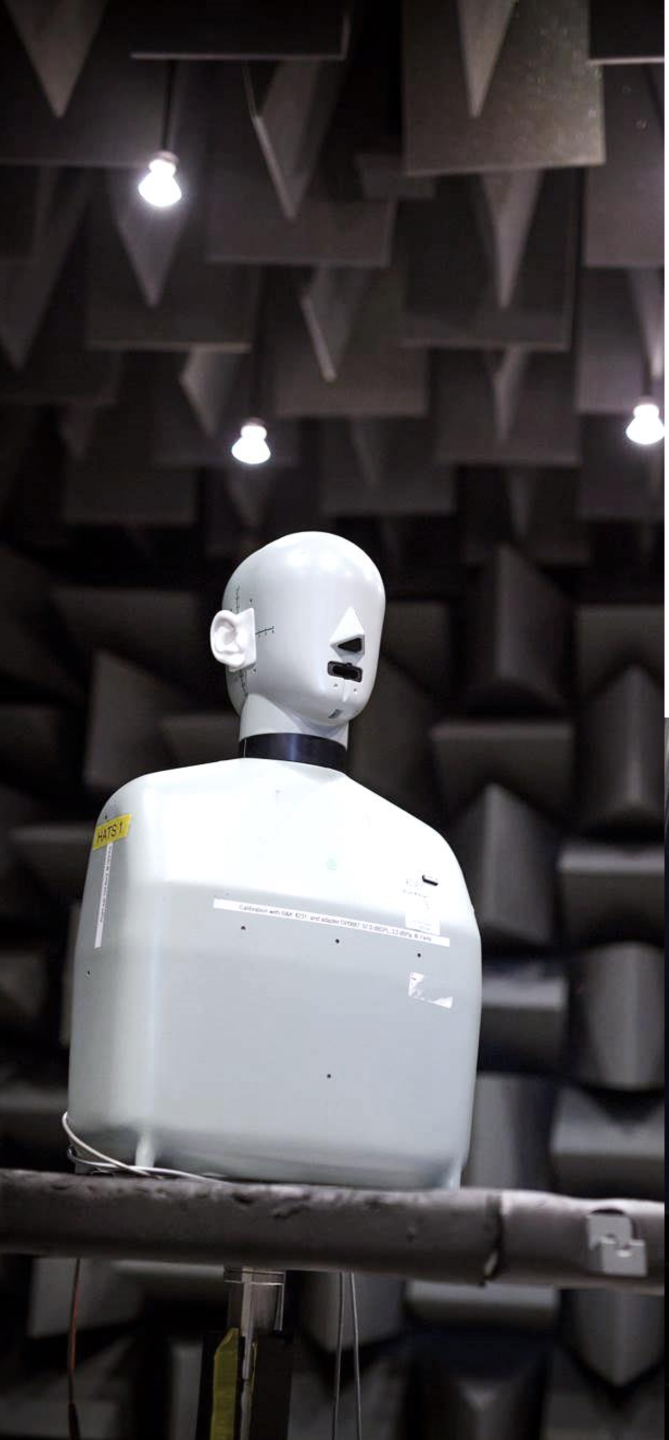

CHBC Center for Hørelse og Balance

Nationalmuseet

Enhancing sonic experiences with multisensory technologies

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Multisensory Experience Lab
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Aalborg University Copenhagen, Denmark

ME LAB

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Assistant professor

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Jesper Andersen
PhD student

Emil R. Høeg
PhD student

Lui A. Thomsen
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Muriel Algayres
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Mark Dourado
PhD student

Razvan Paisa
PhD student

Lasse E. Sørensen
Research assistant

Daniel Reipur
Research assistant

Francesco Ganis
Ph.D. student

+ Master students

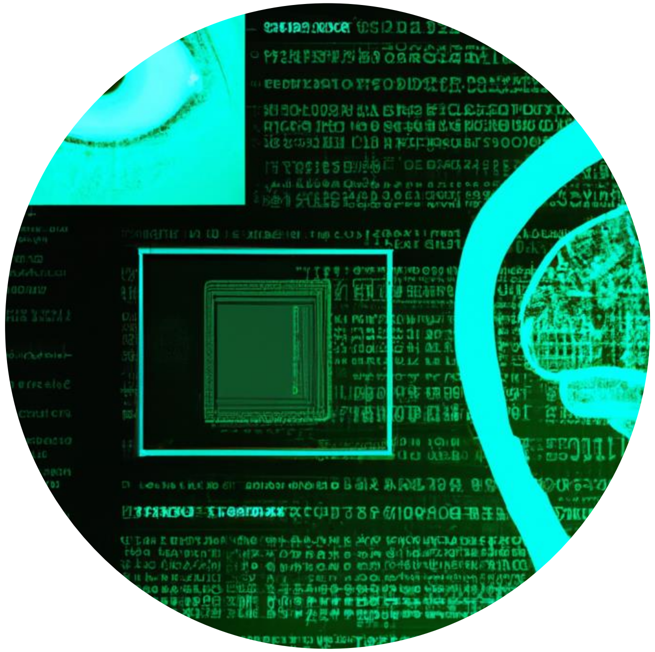
+ Visiting researchers

+ Bachelor students



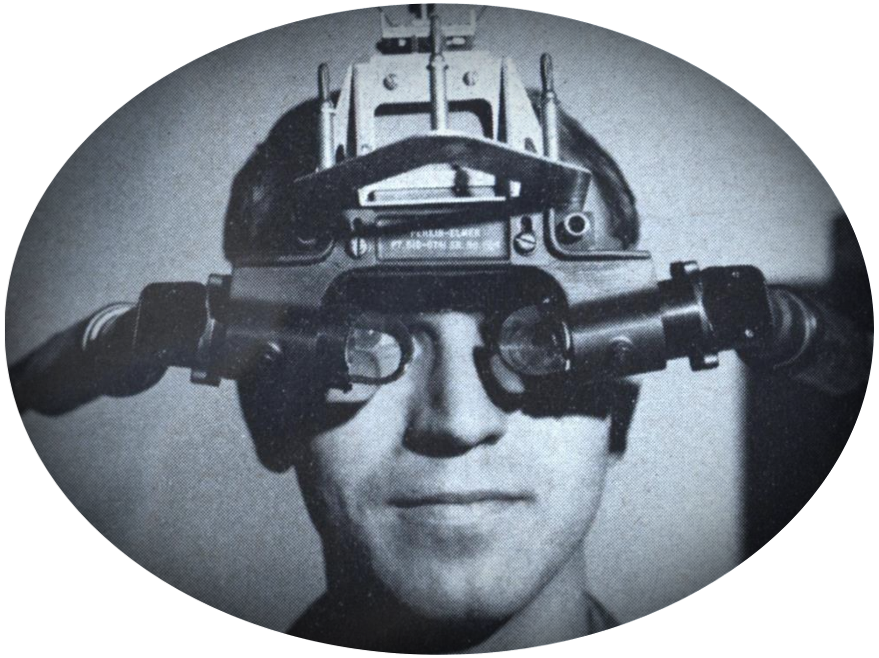

Three types of research

Basic research



Applied research

Cultural applications



1968

2015


haptx

Benogo 2002-2005

Traditional testing methodologies lack ecological validity

Need to develop methods that better address challenges that hearing impaired encounter in real life.

Audio Engineering Society

Conference Paper

Presented at the International Conference on Audio for Virtual and Augmented Reality, 2022 August 15–17, Redmond, WA, USA

VR Test Platform for Directionality in Hearing Aids and Headsets

Jesper Udesen

GN Audio, Lautrupbjerg 7, 2750 Ballerup, Denmark

Correspondence should be addressed to Jesper Udesen (judesen@jabra.com)

ABSTRACT

This paper describes how Virtual Reality (VR) is used to test the directionality algorithms in headsets and hearing aids. The headset directionality algorithm under test is based on anechoic chamber measurements of microphone impulse responses from a physical headset prototype, with 8 MEMS microphones. The algorithm is imported into Unity3D using the Steam Audio plugin. Audio and video are recorded in different realistic environments with the 4^{th} order ambisonic Eigenmike and the 360-degree Garmin Virb camera. Recordings are imported into Unity3D and audio is played back through headphones using a virtual speaker array. Finally, the combined system is evaluated and tested in VR on human participants.

