DEGA SYMPOSIUM:
Interactive auralization
for the planning of rooms

BINAURAL TECHNOLOGY FOR THE AURALIZATION OF ROOMS

Fabian Brinkmann

Technische Universität Berlin
berlin
audiokommunikation

Sound field synthesis vs. binaural synthesis

Sound field synthesis (SFS)

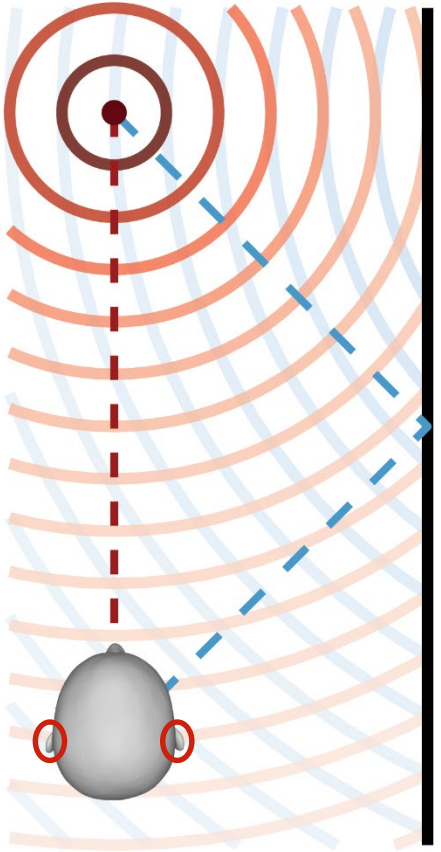
Simulate sound field over an extended area

+ Multiple listeners
+ Free sound field exploration
+ Individual simulation
- Lots of loudspeakers
- Limited bandwidth
- Acoustically treated room

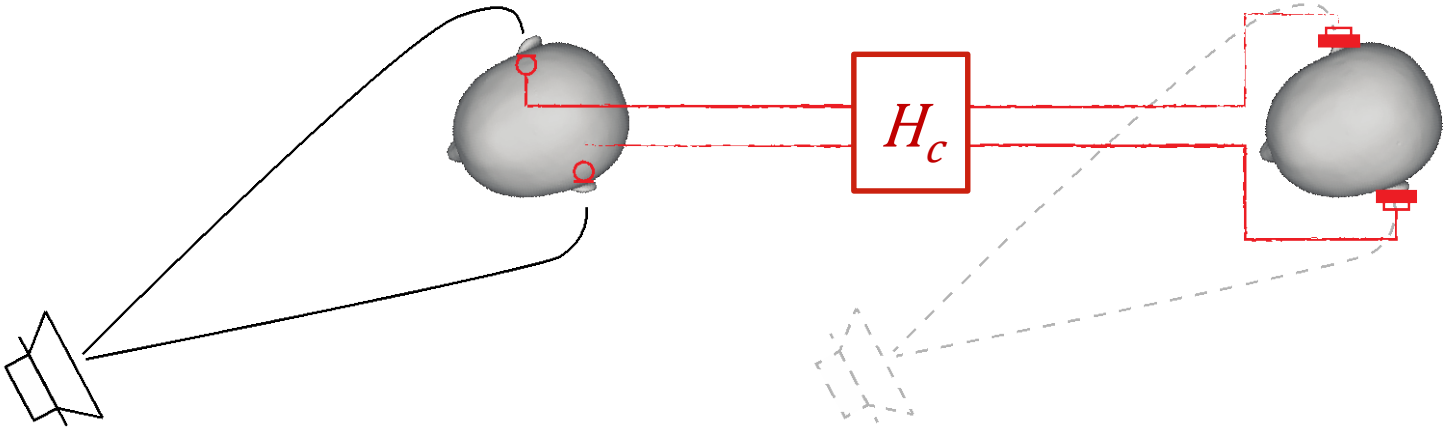
Binaural synthesis

Simulate sound pressure at the ear

- Single listener
- Fixed listening position
- Non-individual simulation
+ Pair of headphones
+ Full bandwidth
+ Any room
+ Virtualization of SFS

