Audio Output

Learning Goals

- Understand …
  - Available audio output technologies
  - Different types of sounds that can be used
  - How information is communicated using audio
  - The basics of sonification
- Know
  - Advantages and disadvantages of using sound for information presentation
  - How data can be mapped to sounds
  - How to design auditory icons and Earcon

Audio Output Technologies

Technologies and Parameter

- Speakers
  - Mono, stereo
  - Multi-speaker system
- Headphones
  - Over-ear / on-ear
  - In-ear / earbuds
  - Bone conduction
- Parameters:
  - Frequency range and Frequency response
  - Volume range
  - Directionality
  - Physical setup and size
  - Connections and data transmission

Audio Output Types

What sound is it?

- Simple sounds
  - Beeps, e.g. warnings
  - Single frequency
- Designed sounds
  - Auditory icons
  - Earcons
  - Composed / Music
- Sonification
  - Turning other media into sound
- Existing sounds
  - Speech, nature, music

Audio Output

How is the sound created on a computer?

- Synthesized audio, e.g.
  - Midi
  - Text to speech
- Playback of captured audio

Auditory Icons vs. Earcons

Icons that you can hear

- **Auditory Icons**

  “informative sounds as an auditory icon” (Gaver, 1986)

  “Gaver’s auditory icons have been used in several systems […] These use **environmental sounds** that have a semantic link with the object or action they represent.” (Brewster et al.,1994)

- **Earcons**

  “We call such **structured sounds** earcons, which are defined as **nonverbal audio messages** used in the user-computer interface to provide information to the user about some computer object, operation, or interaction. Examples of computer objects are files, menus, and prompts. Editing, compiling, and executing are examples of operations. An example of an interaction between an object and an operation is editing a file.” (Blattner et al. 1989)

-Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. *Human-computer interaction*, *2*(2), 167-177.
-Brewster, Stephen A., Peter C. Wright, and Alastair DN Edwards. "A detailed investigation into the effectiveness of earcons." SANTA FE INSTITUTE STUDIES IN THE SCIENCES OF COMPLEXITY-PROCEEDINGS VOLUME-. Vol. 18. ADDISON-WESLEY PUBLISHING CO, 1994.
-Blattner, M. M., Sumikawa, D. A., & Greenberg, R. M. (1989). Earcons and icons: Their structure and common design principles. Human–Computer Interaction, 4(1), 11-44.

Auditory Icons

Bill Gaver, 1986

- Sound vs. Vision

	TIME	SPACE
SOUND	**Sound exists in time.** • Good for display of changing events. • Available for a limited time.	**Sound exists over space.** • Need not face source. • A limited number of messages can be displayed at once.
VISION	**Visual objects exist over time.** • Good for display of static objects. • Can be sampled over time.	**Visual objects exist in space.** • Must face source. • Messages can be spatially distributed.

Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. *Human-computer interaction*, *2*(2), 167-177.

