Auditory Displays and Data Sonification

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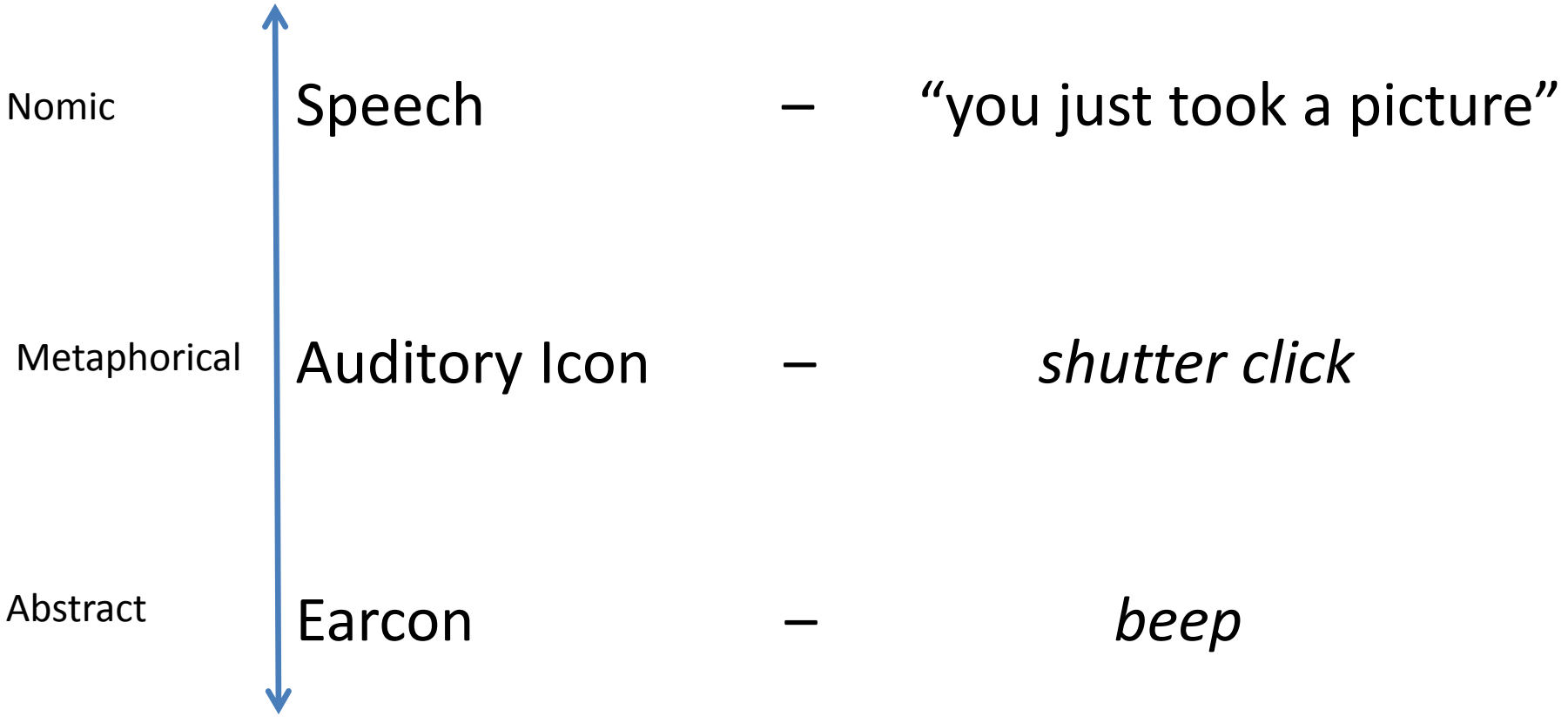
Auditory Displays

Sound is just touch at a distance…

- Enhance/replace visual displays
- Omnidirectional
- Passive/active monitoring tasks
- System state/user performance feedback
- Increase UX/Usability/Situation Awareness
  - **Small screens** (cellphones, watches)
  - **No screens** (Geiger counter, metal detector, Air raid sirens)
  - **TV/Film** (emotional lubricant, “sonification” of storyline)
  - **GUI’s (clicks, notifications, warnings, plug in/out USB**
  - **Cockpits, control rooms, kitchens, appliances, etc.**

Types of discrete auditory displays

Example: Some gadget/app that takes a picture.

