SCHOOL OF INFORMATICS

INDIANA UNIVERSITY

IUPUI

Audemes as Non-speech Sounds for Content-rich Acoustic Interfaces

Mexhid Ferati

June 26th, 2012

How do we Learn?

The United States Constitution was adopted on September 17, 1787, by the Constitutional Convention in Philadelphia, Pennsylvania, and ratified by conventions in eleven states.

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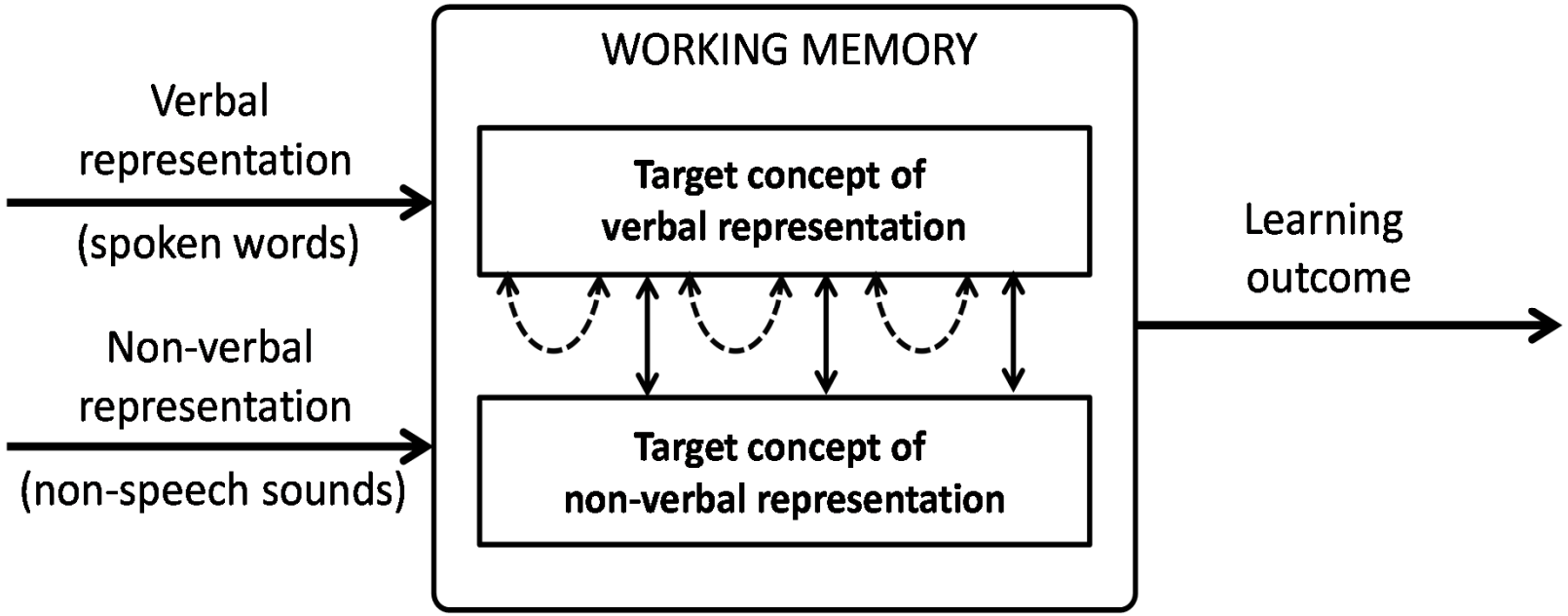
The Role of Audemes

Audemes are non-speech sounds formed of a combination of music and sound effect sounds for vivid representation of theme-based content

Multimedia Learning

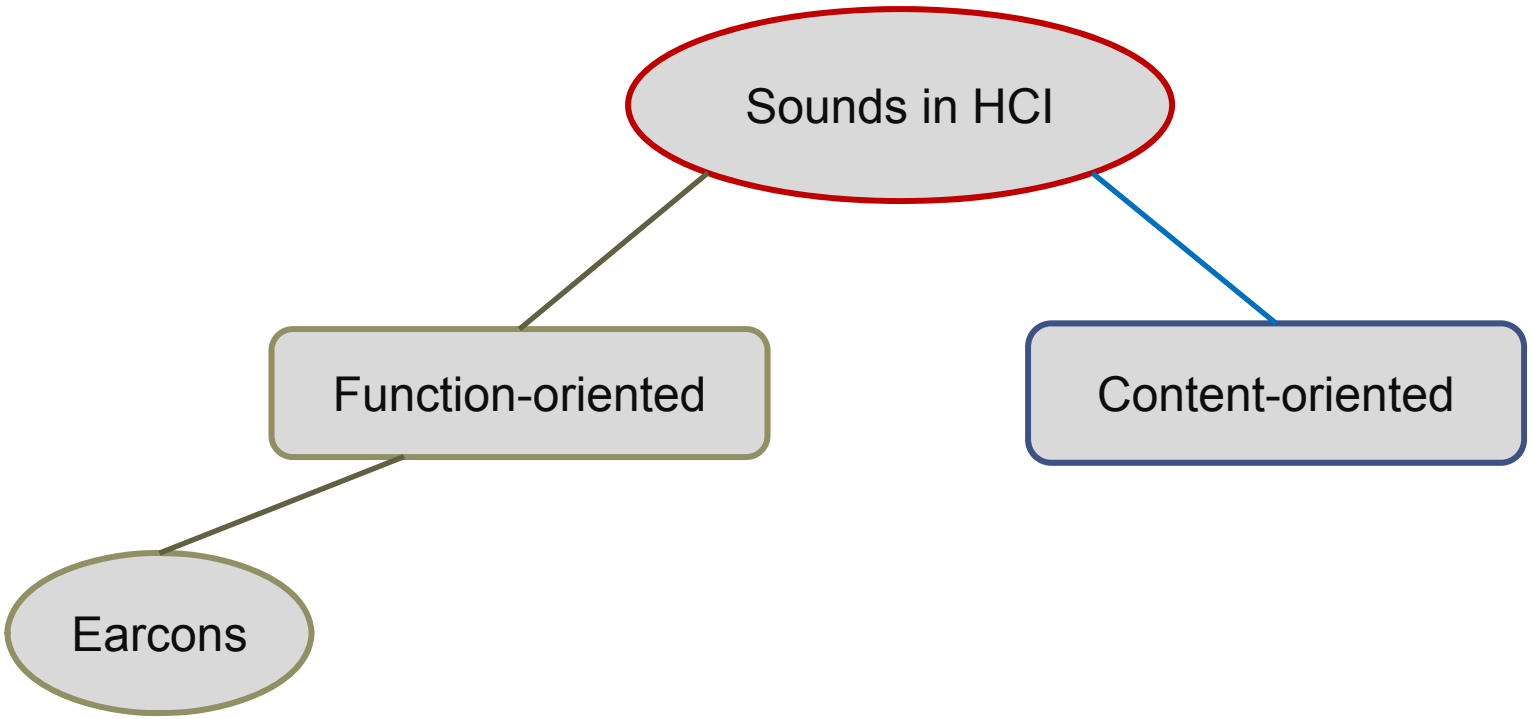


Adapted from Mayer & Moreno (1998)

From the Visual to the Aural Paradigm

- Traditionally, the education of the blind and visually impaired (BVI) has been vision-centric
- Digital information consumption through Graphical User Interface (GUI)
- A drawback for a community that mainly utilizes auditory channel
- Only 19% of the BVI pursue college education
- Researchers have recognized this need and invented different types of non-speech sounds to help BVI community

