

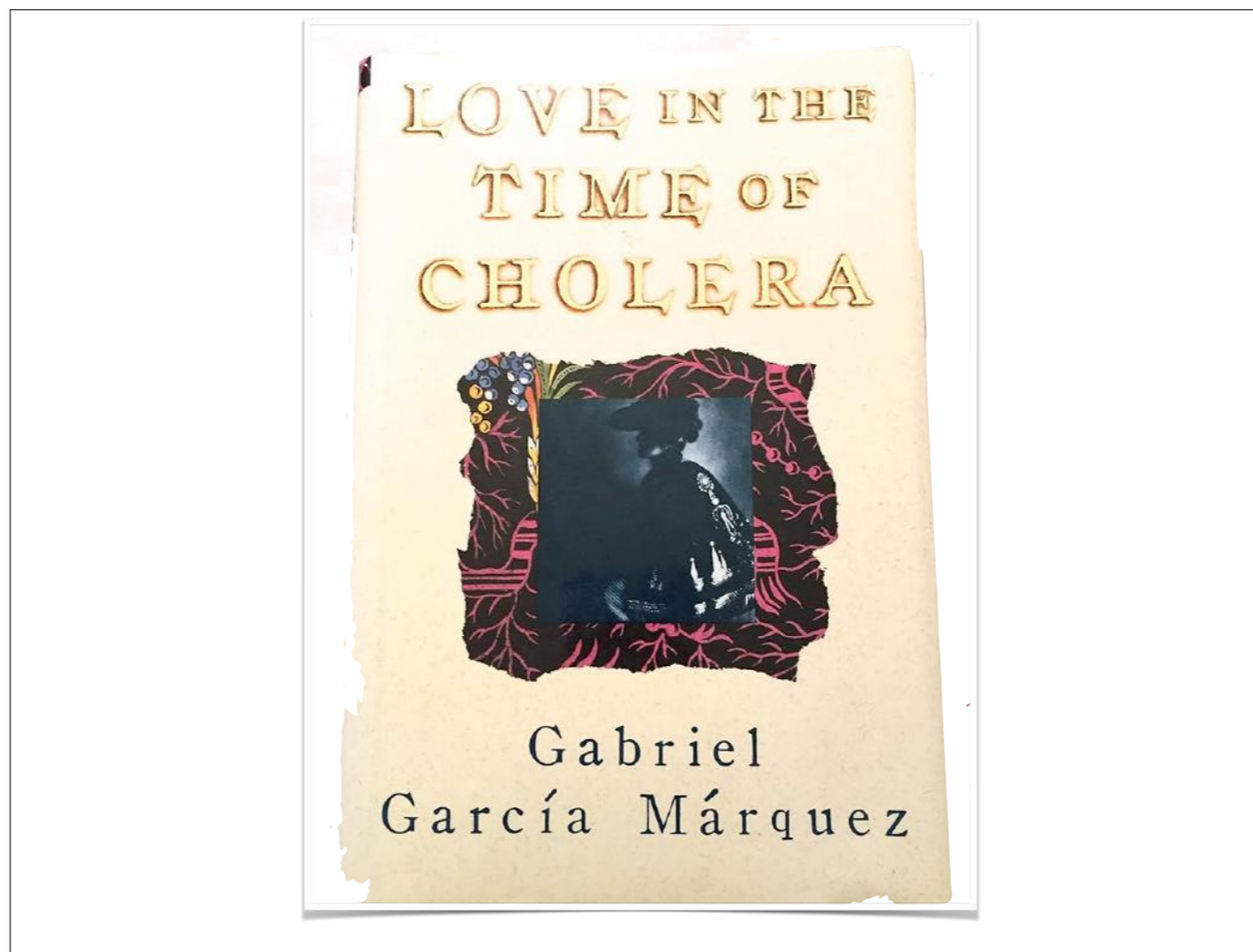
Sound Art in the Time of Crisis: Climate Data Sonification for Exploration, Understanding, and Aesthetic Renewal

PerMagnus Lindborg, PhD, City University of Hong Kong

Communication University of China, Beijing, 27 November 2023

專業 創新 胸懷全球
Professional · Creative
For The World





The title of the talk paraphrases a famous book (García Márquez 1985) and also a research paper (Lenzi S, Sadaba J & Lindborg PM (2021/03.). "Soundscape in Times of Change: Case Study of a City Neighbourhood during the COVID-19 Lockdown". Frontiers in Psychology.)

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KEYWORDS

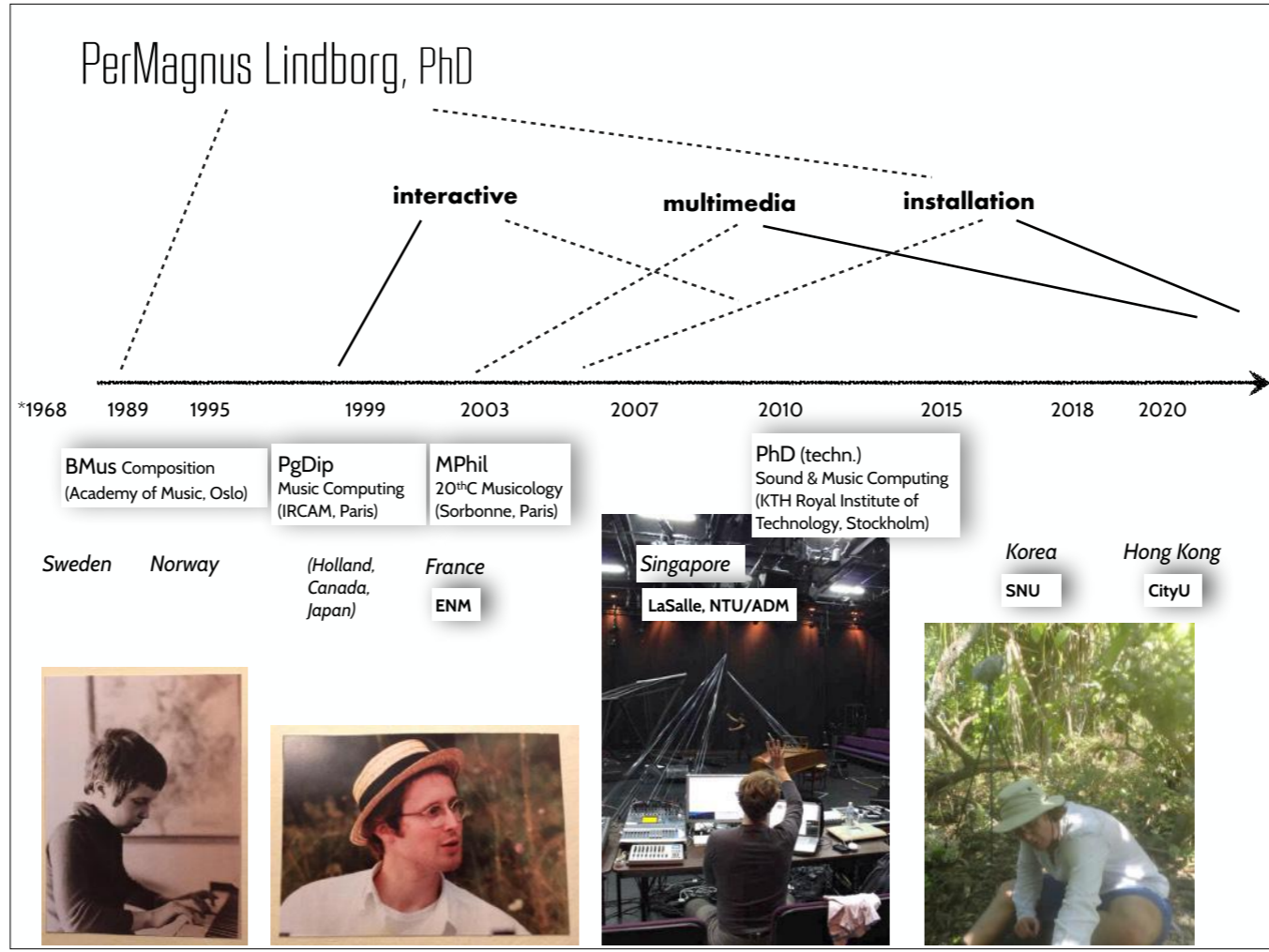
Sound Art Music Composition Perception Psychoacoustics Sonification
Multimedia Soundscape

BACKGROUND

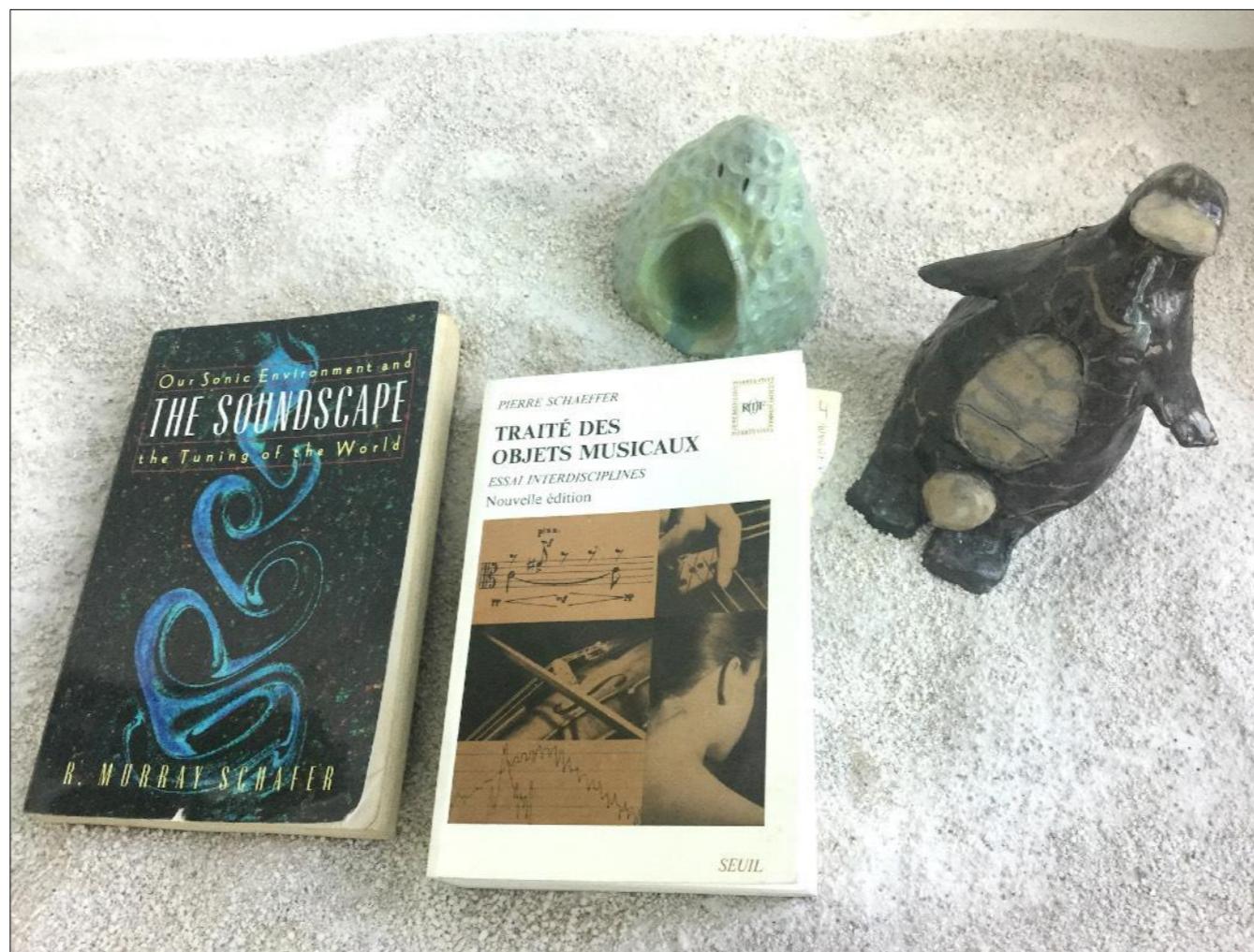
PerMagnus Lindborg, PhD, is a composer, sound artist, and researcher in sound perception. The first author of more than 150 scholarly publications, compositions, and media artworks.