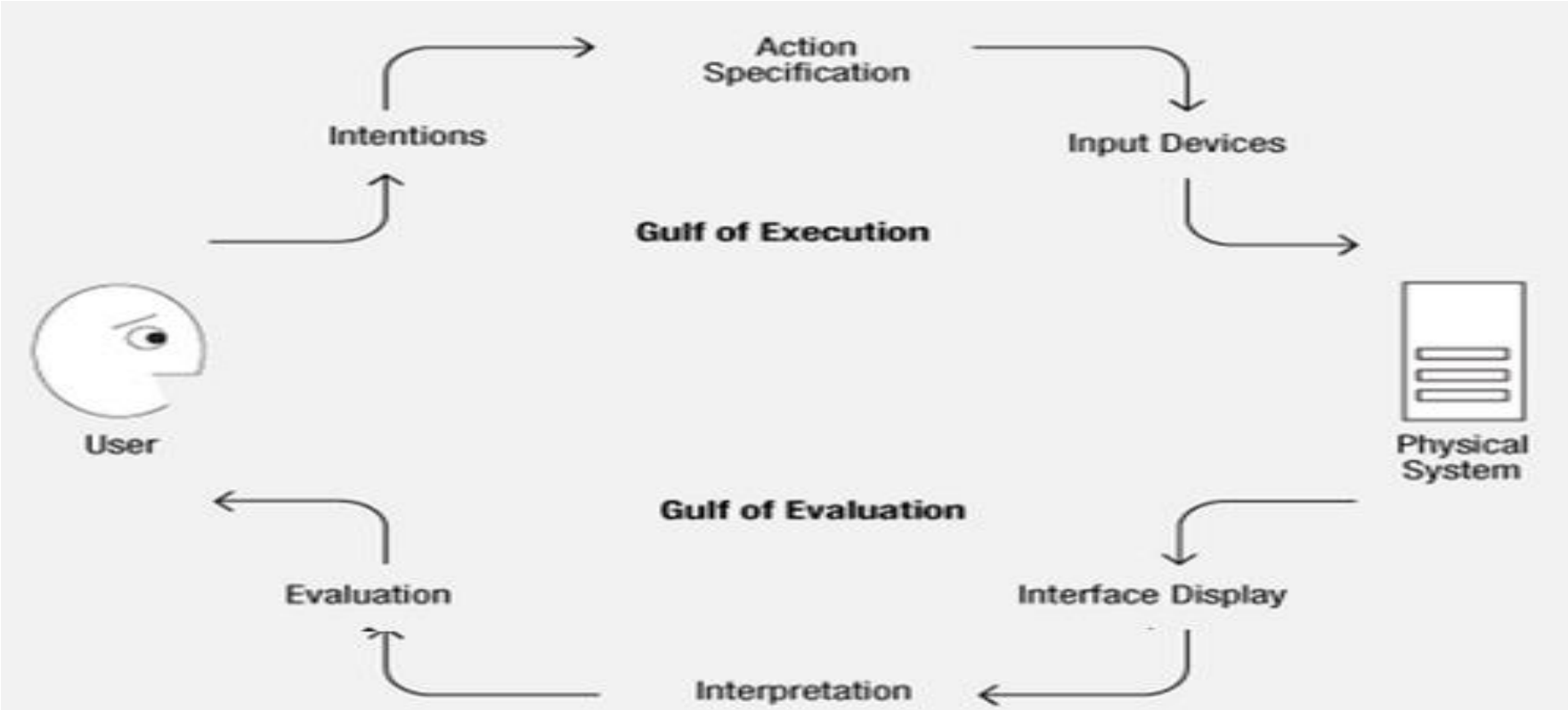


Data Sonification

- The use of non-speech audio to convey information
- “sonification is the transformation of data relations into perceived relations in an acoustic signal for the purpose of facilitating communication or interpretation”

