Universität Bielefeld

Ambient Intelligence Group

CITEC

Improving Interaction with Sonification: Applications from Science to Smart Environments

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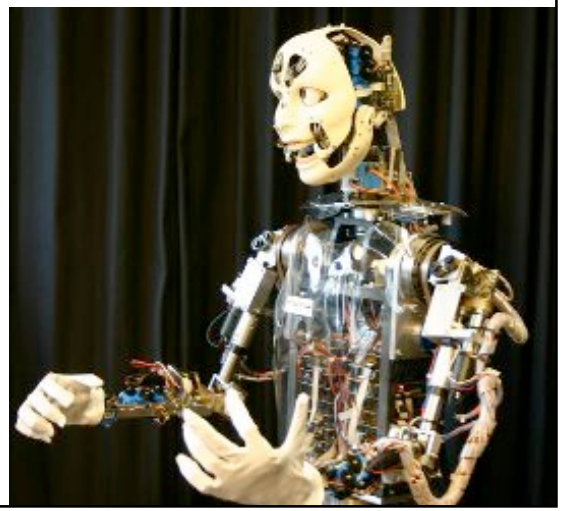
Imagine…

Sonification – What and Why?

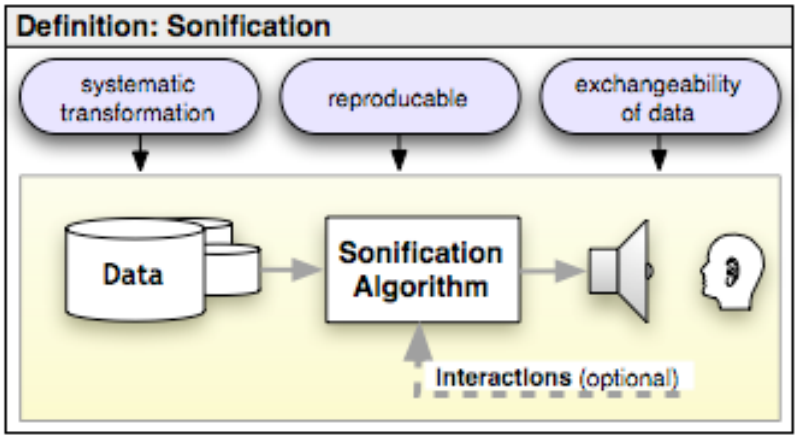
- **Sound is a neglected modality!**
- **Benefits:**
  - neglected resource, backgrounding, habituation, high time-resolution, holistic listening, direction of attention, highly developed listening skills, auditory gestalt formation, etc
- **Sound has a long tradition in Science**
  - Stethoscope
  - Geiger Counter
  - Machine Diagnostics
- **Sonification extends our skills to 'normaly silent' situation**



Outline

1. About Sonification
2. Examples for Sonification in the Sciences
3. What can Sound do for Ambient Intelligence?
4. Guidelines for Designing Auditory Interfaces

New Definition: Sonification
(Hermann, 2008, ICAD)



- **A technique that**
  - uses **data as input**, and
  - generates sound signals
    (eventually in response to optional additional excitation or triggering)

may be called sonification, if and only if

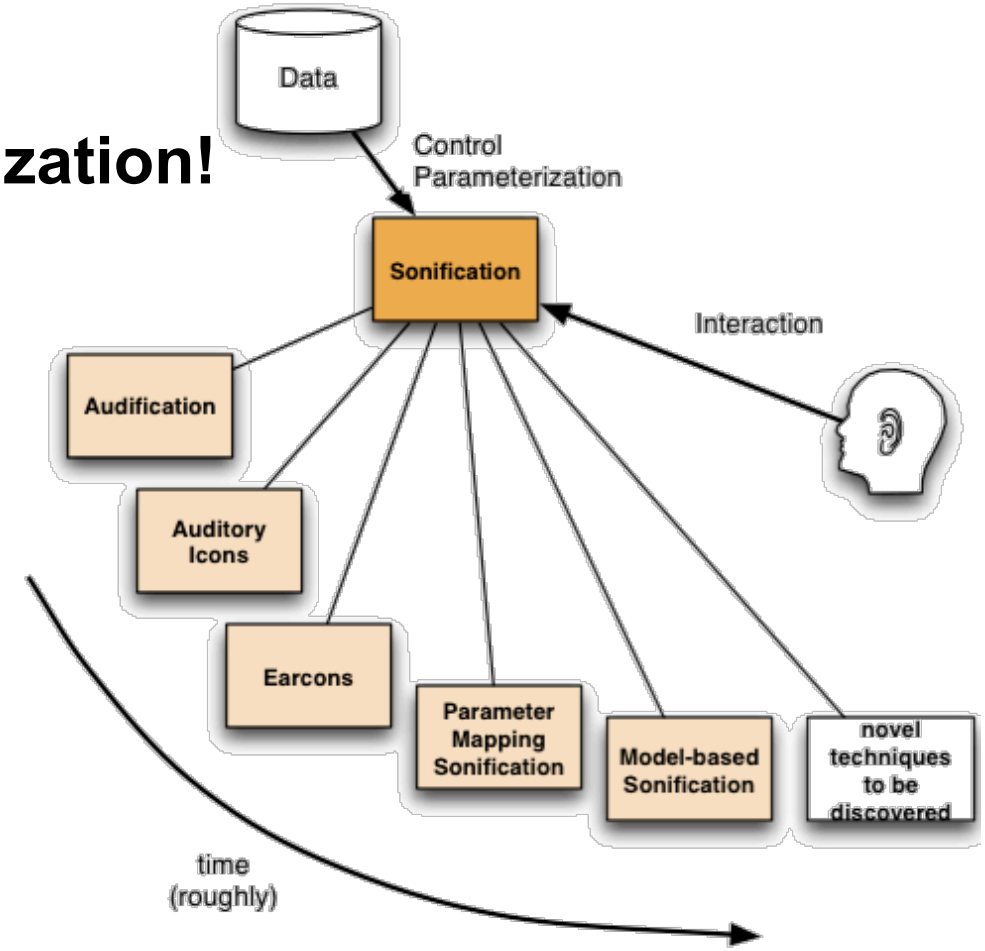
1. **The sound reflects objective properties or relations in the input data.**
2. **The transformation is systematic.**
3. **The sonification is reproducible.**
4. **The system can intentionally be used w/ different data.**

Discussion: General Comments

- **Sonification:**
  Generality equal to visualization!

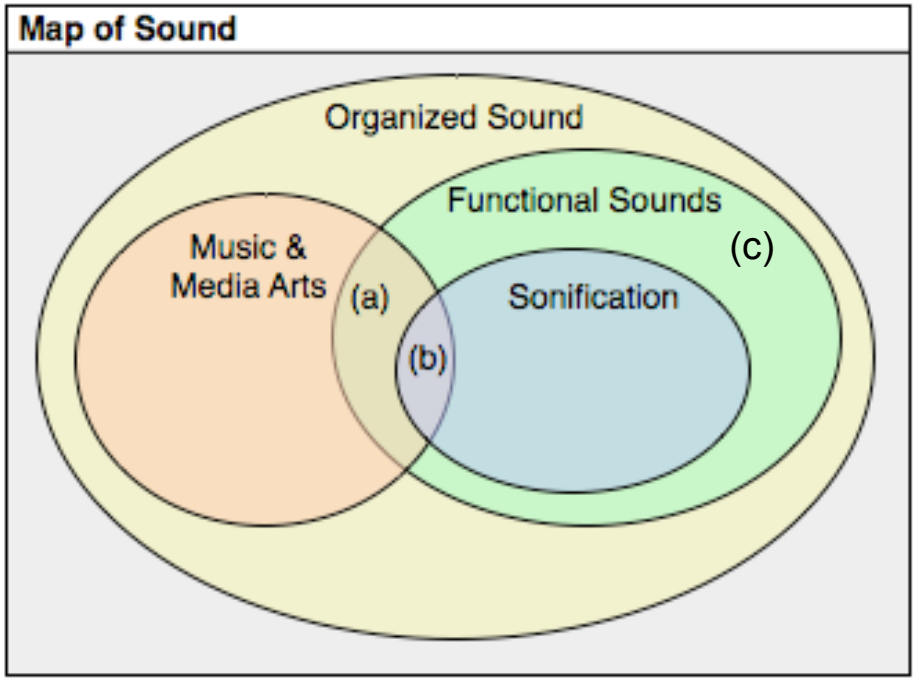
- **Sonification Techniques:**

- **Sonification**
  - ⇔General Term
  - ⇔Algorithm and Sound
  - ⇔Scientific Method