Auditory Icons

Bill Gaver, 1986

- Example: Deleting a File

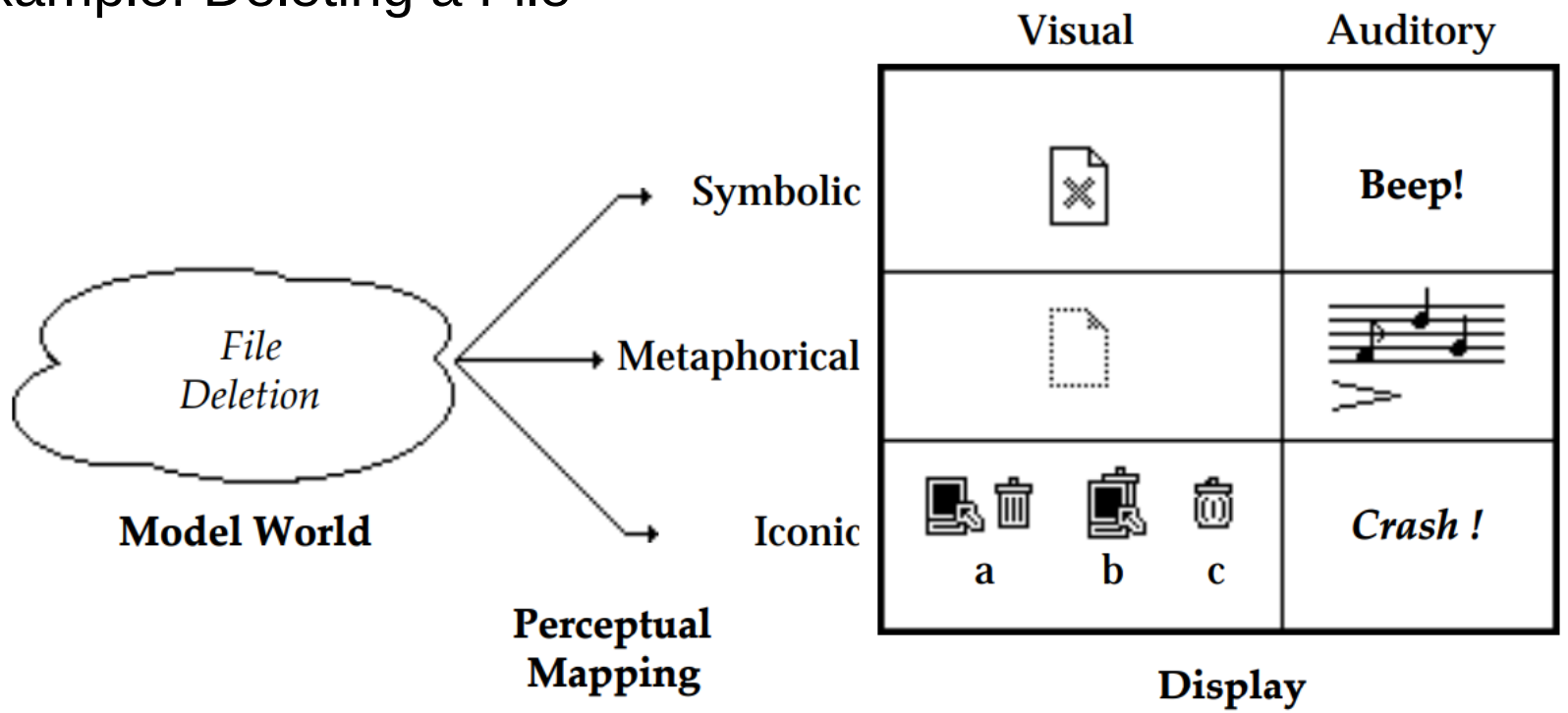


Figure 4. A conceptual file deletion may be mapped to a display in many different ways. Here six possibilities are shown, one visual and one auditory example each of symbolic, metaphorical, and iconic mappings between the event and the display.

Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. *Human-computer interaction*, *2*(2), 167-177.

Auditory Icons

Bill Gaver, 1986

- Creating sounds that can be linked to events
- Sound helps to discriminate
  - Objects
  - Activities
  - Properties (e.g. size, number)

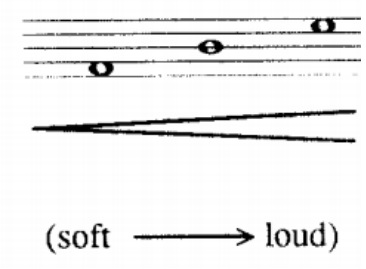
MAPPING EVENTS TO SOUND IN THE SONICFINDER

FINDER EVENTS	AUDITORY ICONS
Objects	
Selection	Hitting sound
Type (file, application, folder, disk, trash)	*Sound source (wood, metal, etc.)*
Size	*Frequency*
Opening	Whooshing sound
Size of opened object	*Frequency*
Dragging	Scraping sound
Size	*Frequency*
Where (windows or desk)	*Sound type (bandwidth)*
Possible Drop-In?	*Selection sound of disk, folder, or trashcan*
Drop-In	Noise of object landing
Amount in destination	*Frequency*
Copying	Pouring sound
Amount completed	*Frequency*
Windows	
Selection	Clink
Dragging	Scraping
Growing	Clink
Window size	*Frequency*
Scrolling	Tick sound
Underlying surface size	*Frequency*
Trashcan	
Drop-in	Crash
Empty	Crunch

Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. *Human-computer interaction*, *2*(2), 167-177.