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),

This is my faculty website. There are links to publications. I like nature. Here I'm out kayaking in Stockholm.



This is my journey through education and professional work.



The two books that have been most important for me. Schaeffer's book (to the right) is about how we perceive music as objects. His thinking is based on phenomenology. Schafer's book (to the left) is about how we listen to the acoustic environment. His thinking is based in ecological perception.

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



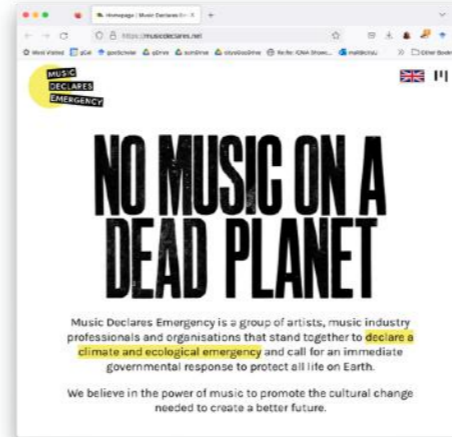
One year ago I spoke about how we as academics and sound artists could be more attuned to the problems posed by the climate crisis.



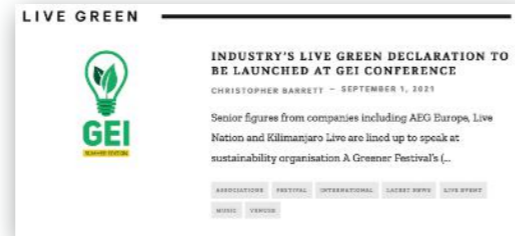
<https://www.djs4ca.com/>



<https://musicdeclares.net>



<https://accessaa.co.uk>



Pop music including DJs are finding better solutions to mitigate their CO2 impact. For example, they do this by improving travel logistics on tours, by sharing equipment (stage rigs, loudspeakers etc). But isn't the music still all about escaping reality?



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

Richard Parncutt^{1*}, PerMagnus Lindborg², Nils Meyer-Kahlen³ and Renee Timmers⁴

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

OPEN ACCESS

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One of the largest carbon footprints of academics comes from long-haul flights to international conferences. In this paper, we analysed the situation and proposed a concrete model for hybrid internet-based conferencing. It has been successful at for example ICMPC and DACA. But it demands coordination and collaboration between several groups of conference organisers. This can be hard.

School of Creative Media



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

One course has this as its focus

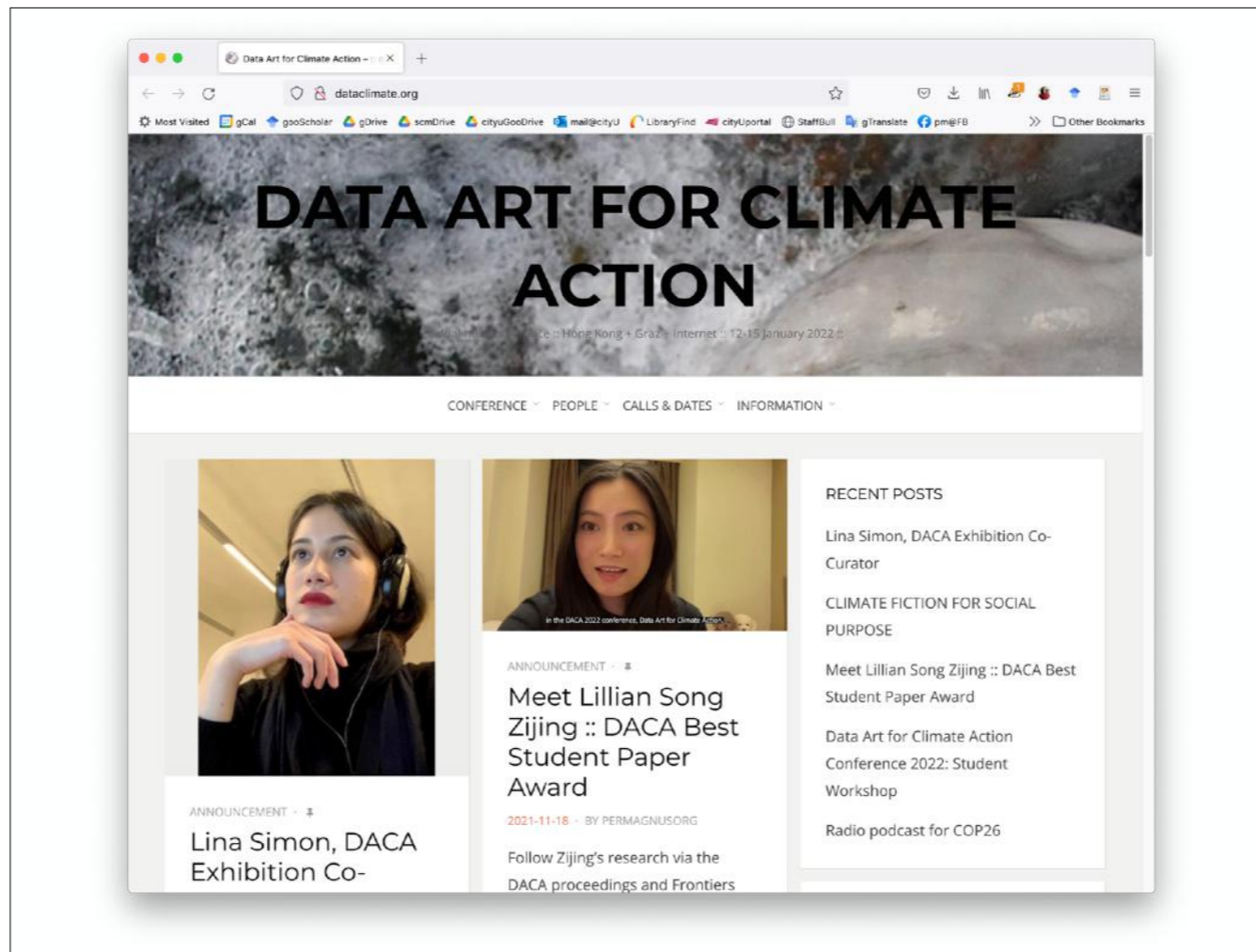
DJs for Climate Action

“HOW DO WE WANT OUR FUTURE TO SOUND?”



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

At art schools, sustainability could be highlighted. The crisis challenges our creative minds and offers ways for new collaborations, for example with scientists and engineers.



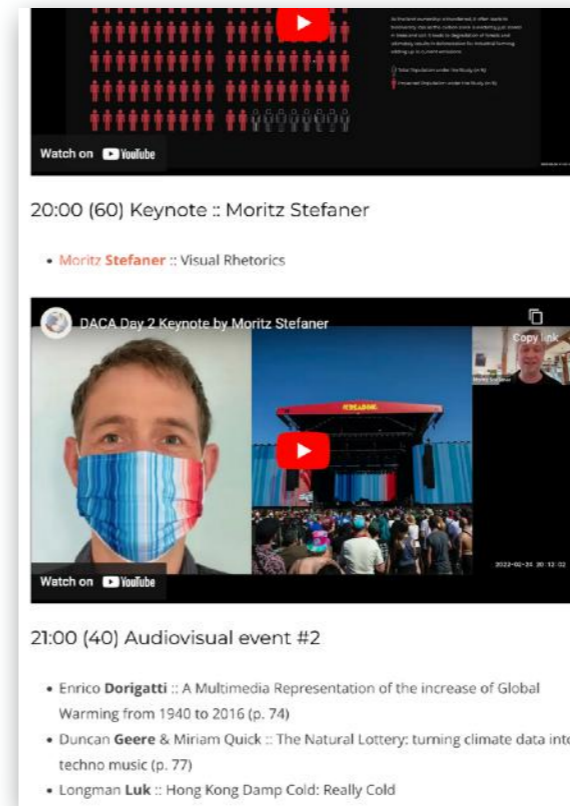
DACA conference was held online in February 2022. I was the initiator and chair. It was funded by a grant from the Hong Kong Environment and Conservation Fund. Ryo co-created an exhibition as part of DACA.

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/>



The image shows a screenshot of a YouTube playlist titled "DACA Day 2 Keynote by Moritz Stefaner". The first video in the playlist is "20:00 (60) Keynote :: Moritz Stefaner", which includes a sub-entry for "Moritz Stefaner :: Visual Rhetorics". The second video is "21:00 (40) Audiovisual event #2", which includes sub-entries for "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)", and "Longman Luk :: Hong Kong Damp Cold: Really Cold". The screenshot also shows a video player interface with a red play button and a "Watch on YouTube" link.

The DACA papers are published in a Proceedings + Catalogue which you can download from the website. There are recordings from keynotes and other sessions. The DAT-ACT exhibition is also available online.