Sounds in Human-Computer Interaction



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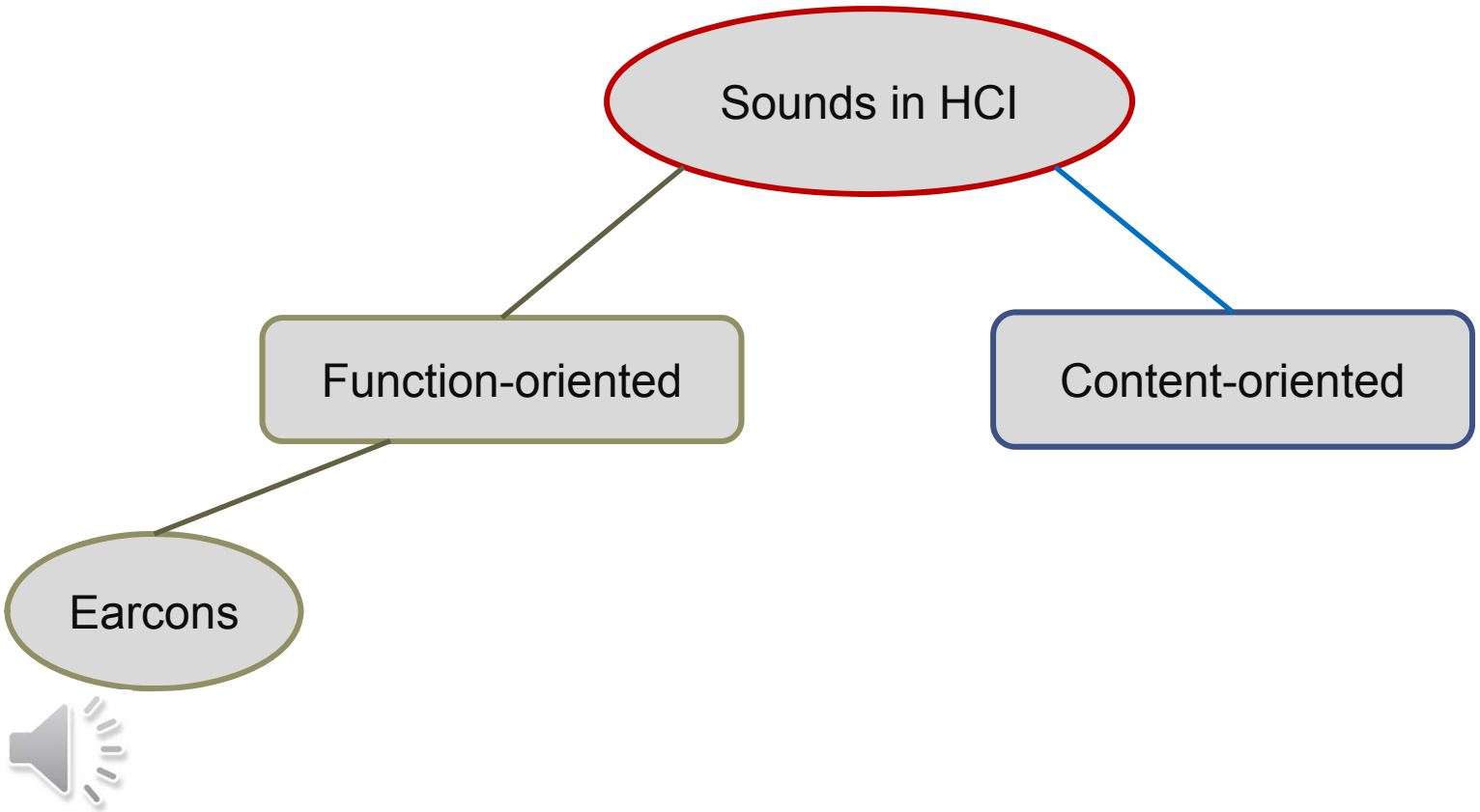

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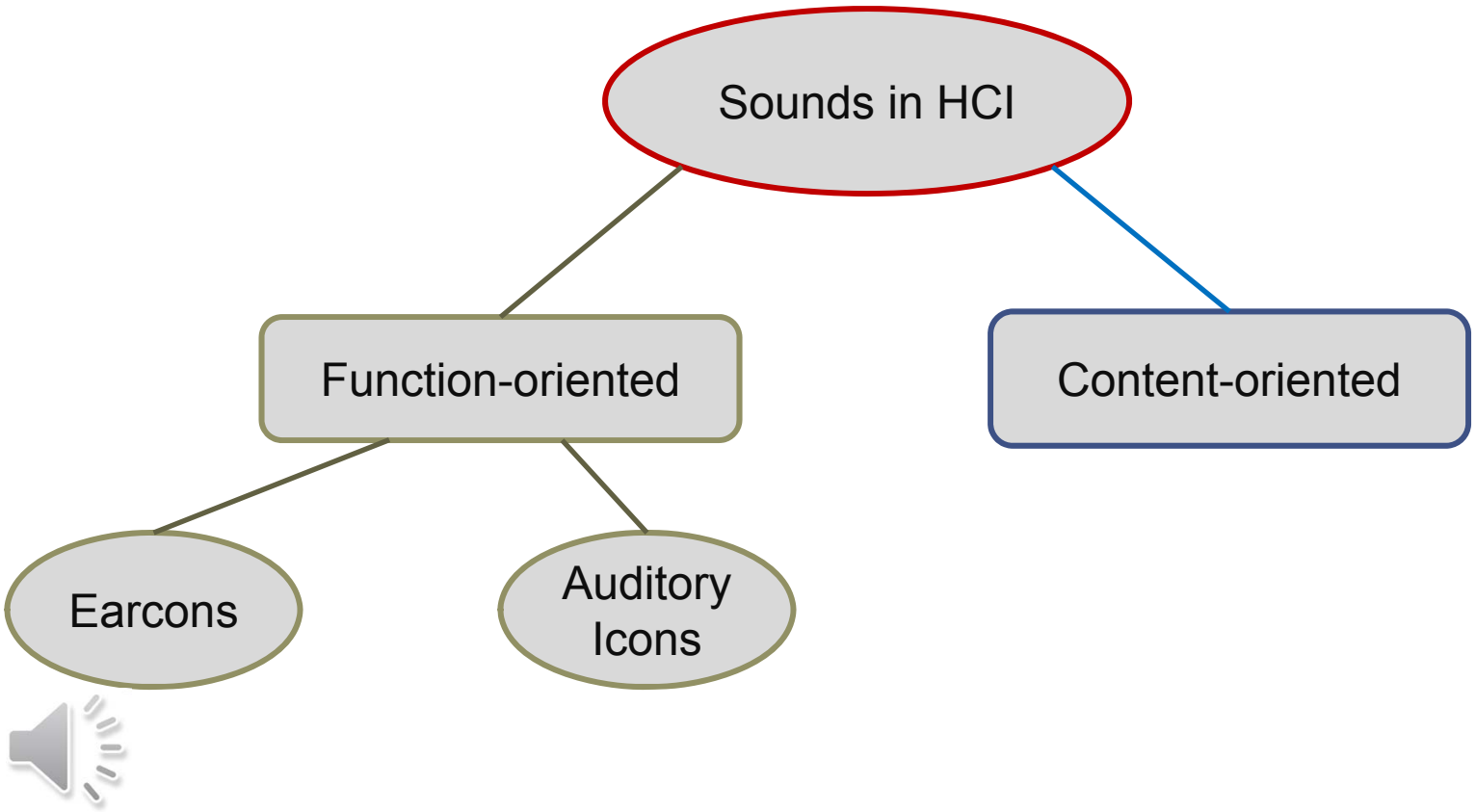