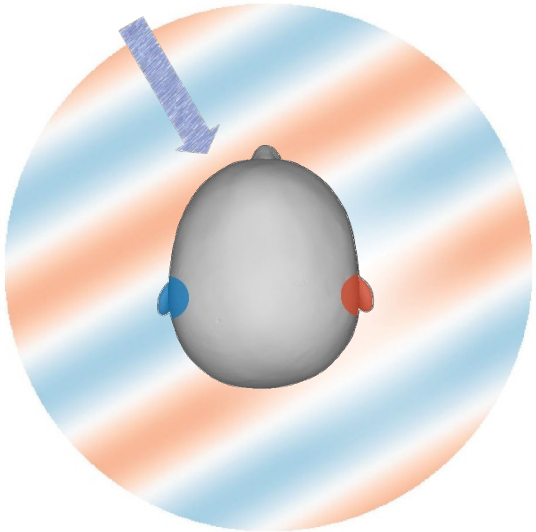


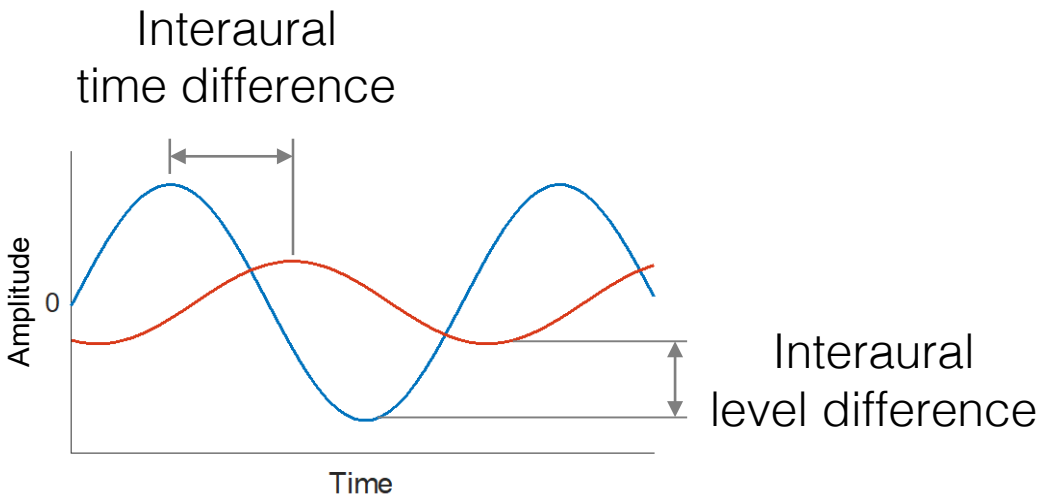
Binaural Technology: How it works



Møller (1992). Fundamentals of binaural technology, *Applied Acoust.* 36, 171–218.

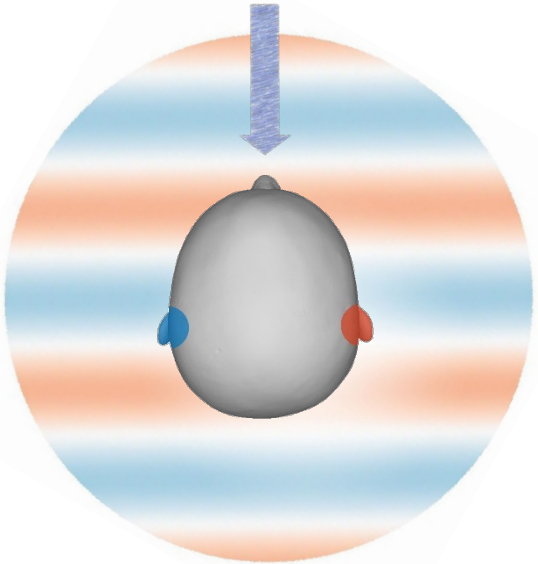
Binaural Technology: Why it works

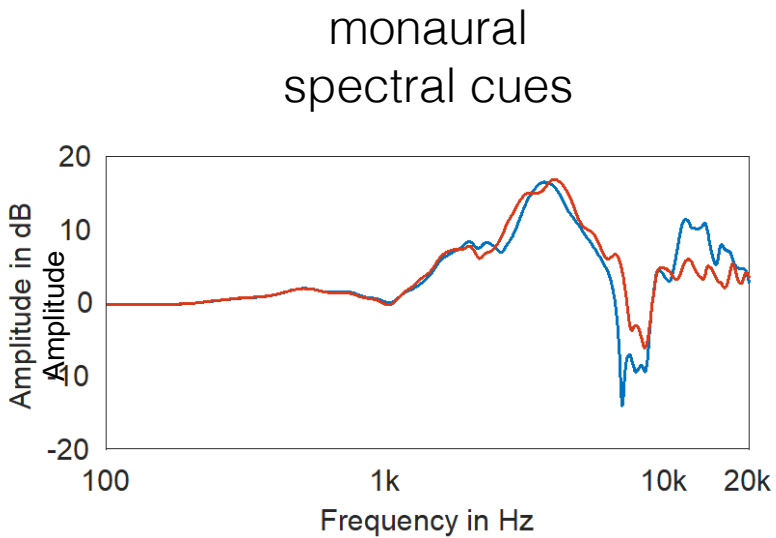




Blauert (1997). *Spatial hearing. The psychophysics of human sound localization*, (MIT Press, Cambridge, Massachusetts)