One Element Earcons

- “One-element earcons may be **digitized sounds, a sound created by a synthesizer, a single note, or a motive**. An element may be compared to a word, whereas a note may be compared to a letter of the alphabet.”
- “A single-motive earcon has the attributes **of rhythm, pitch, timbre, register, and dynamics**. Because single-motive earcons are relatively simple, they can represent basic, common computer entities such as certain error messages, system information, windows, and files.”
- “The user hears the click each time a character is deleted.”

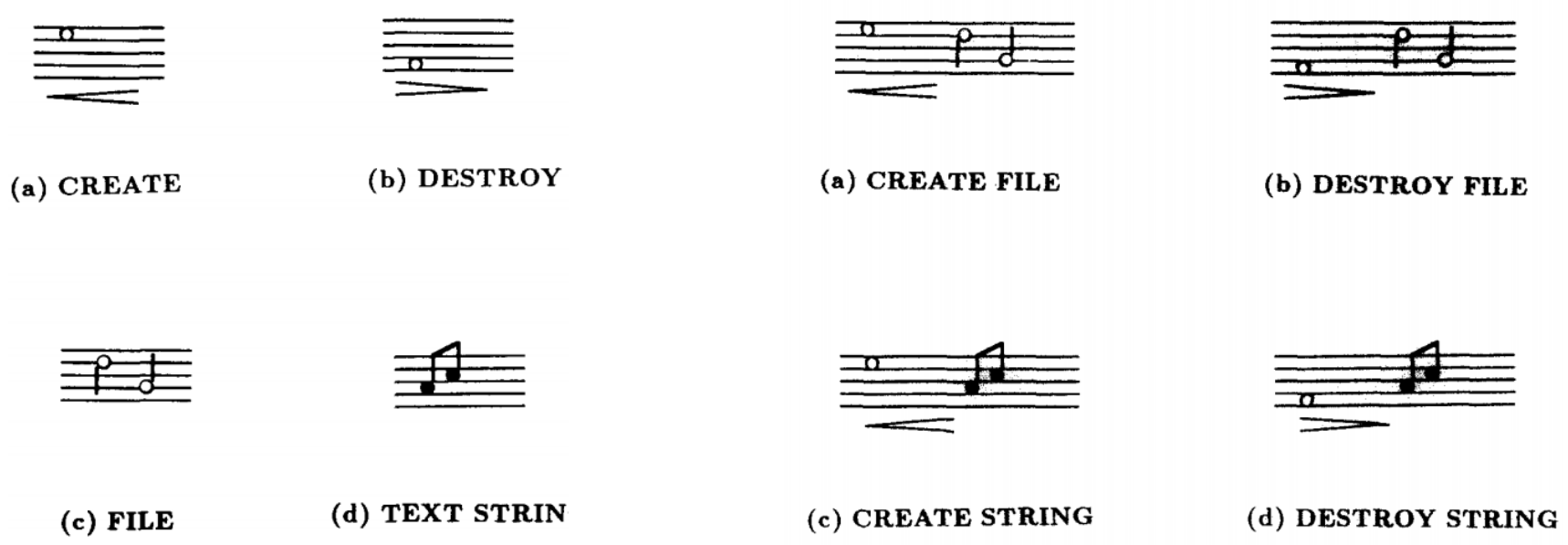


An earcon with dynamics that change from soft to loud.

Blattner, M. M., Sumikawa, D. A., & Greenberg, R. M. (1989). Earcons and icons: Their structure and common design principles. Human–Computer Interaction, 4(1), 11-44.