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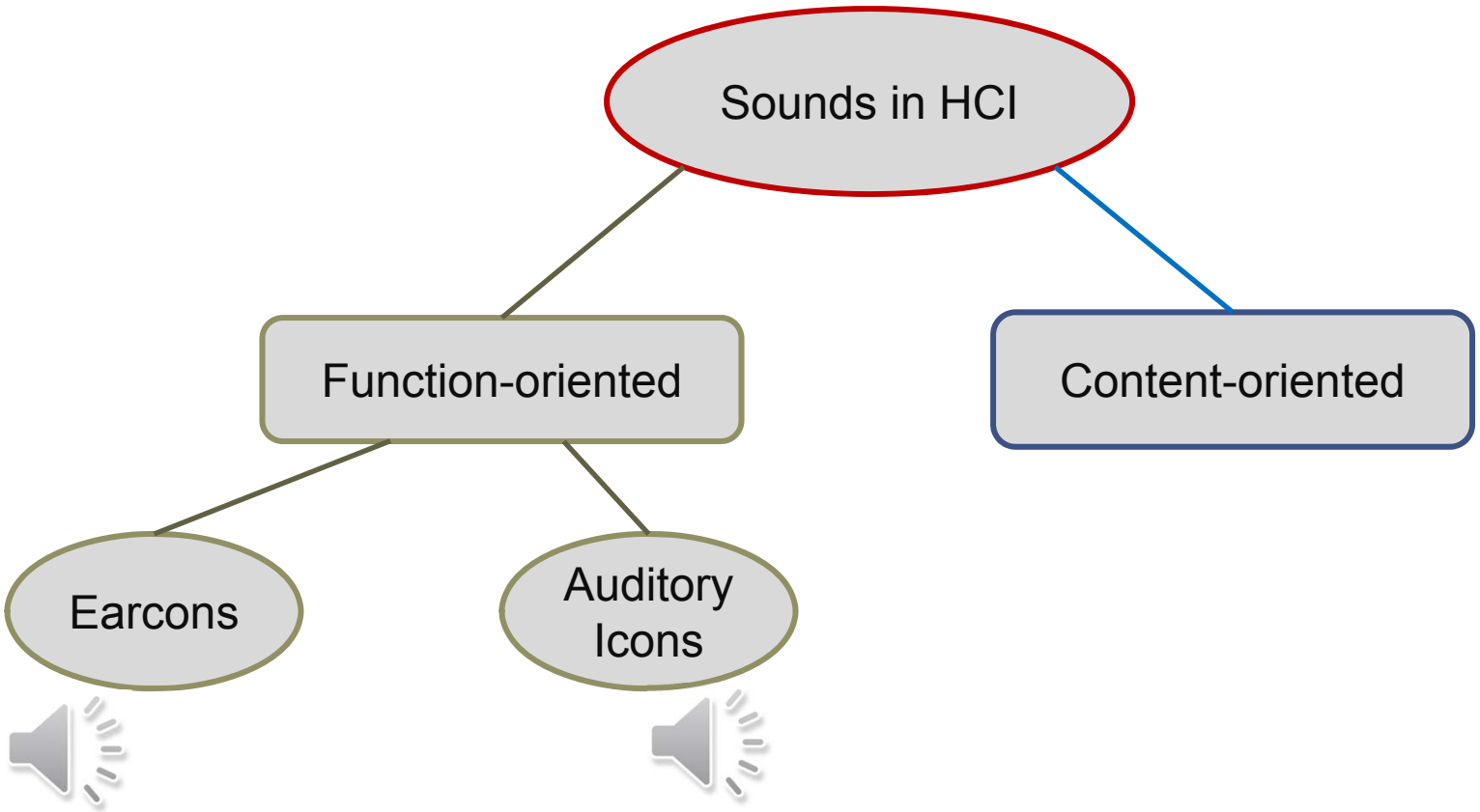

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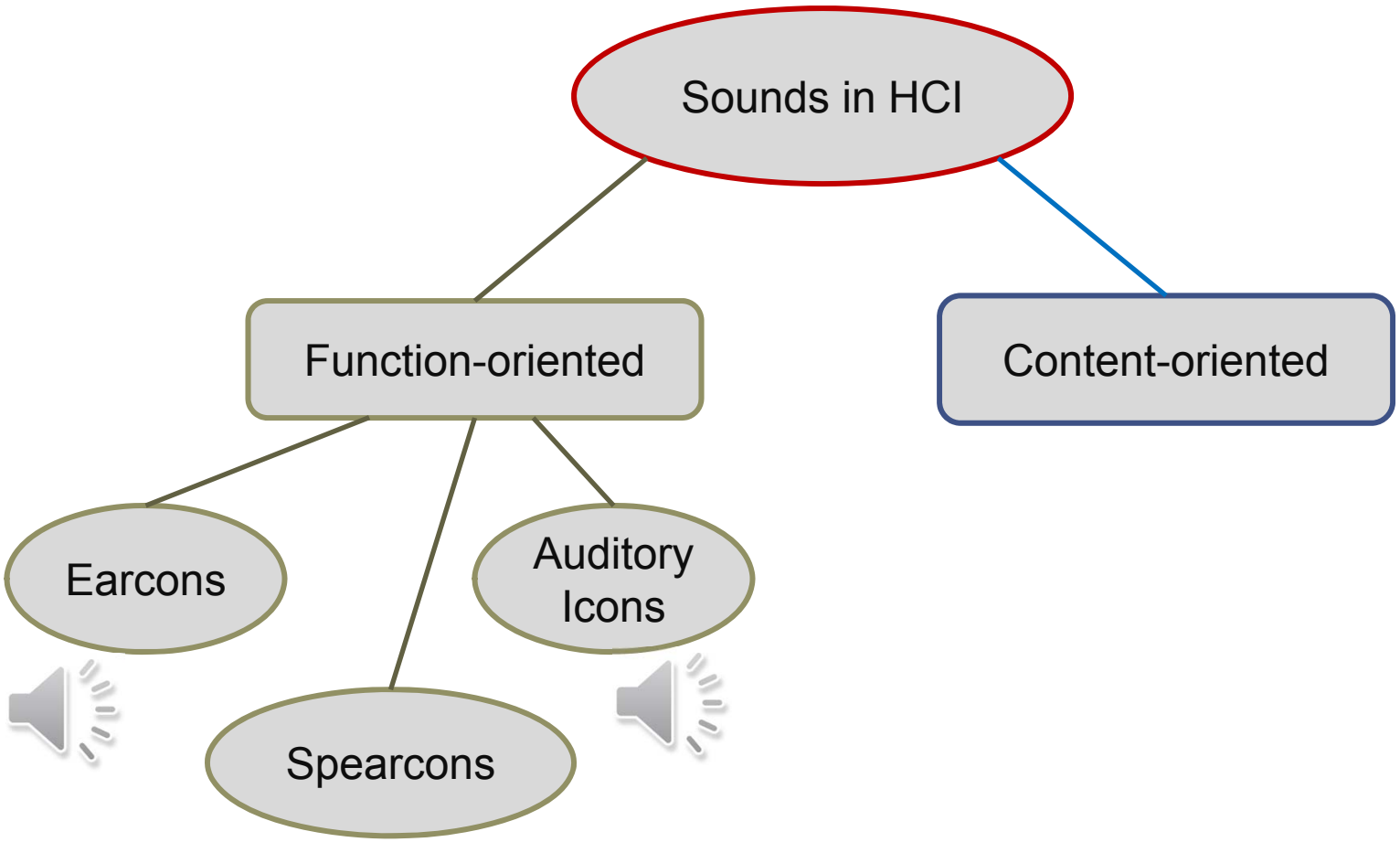