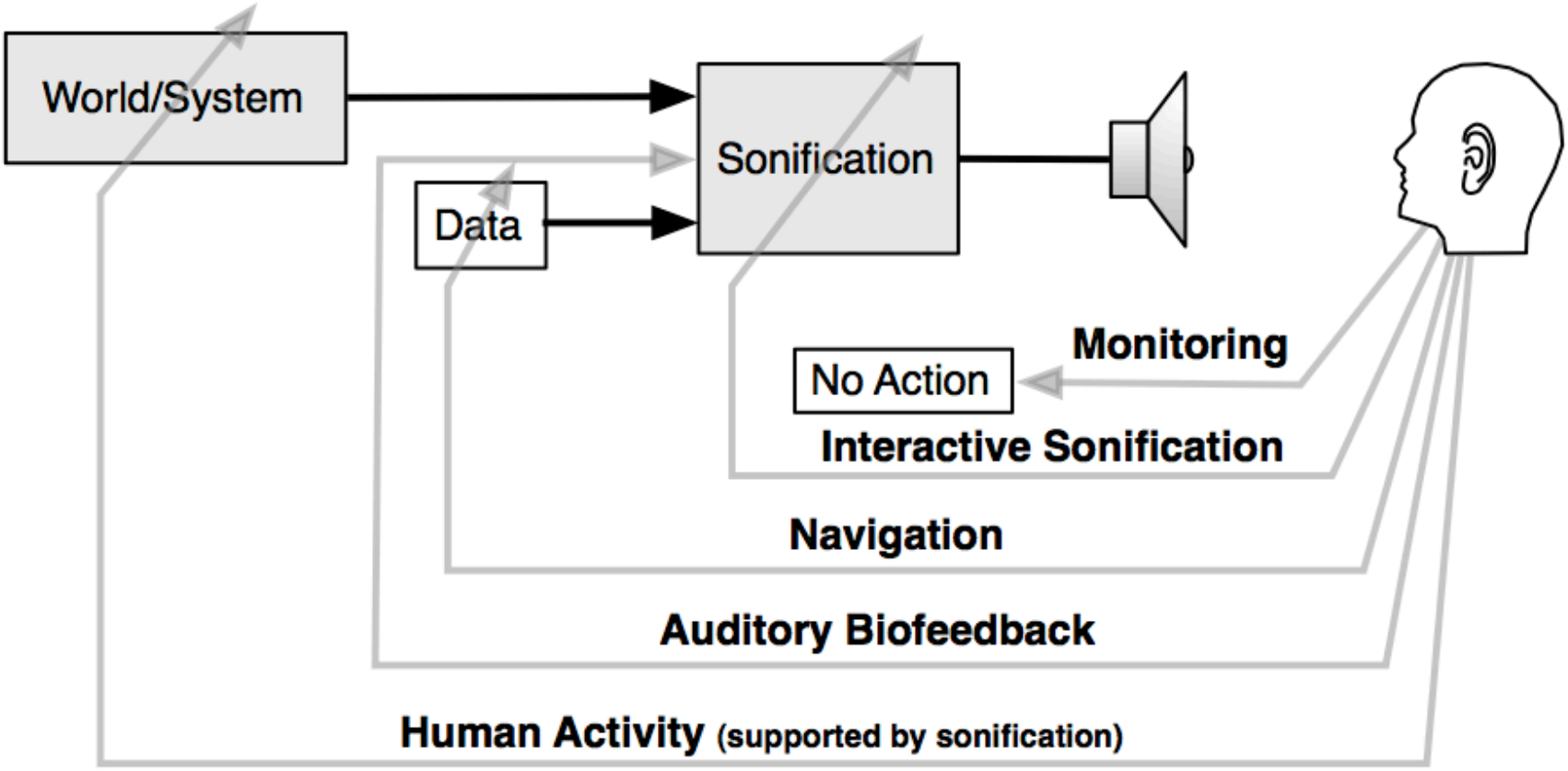


Hierarchy
from Sound to Sonification

- **Organized Sound**
  = intentionally organized
- **Music/Functional Sound**
  as intersecting subset
  - (a) supermarket music,
    march music
- **Sonification as subset of**
  Functional sound:
  - (c) Mosquito Sonic Weapon
  - (b) Sonification in arts: exists, but many are perhaps better called „**data-inspired music**“

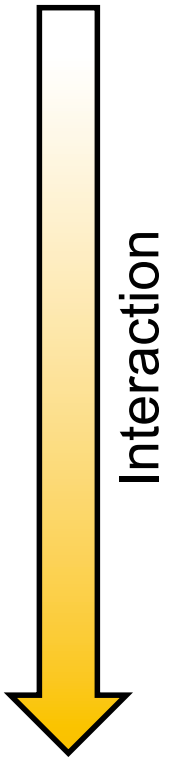


Closed Interaction Loops in Auditory Displays



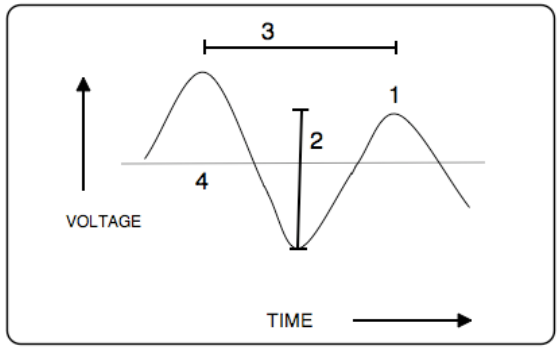
Functions of Sound in the Sciences

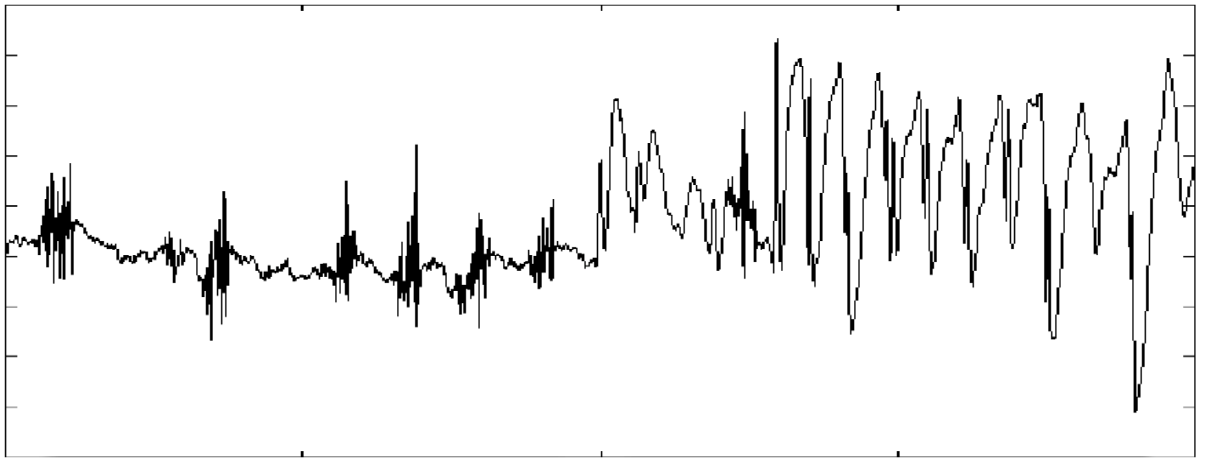
- **Monitoring**
- **Rapid Summary**
- **Navigation – Search for relevant patterns**
- **Discovery – Exploratory Data Analysis**
- **Sonic Feedback**
- **Work on experimental setups**



Sonification of Human EEG
[for monitoring, diagnosis, analysis]

- **Diagnosis of Human EEG**
  - Epilepsy: “Petit-Mal Absence”
  - 24h recordings of EEG
- **Parameter Mapping Sonification:**
- **Event-based Sonification:**

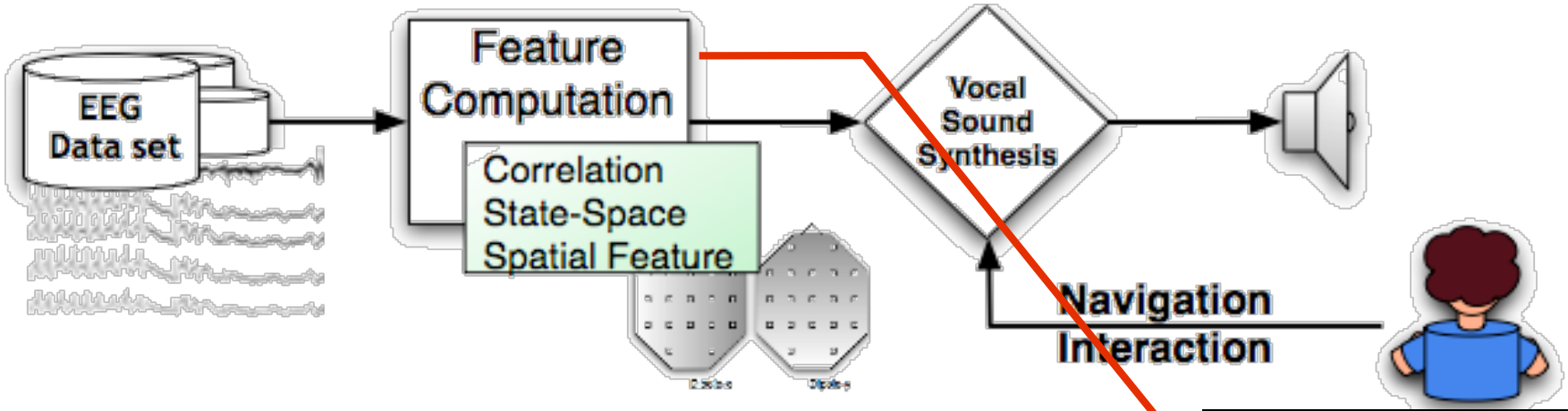




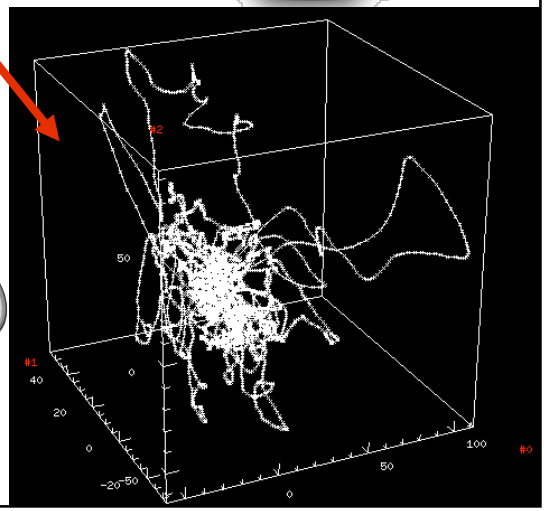
Online Sonification of EEG

- Enables Video observation and simultanous data reviewing
- Ideal for directing attention in clininal monitoring & analysis