- Auditory graphs
- Piano stairs
- Sonification of Wikipedia edits

Bad auditory displays



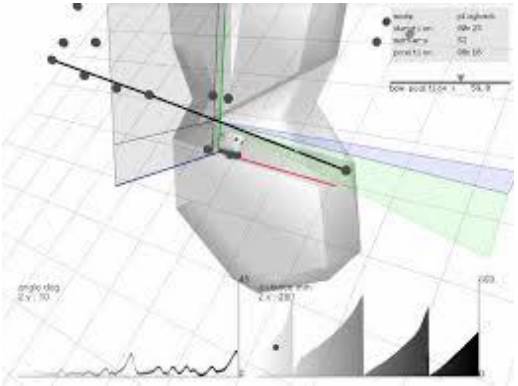
User's Psychological Goals	Gulf of evaluation and Execution	System Interface
To use audio display to extract information about the situation to prioritize sub-goals		"Beep"

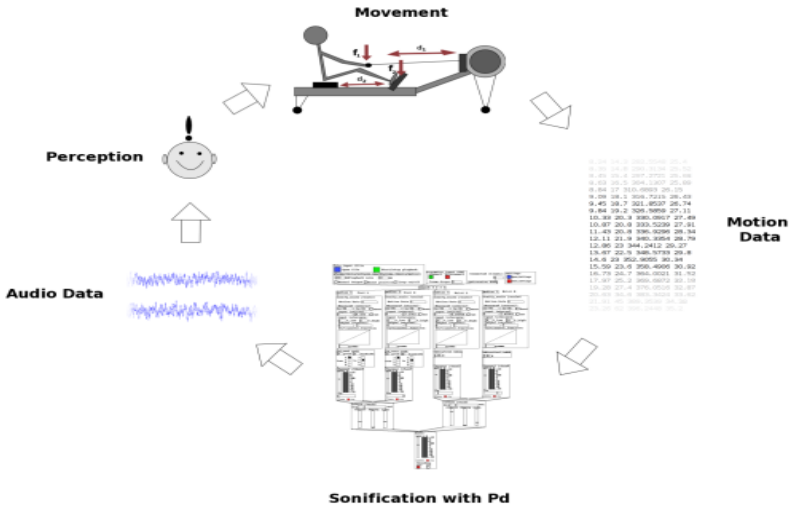
Usability in auditory displays

- Must use intuitive metaphors (what makes sense)
- Must consider the task (what is important to know)
- Must consider the listener (blind people and money)
- Must consider the environment (What is audible)
- Must not be annoying (repetitive, boring, loud, “ugly”)
- Must not be confusing (referent should be obvious)

Applications of data sonification

- Monitoring (automated) tasks
  - Control room operations
  - Vehicle operation
- Big data exploration
- Physical training
- Rehabilitation