The image shows a screenshot of a web browser displaying the Frontiers Research Topics page for "Data Perceptualization for Climate Science Communication". The browser's address bar shows the URL: frontiersin.org/research-topics/20827/data-perceptualization-for-climate-science-communication. The page features a navigation menu with "ABOUT", "JOURNALS", "RESEARCH TOPICS", "ARTICLES", and "SUBMIT". A search icon is also present. The main content area includes a globe icon, the title "Research Topic: Data Perceptualization for Climate Science Communication", and three buttons: "Submit your abstract", "Submit your manuscript", and "Participate". Below this, there are tabs for "Overview", "Articles", "Authors", and "Impact". A green bar displays statistics: "1,201 Total Downloads" and "10k Total Views and Downloads". The "About this Research Topic" section contains two paragraphs of text. The "Topic Editors" section lists two editors: PerMagnus Lindborg and Shauhrat S Chopra, each with a "Follow" button and their respective affiliations.

frontiers
Research Topics

Data Perceptualization
for Climate Science
Communication
Frontiers in Psychology

Research Topic
**Data Perceptualization for Climate Science
Communication**

Submit your abstract Submit your manuscript Participate

Overview Articles Authors Impact

1,201
Total Downloads

10k
Total Views and Downloads

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 to merge the two

Topic Editors

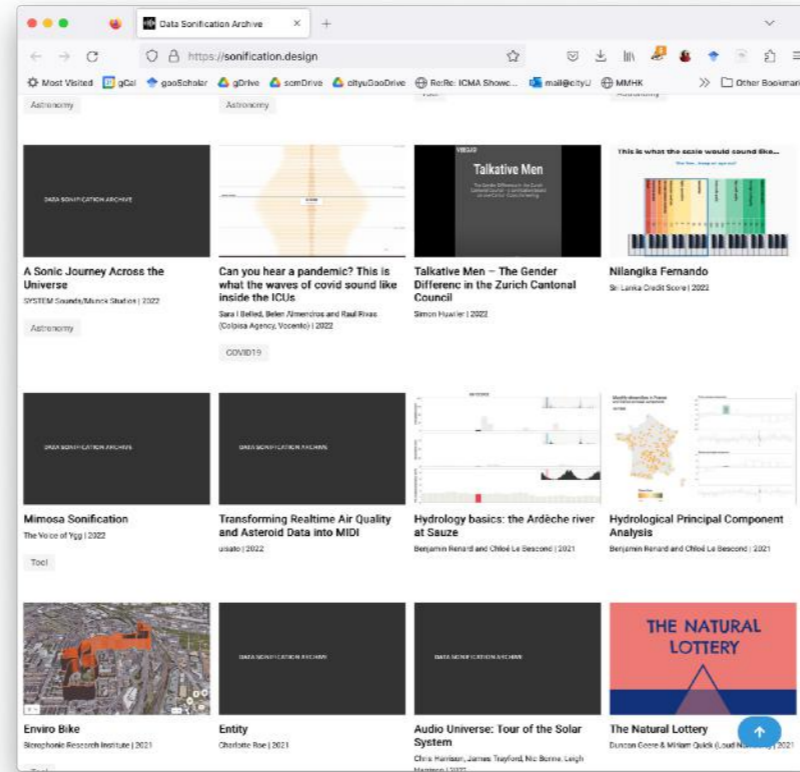
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19 publications

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

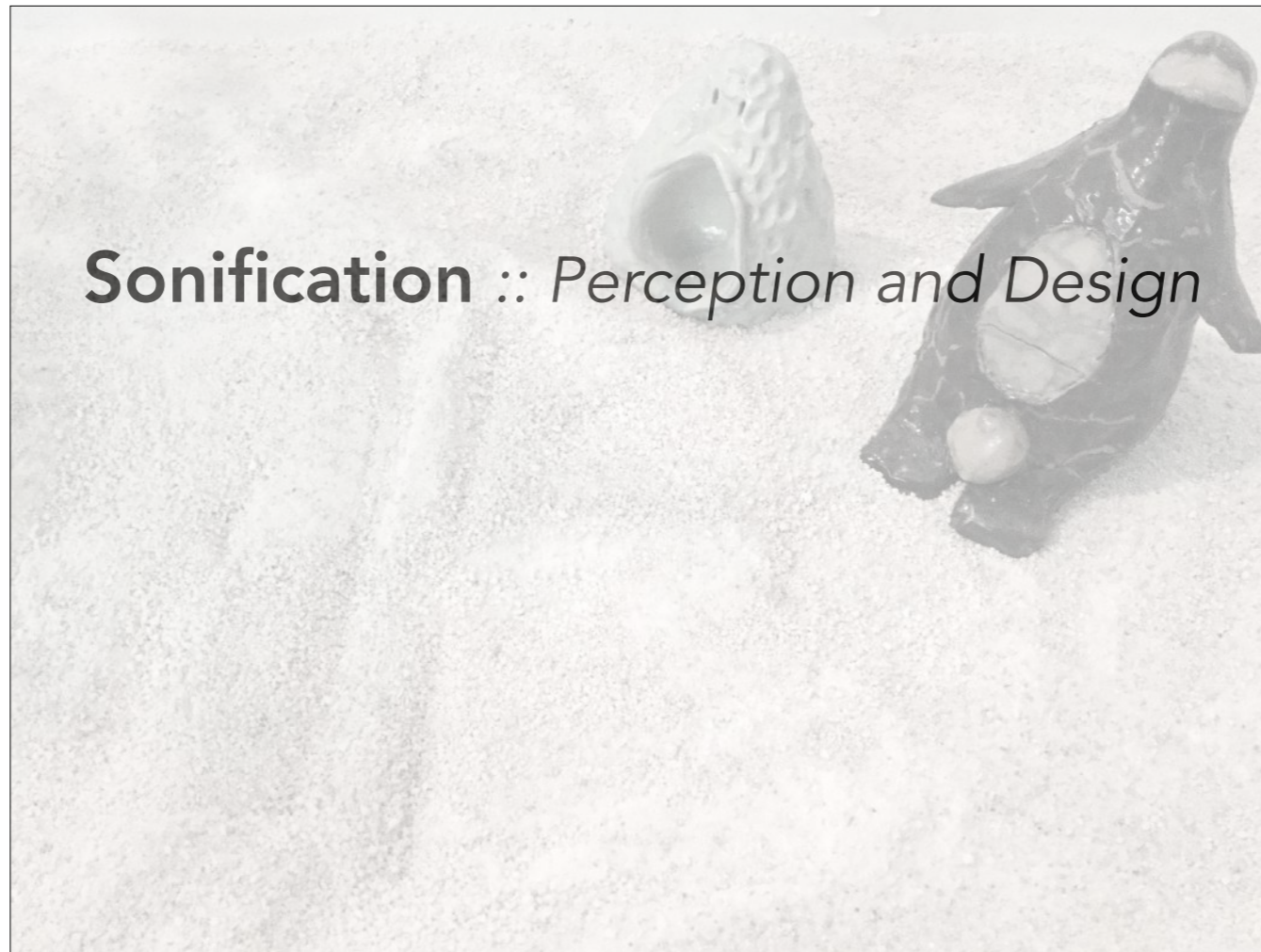
I co-edited a Research Topic in Frontiers journal. This was an extension of the DACA conference.

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



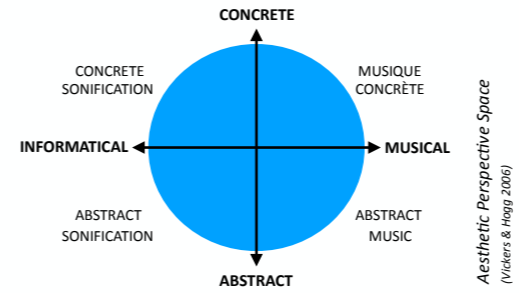
The DSA has almost 500 sonification and visualisation projects. Many of them are based on data that relate to the climate crisis.

Sonification :: *Perception and Design*



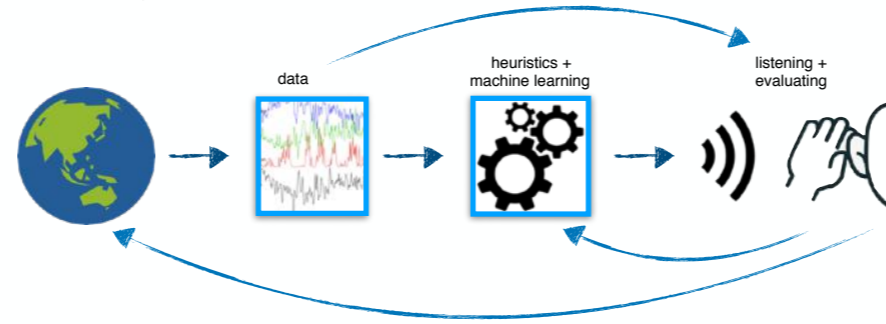
Sonification makes data *audible*

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



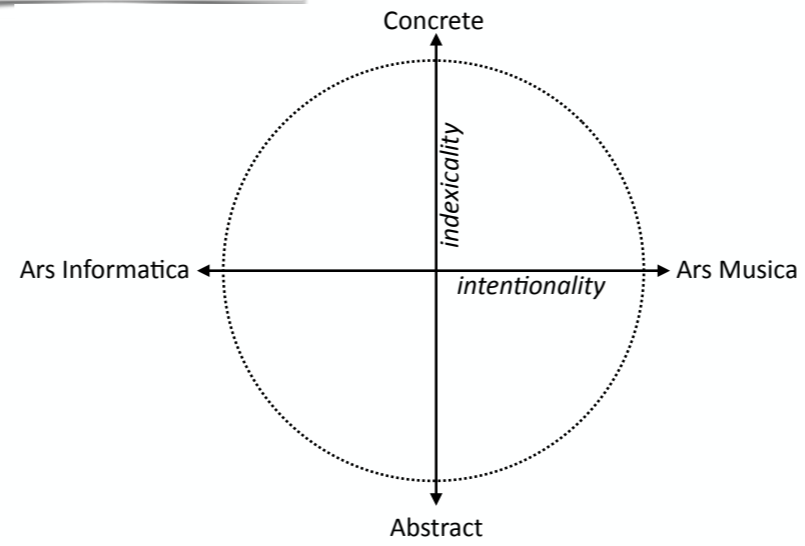
Sonification is a *design process*

“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)

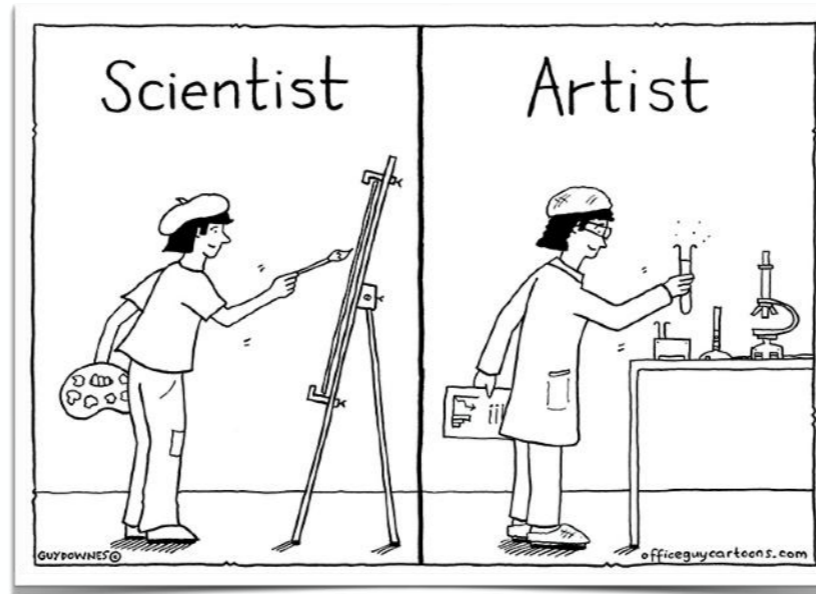


Sonification is to *music* as visualisation is to visual art: **a strategy for explaining.**
Sound design is to *composition* as graphic design is to visual imagination: **a method for making**