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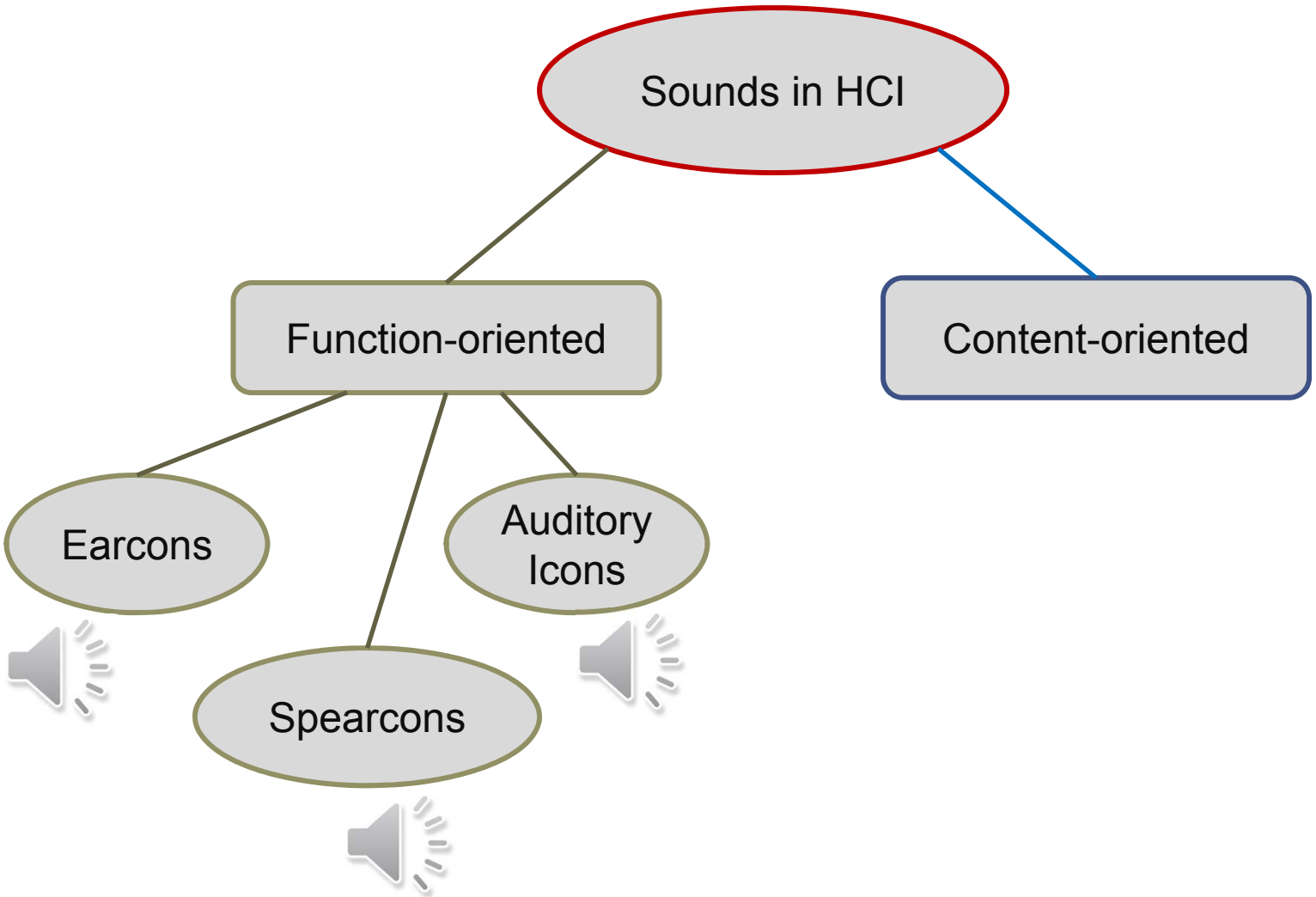

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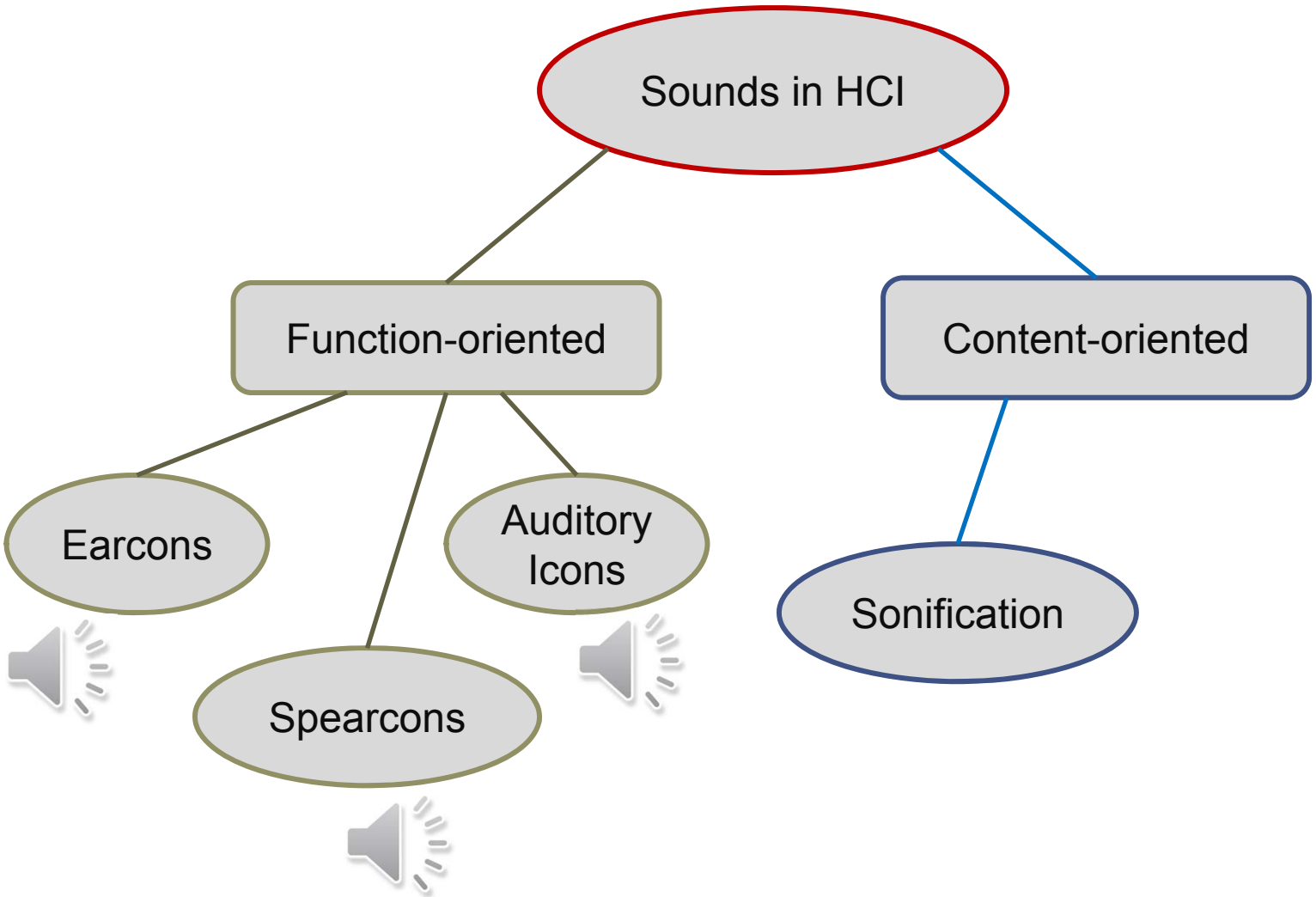