Binaural Technology: Why it works





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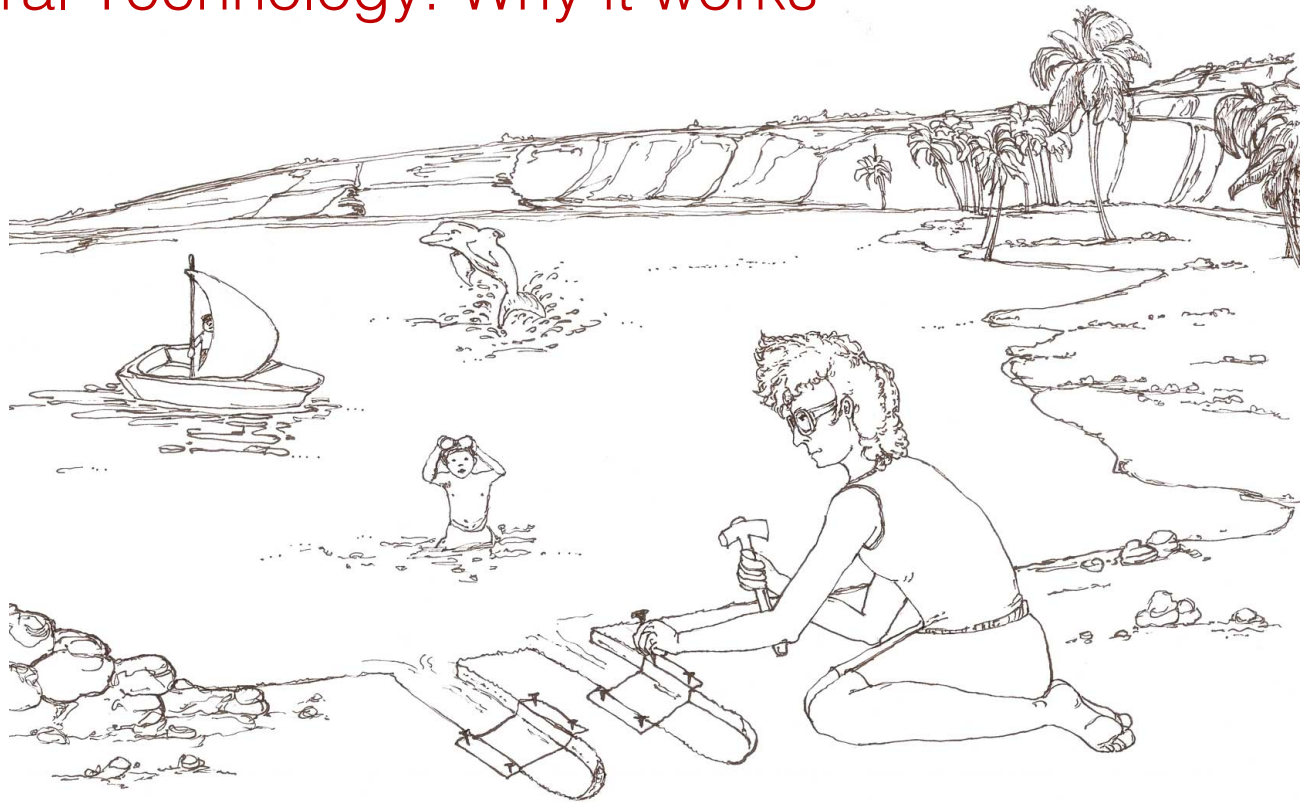
Binaural Technology: Why it works

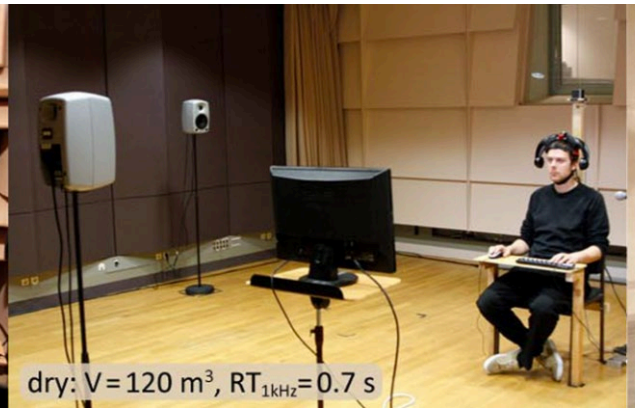


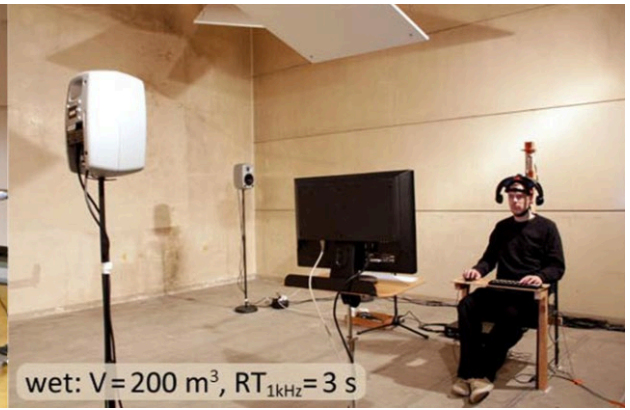
after A. S. Bregman (1994): Auditory scene analysis, MIT Press, Cambridge, USA, pp. 5.