Aesthetic Perspective Space



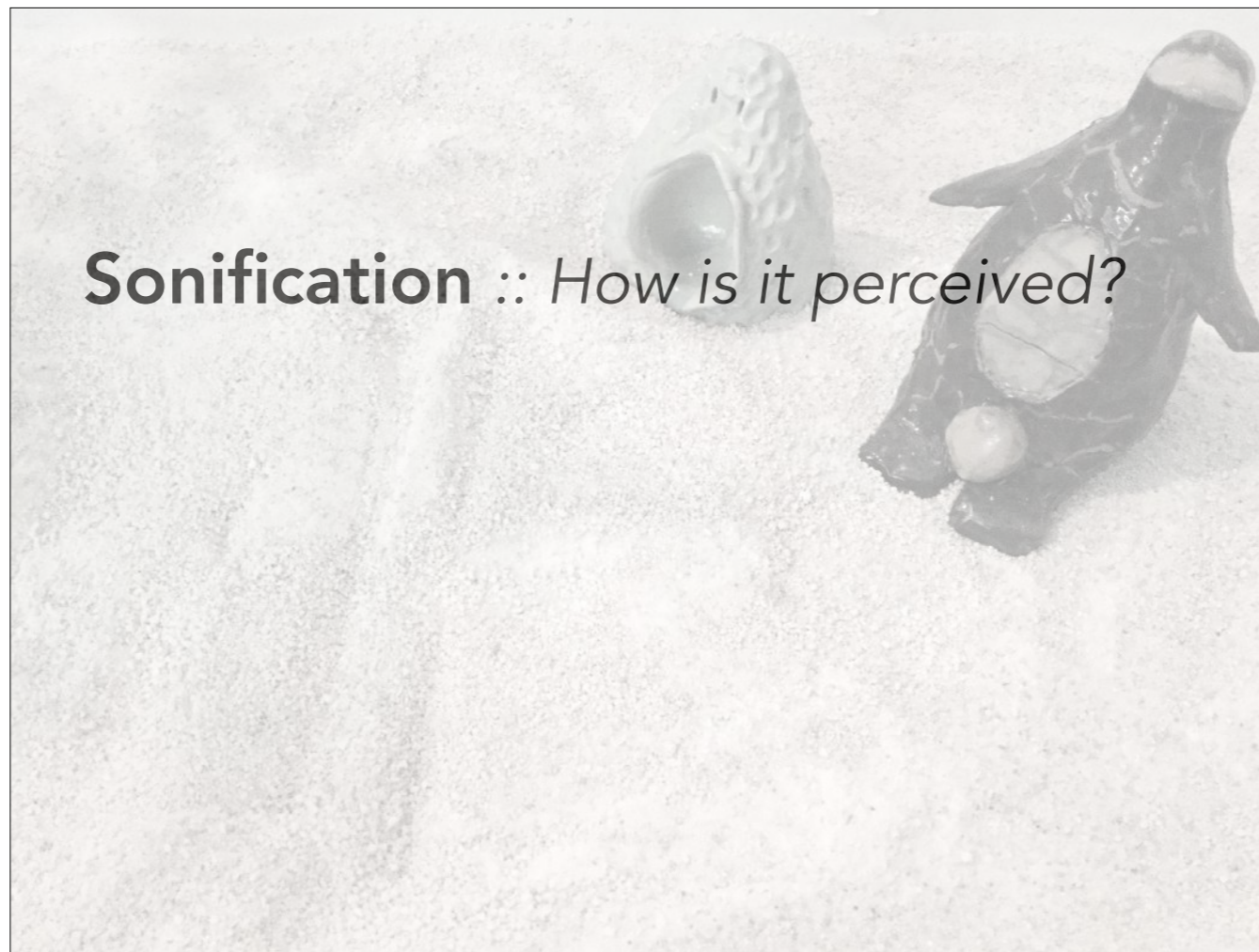
Vickers & Hoggs 2006; Vickers 2017



https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.officeguycartoons.com%2Fproduct%2Fart-vs-science%2F&psig=AOvVaw39FWB5gH5M Cxa2deqQzE_9&ust=1631845771091000&source=images&cd=vfe&ved=0CAkQJRxqFwoTCNigtKu5gvMCFQAAAAAAdAAAAABA
D

I find sonification a very interesting technique. It is rewarding for me to work with geodata and make sonic artwork. Sometimes I feel that sonification is a bridge between art and science.

Sonification :: *How is it perceived?*



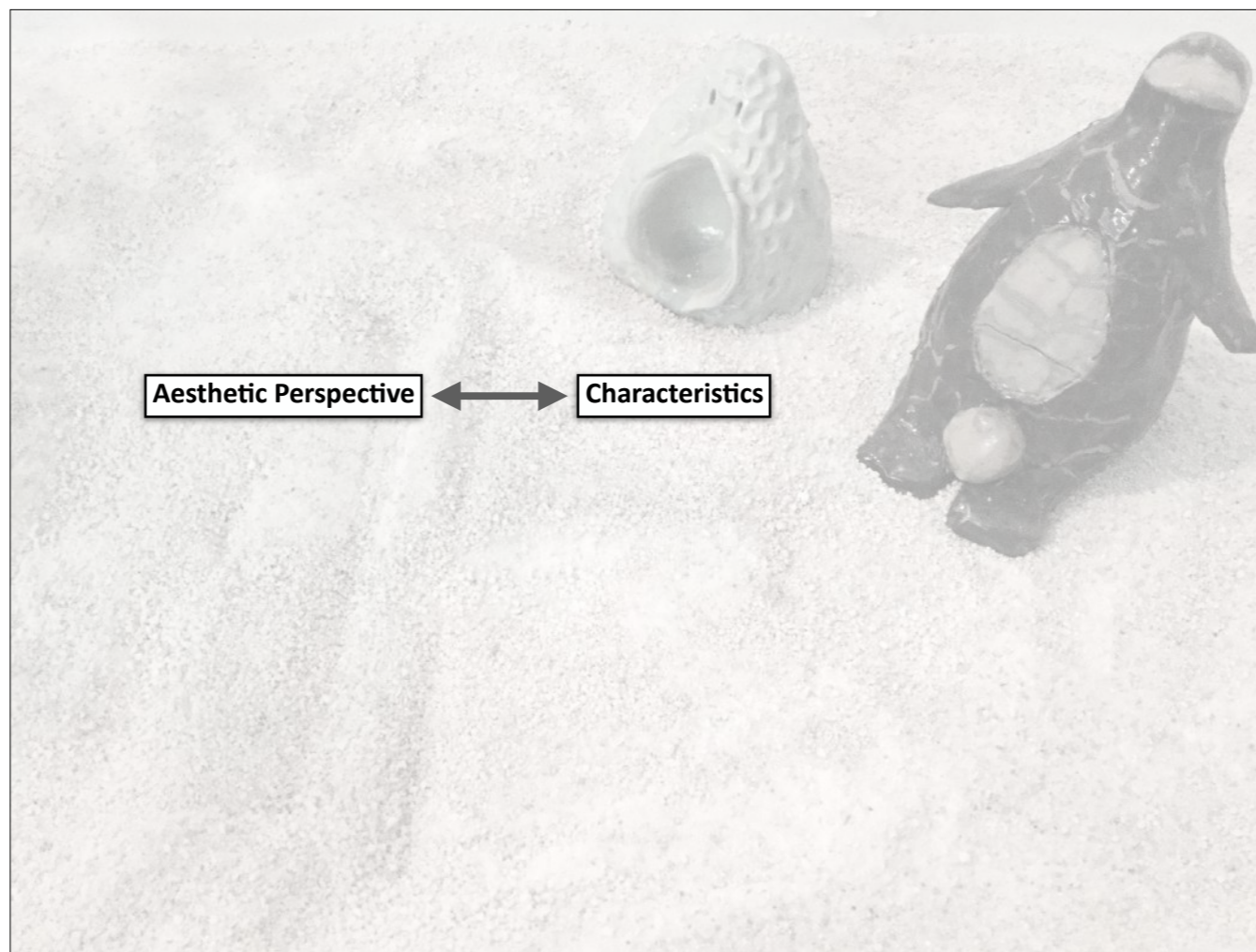
The screenshot shows a web browser displaying a Frontiers article. The article title is "Climate data sonification and visualization: An analysis of topics, aesthetics, and characteristics in 32 recent projects". The authors listed are PerMagnus Lindborg, Sara Lenz, and Manni Chen. The article is categorized as a "SYSTEMATIC REVIEW article" and is part of the "Research Topic Data Perceptualization for Climate Science Communication". The article has 2,031 total views, 414 downloads, and 2 citations. The introduction discusses the challenge of stimulating climate action with data and the use of sonification and visualization techniques. The methods section mentions the Aesthetic Perspective Space (APS) model.

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

This was a study we completed one year ago. It is about understanding the beauty of sonification.



Me and my co-authors. Manni is my 4th-year PhD student. Sara is a post-doc researcher in Spain and we have worked together for more than ten years now.



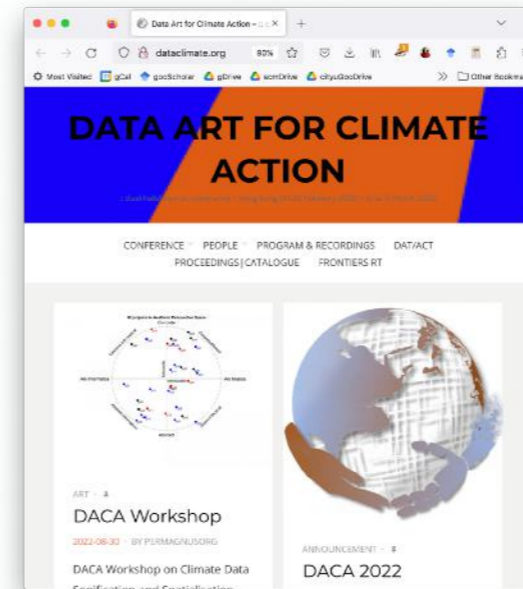
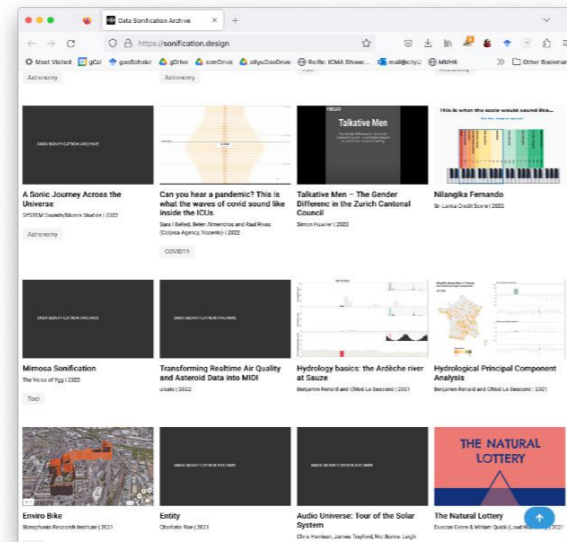
The two concepts that are being compared.