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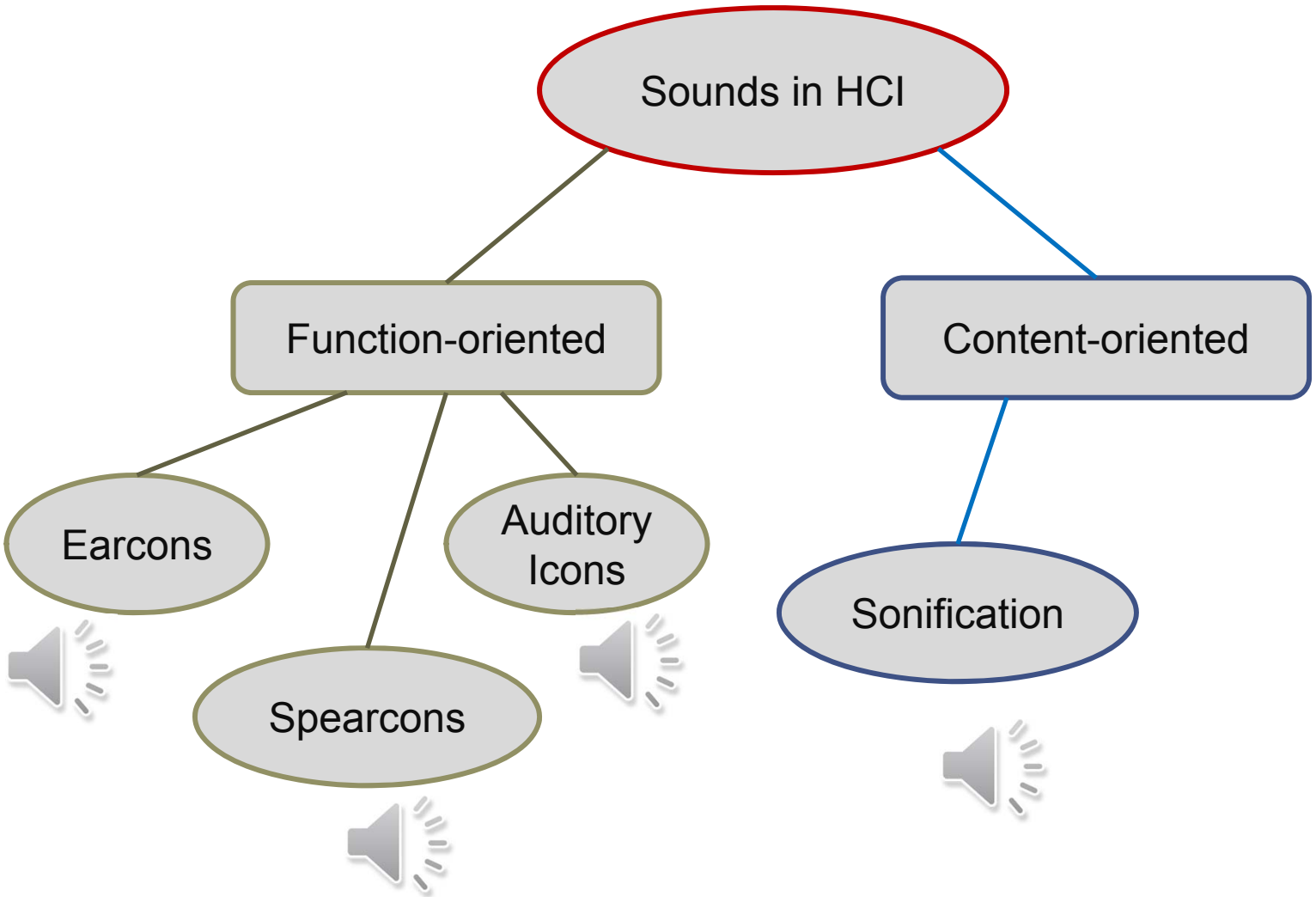

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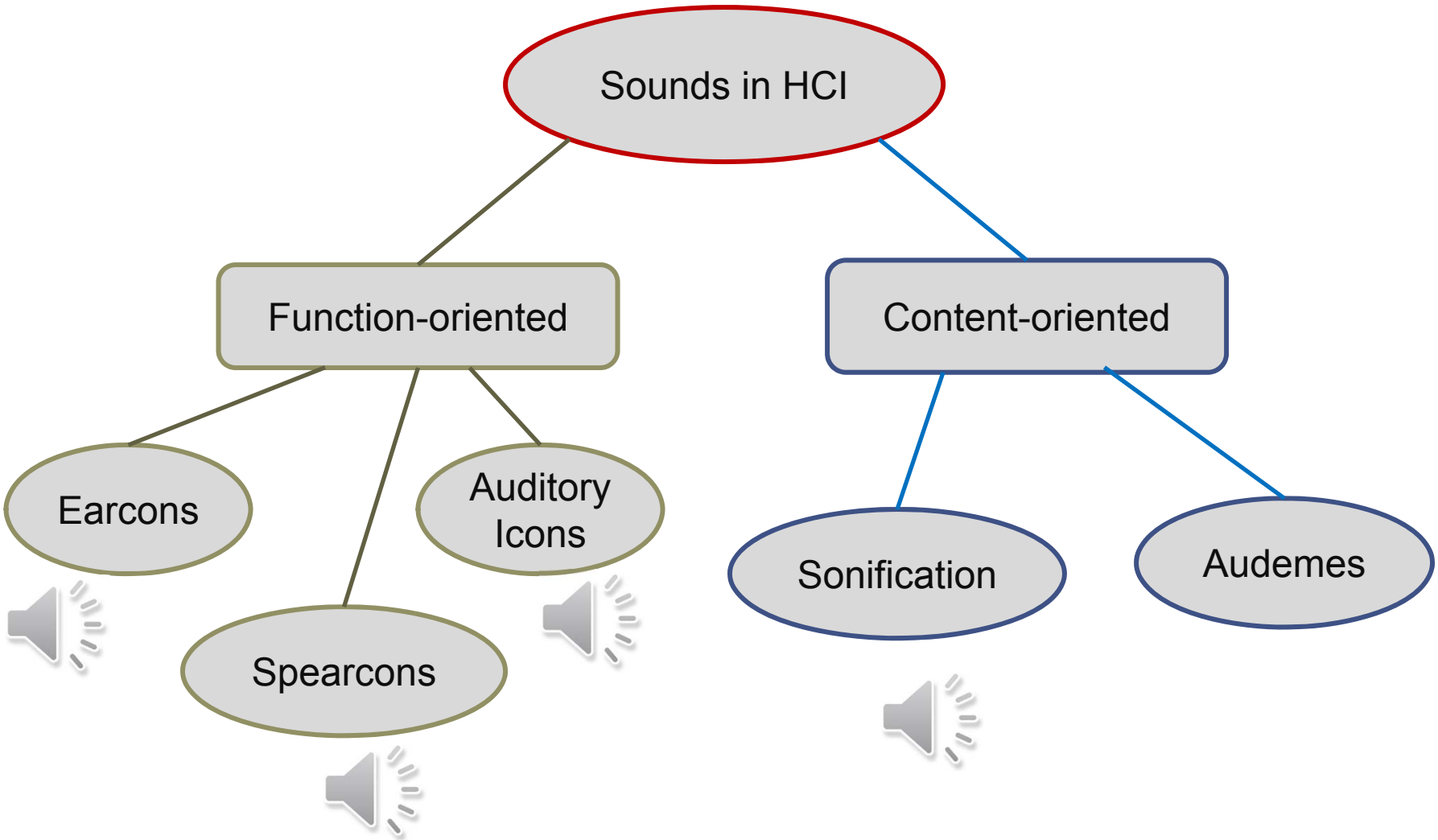