Combined Earcons

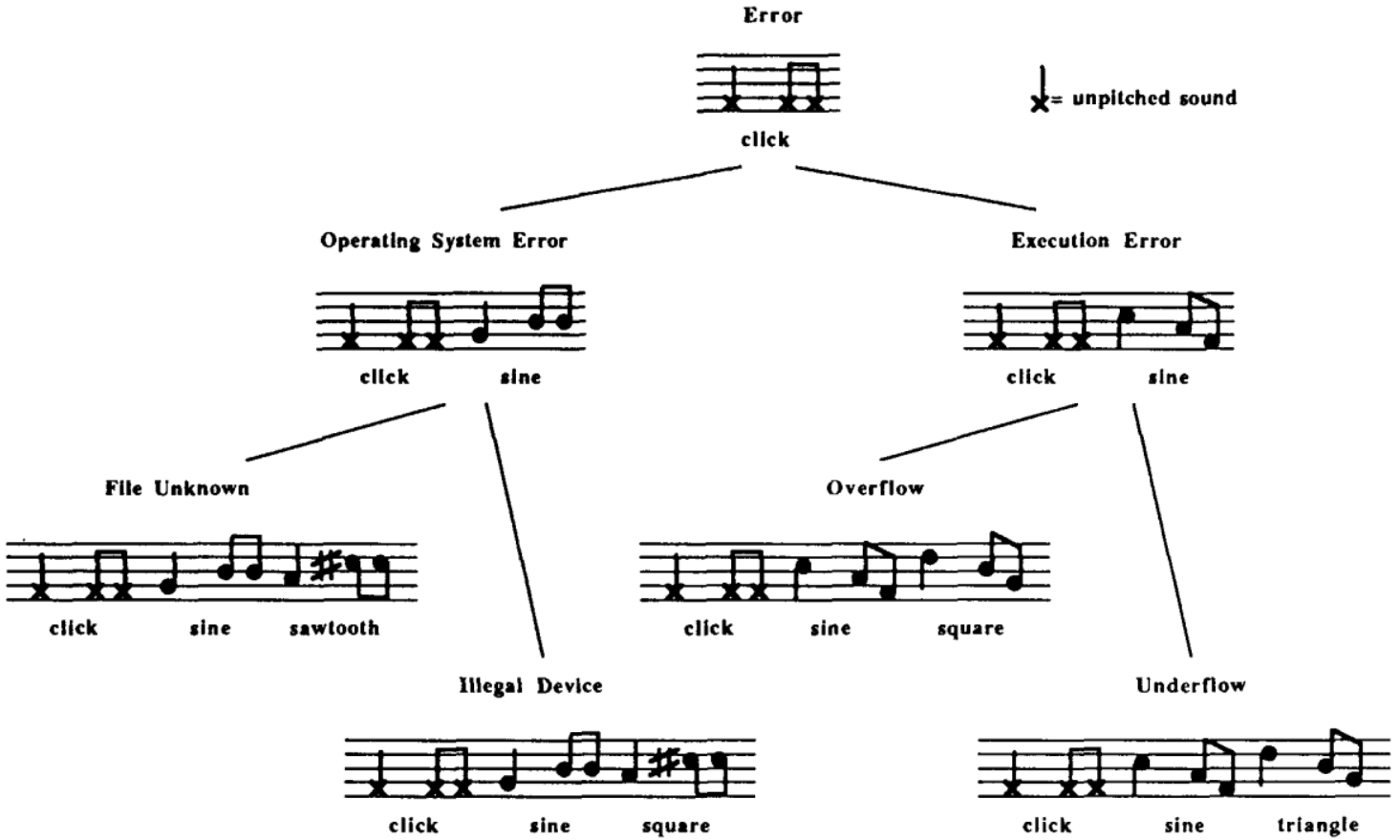
- “The three construction principles for compound earcons are combining, inheriting, and transforming.” p29
- “Combined earcons are formed by placing two or more audio elements in succession.” p29



Blattner, M. M., Sumikawa, D. A., & Greenberg, R. M. (1989). Earcons and icons: Their structure and common design principles. Human–Computer Interaction, 4(1), 11-44.

Composed Earcons

Example Hierarchy – for Expert Users one?



Blattner, M. M., Sumikawa, D. A., & Greenberg, R. M. (1989). Earcons and icons: Their structure and common design principles. Human–Computer Interaction, 4(1), 11-44.

What do you hear?