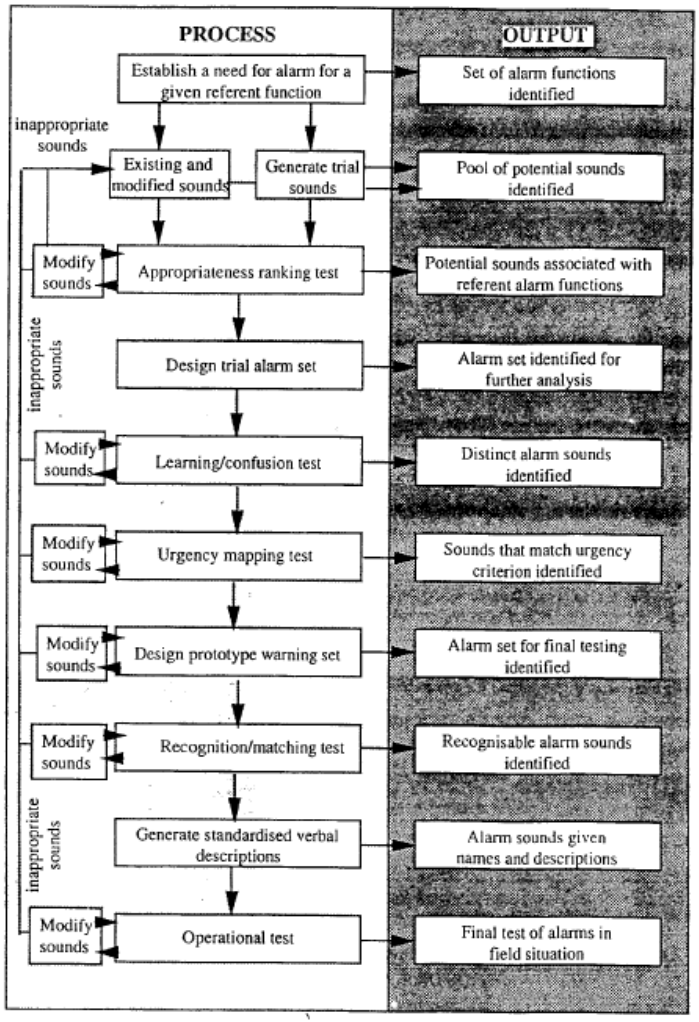




Method: User-Centered Methodology

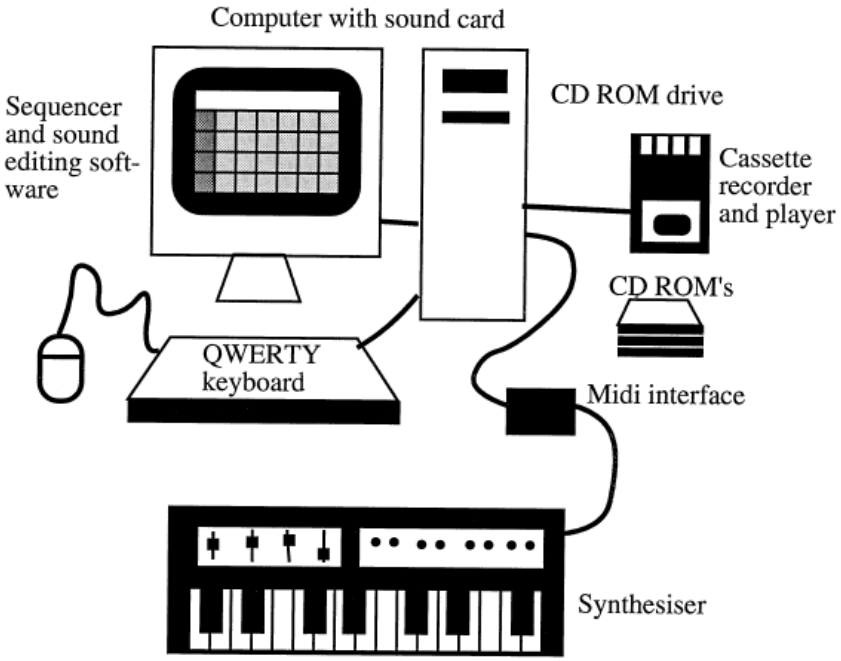
- Edworthy & Stanton (1995) adapted the standardized procedure for evaluating public information symbols to apply to auditory alarms