Vocal EEG Sonification

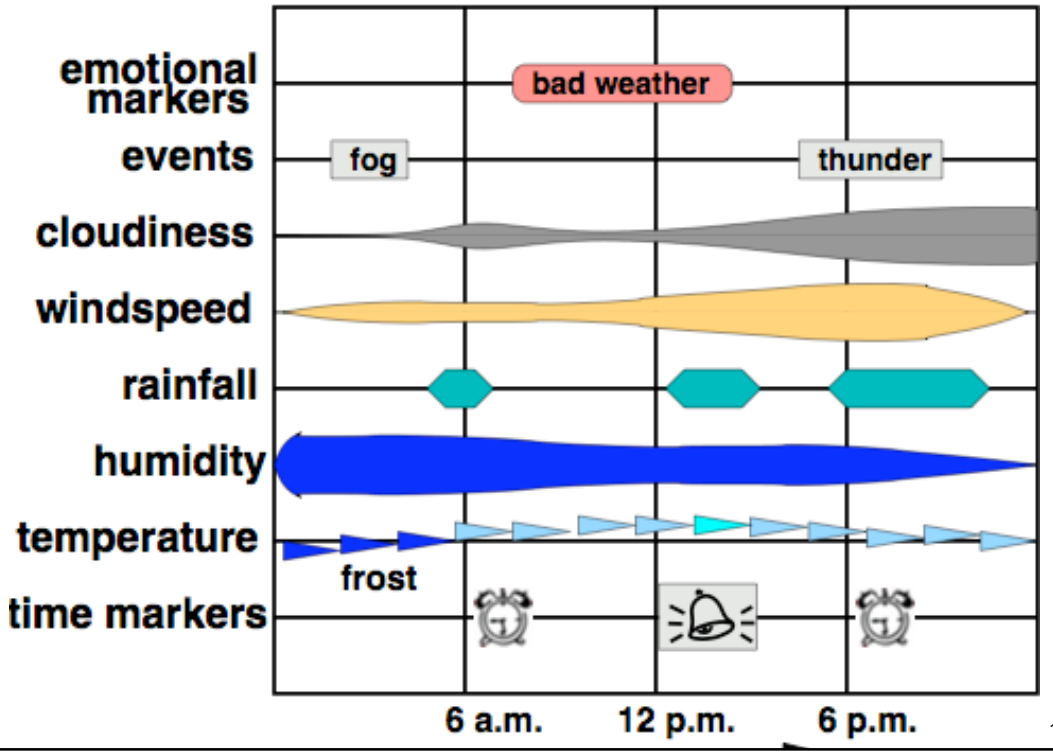


- Vocal Sounds as salient sound domain
- Generic Features used to increase saliency of specific atypical EEG activity
- Patterns that a doctor can memorize and verbalize
- Spike-Wave Formation: Poly-spike Formations:
- Absence: Artefacts: Sleep:



Weather Forecast Sonification

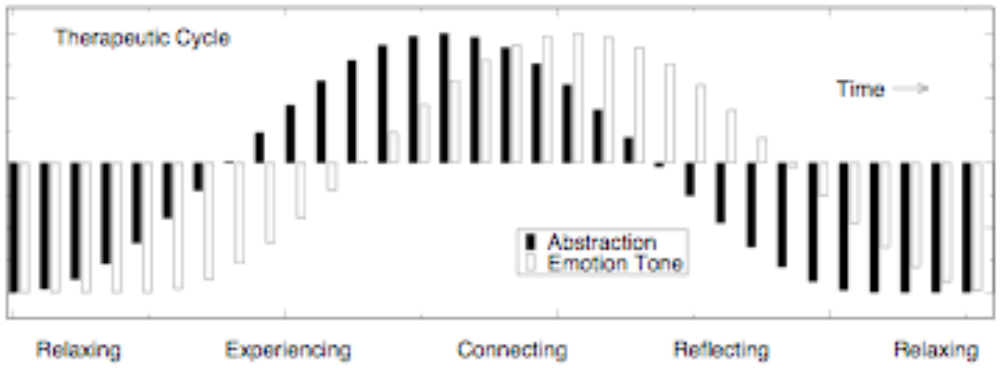
- **"Wettervorhörsage"**
- **Broadcasted 6 months daily on Hertz 87.9**
- **Complex information conveyed in 12 s**
- **Examples:**
  - Nice spring day
  - Ugly November day



Sonification of Psychotherapy Sessions

with Prof. E. Mergenthaler (Ulm)

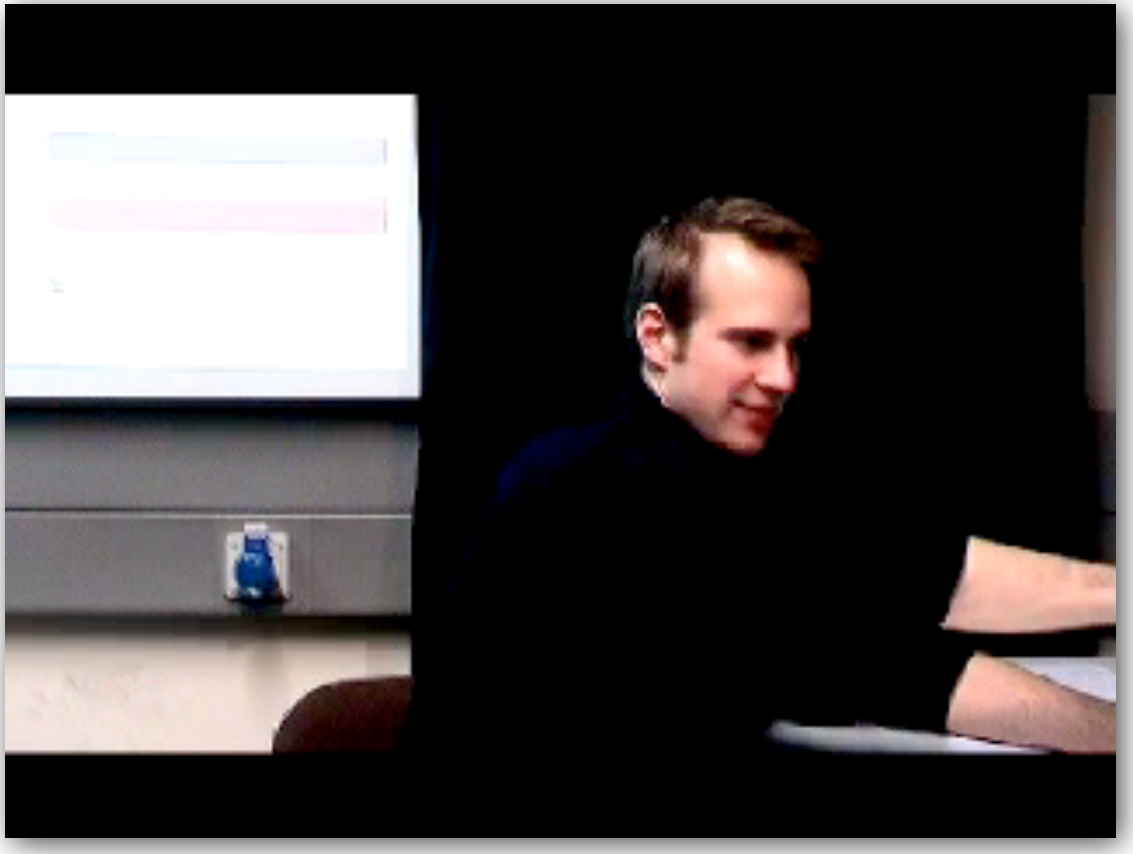
- **Goal: fast detection of key-moments in Therapy**
- **Data: Transcripts**
  - Lexicon of emotional and abstract Words
  - Word length, speaker, type, etc
- **Result: exploratory technique, rapid scanning**



Events:
CRA, Abstract, Emotional

Example Sessions:

Sound Grasp
[Drag Audifications]