Auralization strategies

- Measured individual binaural signals
- Measured non-individual binaural signals
- Simulated non-individual signals
- Non-individual signals rendered from microphone arrays

Auralization using measured individual signals

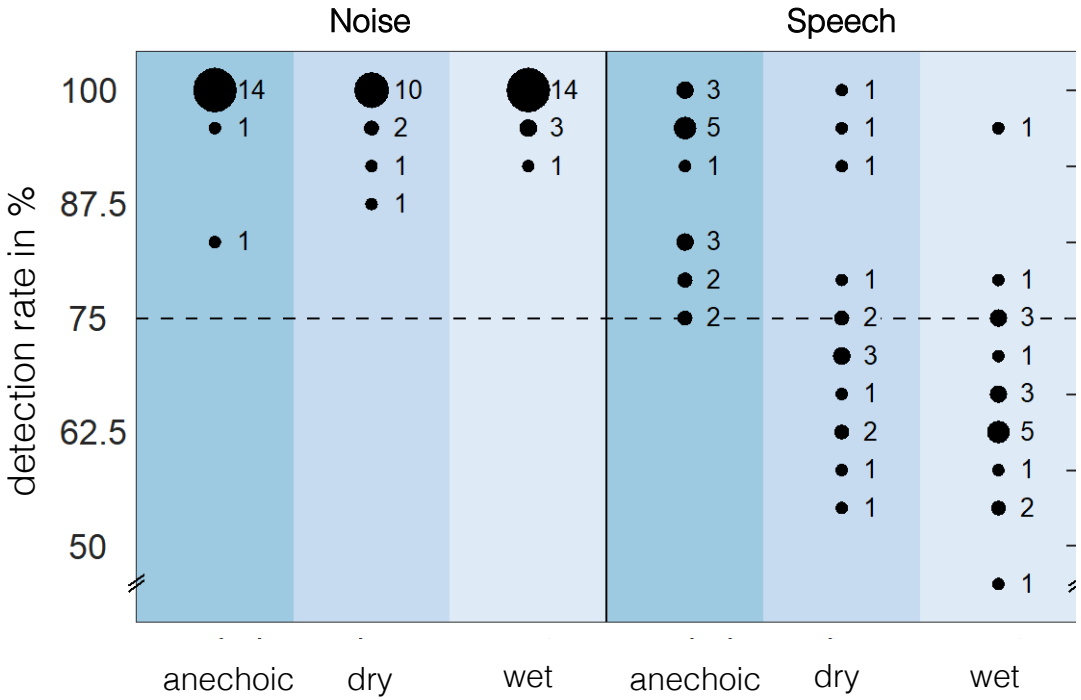




A B X

A = X or B=X

Auralization using measured individual signals



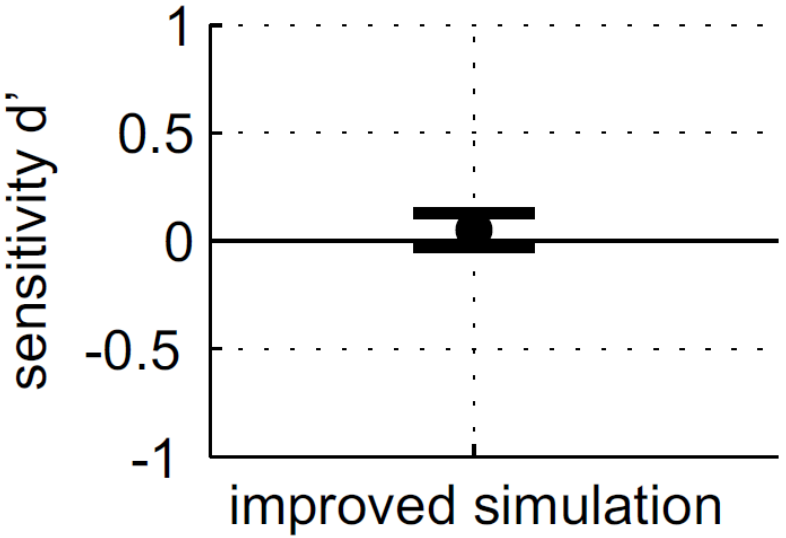
Brinkmann et al. (2017). „On the authenticity of individual binaural synthesis," *J. Acoust. Soc. Am.* 142(4), 1784–1795.