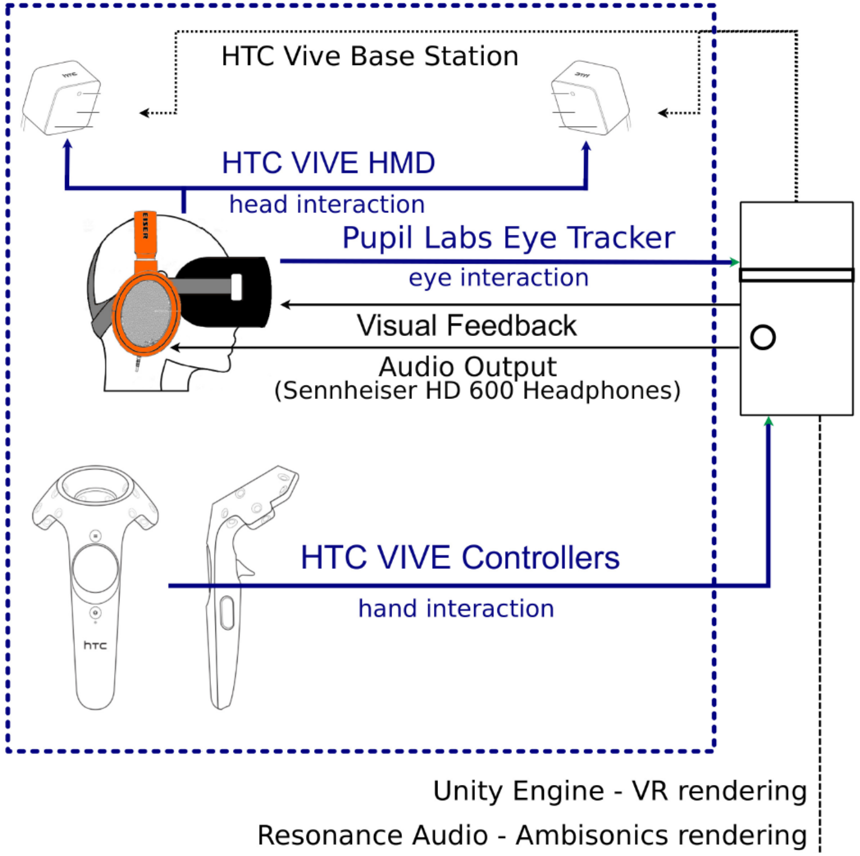
1 Introduction

Hearing aids and headsets (in the following called hearing devices) have traditionally been tested in laboratory conditions and field tests on real users. The laboratory has the benefit of being a controlled environment where the hearing device performance can be carefully investigated e.g., on a dummy head in an anechoic chamber. However, the controlled environment comes at a price. The laboratory tests are often far from the reality a human user will experience with the hearing device on his ears and the ecological validity is low. Therefore, the laboratory tests are supplemented with field tests where real humans test the hearing devices in everyday usage. Here, there is a high degree of ecological validity, but the test data will be subject to noise sources that are difficult to control and quantify. Hence the field test data are challenging to reproduce. Furthermore, the field tests are often conducted a long time (sometimes years) after the first laboratory tests. This makes it time-consuming and expensive to optimize a given hearing device if several cycles of laboratory tests and field tests are needed.

It has been proposed to close the gap between unrealistic laboratory tests and uncontrolled field tests using an advanced speaker array system combined with a VR headset (e.g.,[1][2]). The playback audio can be simulated or prerecorded using a higher-order ambisonic (HOA) microphone. Visual playback in the VR headset must match the audio and can be prerecorded using a 360-degree video camera. This setup requires the test subject to sit in the center of the speaker array with the hearing device on his ears. However, such speaker array systems are often costly and they should ideally be placed in an anechoic chamber. Also, the human test subject must wear a real physical hearing device which has to be designed and built; a process that can take several months and involves hours of laboratory testing.

This paper investigates the possibility to circumvent the expensive speaker array and the physical construction of the hearing device by using a *virtual* hearing device and a *virtual* speaker array

Multi-talker scenario, selective auditory attention voice-pairing task



- Geronazzo, M., Vieira, L. S., Nilsson, N. C., Udesen, J., & Serafin, S. (2020). Superhuman hearing-virtual prototyping of artificial hearing: a case study on interactions and acoustic beamforming. *IEEE transactions on visualization and computer graphics*, 26(5), 1912-1922.

CHBC Center for Hørelse og Balance

2021

CHBC Center for Hørelse og Balance

Lone P.

Lone J.

Lærke

Nete

Evaluating the app

Focus group meeting

Observations in school

Social well-being

Dialogue meeting with local speech and language pathologists

Lyt igen 2021-2023

VELUX FONDEN

CHBC Center for Hørelse og Balance

AALBORG UNIVERSITET

Decibel BØRN OG UNGE MED HØRETAB

Goal: To train children and adolescents with hearing loss to navigate in different listening situations

Participatory design

- VR-app developed by Multisensory Experience Lab, AAU and Decibel
  - Four children with HL co-created development of the VR-app
  - Two scenarios: Music museum and
    school yard (hide-and-seek sound play)

VELUX FONDEN Decibel BØRN OG UNGE MED HØRETAB AALBORG UNIVERSITET CHBC Center for Hørelse og Balance

VR game

VELUX FONDEN

Decibel
BØRN OG UNGE MED HØRETAB

AALBORG UNIVERSITET

CHBC Center for Hørelse og Balance

To give families, teachers, speech and language pathologists around children and adolescents knowledge and the necessary tools to optimise social and academic inclusion.

- 2 year project period – September 2021 – September 2023
- 22 children, aged 8-12 year
  - 16 children fitted with bilateral cochlear implants
  - 5 children fitted with bilateral hearing aids
  - 1 child with bimodal hearing solution; i.e. one hearing aid and one cochlear implant
  - VR training with the LYT IGEN-app twice a week for 3 months

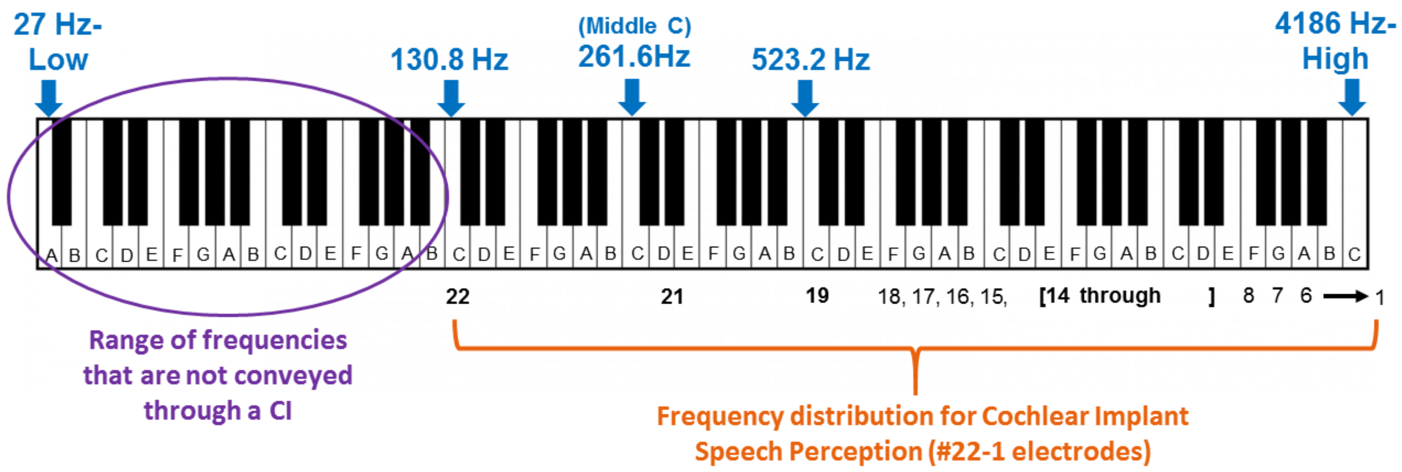

27 Hz-
Low
130.8 Hz
(Middle C)
261.6Hz
523.2 Hz
4186 Hz-
High
A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C D E F G A B C
22
21
19
18, 17, 16, 15,
[14 through]
8 7 6 → 1
Range of frequencies
that are not conveyed
through a CI
Frequency distribution for Cochlear Implant
Speech Perception (#22-1 electrodes)