Background

DACA conference - dataclimate.org

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

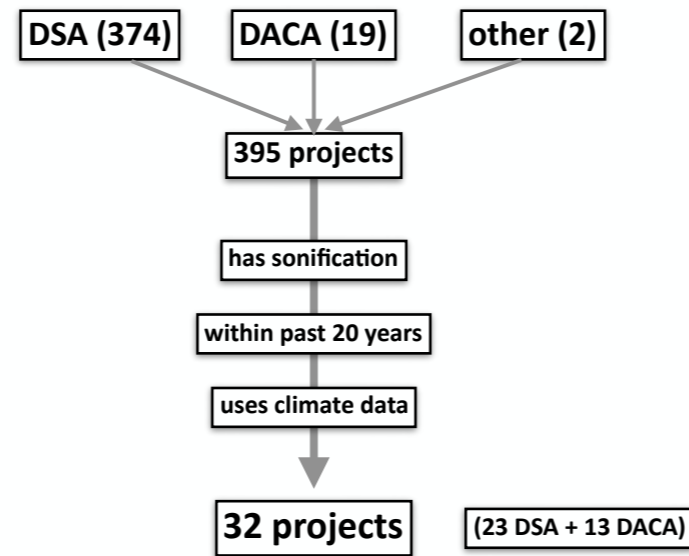
Data Sonification Archive (DSA; <https://sonification.design>)



Material for the study was collected from DACA conference and DSA.

Methods & Materials

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



This study is a systematical analysis of sonification and visualisation projects made by others. We started by looking at almost four hundred projects and selected 32.

Corpus

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

Project	Author(s)	Title	Year
p01	Arelis Aggrey	Sonicification of atmospheric carbon dioxide in PP34 (1958–2008)	2022
p02	Renick Bell and Moon Hwang	IKCO_hot_temp_rain_ses_1884-2021_30220225	2022
p03	Jon Bellona	#Carbonfeed	2022
p04	Andrés Blazsek	Extreme weather in three movements	2021
p05	Chris Chafe	Hear climate data turned into music	2021
p06	David Crawford and Scott S. George	A song of our warming planet	2021
p07	Erico Dorigatti	76	2021
p08	Frank Elberg	Ingenmansland	2021
p09	Brian Foo	Too blue	2020
p10	Duncan Geere and Miriam Quick	The natural lottery	2020
p11	Nelson Guata	Threshold	2019
p12	Band of Woods (Kalle Hamon, Olli Aarai, Lauri Aimala, and Hermann Kela)	Waiting for the extinction --(2019
p13	Band of Woods (Kalle Hamon, Olli Aarai, Lauri Aimala, and Hermann Kela)	The weep of trees	2019
p14	Sara Lenti	While I was not there	2019
p15	Per Magnus Lindborg	Locust wrath	2013
p16	Per Magnus Lindborg	LW24	2015
p17	Per Magnus 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	Hiroshi Okumura, Valerie Williams, Jenn Kirby, Thomas B. Johnson, and Joseph Vaughan	Atmos actiana	2016
p22	Jamie Petera	Fatline	2016
p23	Jamie Petera	Anthropocene in C major	2015
p24	Jamie Petera	If the oceans could speak	2015
p25	Matty 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 Reznick	Oceans eat cities	2013
p29	Nik Sævi and Lauren Oakes	Sonicification of Alaskan forest changes	2013
p30	Katja Striedelmeyer	Shifting apple blossom in Bremen—data sonification with a music box	2013
p31	Marco Tolencio and Polar Seeds Group	Polar seeds	2010
p32	Judy Tweet	Piano piece	2007

A list of the selected projects.

Methods

Duration (seconds, logarithmic)

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

Topics :: author's description, website, article

provenance (focus) of data

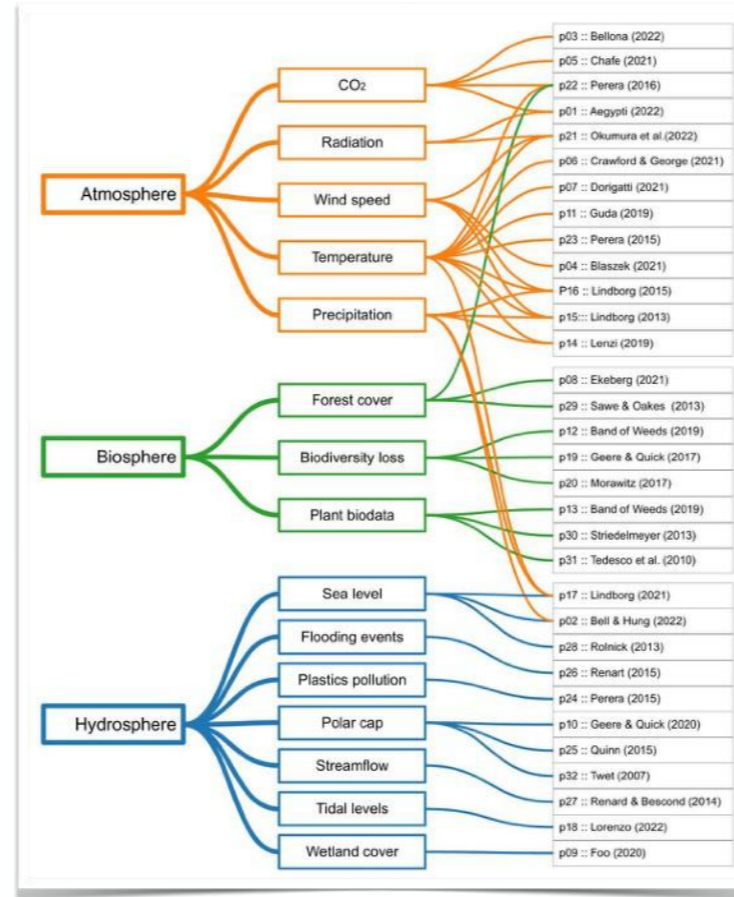
source data type

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

goal

Corpus

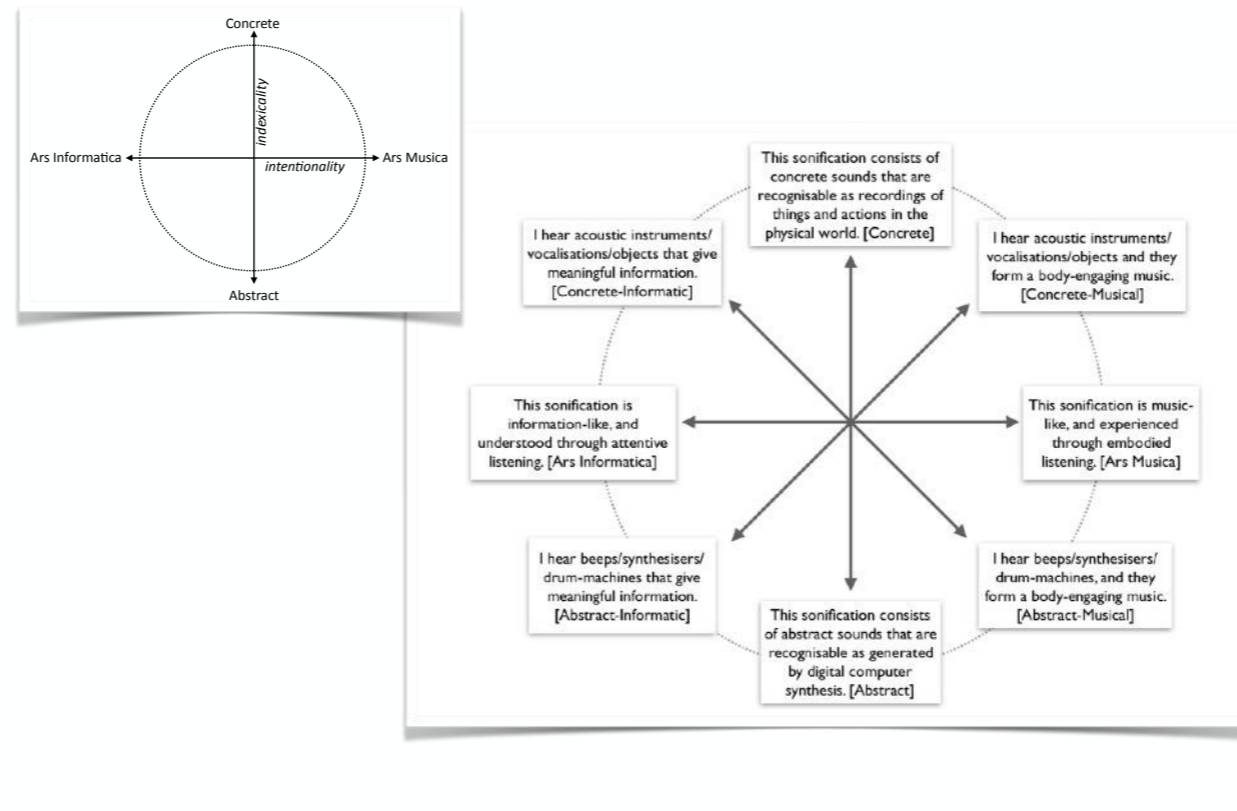
Topic,
content



A hierarchical map of which kinds of geodata were used in the 32 projects.