Auralization strategies

- Measured individual binaural signals
- **Measured non-individual binaural signals**
- Simulated non-individual signals
- Non-individual signals rendered from microphone arrays

Auralization using measured non-individual signals

A

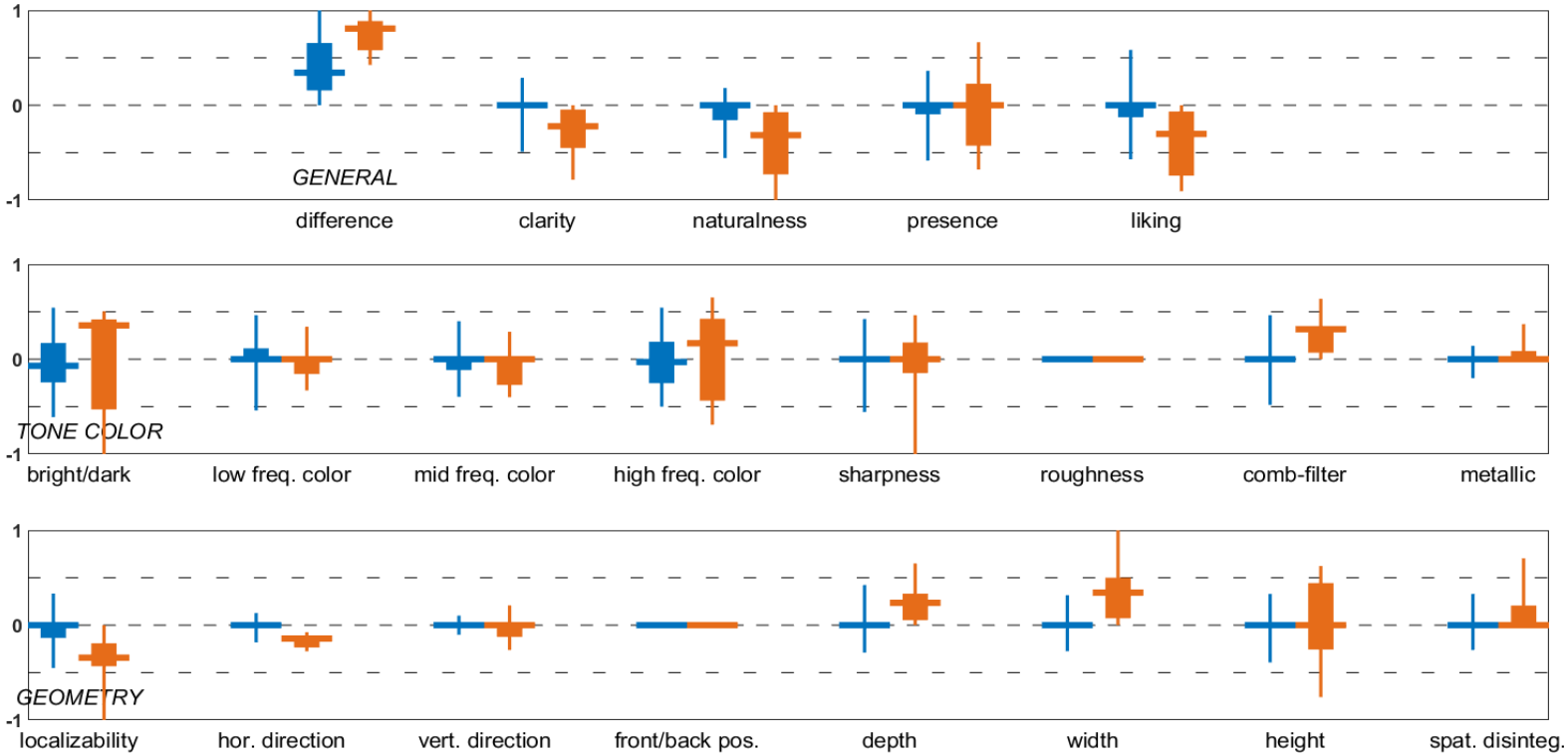


Was this example simulated?

Yes | No

Lindau and Weinzierl (2012). „Assessing the plausibility of virtual acoustic environments," *Acta Acust. United. Ac.* 98(5).