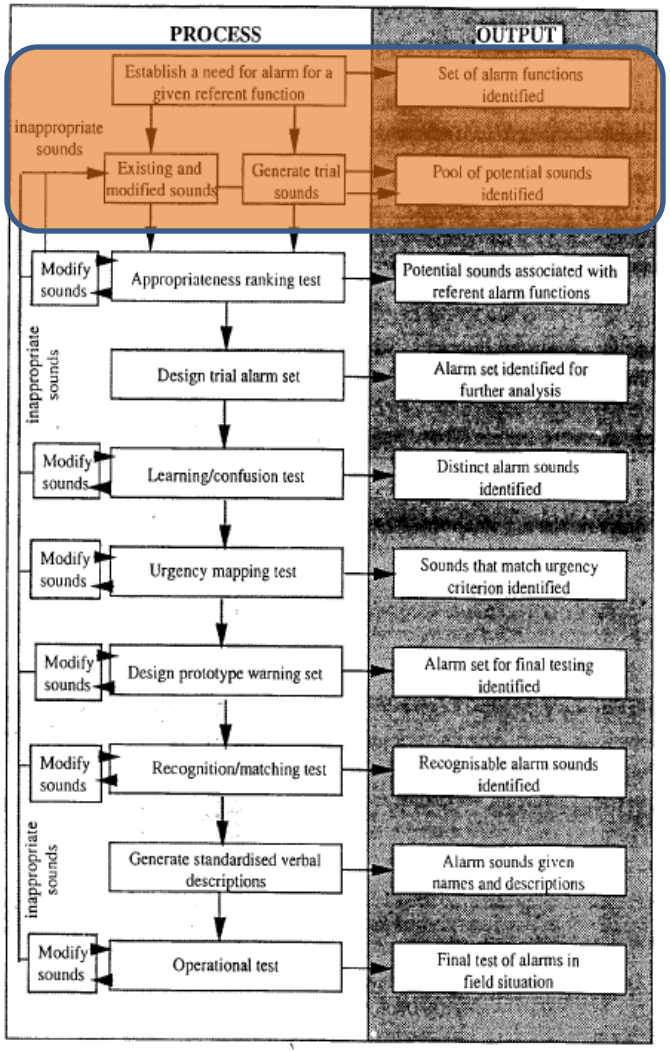
- Requirement gathering
- Generate pool of potential stimuli
- Appropriate ranking test
- Learning/Confusion test
- Urgency Mapping test
- Recognition/matching test
- Operation test*



Requirement Gathering

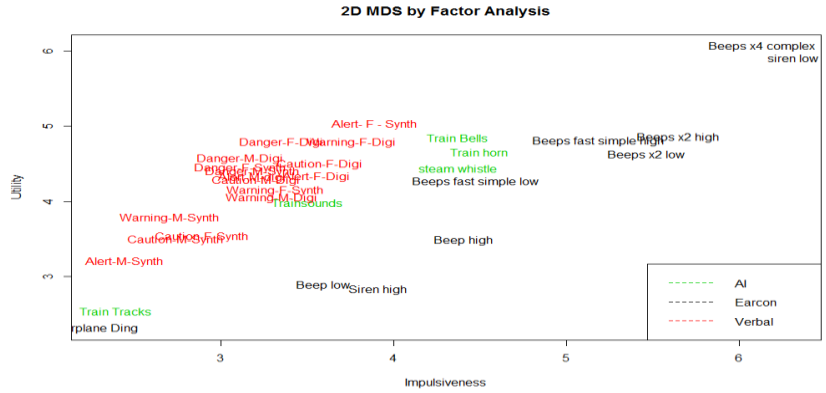
- Identify situations that require an auditory alarm
- Brainstorming session