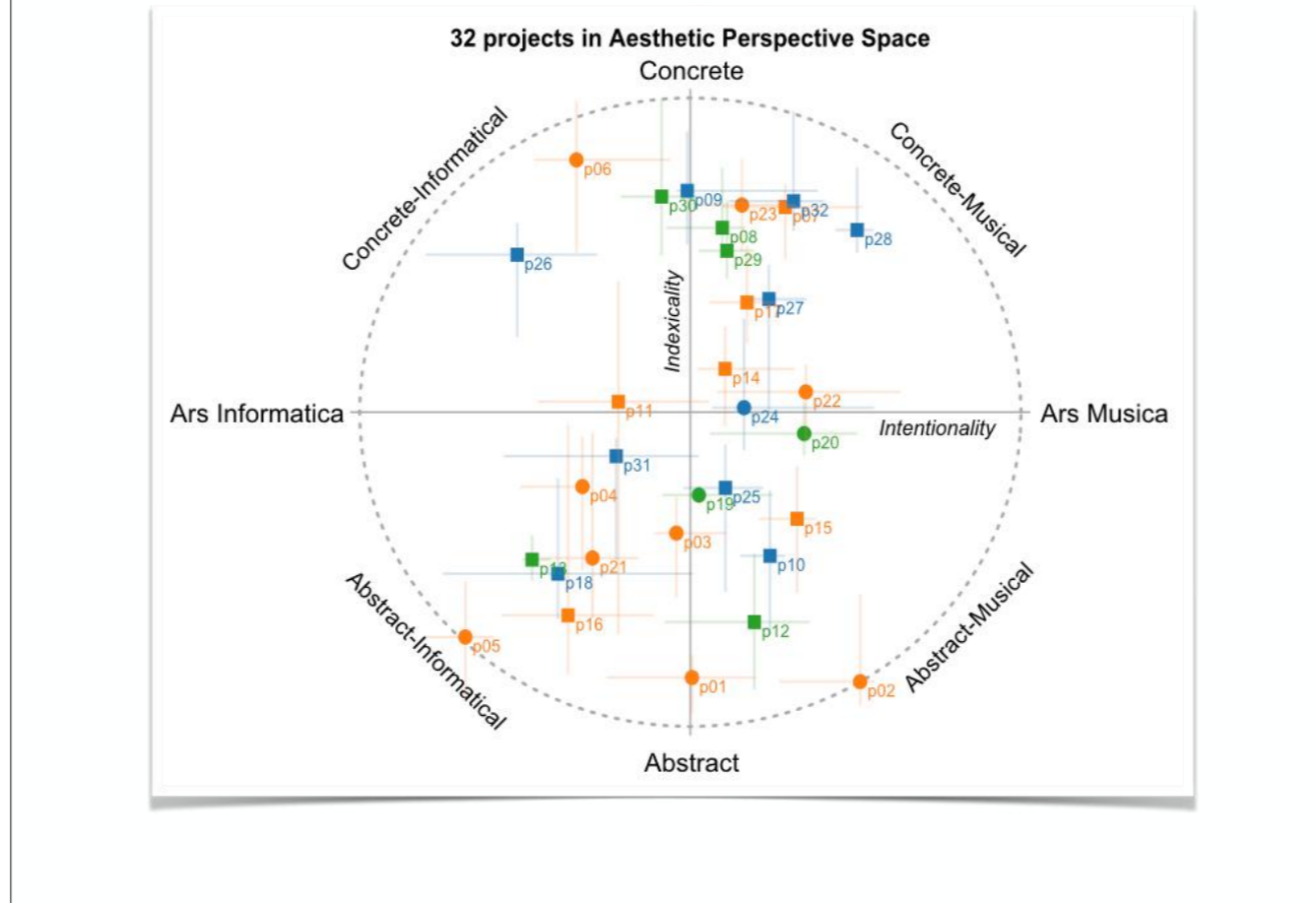
Methods

Aesthetic Perspective



To measure aesthetic perspective, we developed eight rating scales to span Vicker's circumplex. We tested the model and the collected data supports the APS.

Result



Here are the 32 projects plotted in the aesthetic perspective space. The colours refer to the source of the geodata. In the article we discuss the projects, for example the ones that are the “most concrete”, or “most abstract”

Methods

Qualitative characteristics

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

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

We designed 25 questions, or rating-scales, through which 6 experts evaluated the projects (text descriptions, sound, and visuals).

Analysis

Qualitative characteristics

Exploratory Factor Analysis (EFA)

32 projects x 6 raters

20 scales

4 latent factors

Action, Technical, Perspective, Context

variance explained = 56%

18 projects x 6 raters

5 scales

1 latent factor

Visualisation

variance explained = 39%

EFA is a way to reduce the complexity in a description of a dataset, while maintaining a good degree of explained variance. In this case, from 25 dimensions (scales) to 4 + 1.

Results

Multivariate Analysis of Variance (MANOVA)

Linear Regression modelling (linreg)

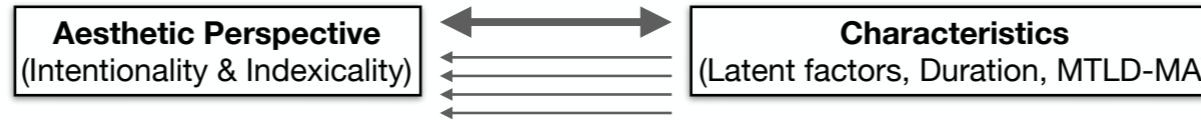


TABLE 4 Statistics for regression models predicting Intentionality and Indexicality from rated characteristics, duration, and lexical diversity, in all 32 projects and a subset of 18 projects integrating visualization.

In 32 projects	Intentionality (R2 = 0.27, adjusted = 0.25)				Indexicality (R2 = 0.17, adjusted = 0.14)			
	est.	t	p	β	est.	t	p	β
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

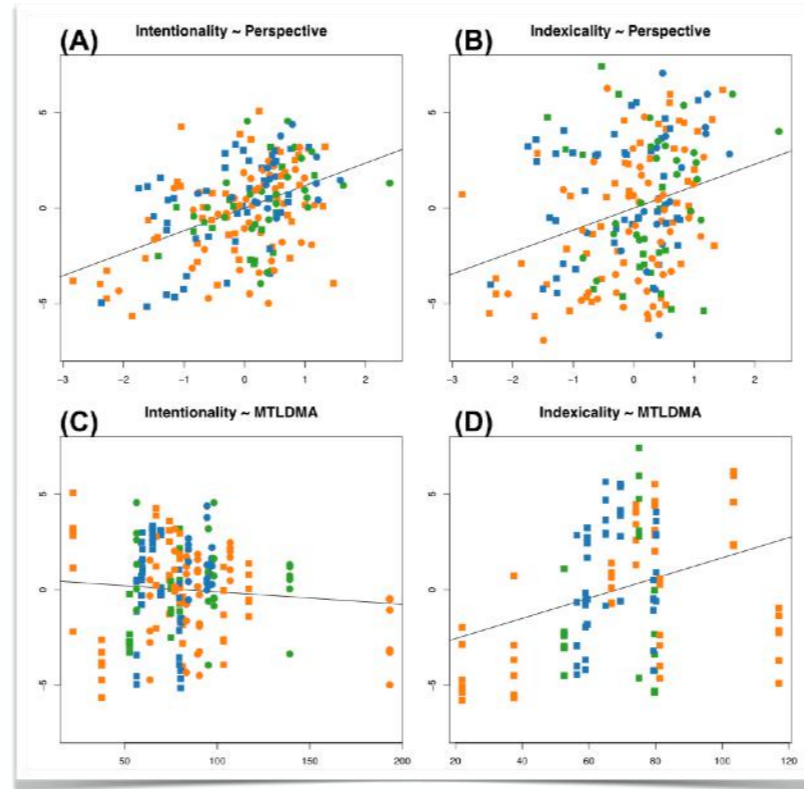
In 18 projects	Intentionality (R2 = 0.12, adjusted = 0.10)				Indexicality (R2 = 0.15, adjusted = 0.12)			
	est.	t	p	β	est.	t	p	β
Visualization	0.49	1.84	0.068	0.20	0.41	1.10	0.28	0.11
logDuration	0.66	3.82	0.000***	0.42	-0.34	-1.39	0.17	-0.15
MTLD-MA	0.01	0.64	0.52	0.065	0.04	2.85	0.005***	0.28

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; β, standardized beta coefficient.

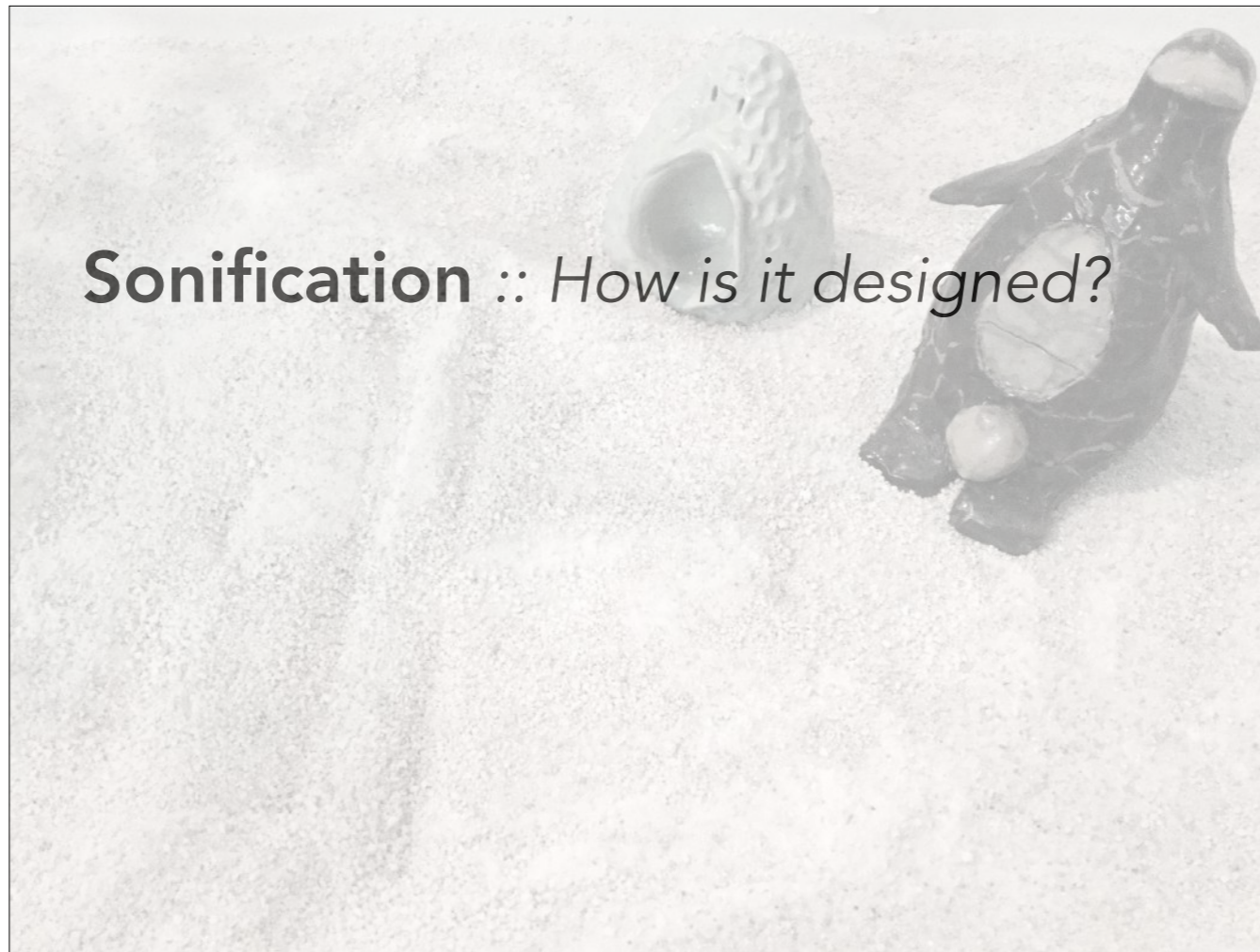
First, MANOVA is conducted to establish if a significant association exists between the two kinds of representation. Since it does, we proceed with regression modelling to determine which variables are the more powerful predictors.

Results

Linear Regression modelling



Sonification :: *How is it designed?*



Journal of the Audio Engineering Society
A Meta-Analysis of Project Classifications in the Data Sonification Archive
--Manuscript Draft--

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,

A study in review that investigates the whole DSA, a corpus of 445 sonification projects. It continues on the preceding study.

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.

in review

Journal of the Audio Engineering Society A Meta-Analysis of Project Classifications in the Data Sonification Archive --Manuscript Draft--

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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First Author:	PerMagnus Lindborg
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A State-of-the-Art Report on the Combination of Sonification and Visualization

K. Enge^{1,2}, V. Caiola³, E. Elmquist⁴, A. Rind¹, N. Rönningberg⁴, M. Iber¹,
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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:

Each work must include both visualization and sonification of

A forthcoming study that describes a large set of sonification and visualisation projects.

The image shows a screenshot of the SOUNDLAB website on the left and a project flowscheme diagram on the right.