Table 3: Per cent correct: individual melody items

Melody title	Category	Normal hearing % Correct	Normal hearing Rank	CI recipients % Correct	CI recipients Rank
Here Comes the Bride	Rhythmic	97.22	1	52.75	1
Frere Jacque	Arrhythmic	97.22	2	25.00	5
Star Spangled Banner	Rhythmic	96.23	3	27.91	4
Rock-a-Bye Baby	Rhythmic	94.45	4	0.78	12
Row, Row, Row	Rhythmic	92.45	5	31.01	2
Twinkle, Twinkle	Arrhythmic	91.96	6	16.13	7
Happy Birthday	Rhythmic	88.89	7	30.68	3
Yankee Doodle	Arrhythmic	88.68	8	5.60	8
America	Arrhythmic	77.36	9	23.85	6
On Top of Old Smokey	Arrhythmic	71.70	10	1.55	11
Jolly Good Fellow	Rhythmic	66.67	11	5.56	9
Down in the Valley	Arrhythmic	36.11	12	4.30	10

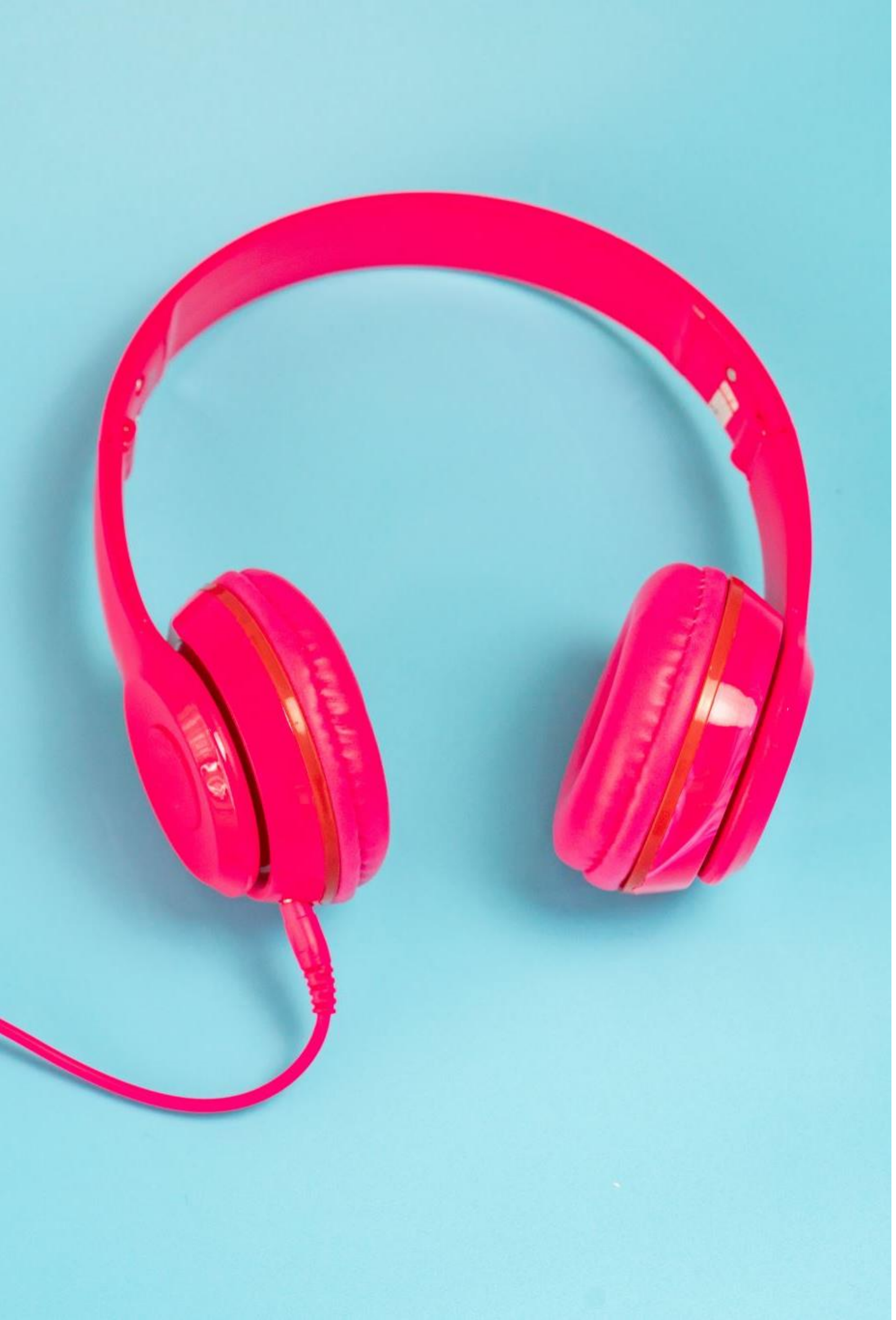
Gfeller, K., Turner, C., Mehr, M., Woodworth, G., Fearn, R., Knutson, J. F., ... & Stordahl, J. (2002). Recognition of familiar melodies by adult cochlear implant recipients and normal-hearing adults. *Cochlear implants international*, 3(1), 29-53.