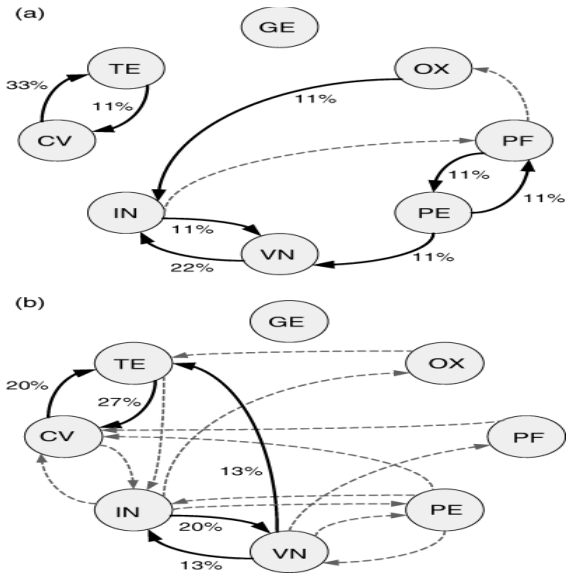


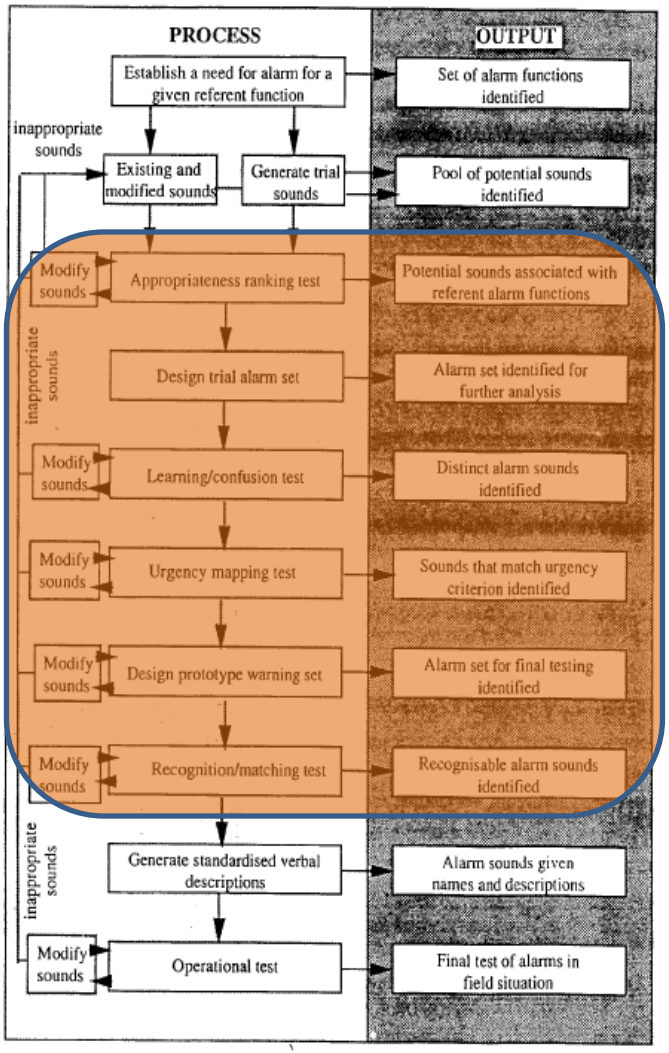


Appropriateness/Learning/Confusion tests

- **Subjective data -** “How does this sound make you feel”?
- **Objective data: -** “What does this sound mean?”







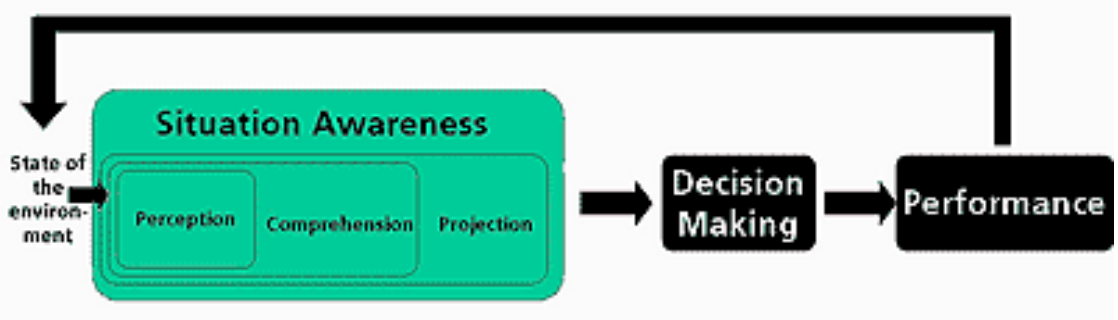
Appropriateness/Learning/Confusion tests