Auralization using measured non-individual signals



Auralization strategies

- Measured individual binaural signals
- Measured non-individual binaural signals
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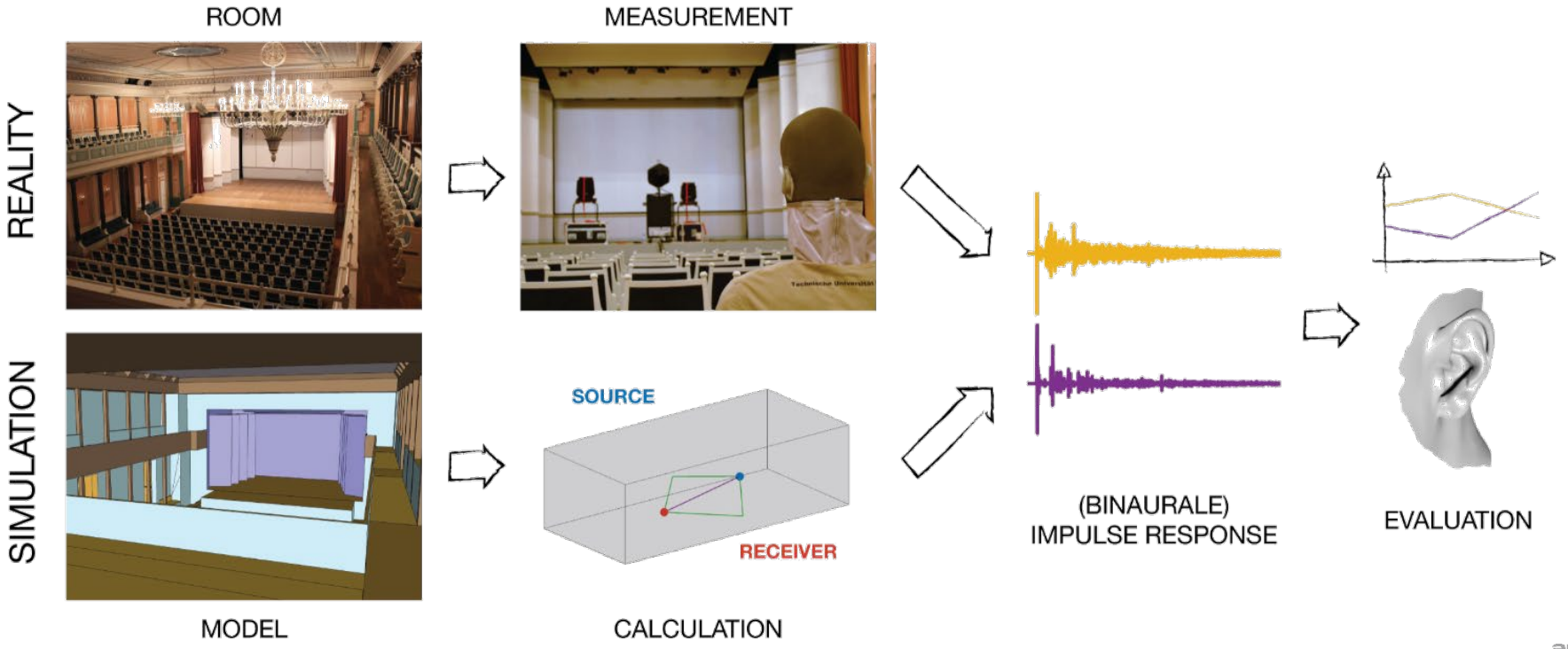
Auralization using simulated non-individual signals



Auralization using simulated non-individual signals

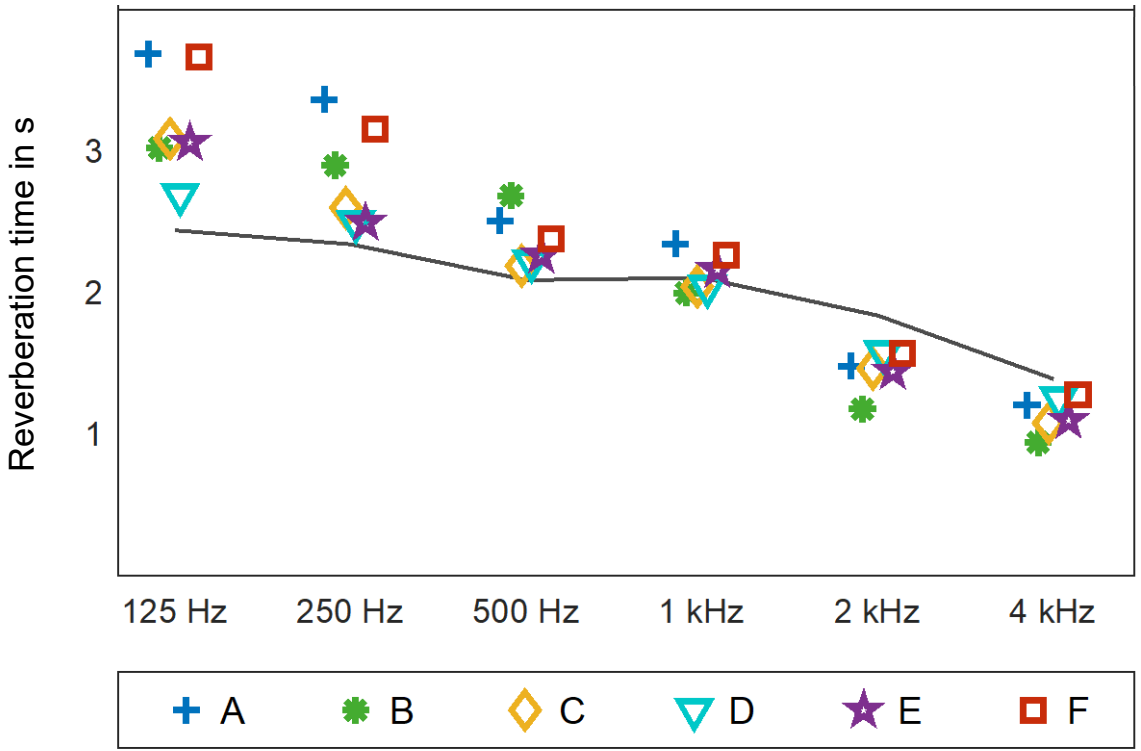
BRAS

benchmark for **r**oom
acoustical **s**imulation

Use case: Acoustic planning

Brinkmann et al. (**2019**). „A round robin on room acoustical simulation and auralization," *J. Acoust. Soc. Am.* **145**(4), 2746–2760.