Challenges

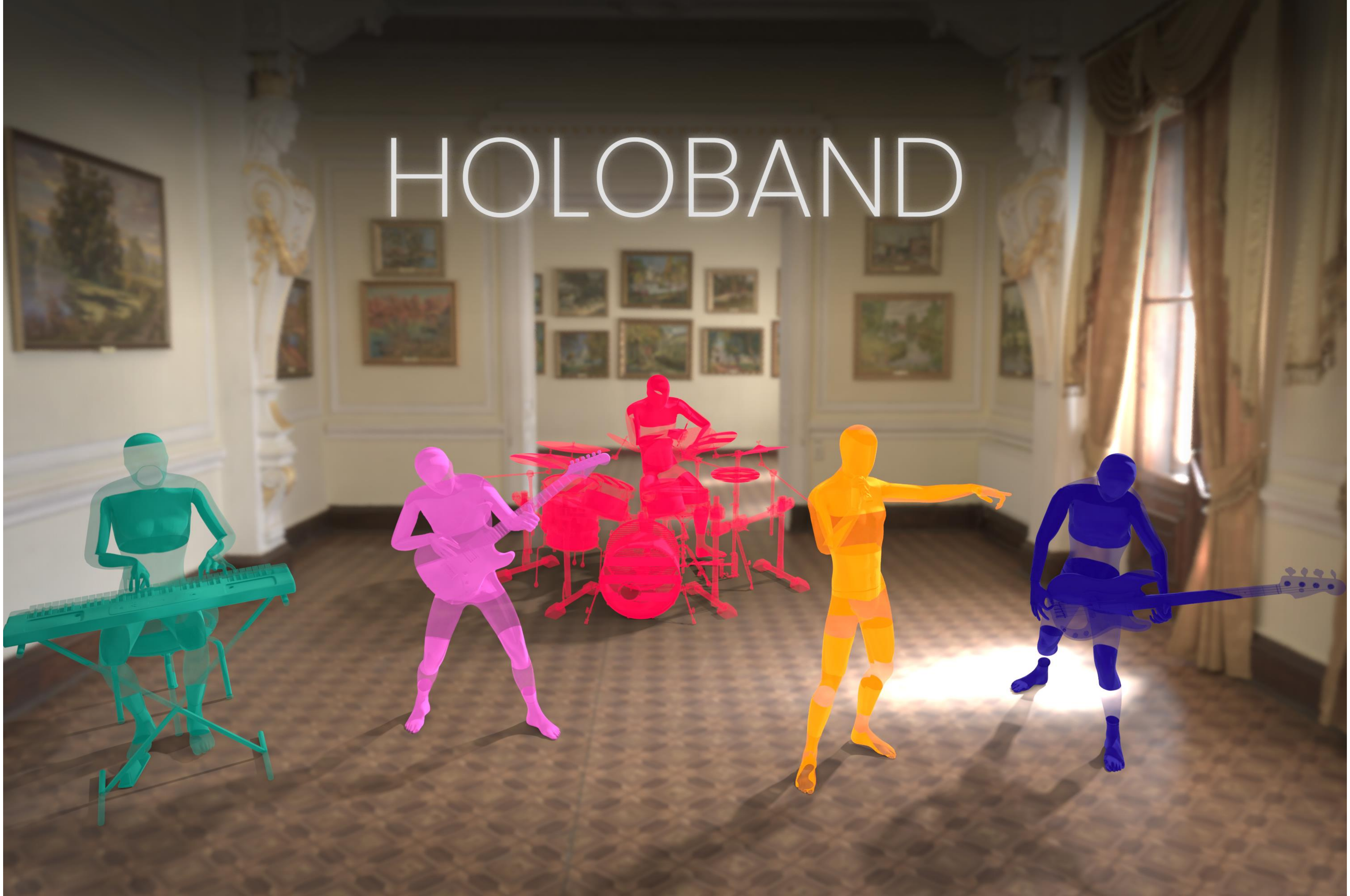
Melody recognition

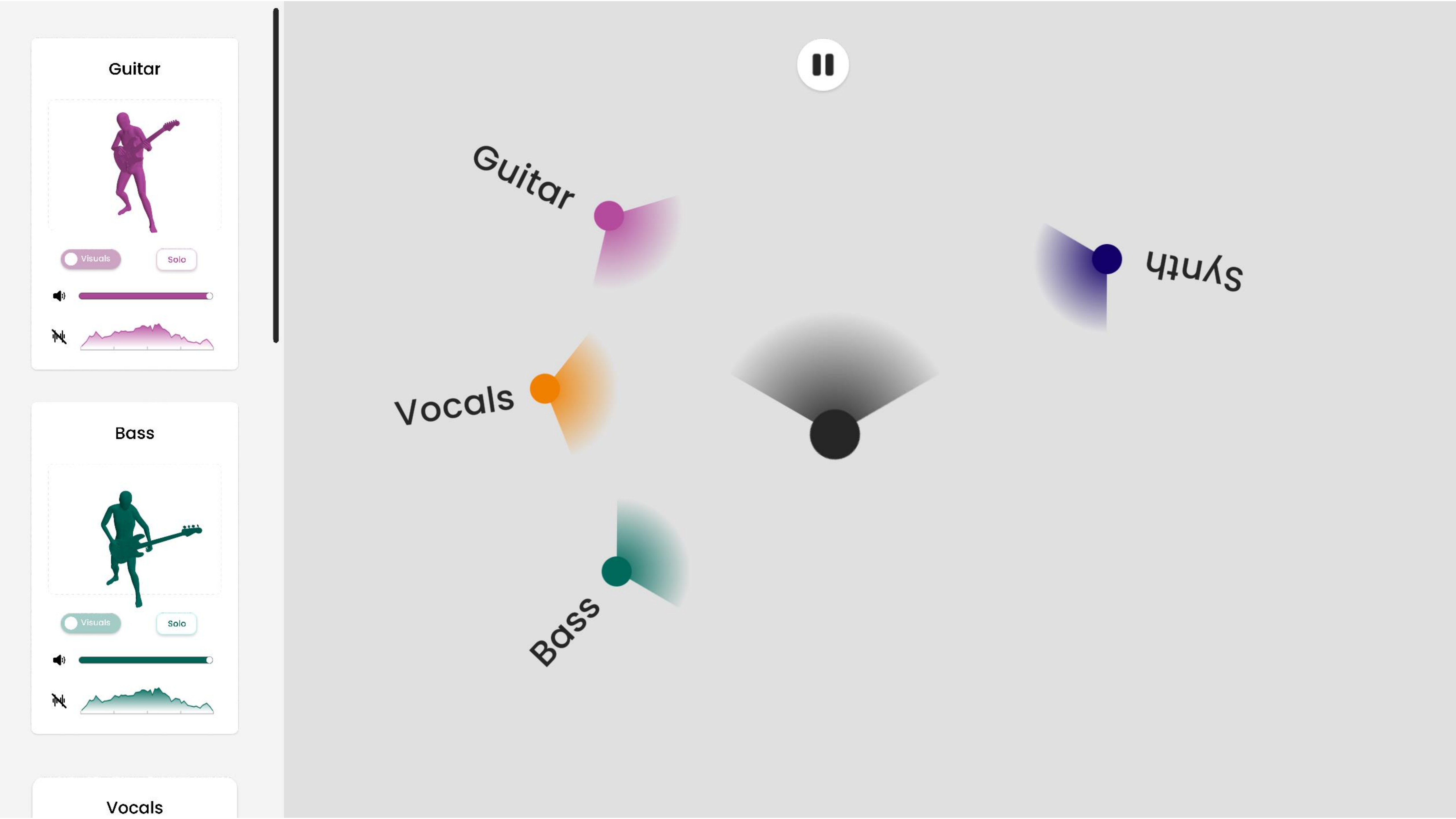

Sound localization

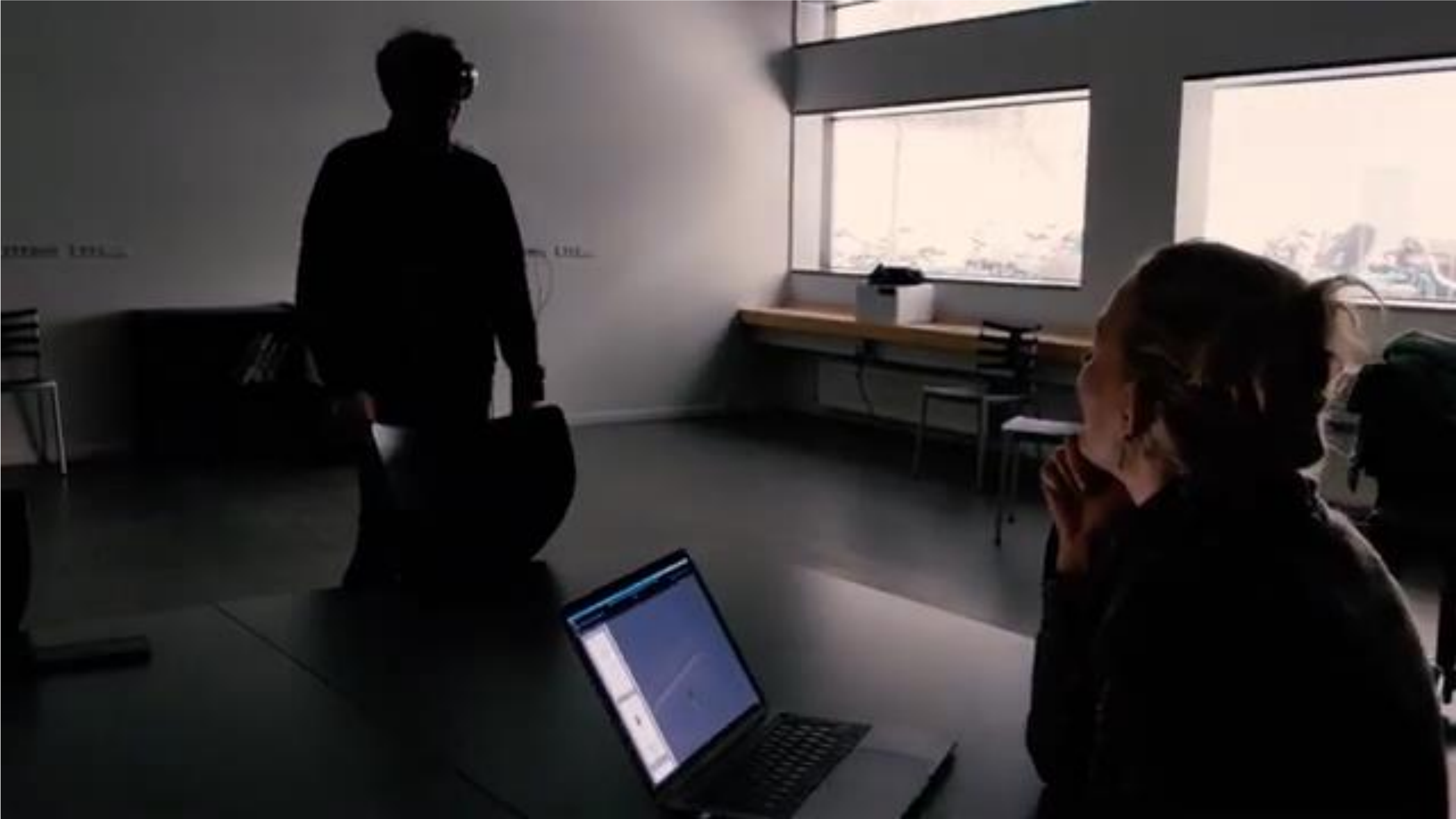
Timbre recognition



- Enjoyment can improve with music training, a lot of focused listening, and changing expectations.
- The incoming signal doesn't change, but the brain 'learns' to use the incoming sound more effectively. This is called neuroplasticity.