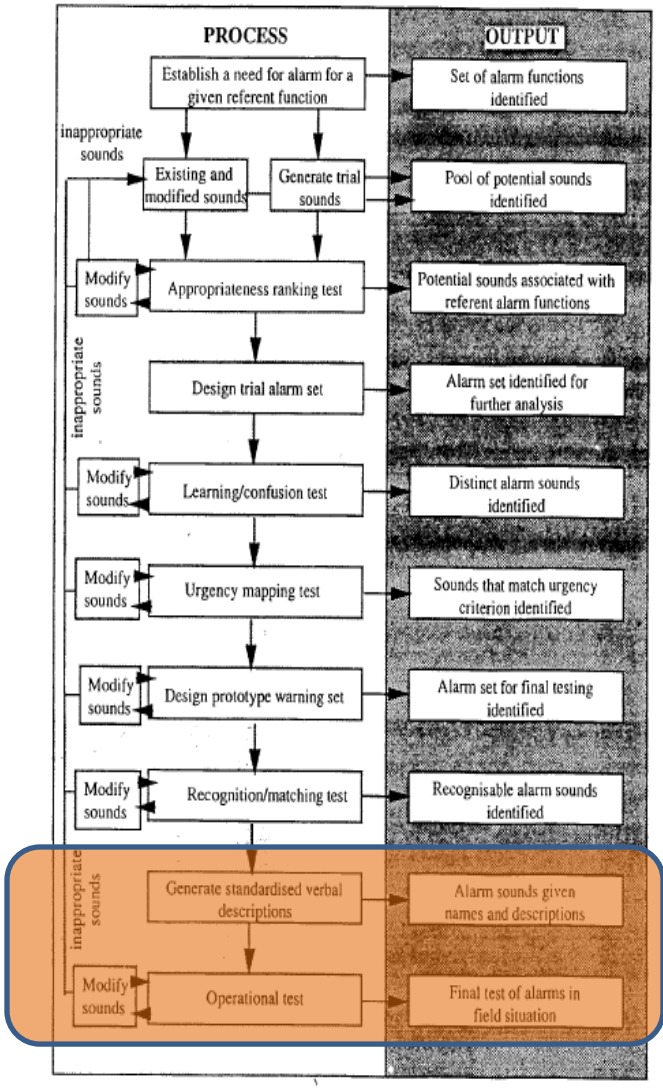
- Likert scales
  - How appropriate is this sound for this referent?
  - How urgent does this sound?
- Card sorting to assess
  - learnability
  - confusion

- How long does training take before participant reaches 100% accuracy

Operational test

- *Let them use it in context
- Collect performance data
- Reaction time
- A/B testing
- Situation Awareness tests





Immersive Interactive Sonification Platform (iISoP)

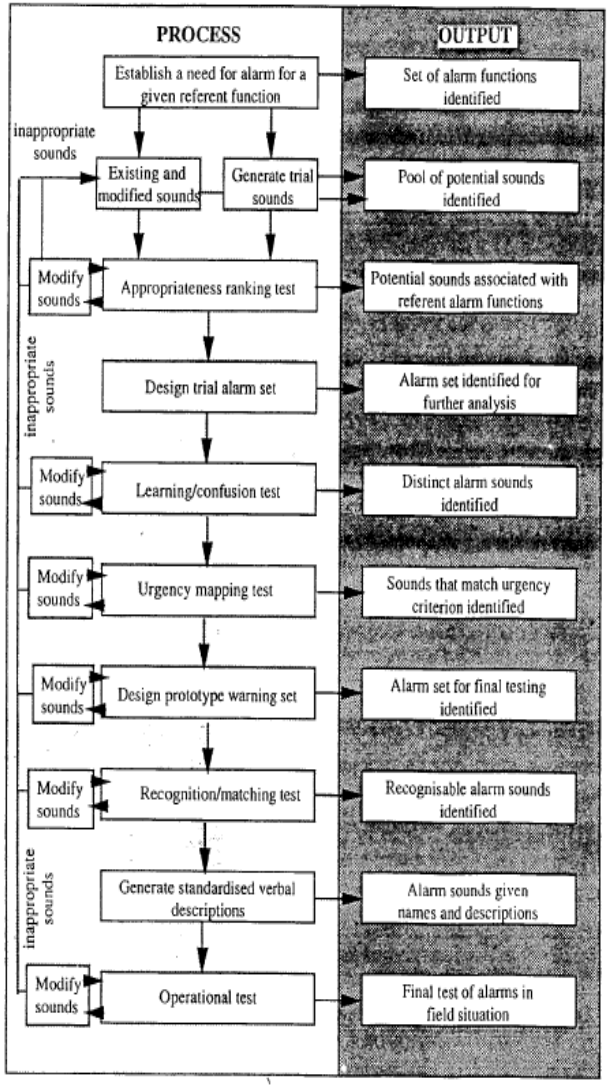
- Vicon Motion tracking cameras
- Large multi-monitor display wall
- 5.1 Surround sound speaker system