RESULTS OF ROOM ACOUSTICAL PARAMETERS



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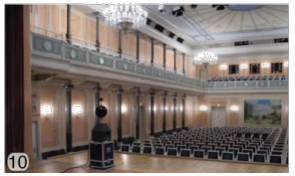
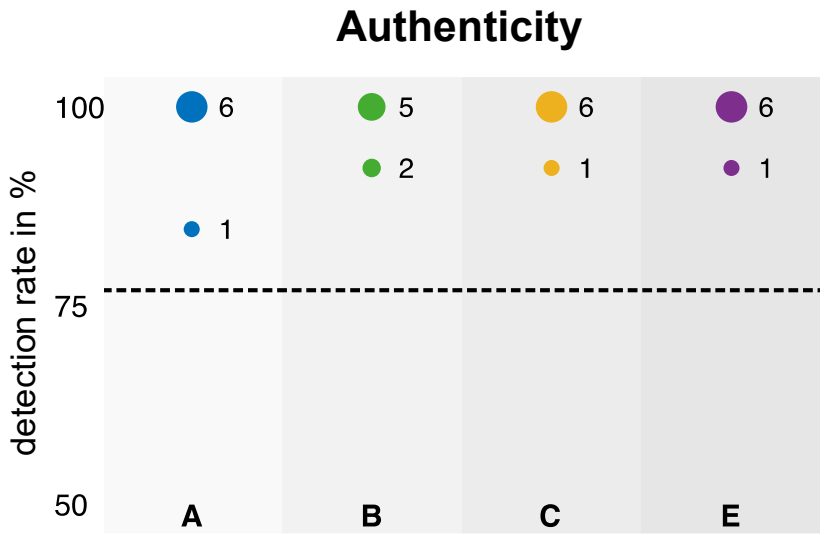
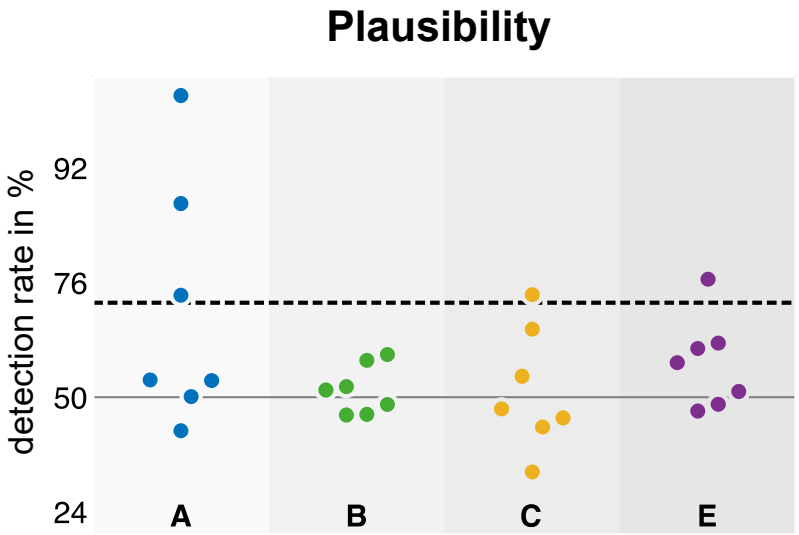
AUTHENTICITY & PLAUSIBILITY







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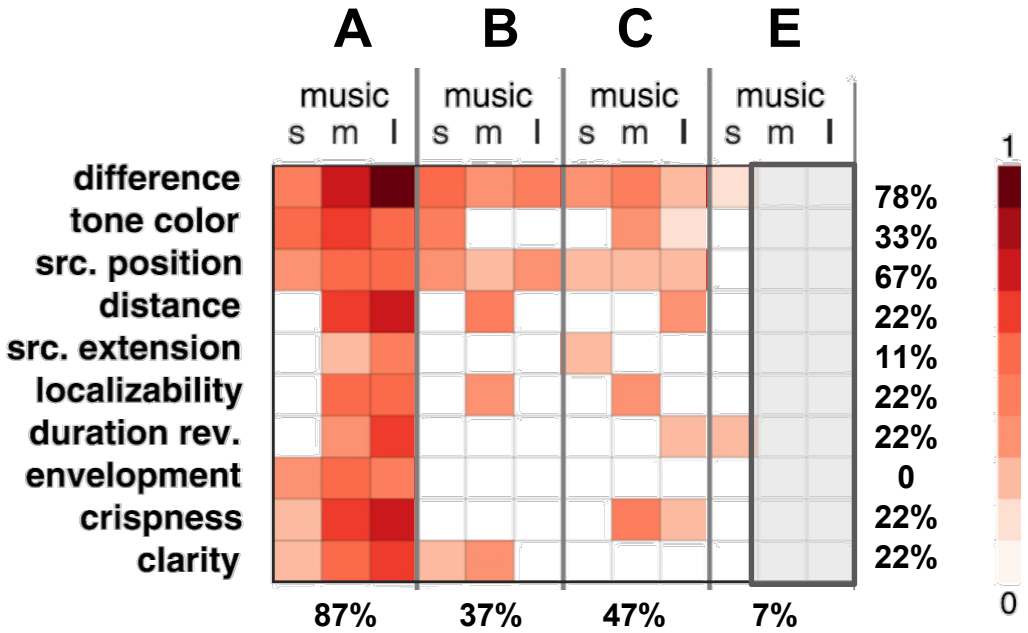
QUALITY