HOLOBAND


Guitar
Visuals
Solo
Bass
Visuals
Solo
Vocals
Guitar
Synth
Vocals
Bass



Danish music museum

Nationalmuseet

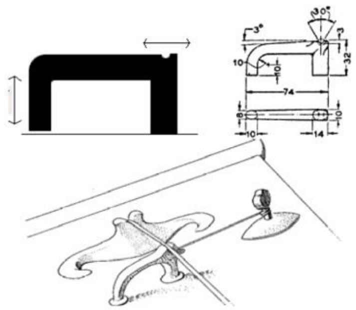

Musikmuseet

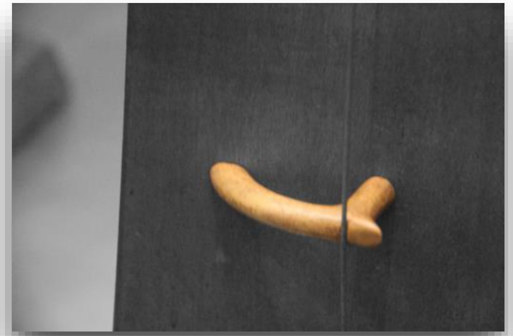
Question: The museum of musical instruments has several ancient instruments.
How can you enable visitors to interact with the instruments without touching them?

Which instrument is this?

Tromba Marina

- Bowed string instrument
- Rattling bridge






MULTISENSORY EXPERIENCE LAB


M.E. LAB

CoolHear Worskhop

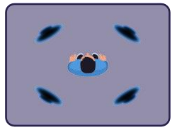
live performance
multisensory workshop
interactive demos

19^{th} April - 3.00 to 5.00 PM

ROYAL DANISH ACADEMY OF MUSIC
Rosenørns Alle 22, 1970 Frederiksberg

HoloBand
Augmented reality for perceptual music training
Balázs Iványi, Christian Tsalidis, Scott Naylor, Truls Bendik Tjemsland

Music trainining in VR
Vitual Reality application for training listening to music
Sine Marie Kromann Kristiansen, Emil Sønderskov Hansen



Name the instrument
Listening experiment where the system helps to identify what instruments are playing in a music piece
Doga Buse Cavdir, Francesco Ganis

Uncharted Chants
Mobile game for musical perception training
Erik Frej Knudsen, Jonas Siim Andersen, Helmer Nuijens

Lyt igen
Empowers young people with hearing loss to reach their full potential using VR
ME-Lab, CHBH and Decibel

VAM
High fidelity vibrotactile actuator
Razvan Paisa

Tickle Tuner
Haptic cellphone cover for musical training
Francesco Ganis

Effects of spatialization
Listening experiment to examine how extreme spatialization influences musical appreciation and instruments segregation in a string quartet
Jesper Andersen

Multisensory live music
Bass and voice duo can be felt in the entire body through custom designed furniture
Antonia Barišić, Peter Williams, Razvan Paisa

For more information and booking
melcph.create.aau.dk/coolhear-workshop

Contact us

Stefania Serafin
sts@create.aau.dk

Lone Marianne Percy-Smith
lone.percy-smith@regionh.dk

Event organized by

AALBORG UNIVERSITY · ME LAB · CHBC Center for Hørelse og Balance · REGION H Rigshospitalet · THE ROYAL DANISH ACADEMY OF MUSIC