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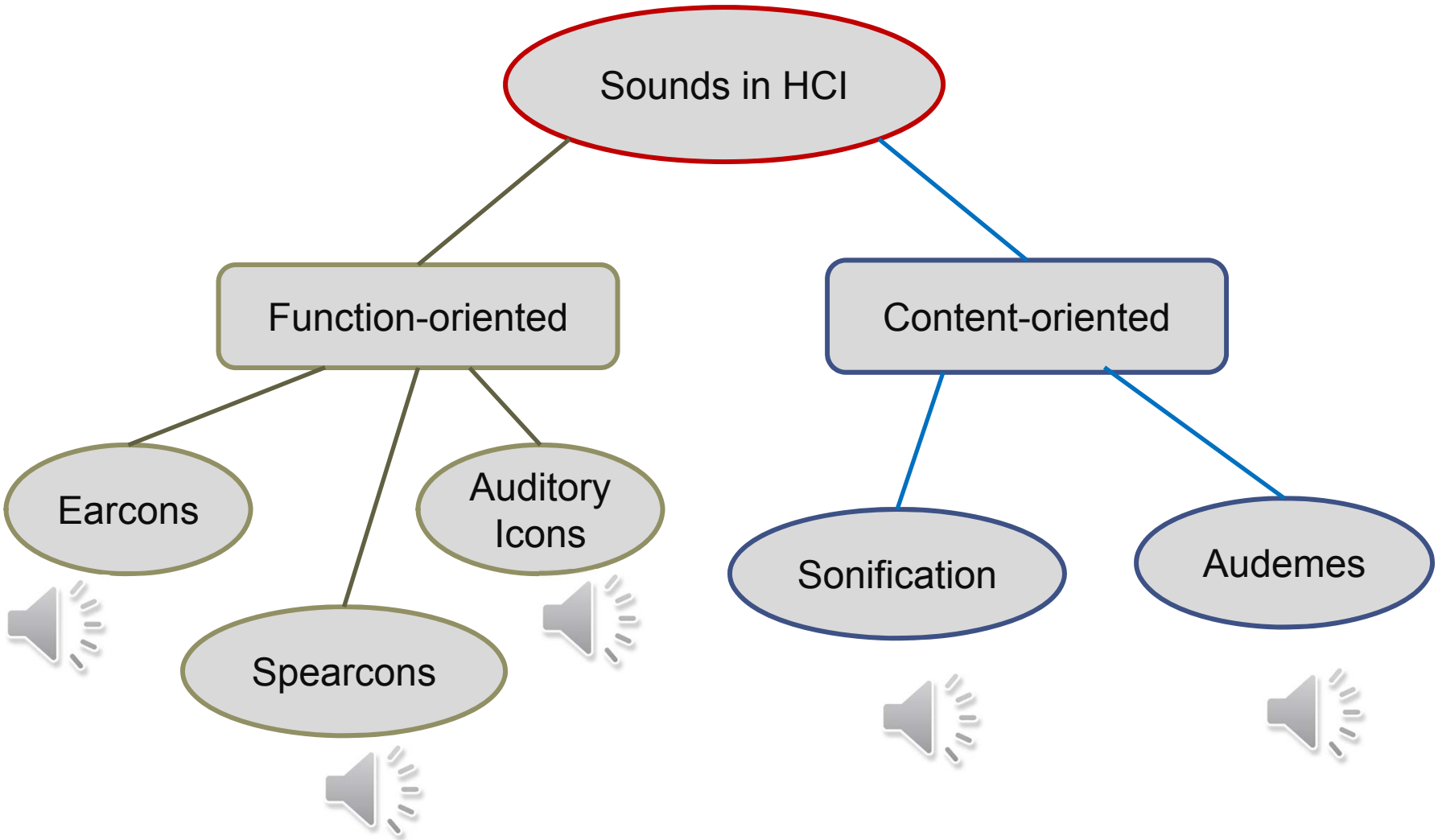


Limitations of Existing Non-speech Sounds

- Existing non-speech sounds have been used only to represent *brief information* about objects or events in user interfaces

- Not suitable to convey large theme-based information, such as educational content

Need for a New Type of Non-speech Sounds to Convey Theme-based Content

- Content used for educational purposes is typically large and well-organized around a single theme
- For instance, a 500-words informal essay with unifying or dominant idea that describes a specific and distinctive quality, characteristic, or concern about a subject, event or place
- Content designed to support effective issue-centered learning
- Therefore, we need to investigate audemes, a new category of non-speech sounds, whose semiotic structure and flexibility open new horizons for facilitating the education of BVI students.

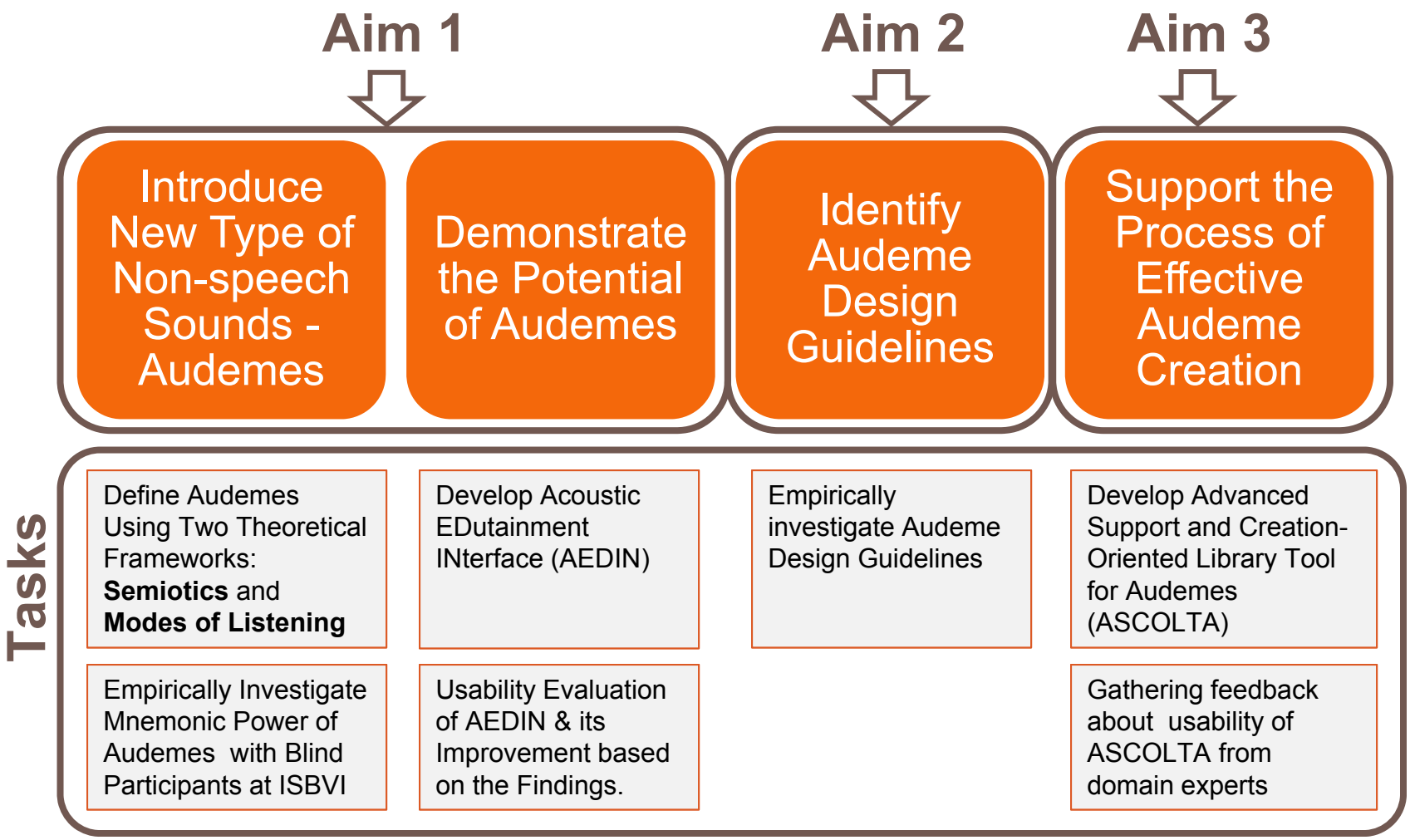
Research Questions

1. When a new type of non-speech sound (*audeme*) is played along with theme-based information, does it help to better memorize content?

2. What is the function(s) of audemes in content-rich interfaces for the BVI?

3. What characteristics of audemes help BVI users recognize audeme meaning?

Dissertation Aims



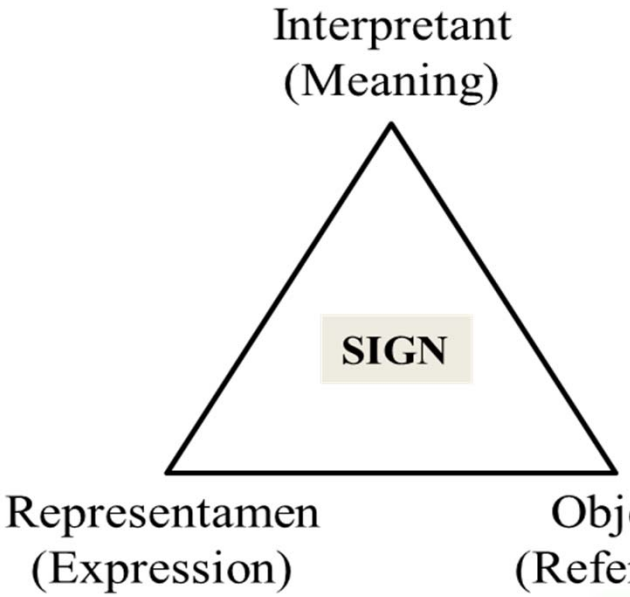
Theoretical Frameworks. Why We Need Them?