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audiokommunikation

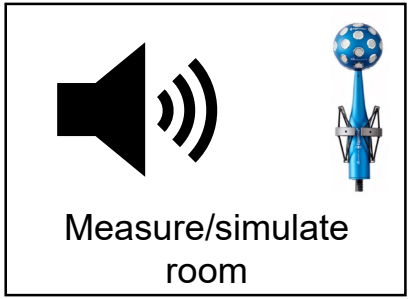
Auralization strategies

- Measured individual binaural signals
- Measured non-individual binaural signals
- Simulated non-individual signals
- Non-individual signals rendered from microphone arrays

Auralization using microphone array signals

"Concert" by cch44 (CC BY-NC-SA 2.0)

Record natural scene



Measure/simulate room

Stream

Spatial Room Impulse Response

Non-Parametric

- Ambisonics
- WFS
- SH…

Parametric

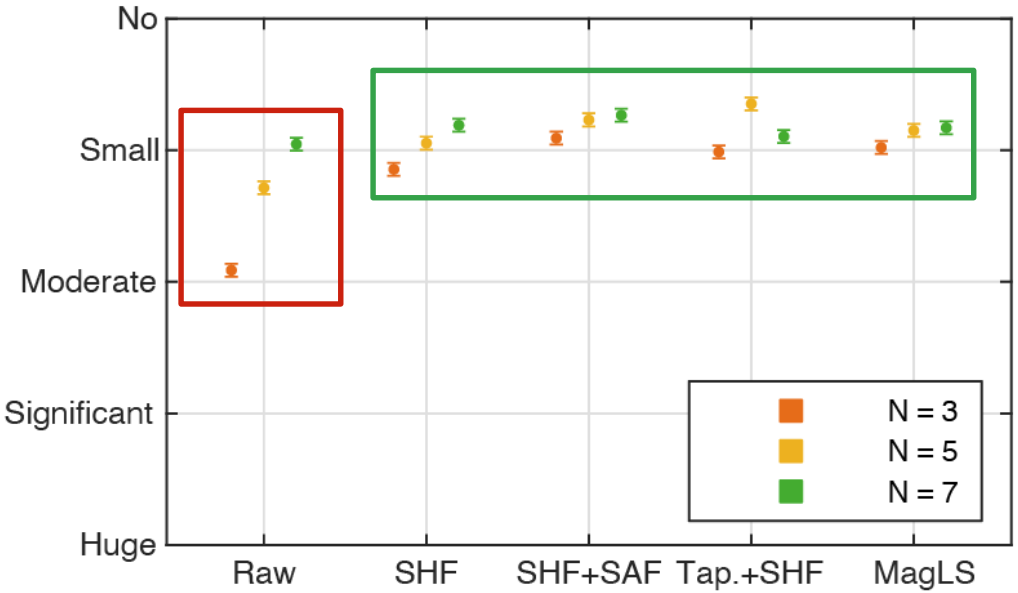
- DirAC
- SDM
- COMPASS…

CC-BY, Franz Zotter & Matthias Frank

encoding to loudspeakers

encoding to headphones

Auralization using measured microphone array signals



Lübeck et al. “Perceptual Evaluation of Mitigation Approaches of Impairments due to Spatial Undersampling in Binaural Rendering of Spherical Microphone Array Data,” *J. Audio Eng. Soc.*, vol. 68, no. 6, pp. 428–440, Jun. 2020.

Summary of Auralization approaches

	Plausible	Authentic	Feasible	Movements
Measured individual Binaural signals	✓	✓	✗	1 DOF
Measured non-individual Binaural signals	✓	✗	✓	Up to 3 DOF (Interpolation!)
Simulated non-individual Binaural signals	✓	✗	✓	6 DOF (not always real-time)
Measured non-individual Array signals	?	✗	✓	6 DOF (not always real-time)

Outlook

Improving room acoustical simulations

- Account for diffraction
- Speed up simulations
- Interfaces for HRTFs and automation

Improving binaural technology

- HRTF individualization

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