In collaboration with

Stanford University · CCRMA

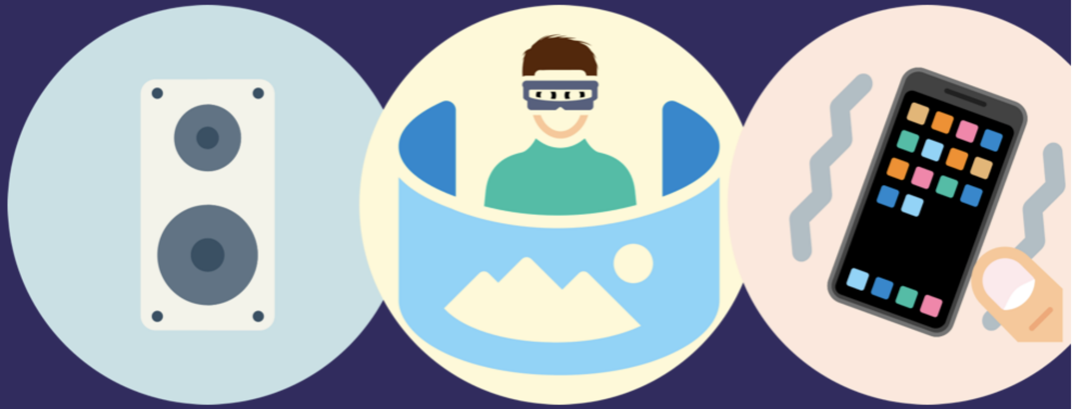
HEAR FIRST

Sound & Haptics projects from the ME Lab Aalborg University

Home Projects About us Partners

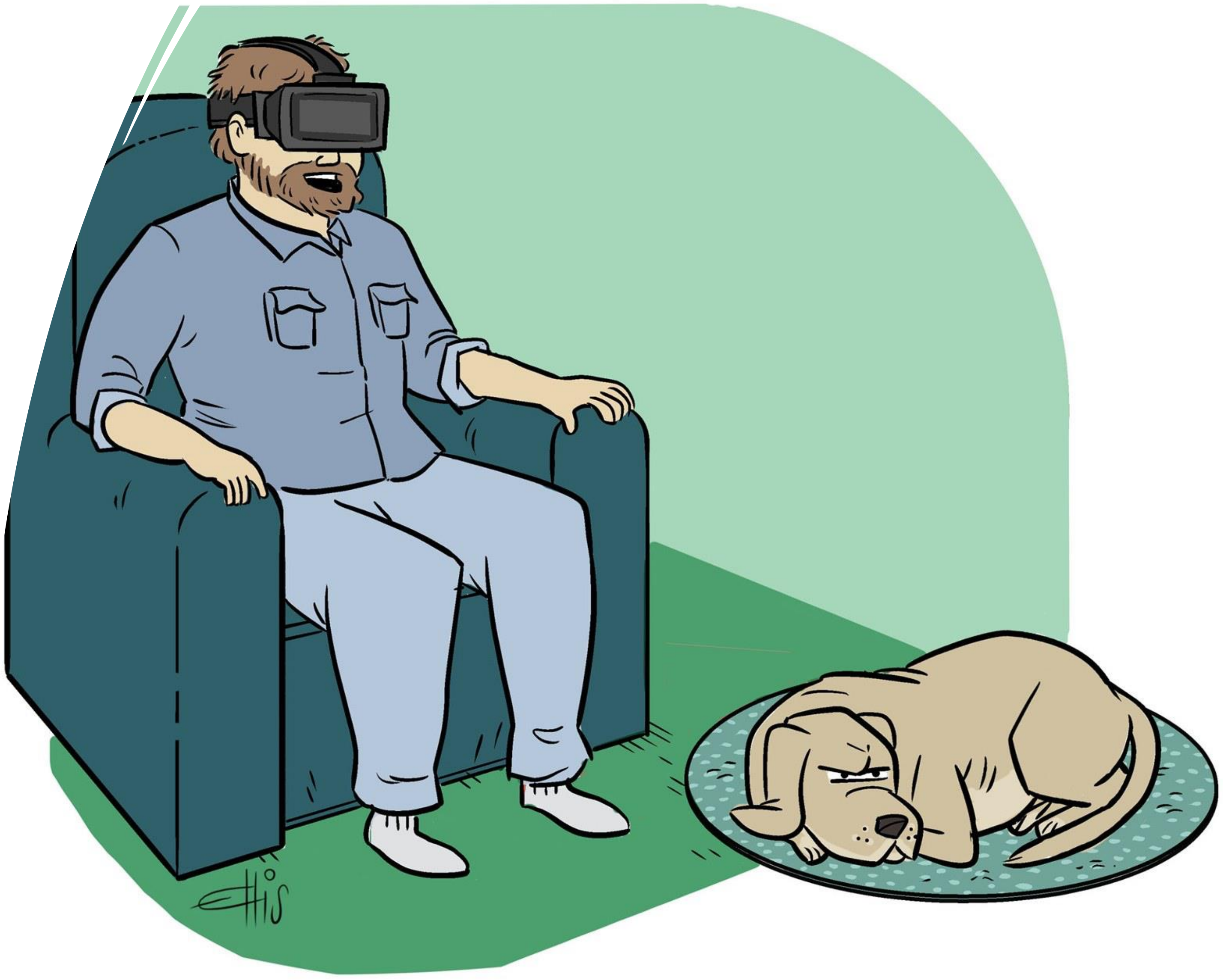
OUR WORK

Our team is working on new techniques that aim to help hearing impaired people with the most recent and advanced technologies such as augmented reality and haptics.



https://hearfirst.create.aau.dk

What are the main challenges when taking devices from the lab to the clinic? What about public spaces?
What about home?



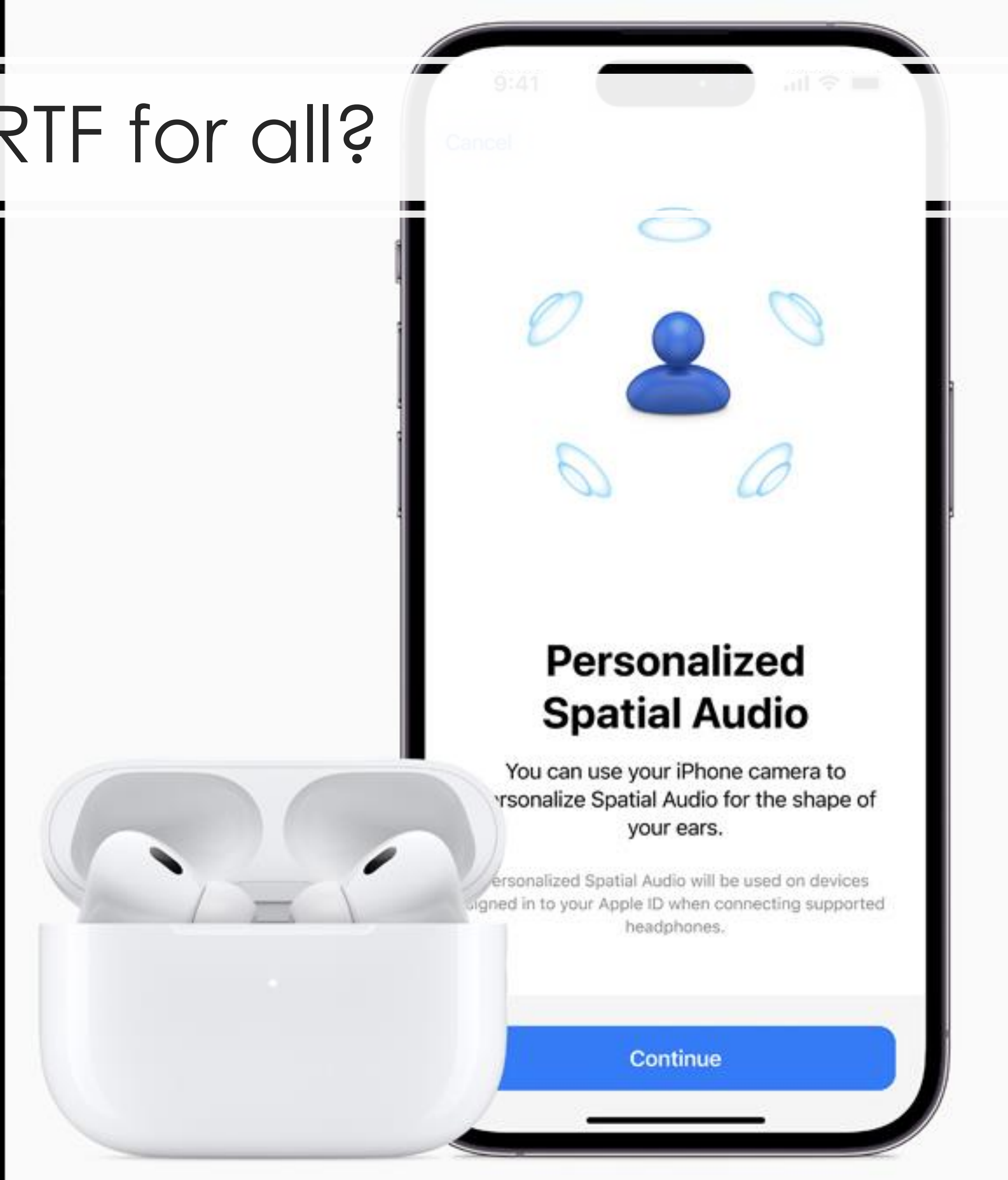
“It’s like I’m actually walking my dog!”

Hardware

Visual displays

Auditory displays

Software: HRTF for all?



AALBORG UNIVERSITET

IT'S A DIVE

INDIVIDUAL THREE-DIMENSIONAL SPATIAL AUDITORY DISPLAYS FOR IMMERSIVE VIRTUAL ENVIRONMENTS

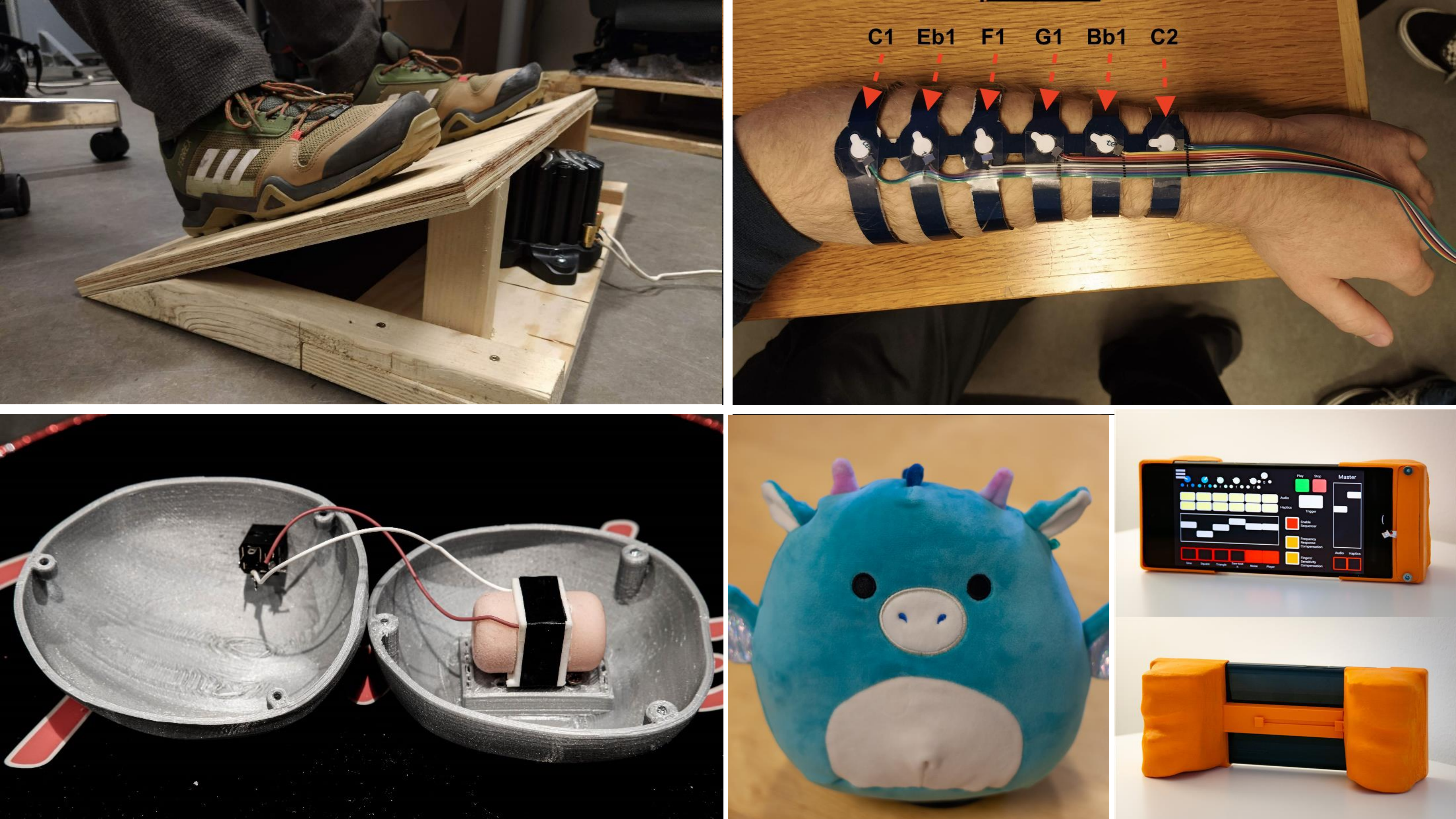
This project is fundend by the European Union