To understand how audemes build meaning, I use two theoretical frameworks

1. **Semiotics –** for internal modeling of audemes
2. **Modes of Listening –** for perceptual modeling of audemes

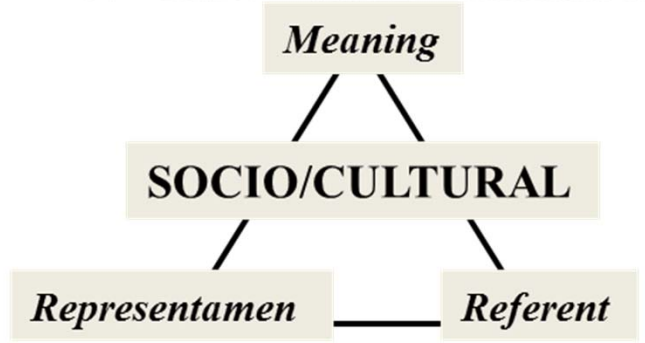
Semiotics

DANGER



"FIRE"

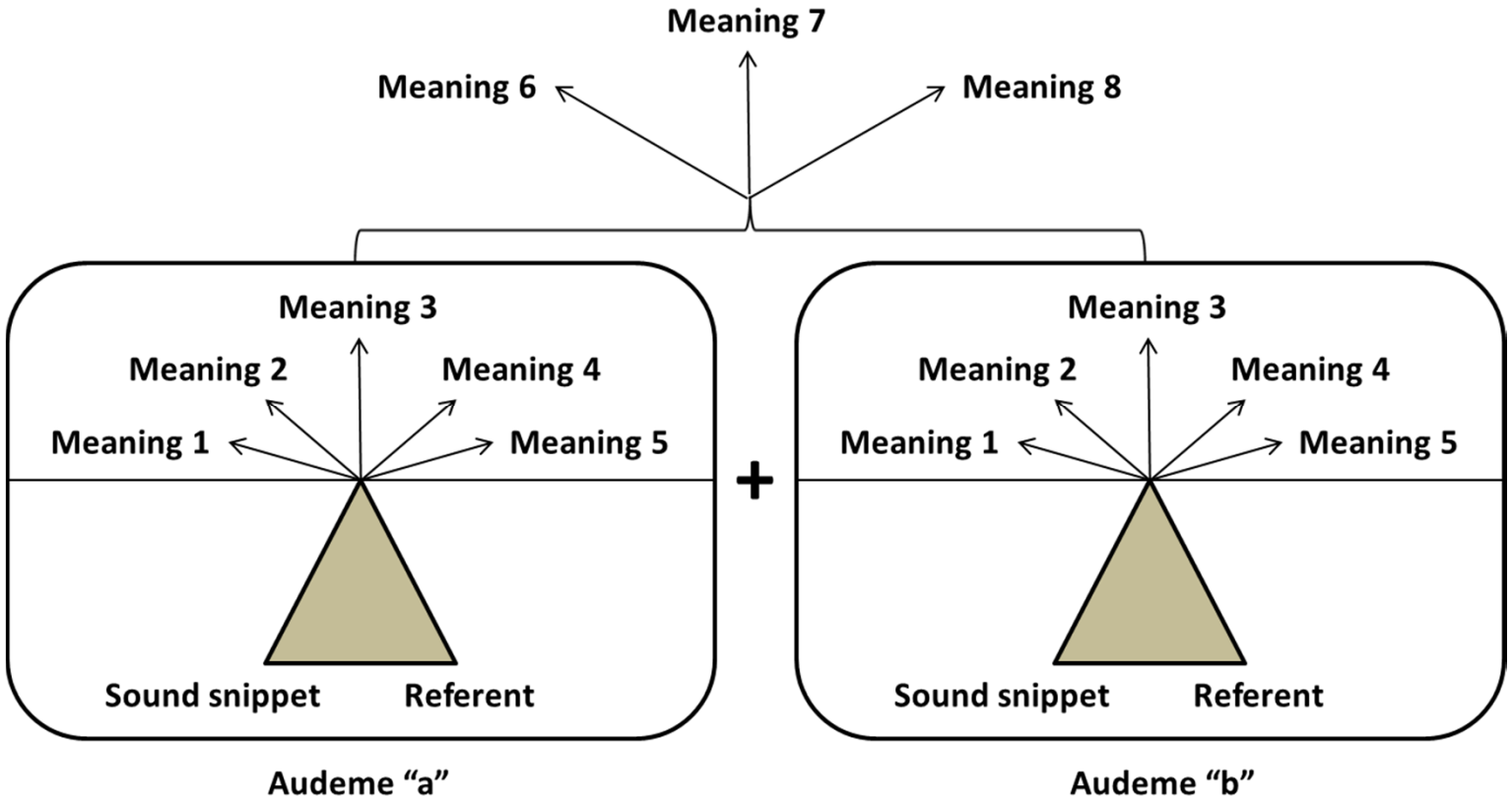
1. Rain: Rain, Weather
2. Song
3. Rain + Violin = Melancholy

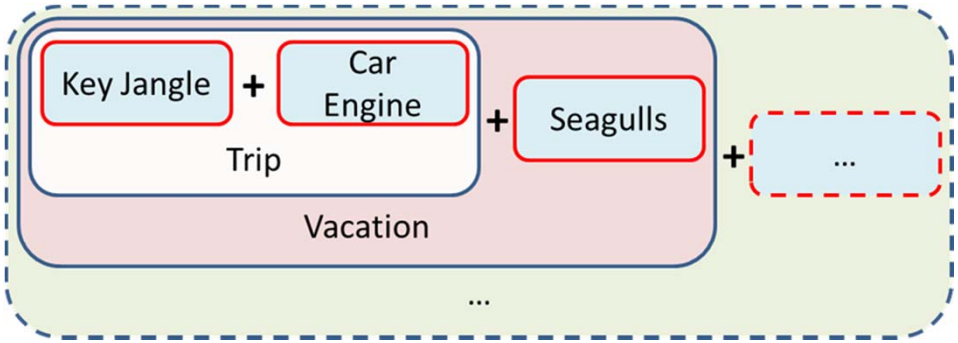


1. "Rain" Audeme	1. Rain
2. Violin Audeme	2. Violin Playing
3. Rain + Violin Audeme	3. Rain and Violin Together

Adapted from Peirce (1908)

Meaning Generation in Audemes





Mannheimer et al (2009)