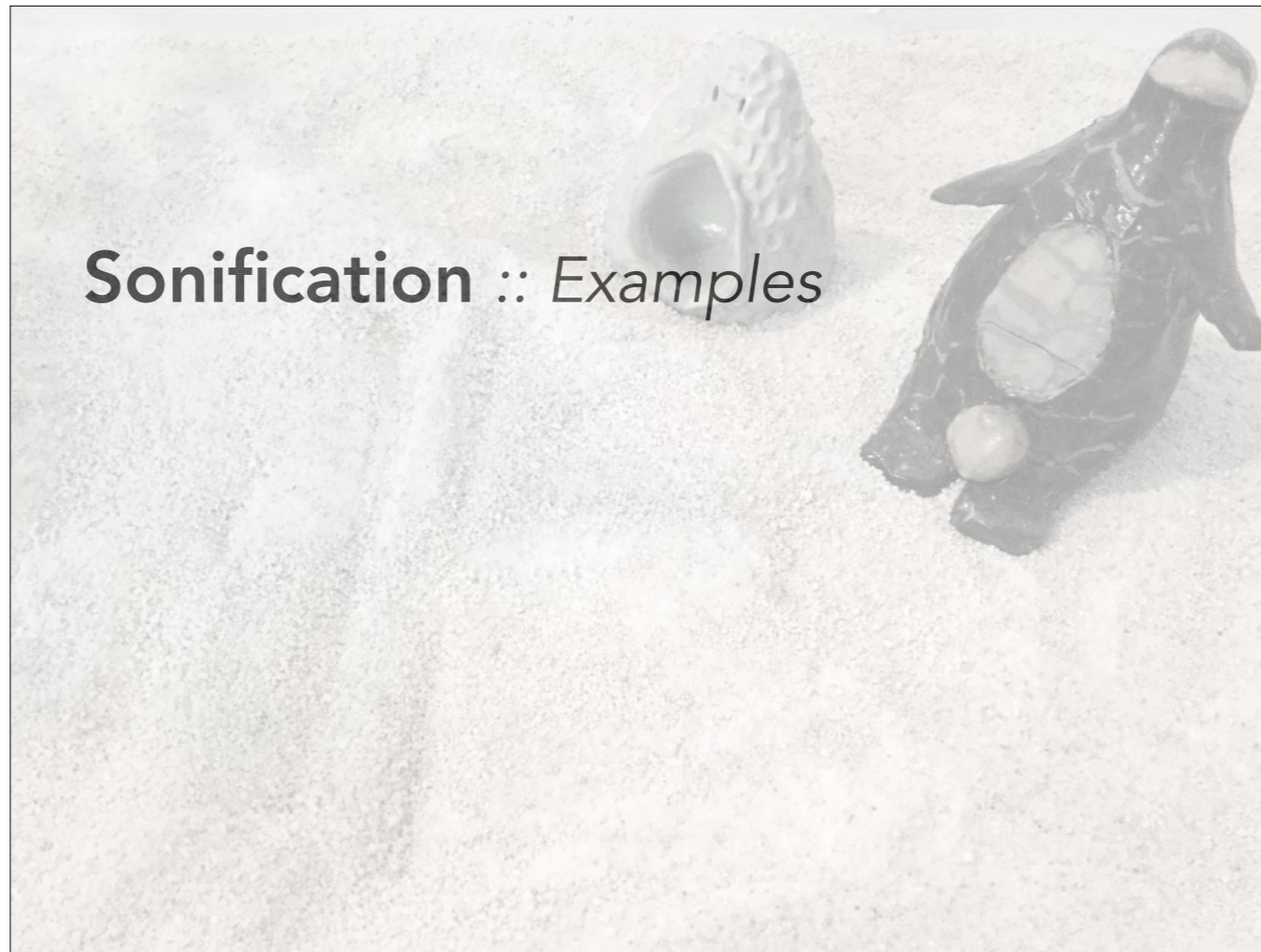
SOUNDLAB Website:
 The website header includes the title "SOUNDLAB" and the subtitle "High Spatial Resolution Audio - Sound Art, Design and Perception Research". The main heading is "All Ears, All Eyes" followed by "Design Strategies for Concurrent Sonification-Visualisation of Geodata". The page lists three principal investigators (PIs) and an "About" section describing the project's interdisciplinary nature and goals.

Flowscheme Diagram:
 The diagram, titled "All Ears, All Eyes", illustrates the project's workflow. It starts with "1a. sonification-visualisation projects" (purple box) and "1b. meta-study" (red box) at the bottom. Arrows lead to "2a. cross-modal perception informed theory" (red box) and "2b. design guidelines" (blue box). From "2a", arrows point to "3b. evaluation" (blue box) and "scholarly publications" (red box). From "2b", arrows point to "3a. prototypes" (blue box) and "guidelines" (blue box). "3a. prototypes" leads to "proof-of-concept" (blue box). At the top, "citizen science" and "mobile apps" (yellow boxes) are linked to "proof-of-concept", while "outreach" and "workshops" (yellow boxes) are linked to "guidelines".

Figure 1. Flowscheme of project components and objectives.

An ongoing granted project to investigate concurrent sonification-visualisation of geodata. It will continue for two years.

Sonification :: *Examples*



Loki's pain



Artwork from 2021 where I designed and constructed a dodecahedron aluminium structure to hold 15 loudspeakers. Listeners are seated on a subwoofer. The audio plays a 3D spatialise sonification of recent earthquakes.

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



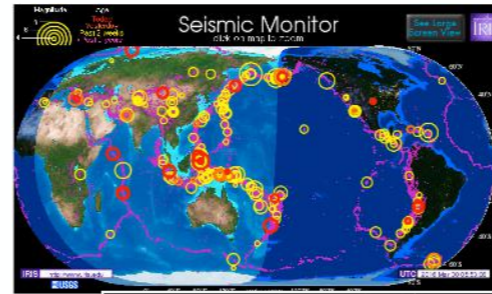
A ladder is essential during the installation!

XLR cable runs between subwoofer and equipment platform



It was a fun experience to build the structure. It now ands in my office while I think about how to use it the next time.

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



The data is retrieved in real-time from the Internet.

Loki's pain

LOKI'S PAIN

Evaluation protocol for participant: _____ (name or nickname)

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

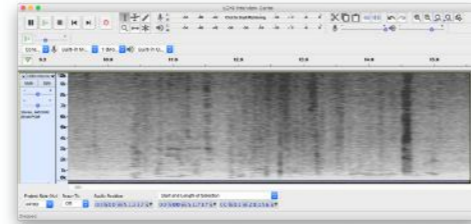
Instructions. Immediately after listening to the whole piece (10 minutes) in one of the setups, please evaluate your impressions, individually and without speaking with your group mates. For each topic below, indicate what the listening experience was like by circling one response.

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

I conducted a small study to investigate listener impressions of the Loki installation, comparing the experience inside the structure against listening on headphones.

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.

	A	B	C	
1	Focus vs. Distraction	Installation "[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]"	Headphones "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]"	Either/both "As for the r as annoyed e distracted in
2	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]"	
3	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]"
4	Expectation		"suddenly there was a moment with a loud part [C2.VI]"	"sometimes t finish, but in is like a puni middle part c
5	Immersivity (sonic)	"sound came from various directions... more immersive [M3.II]", "more immersive for me when sitting 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

Qualitative analysis of the respondents' comments during focus-group interviews.

Loki's Pain

PerMagnus Lindborg

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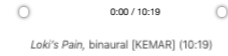
Loki's Pain [NIME Art Installation]

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 shown 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 hand 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 Modabys (IRCAM). Data from IRIS is retrieved from the Internet and pre-processed in R (R Core Team), and then sonified in Max (Cycling74) using virtual cymbals that are spatialised with Spat (IRCAM).



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

PerMagnus Lindborg

SoundLab, School of Creative Media
City University of Hong Kong
Hong Kong SAR
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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 multisensory 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*¹ 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

¹ *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.

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 $\bar{\Gamma}$ -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 (WavePlayer), 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.

Published in NIME and ICAD proceedings (different papers).

Stairway to Helheim

The screenshot shows the website for Soundislands, which has a logo consisting of a soundwave above the text 'SOUNDISLANDS' and the tagline 'CONNECTING WAYS OF HEARING'. The navigation menu includes 'INSTALLATION', 'MUSIC', 'FILM', 'EVENTS', 'PEDAGOGY', and 'ABOUT'. The main content area features two images: one of a person working with large coils of audio equipment in a studio, and another of the Esplanade - Theatres on the Bay in Singapore. Text on the right side of the page reads 'Eight-channel site-specific sound installation PerMagnus Lindborg'. Below the images, there is a section titled 'STAIRWAY TO HELHEIM' with a 'STICKY' label and a date 'ON: 2021-11-10 | IN: 2021, EVENT, INSTALLATION'. The text describes the installation as an eight-channel site-specific sound installation for Soundislands: Re:Sound at ArtScience Museum, Singapore, created by PerMagnus Lindborg in 2021. It is a sonification of meteorological data for Hong Kong covering 138 years, from January 1884 to September 2021, including daily rainfall, temperature, monthly 'hot nights' and 'hot days', and yearly sea level averages in Victoria Harbour. The data was calculated from files provided by the Hong Kong Observatory, totaling 1654 rows. To the right of the text is a sidebar with the text 'Soundislands Festival soundscape strings' and 'text: The Arts House theory', along with a 'Select Category' dropdown menu.

Eight-channel sonification of 138 years of weather data from Hong Kong. This 45-minute piece was designed as an installation in a large, open staircase at ArtScience Museum in Singapore.

Stairway to Helheim

ArtScience Museum, Singapore
Commission, 15-30 Nov. 2021
DACA Dat-Art CityU HK,
22 Feb. - 31 May 2022

138 years of meteorological data
[Hong Kong Observatory]

Year	Month	Hotnights	Holidays	Temp_min	Temp_max	Rain_min	Rain_max	Sealevel
1881	1	0	0	16.9519315	24.3	0.07124032	0.05	1.32777
1881	2	0	0	14.1172434	21.1	3.00344828	32.2	1.32777
1881	3	0	0	18.3435484	24.5	4.79084518	50.6	1.32777
1881	4	0	0	18.8733318	26.8	6.07688657	55.5	1.32777
1881	5	0	0	23.7879908	30.8	7.40322581	67.2	1.32777
1881	6	0	0	26.7	33.8	9.35	65.7	1.32777
1881	7	0	4	17.8805136	24.9	10.7149486	64.1	1.32777
1881	8	0	3	27.6645161	33.4	8.87065724	58.4	1.32777
1881	9	0	1	27.31	33.1	10.4833333	141.0	1.32777
1881	10	0	0	25.1548119	30.7	7.53548307	54.7	1.32777
1881	11	0	0	19.8708667	28.4	1.26649697	23.4	1.32777
1881	12	0	0	15.3482871	21.7	0.06322581	0.05	1.32777
1885	1	0	0	14.8514329	21.7	0.27254865	18.1	1.32777
1885	1	0	0	11.1	16.1	7.44437476	50.9	1.32777

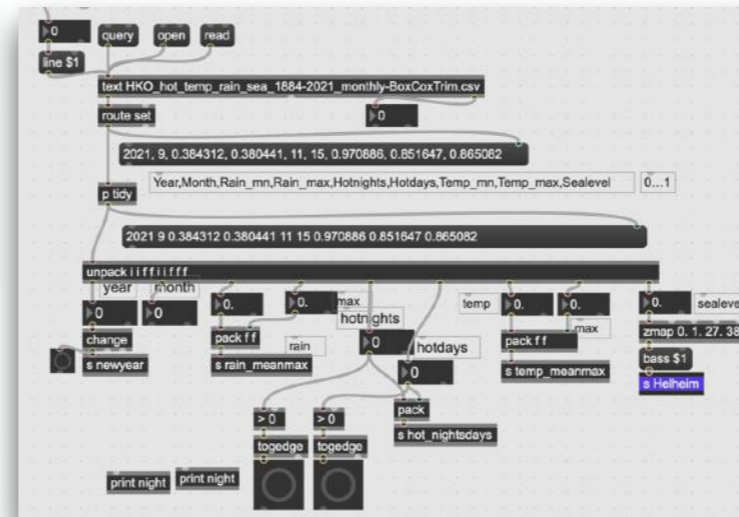
219 samples → 8
categories → 3
sonification layers

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

sonification
(Max)

sea water level → tonality

temperature → original-sawtooth cross-synth



The dataset comes from Hong Kong Observatory. It describes sea level in Victoria harbour, rainfall, temperature, and 'hot nights' since 1881. Data analysis and pre-processing was made in R, and synthesis in Max.