Spagnol, S., Miccini, R., Onofrei, M. G., Unnthorsson, R., & Serafin, S. (2021). Estimation of Spectral Notches From Pinna Meshes: Insights From a Simple Computational Model. *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, 29, 2683-2695.

Interactions

VIVE

oculus

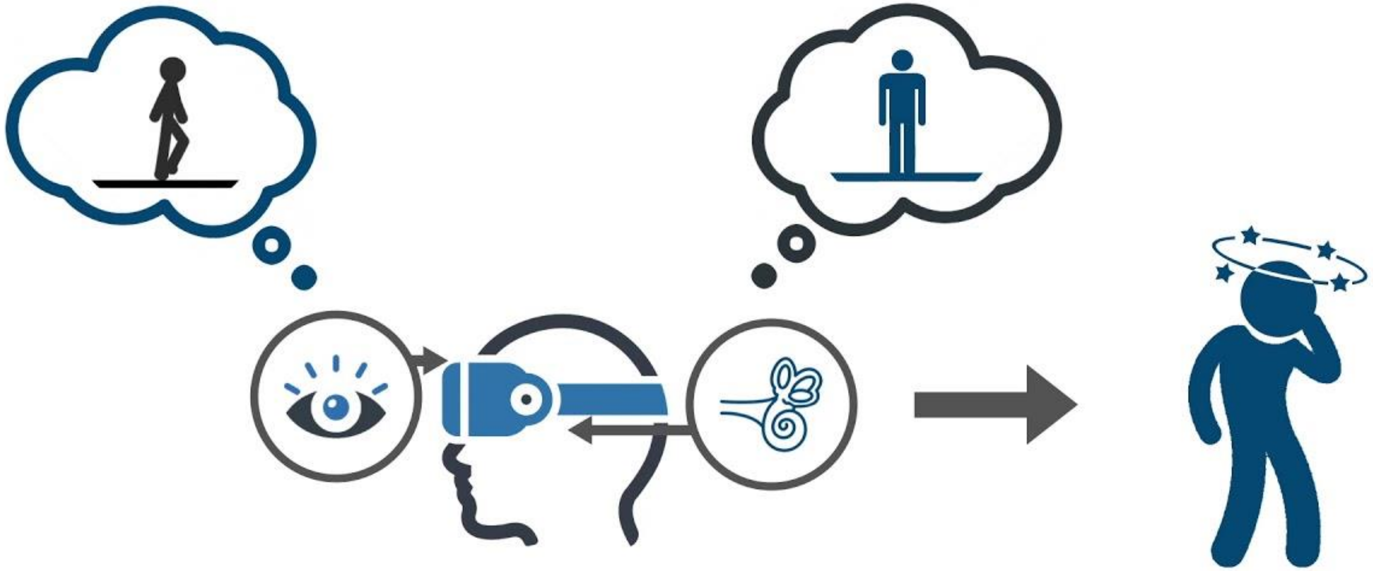

C1
Eb1
F1
G1
Bb1
C2
Master

Ambeo

Insta 360 pro

Participatory design approach

How to cope with cybersickness?