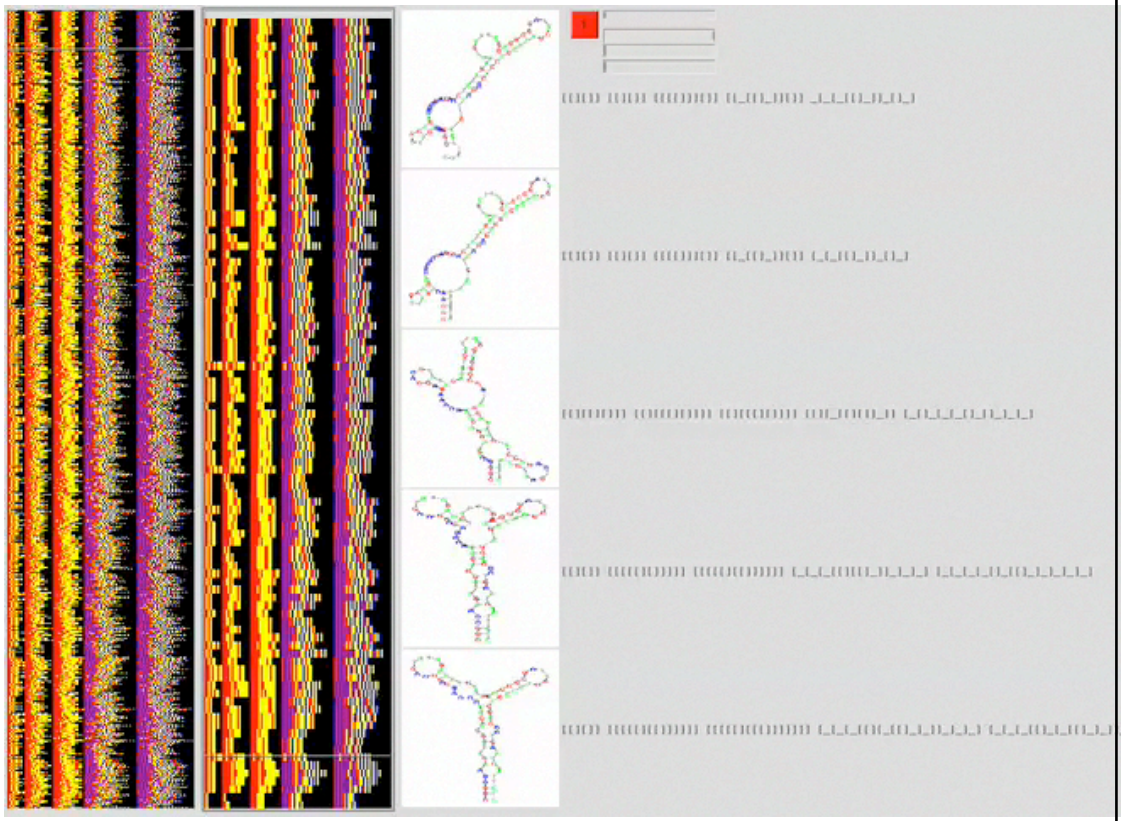
- Gestures-based Audification
- Two-handed Gestures for Interactive Filtering
- Allows to close the eyes to focus on listening

Sonic RNA browsing

Florian Grond et al.

- **Acoustic browser for folded RNA strings**
- **Goal**:
  - Support the rapid classification of (un-)/typical foldings from large databases of candidates foldings
- Example RNA:

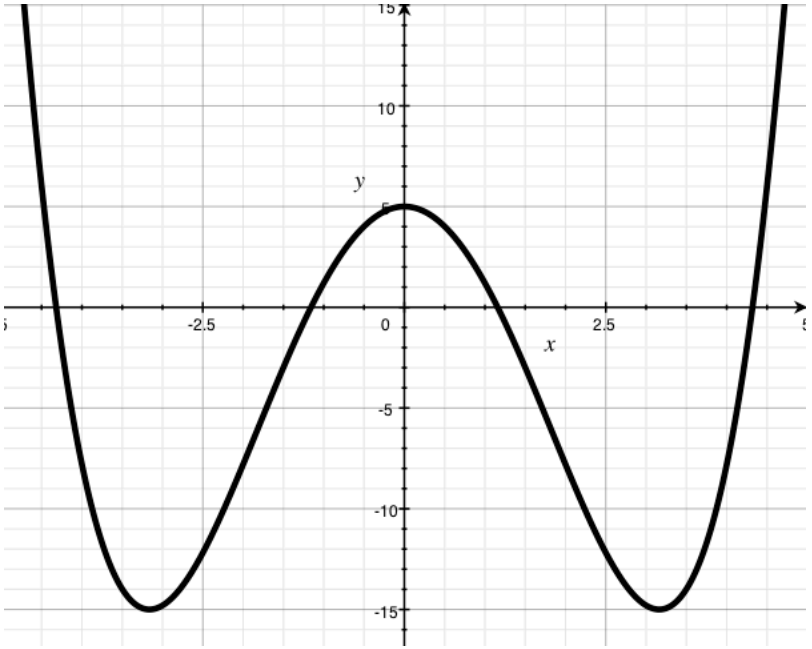
CTCTTCCGTCAGTAAGCGGCGCCCCGGCTAG
GGGGCGGCTTCGTCCCGCTCTGAAGGAGAAA
AACCGCGGCTCGCAAAGGG



Sonic Function

Florian Grond & Trixi Drossard

- **Sonification of Mathematical Functions for Visually Impaired Pupils**
- **Pedagogic Application**



$$y=-4x^2+0.2x^4+5$$

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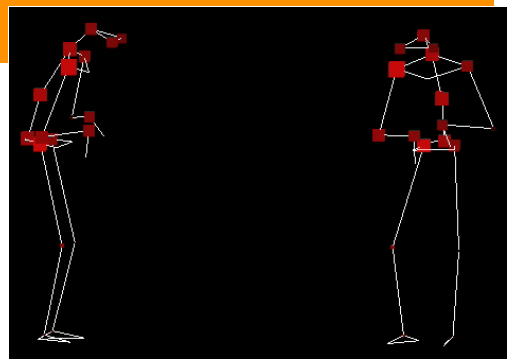
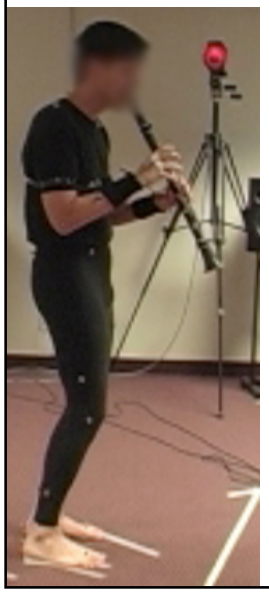
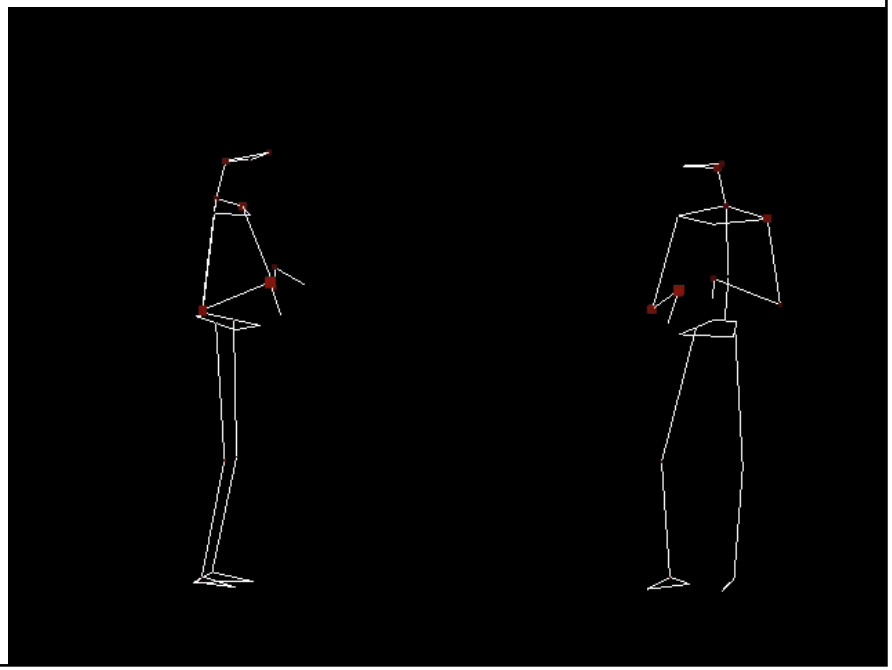
SciSon
[Ancillary Gesture Sonification of Clarinetists]

Florian Grond



- **Support consistency in extracting movement segments by multimodal display**
- Cooperation with IDMIL McGill Montreal
- **Results:**
  - Audio-visual display decreases entropy of click density
  - Sonification seems to guide visual attention to correlating events