Geiger Counter

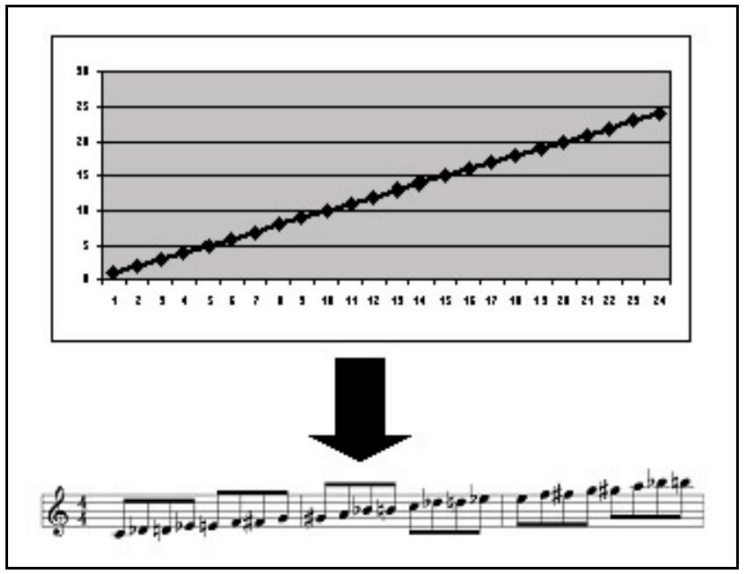
Sound of Radiation

Sound from BBC - http://bbcsfx.acropolis.org.uk/?q=geiger

Sonification

Basics

- non-speech audio
- convey information
- Make data / information audible
- alternative or complement to visualizations



As the y-value increases the pitch of the musical note gets higher

Brown, L.M. and Brewster, S.A. and Ramloll, S.A. and Burton, R. and Riedel, B. (2003) Design guidelines for audio presentation of graphs and tables. In.9th Int. Conf. on Auditory Display (ICAD), 2003, pp. 284- 287, Boston.

Sonification

Mapping Data to Sounds

- “which specific sound dimension is chosen to represent a given data dimension. […]”
- Typical acoustic dimensions:
  - Pitch / Frequency
  - Amplitude / Volume
  - Tempo / Duration
- Spatial arrangements

Brown, L.M. and Brewster, S.A. and Ramloll, S.A. and Burton, R. and Riedel, B. (2003) Design guidelines for audio presentation of graphs and tables. In.9th Int. Conf. on Auditory Display (ICAD), 2003, pp. 284- 287, Boston.

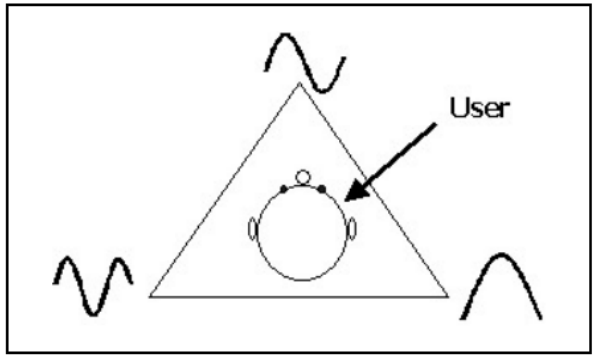


Figure 2: *One series is positioned at each corner of an equilateral triangle, with the user in the centre*

Walker, B. N., & Nees, M. A. (2011). Theory of sonification. The sonification handbook, 9-39.

Functions of Sonification

- Alerting functions
- Status and progress indicating functions
- Data exploration functions
  - Auditory graphs
  - Interactive sonification
- Art and entertainment

Walker, B. N., & Nees, M. A. (2011). Theory of sonification. The sonification handbook, 9-39.

Tasks supported by Sonification

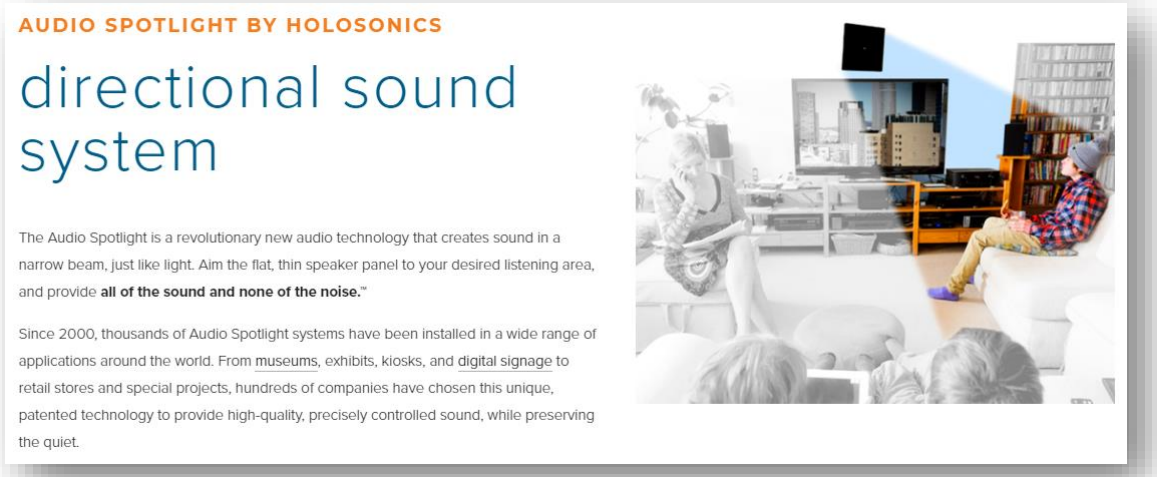
- Monitoring
- Providing Awareness of a process or situation
- Data exploration, exploratory inspection
- Point estimation and point comparison
- Trend identification
- Identification of data structure