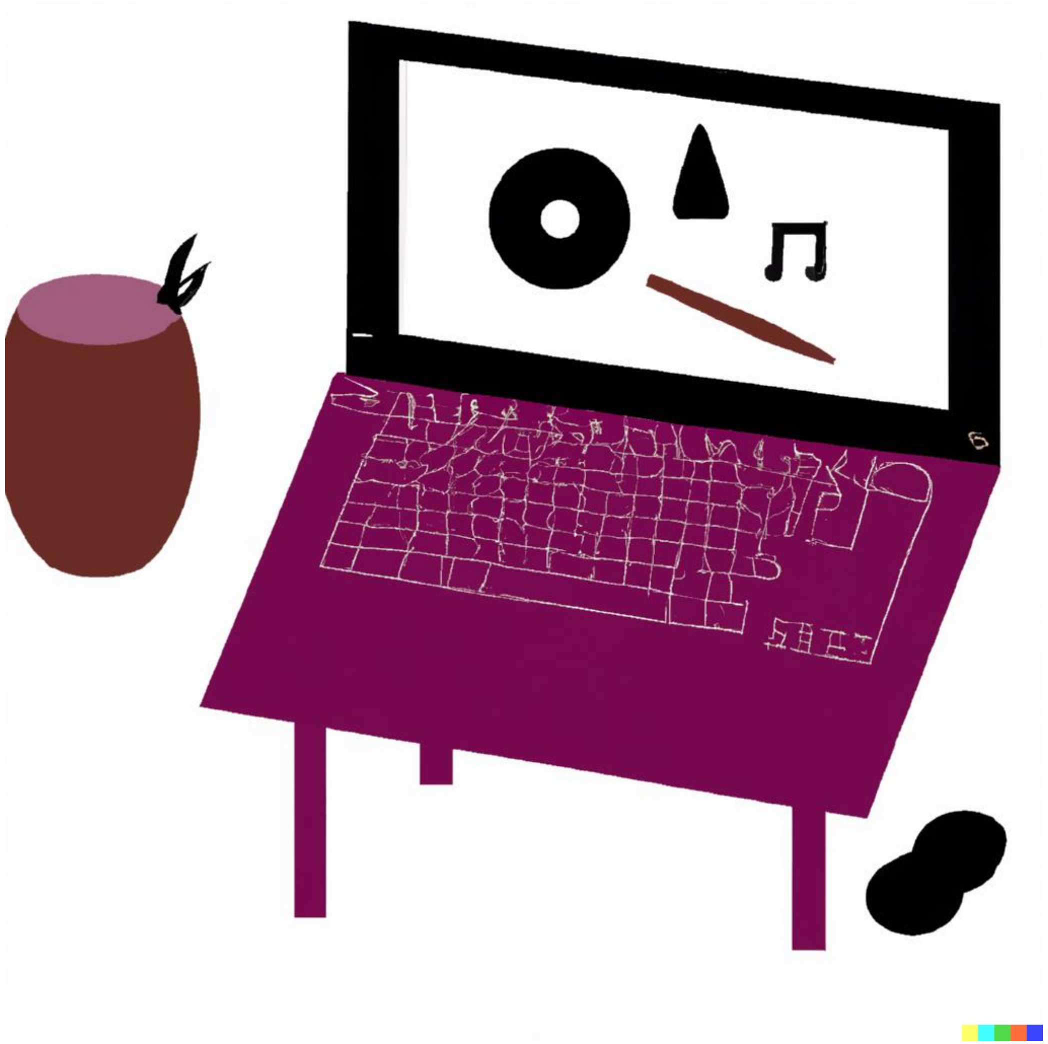


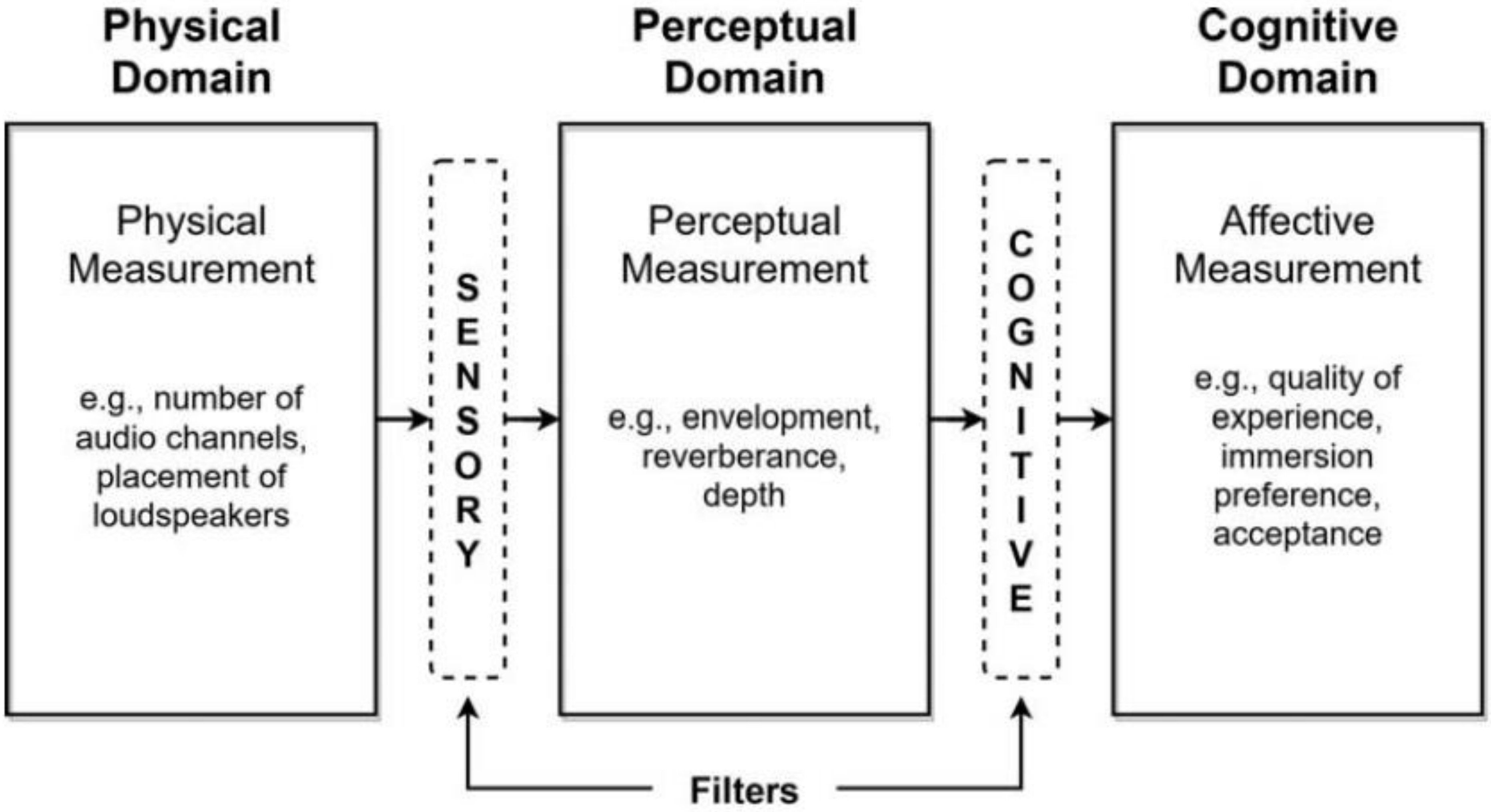
Research pointed out that it is the sensory mismatch between visual and vestibular system that causes sickness and discomfort.

How can we cope with (listening) fatigue?

Personalization

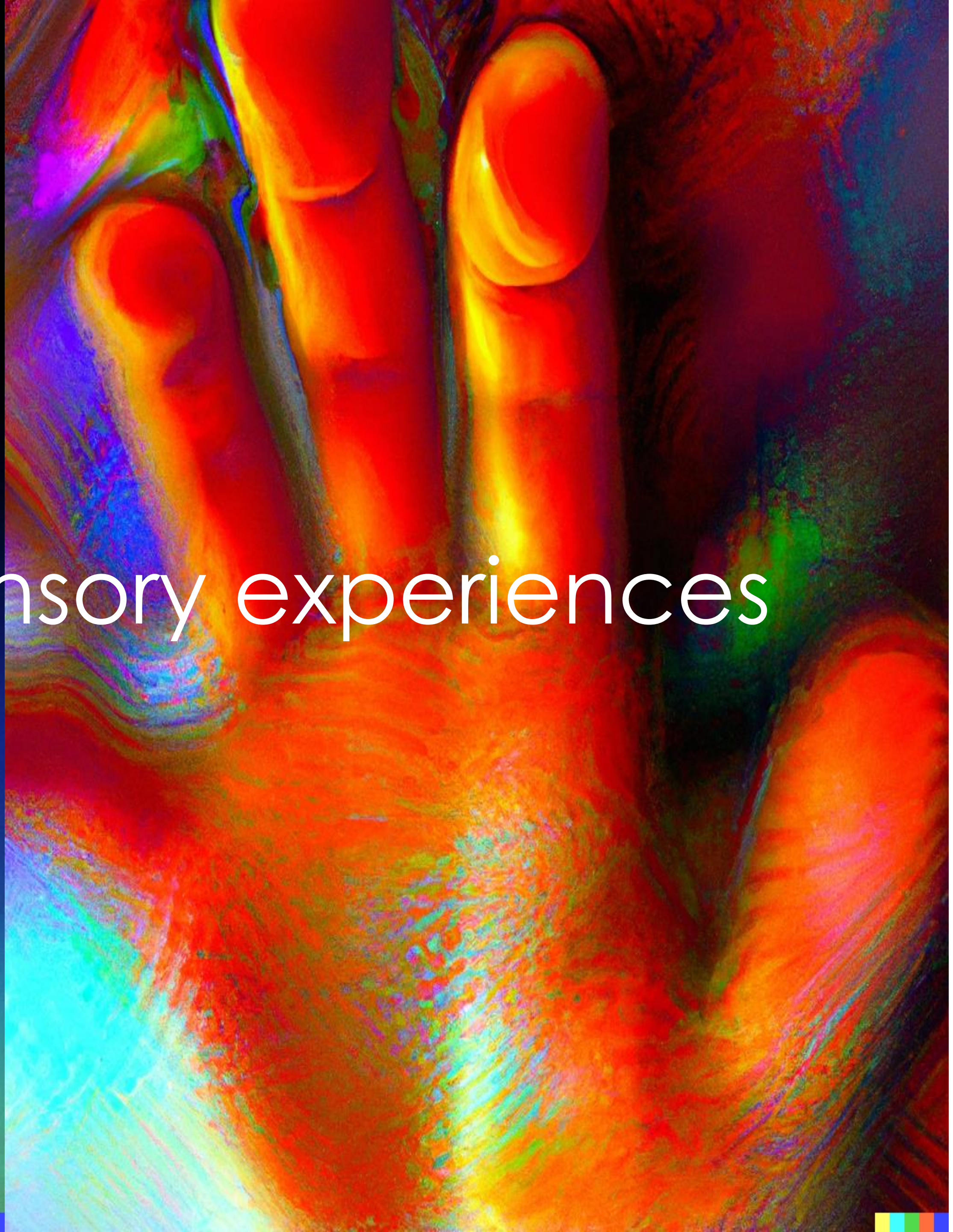
What can we measure?





S. Bech and N. Zacharov, *Perceptual Audio Evalua- tion: Theory, Method and Application* (Wiley, Chichester, UK, 2006).

Measuring multisensory experiences



Thanks!

M.E. LAB

CHBC Center for Hørelse og Balance




Nationalmuseet


GN Foundation

VELUX FONDEN

Questions?

INTERFOND

CHR AUGUSTINUS FABRIKKERS FOND
AUGUSTINUS FONDEN
STIFTET 25. MARTS 1942

AD NYE VEJE
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REGION H

Rigshospitalet