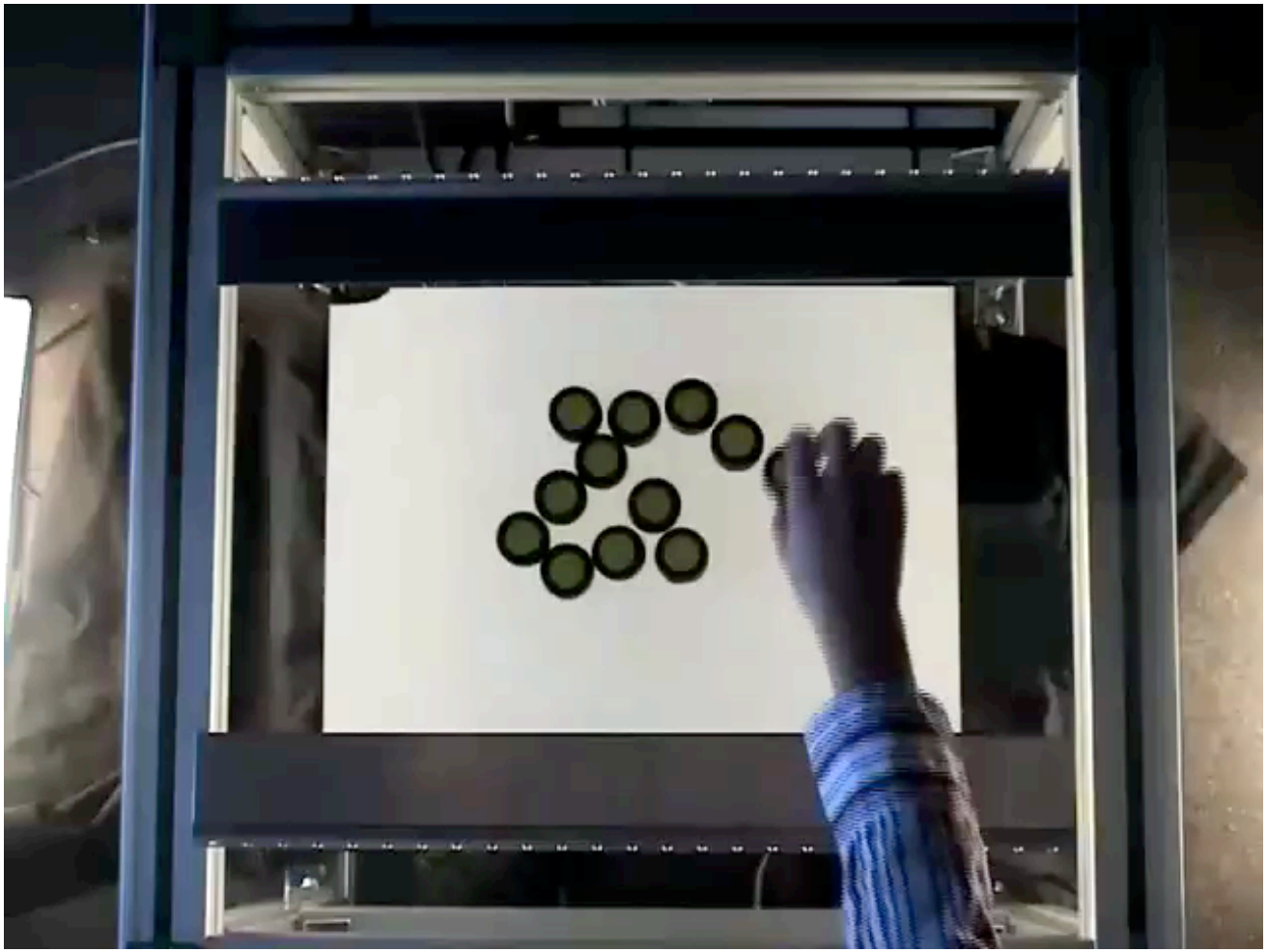


TISon – Tangible Interactive Sonification

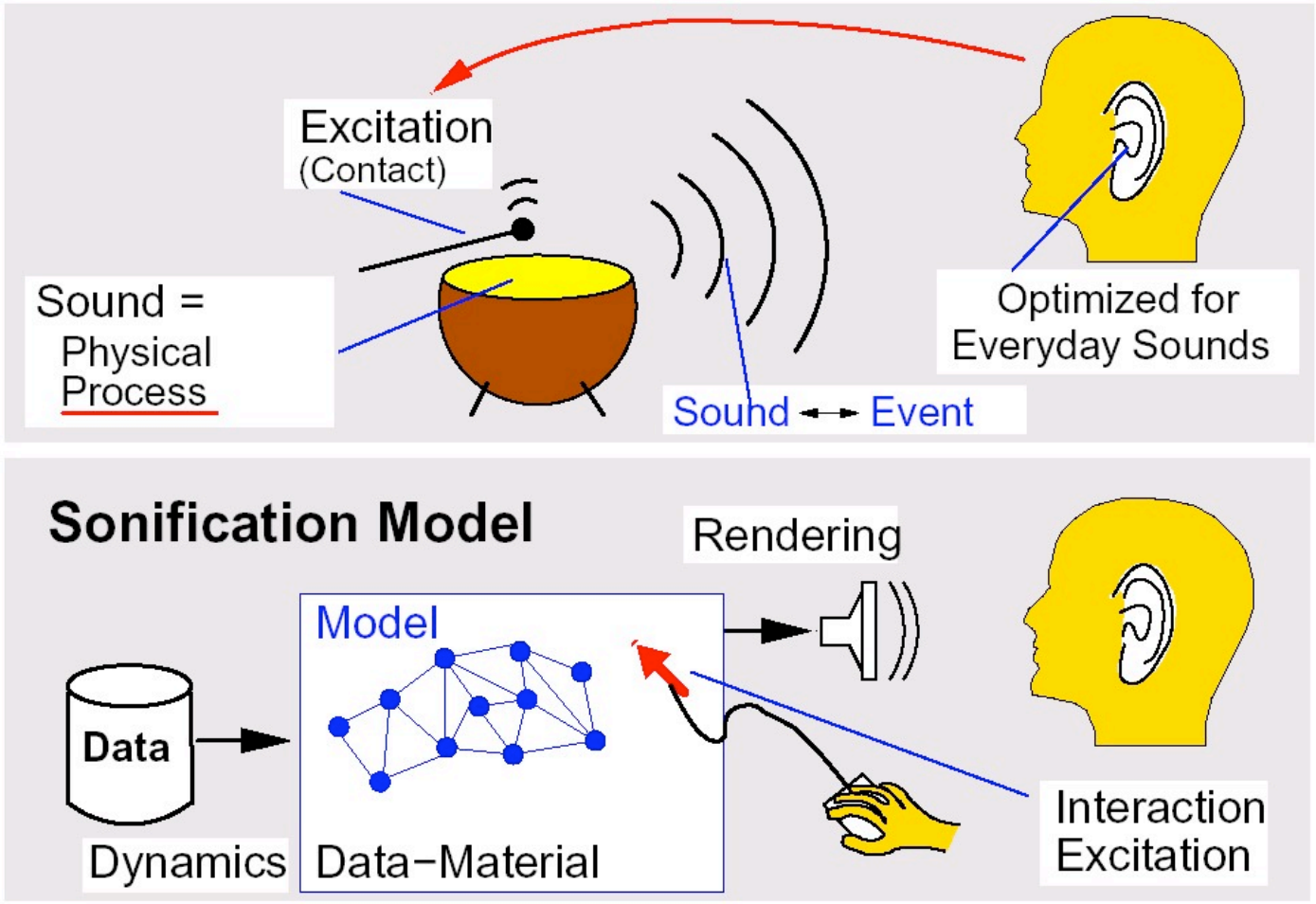
- Data channels become physical objects
- Exploration is turned into physical Interaction

