLab

http://dataclimate.org/
2022/08/30/daca-workshop/

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