Stairway to Helheim

Per Magnus Lindborg

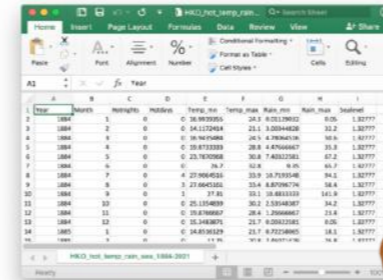
SoundLab, School of Creative Media, City University of Hong Kong
pm.lindborg@cityu.edu.hk

DACA 2022 Proceedings|Catalogue

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



Year	Month	Pressure	Humidity	Temp. min	Temp. max	Rain. mm	Rain. days	SeaLevel
1884	1	0	0	18.903555	24.7	423.23822	0.25	1.82777
1884	2	0	0	14.127244	21.1	3.0294428	32.2	1.82777
1884	3	0	0	16.167448	24.3	4.2364234	34.8	1.82777
1884	4	0	0	19.873333	28.8	4.4763867	35.8	1.82777
1884	5	0	0	23.767008	30.8	7.4022232	37.2	1.82777
1884	6	0	0	26.7	32.8	8.46	38.7	1.82777
1884	7	0	4	27.968453	33.9	16.719248	34.1	1.82777
1884	8	0	3	27.968453	33.8	16.719248	34.8	1.82777
1884	9	0	2	27.8	33.1	16.833333	34.8	1.82777
1884	10	0	0	25.124839	30.2	2.3334387	34.2	1.82777
1884	11	0	0	19.839847	26.4	2.3068867	21.8	1.82777
1884	12	0	0	16.348387	21.7	6.2082238	32.6	1.82777
1885	1	0	0	16.483333	21.7	6.2024865	34.1	1.82777
1885	2	0	0	13.8	19.8	1.82777	34.8	1.82777

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

Sonic material

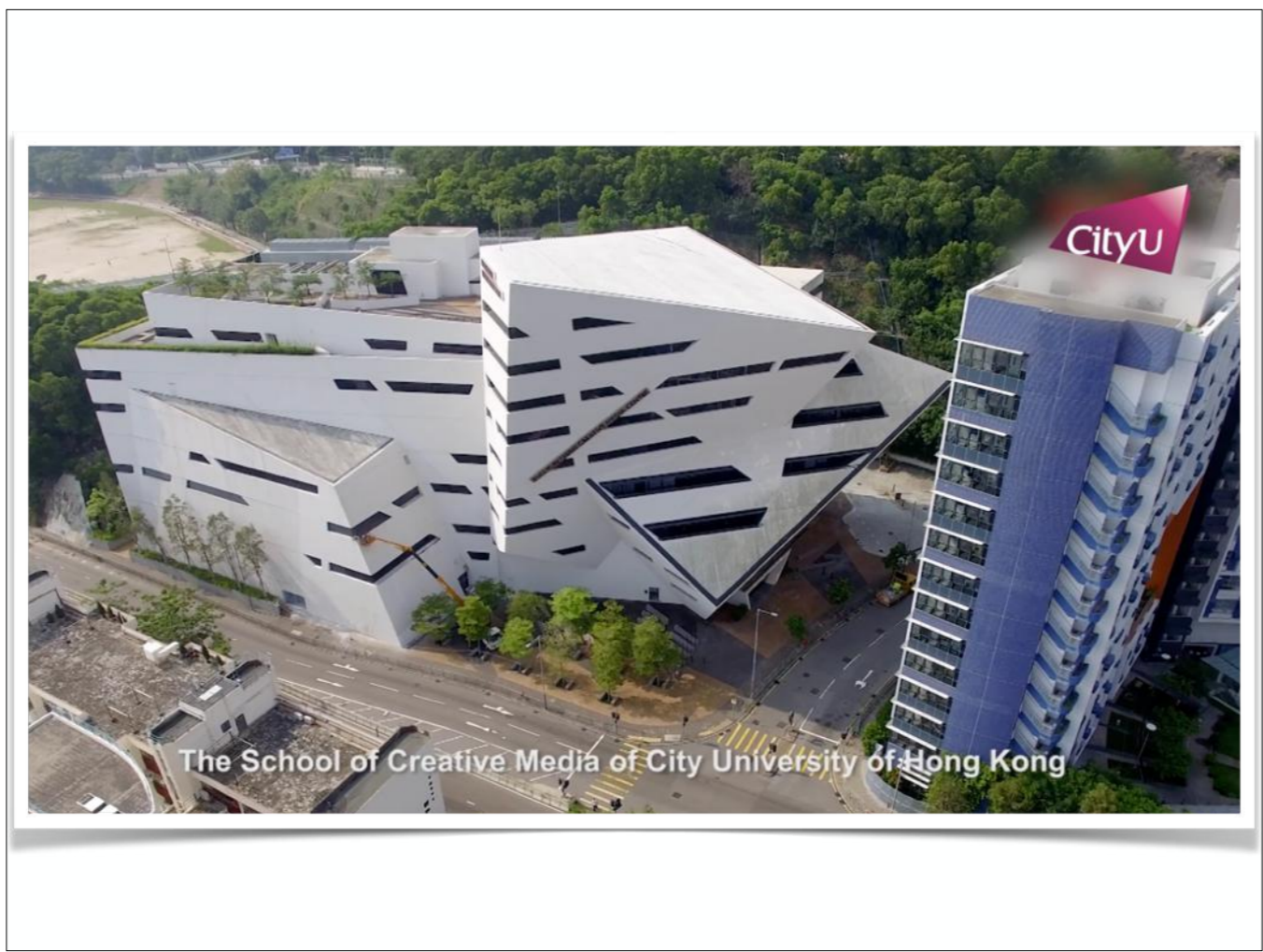
The sonic material was based on action recordings of sound objects such as chairs, bottles, balls, and compact discs, made in October 2021 at [SoundLab](#), City University of Hong Kong, by the



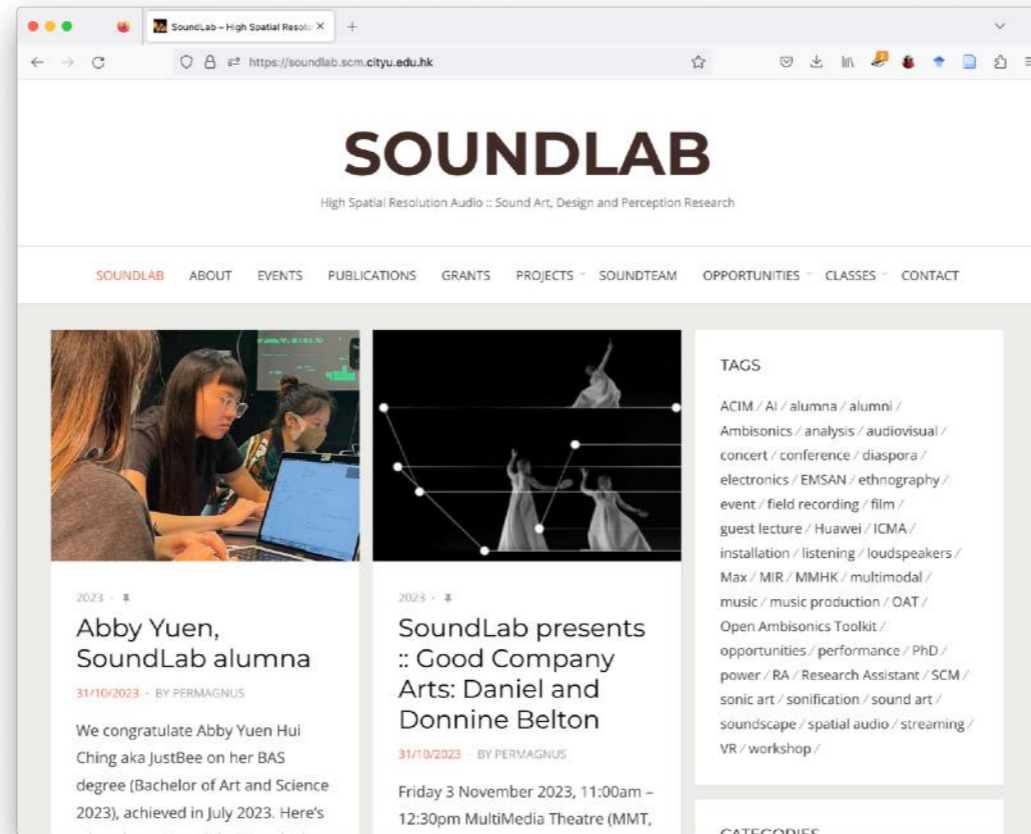
It is described in the DACA proceedings.

Opportunities :: *SoundLab*





Here's an aerial photo of the School of Creative Media.



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

Our SoundLab is now on its third year. We have three faculty, around ten PhDs, and several Research Assistants and undergraduates.

SoundLab



The main rig consists of Genelec IP speakers on a Dante network. We typically arrange them in three concentric rings of 12, 8, 4 speakers. A zenith speaker and two or more subwoofers will be installed in the spring. This creates a hemispheric 3D setup for playback of higher-order Ambisonics pieces and field recordings.

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



SoundLab regularly holds workshops on spatial audio, sonification, music performance, and related topics.



'Sound Objects' is an undergraduate class to explore found stuff to make instruments and perform with them.



Welcome to visit or do research at SoudLab!

Lindborg PM, Caiola V, Chen M, Ciccarelli P, Lenzi S (2023/10, in review). "A Meta-Analysis of Project Classifications in the Data Sonification Archive" Special issue on sonification, Journal of the Audio Engineering Society.

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