AudioDB – Interactive Organisation for Sonic Features

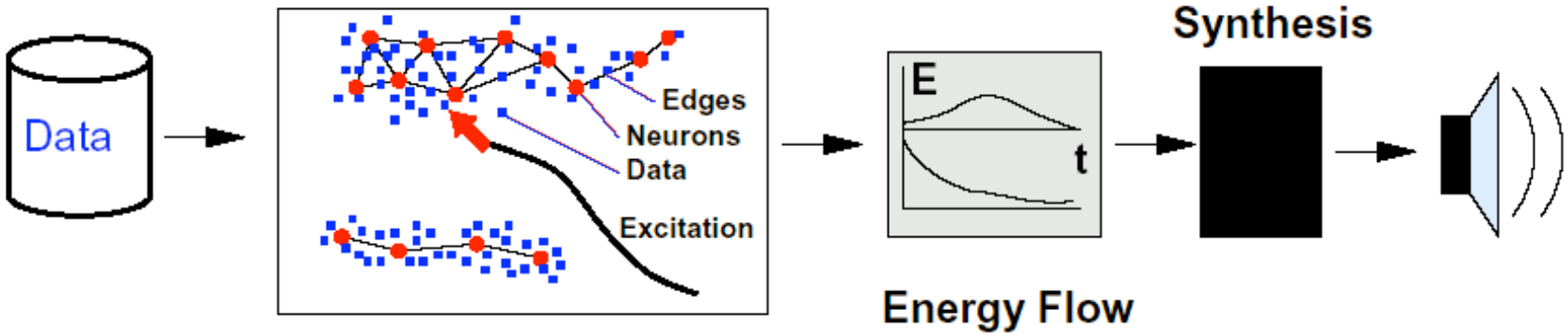
Till Bovermann



Model-based Sonification for Interacting with Data

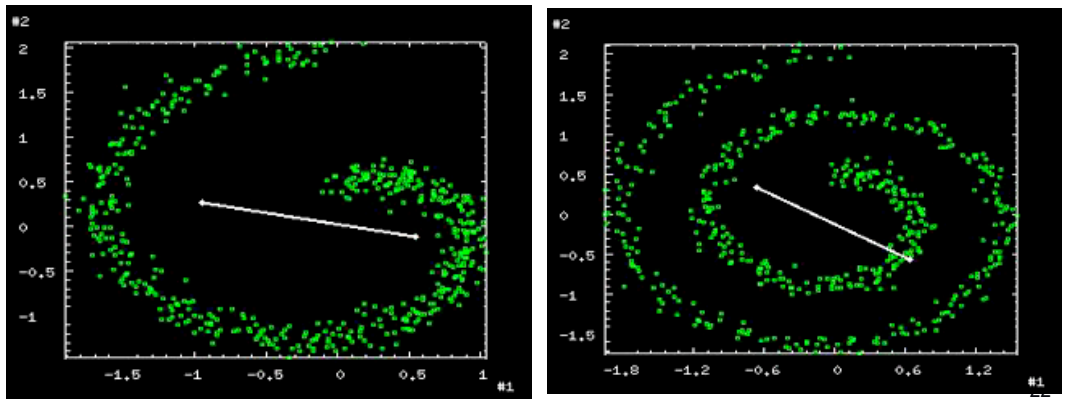


Growing Neural Gas Sonification for Data Dimensionality Analysis



- „Shaking/Hitting“ Data using the Growing Neural Gas
- Subtle Characteristics such as „intrinisic dimensionality“ become audible
- 2d: 4d: 8d:

Network Growth Sonification



Multi-Touch Interaction with Growing Neural Gas Sonifications

Kolbe, Tünnermann

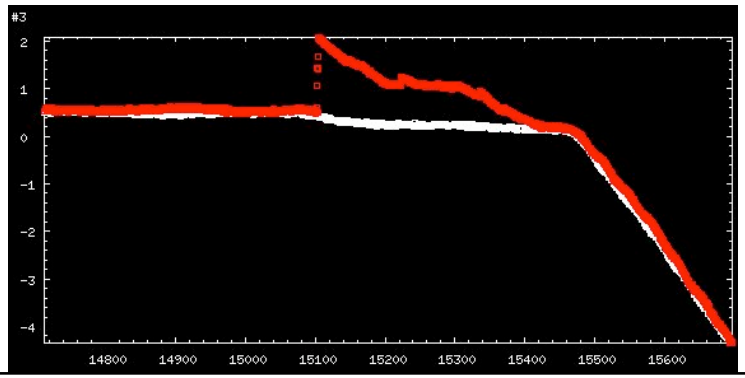
TDS - Tangible Data Scanning

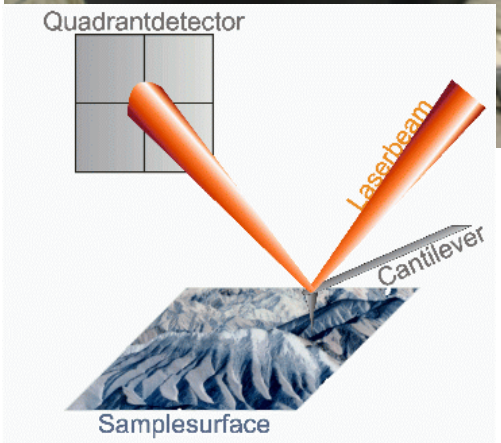
Bovermann, Riedenklau

- **Data become real physical objects**
- **Exploits human manipulation capabilities**
- **Spatial memory help interpreting data**

AFM - Kraftspektroskopie

- **DNA per Cantilever angeln**
- **Bindungskraft bis Abriss**
- **Cantilever als Gramophon-nadel**
- **Hybride Sonifikation**
  - Rohdaten-Audifikation:
  - Interaktive Sonfiikation:





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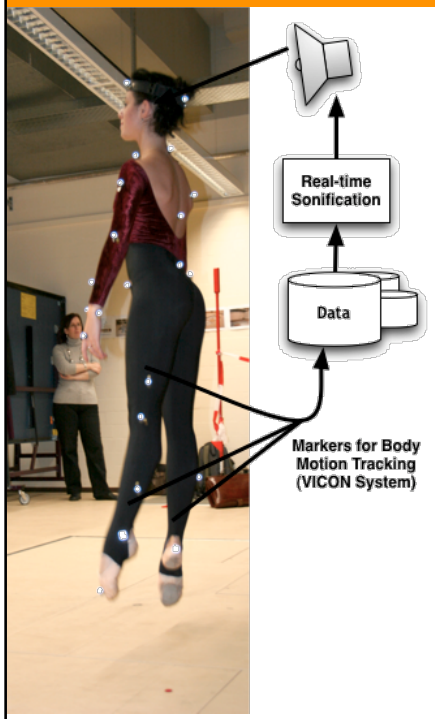
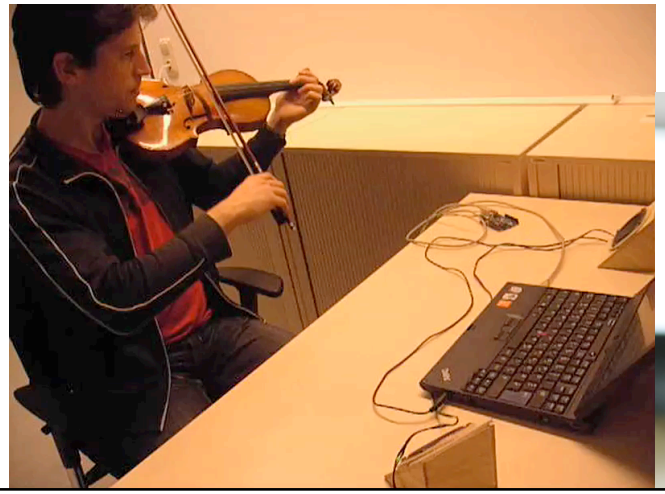
CLAINT – Closed-Loop Auditory Interaction

Tobias Grosshauser



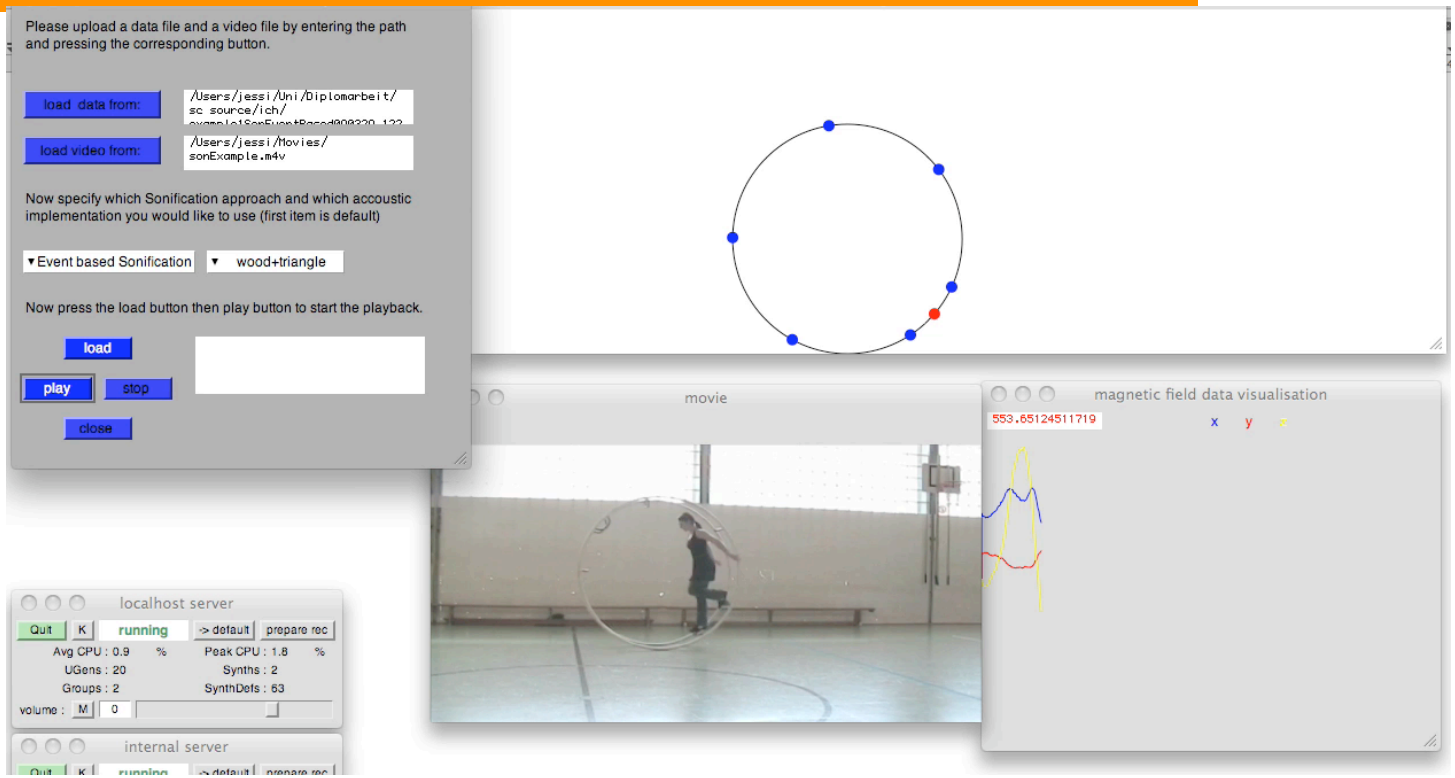
How can users profit from auditory bio-feedback?