Dancer sonification system

- Use motion-capture data to generate pleasant/interesting dancer sonification
- Interactive – The system should act as a reactive and contributing agent, recalling previous messages and generate new messages that add to the conversation
- Recognize and sonify affective information portrayed by the dancer modeled after human performance
- Teach the system to generate music modeled after human composition performance
- Pass a “DJ” Turing test where algorithmic compositions are indistinguishable from human composed pieces

User-centered design methodology

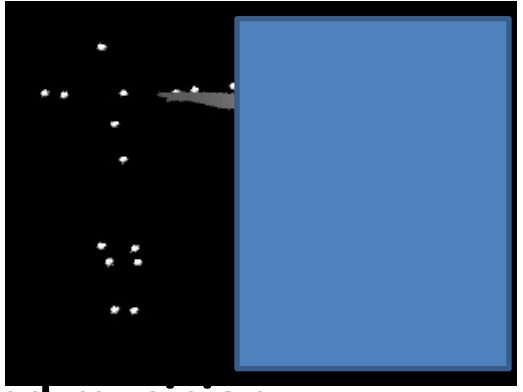
- Requirement gatherings from end users and experts
- Generate a pool of sonification strategies
- Validate visual and audio stimuli
- Operations test



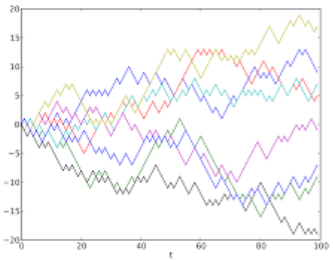
User-centered design methodology

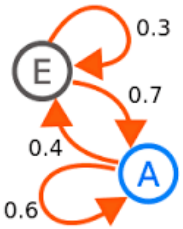
- Requirement gathering
  - Semi structured interviews with stakeholders
  - Record emotional dancing to pre-recorded music
- Sonification strategies gathering
  - Send composers muted videos of dancers
  - Specific instructions for each group
- Stimuli validation surveys
  - Guess the emotion of the dancer/sonification
- Model human performance
  - How do people detect and express emotion from gestures/posture
  - How do people compose music to express motion and emotion?
- Operations test
  - User preference, workload, expressivity, interactivity, virtuosity
  - Audience recall of motion and emotion from only sound

Preliminary results



- **Difference between the needs of the dancer and musician**
  - Automation vs. amount of control
  - Freedom of movement





- **NOT randomly generating notes**
  - Random walk models (melodies)
  - Markov chains/probability/euclidian (rhythms)
  - Round to nearest note in key

- **Laban Movement analysis**
  - Body size (valence)
  - Movement activity (arousal)
  - Obvious affective gestures

Preliminary results

- Algorithmic/stochastic computer music modeled after human composers:
- https://www.youtube.com/watch?v=n0c657I8hNQ
- https://www.youtube.com/watch?v=y5V785NAbpk
- Real-time algorithmic dancer controlled sonification:
- https://www.youtube.com/watch?v=rqW0-mDgyX0
- https://www.youtube.com/watch?v=WSOSq8ffQN8
- https://www.youtube.com/watch?v=erLCkTHNOCw
- https://www.youtube.com/watch?v=-eIPzlcODpI
- Submitted human composed compositions from muted dancer videos:
- https://www.youtube.com/watch?v=Cd_-LW5MJzw
- https://www.youtube.com/watch?v=IhFeT6lkKkM
- https://www.youtube.com/watch?v=LUfGWQ8eIaM
- https://www.youtube.com/watch?v=0iw9oGl9f_c

Preliminary results

- Lets play!
  - Parameter mapping: simple to complex
  - Modeling human compositions
  - Machine learning
    - Discrete classification of images (nearest neighbor, neural network)
    - Continuous sound morphing (regression)
    - Time series data (dynamic time stretch)