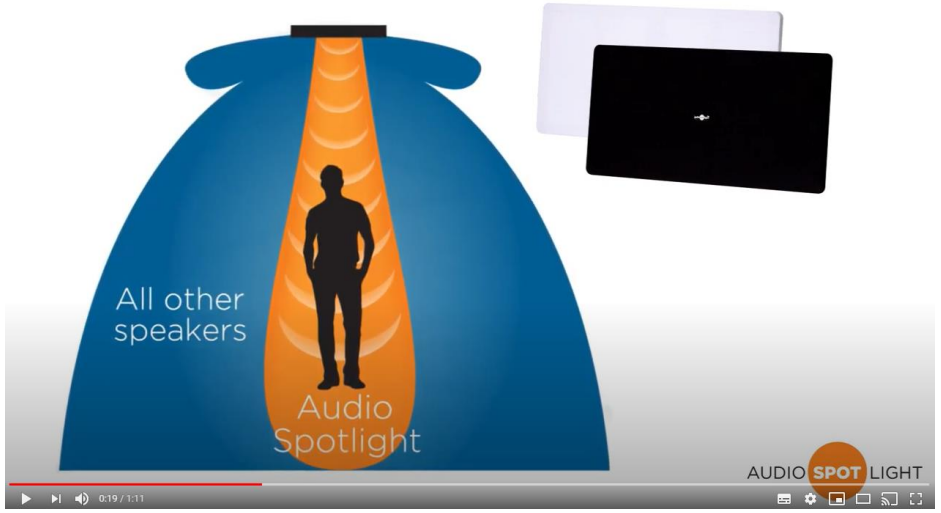
Walker, B. N., & Nees, M. A. (2011). Theory of sonification. The sonification handbook, 9-39.

Further topics in this space

optional

- Speech interaction and speech dialog system
- Spatial audio algorithms and toolkits
  - E.g. Omnitone (Spatial Audio Rendering on the Web) https://googlechrome.github.io/omnitone/
- Speaker systems that provided directed sound
  - E.g. Audio Spot lights, https://www.holosonics.com/





https://www.youtube.com/watch?v=lk7PVZYS_TQ

Did you understand this block?

Can you answer these questions?

- What technologies are available for presenting audio?
- Discuss how sounds can be used to convey information?
- What is the difference between auditory icons and Earcons?
- What is a combined Earcon?
- What are typical functions of sonification?
- What tasks can be supported by sonification?
- What auditory dimensions can be used to map data onto?

Reference

- Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. Human-computer interaction, 2(2), 167-177.
- Brewster, Stephen A., Peter C. Wright, and Alastair DN Edwards. "A detailed investigation into the effectiveness of earcons." SANTA FE INSTITUTE STUDIES IN THE SCIENCES OF COMPLEXITY-PROCEEDINGS VOLUME-. Vol. 18. ADDISON-WESLEY PUBLISHING CO, 1994.
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- Brown, L.M. and Brewster, S.A. and Ramloll, S.A. and Burton, R. and Riedel, B. (2003) Design guidelines for audio presentation of graphs and tables. In.9th Int. Conf. on Auditory Display (ICAD), 2003, pp. 284- 287, Boston.
- Walker, B. N., & Nees, M. A. (2011). Theory of sonification. The sonification handbook, 9-39.
- Sound library from BBC - http://bbcsfx.acropolis.org.uk/?q=geiger

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