- **Skill Learning in Dance and Music**
- **Support Physiotherapy**
- **Basic Research in Closed-Loop Interaction**
- **Augmented Haptics**



German Wheel Sonification

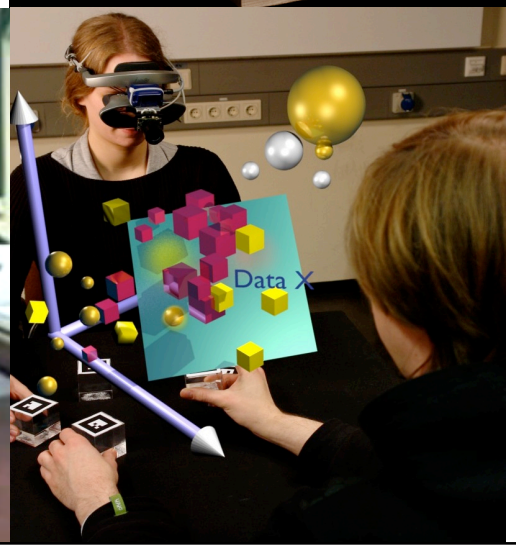
Jessica Hummel



- **Can Sonification of Wheel Status support the accuracy of movement executions? YES!**

Perspectives for Ambient Living

- SmartLounge: „Future Living”
- Ambient Information Awareness
- Shared Presence
- Sound for Augmented-Reality
- Sound for Robot-Interaction



What is Ambient Intelligence?

- **AmI refers to *electronic environments that are sensitive and responsive to the presence of people***

adaptive

ubiquitious

multimodal

context-aware

unobtrusive

calm technology

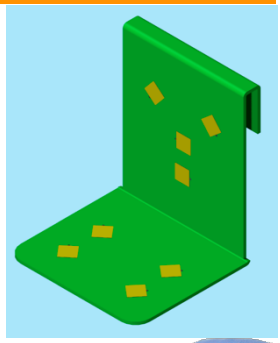
personalized

anticipatory

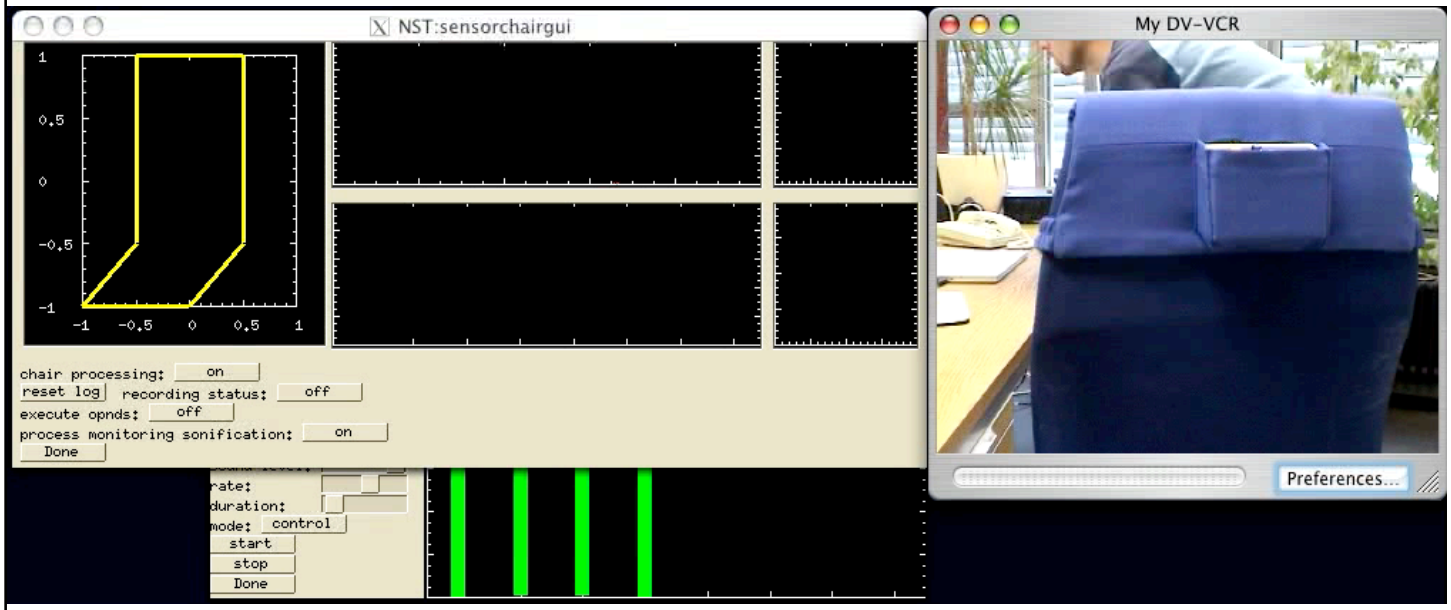
embedded

tacTiles – sensitivity for smart furniture

- **Low-Cost Open Hardware**
- **First Prototype** (coop. with R. Koiva)
  - Lay-on for Office chair
- **Flexible use in other contexts**
- **Towards an artificial skin for smart furniture**



tacTiles – tactile sensitive furniture



- **Monitoring Activity in large office spaces**
- **Application: avoid rigid working style**

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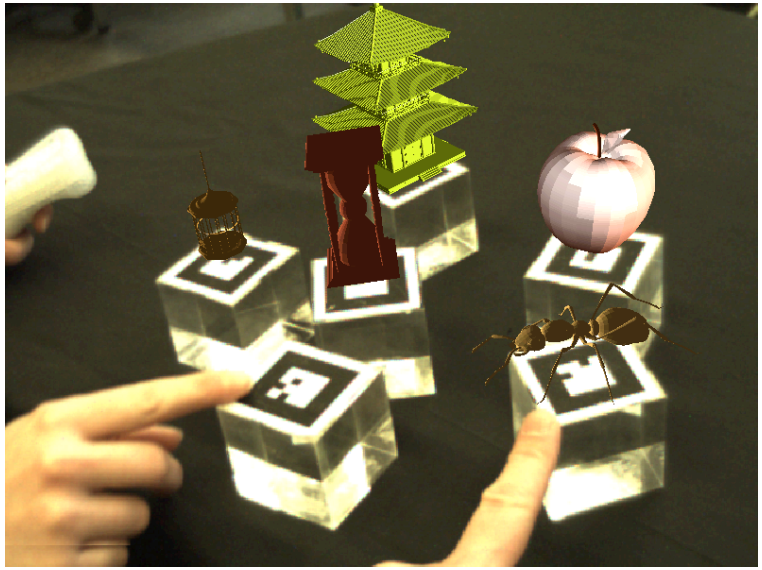
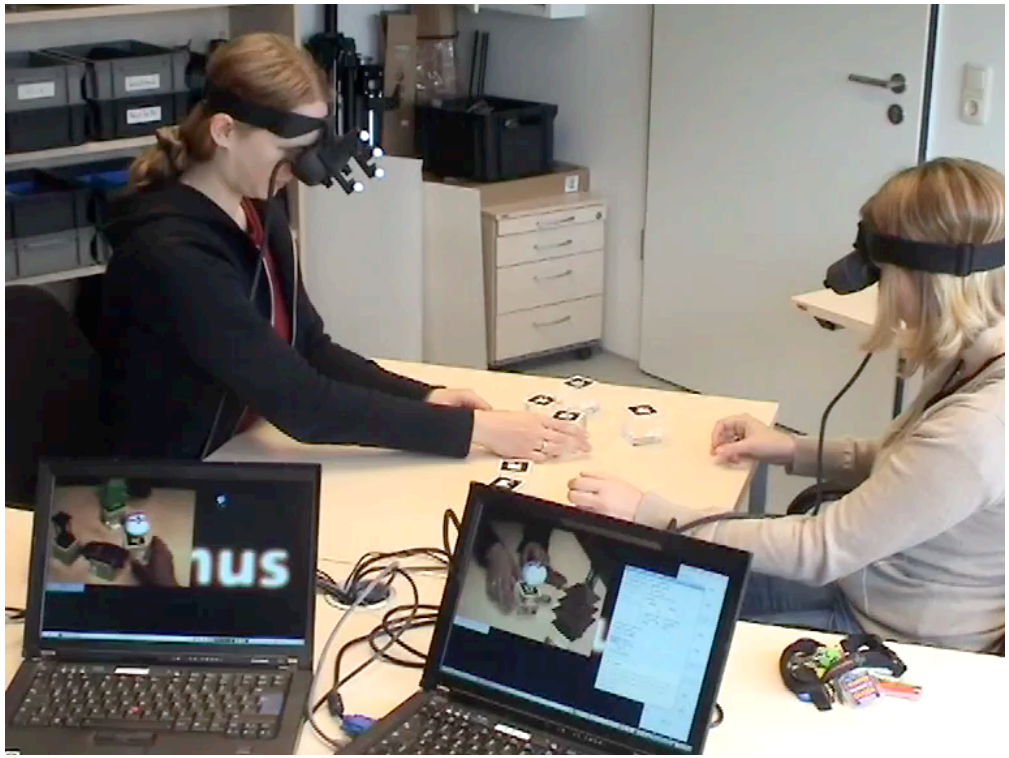
Alignment in AR-based Cooperation – SFB 673

- Scenario: **Gaze Game**
- **Gazer**: find object which is displayed to you as fast as you can
- **Searcher**: find out which object the partner is currently looking at as fast as you can
- Discuss: which object has been displayed?





Acoustic Augmentation for Ambient Information Awareness

Bovermann, Tünnermann

New Types of Sports Games for Blind and for Rehabilitation

- **Blindminton**
- **Goal:**
  - Paired Mobile Phones enable engaging sports game just by listening
  - New Ball Group Sports for the Visually Impaired

Discussion

Sound can:

- Support Task-oriented work and Cooperation
- Enhance Awareness and Presence of Information
- Augment non-acoustic and acoustic processes for self-regulation
- Offer new understanding of Data

But:

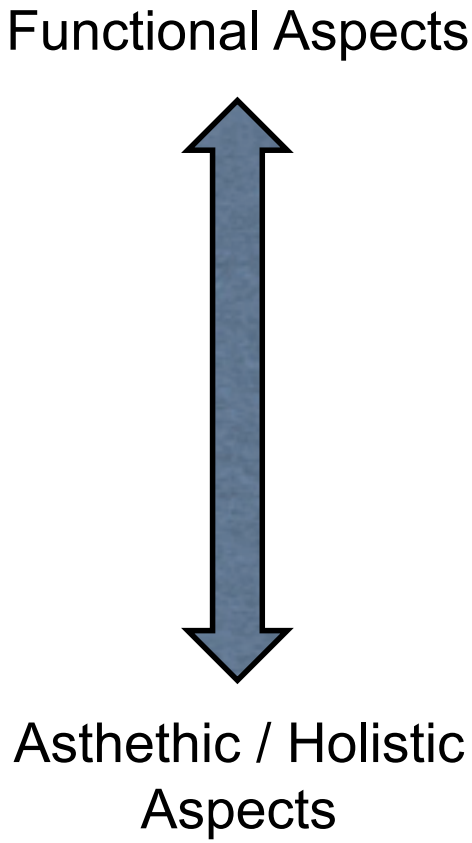
- Care must be taken to do it properly
- **GUIDELINES**

Establish a Design Cycle as Interdisciplinary Dialogue

- **Application Domain Experts**
- **Sonification Experts**
- **Users**
- **Programmers**

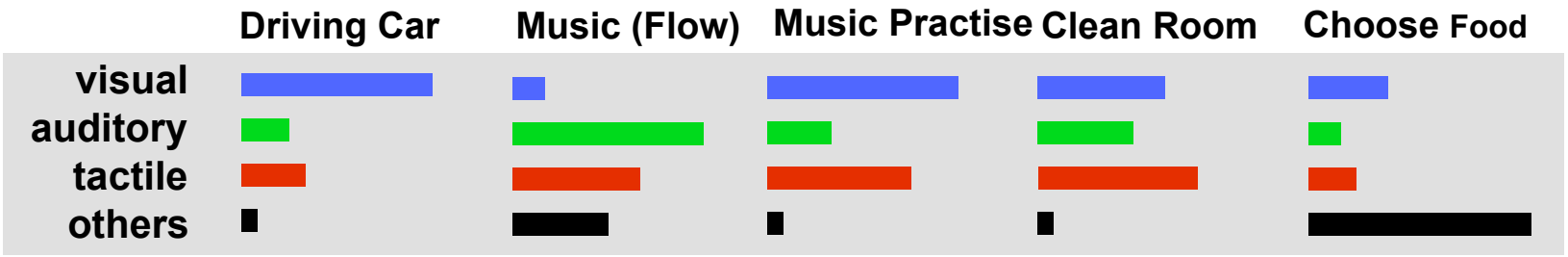
But also:

- **Designers**
- **Psychologists for Evaluation**
- **Interactional Linguistics**
- **Cultural Studies**



Aim at Holistic and Balanced Multimodal Displays

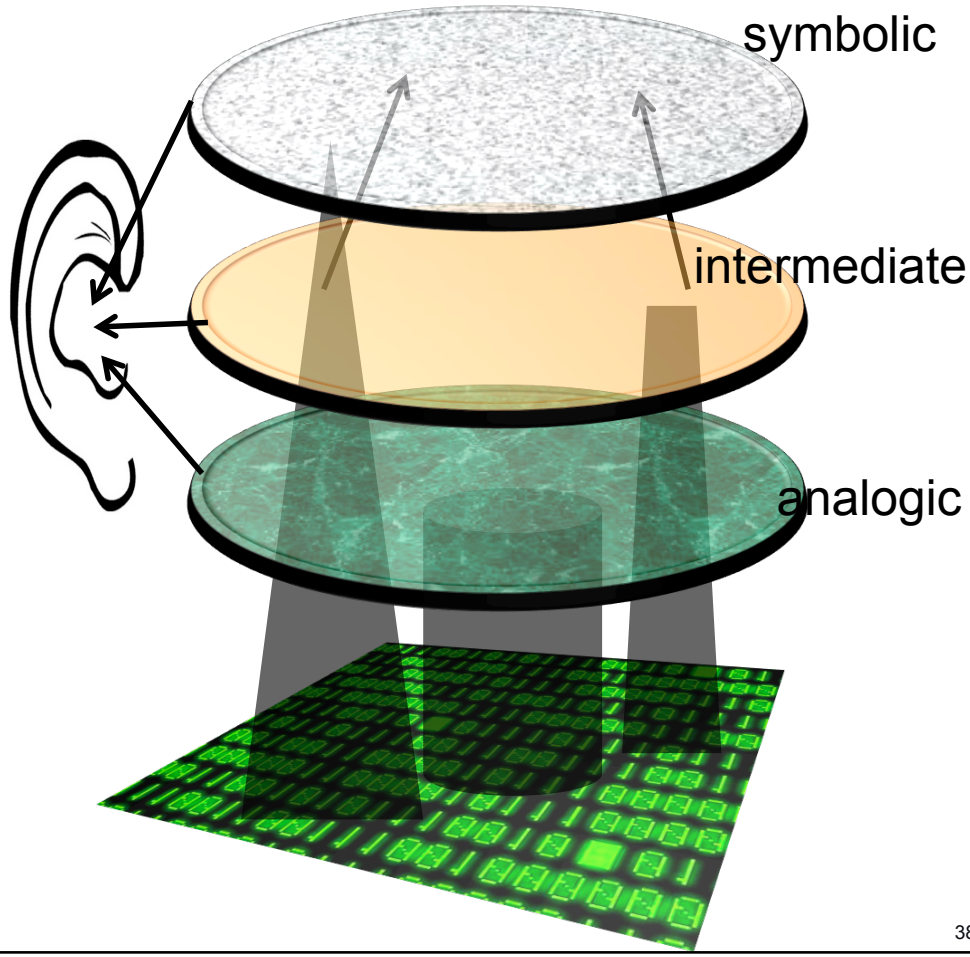
- **Interweave Modes**
  → Partial Redundancy
  → Coherence / Coupling
- **Acknowledge Human Dynamic Attention Allocation during task-oriented procedures**



- **Consider that sound is only a part of the multimodal experience**

Consider Hybrid Sonifications

- **Convey Information on various levels of granularity**
  - From low-level subsymbolic information
  - Over intermediate meaningful features
  - To high-level abstractions symbolic display
- **Data Mining informs hybrid sonification procedures**



Address the Users' Learning Capacity

- Develop Sonifications that are useful even for beginners
- But also provide richness enabling listeners to improve their skills infinitely
- Accomplished by
  - signal-near representation
  - Close coupling to interaction
  - Model-based approaches (MBS)
  - Sonic complexity

Instrument Interaction as good example

Optimize Interaction Ergonomy

- **Respect established bindings from physics / evolution**
  - We are familiar with excitation to trigger acoustic events
  - We expect systems to fade when left alone
  - We are capable to interpret sound in response to our behavior
  - We interpret higher pitch as higher tension, higher level as more energy
  - Low Latency, etc.
- **Automatically: with MBS**
- **Alternative: MBS-informed Mapping Sonifications**

Reduce Interference in Sonic Ecology

- **All displays compete for attention**
- **Take care that relevant information displays can coexist**
  - Example: Avoid verbal information display in situations where people talk or listen to speech…
- **Evolutionary drift towards less-interfering display agents**
  - In Nature: e.g. animal voices
  - In Sonification: selection by users

Overall Conclusion

- **Auditory Interface are embedded in Multimodal Closed-Loop Interaction**
- **Actual Developments are promising…**
- **Auditory Display Development is an enourmous interdisciplinary challenge**
- **Critical Mass of Competence is required!**

Thank you for your Attention!

Questions? Comments?