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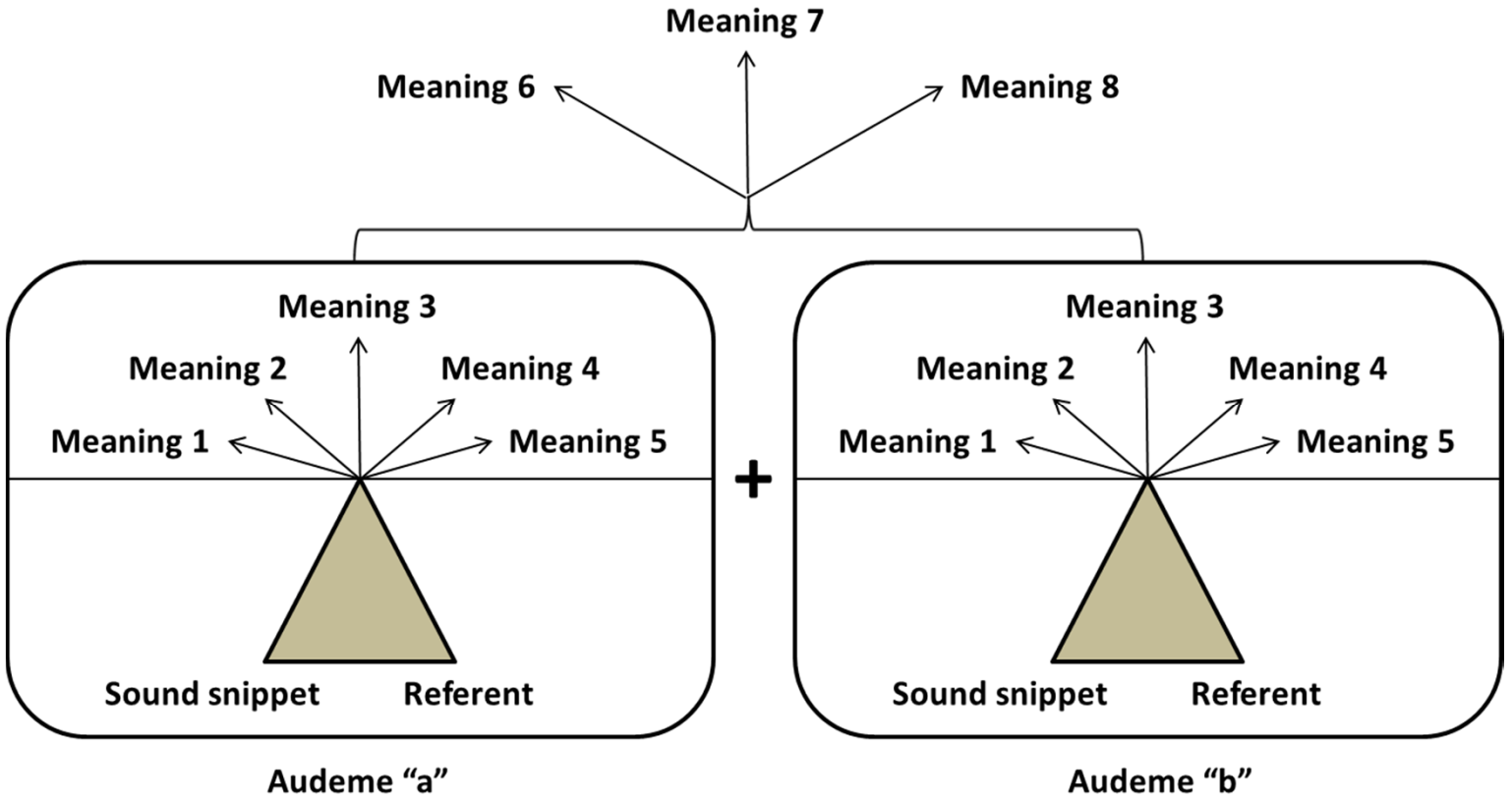

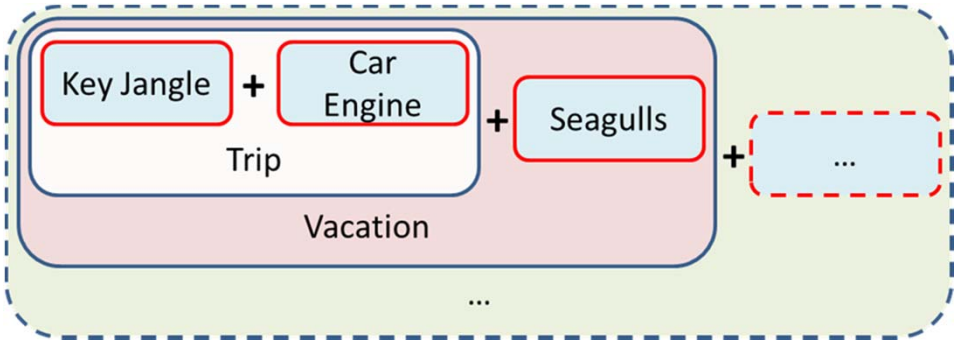

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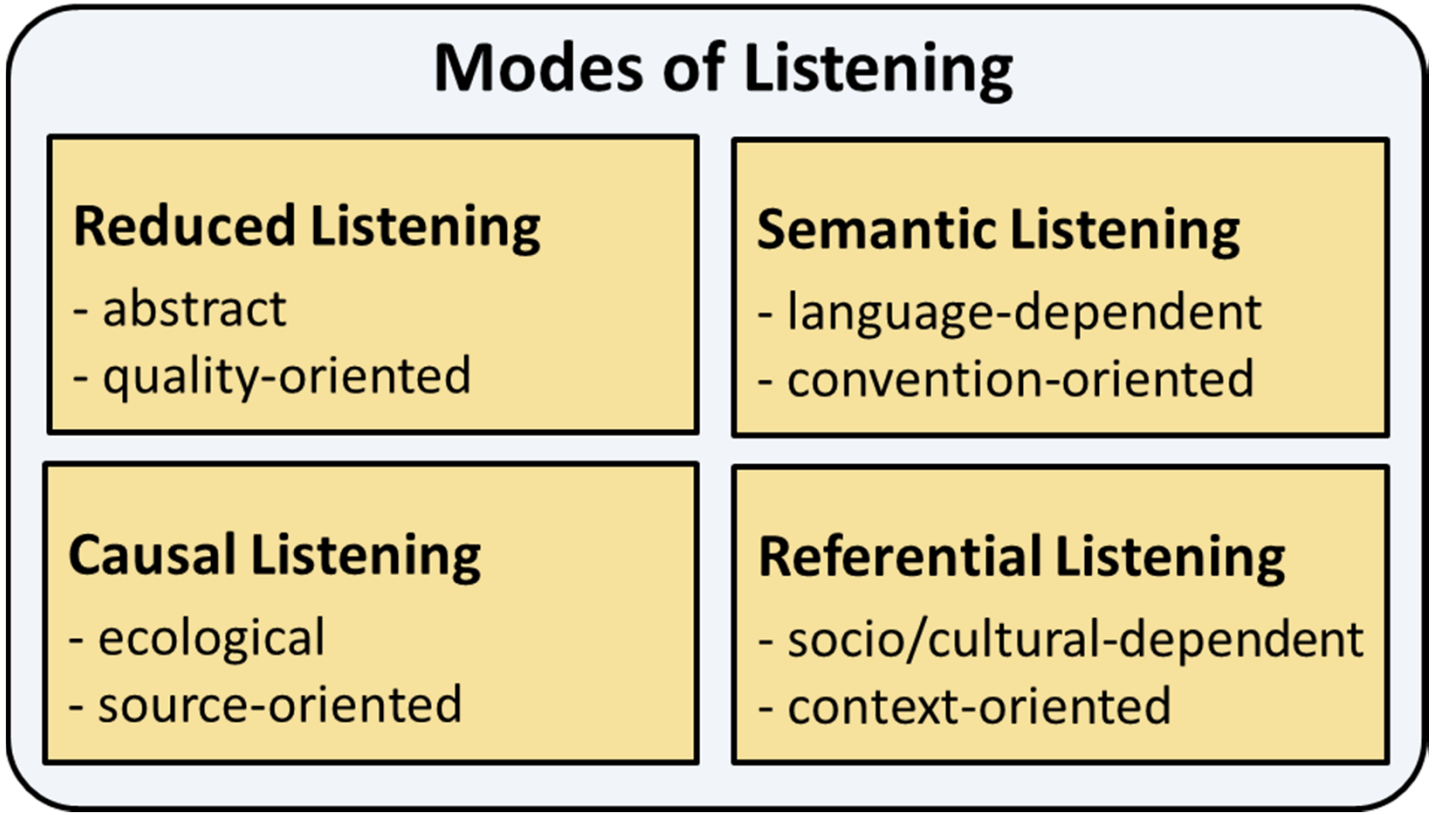
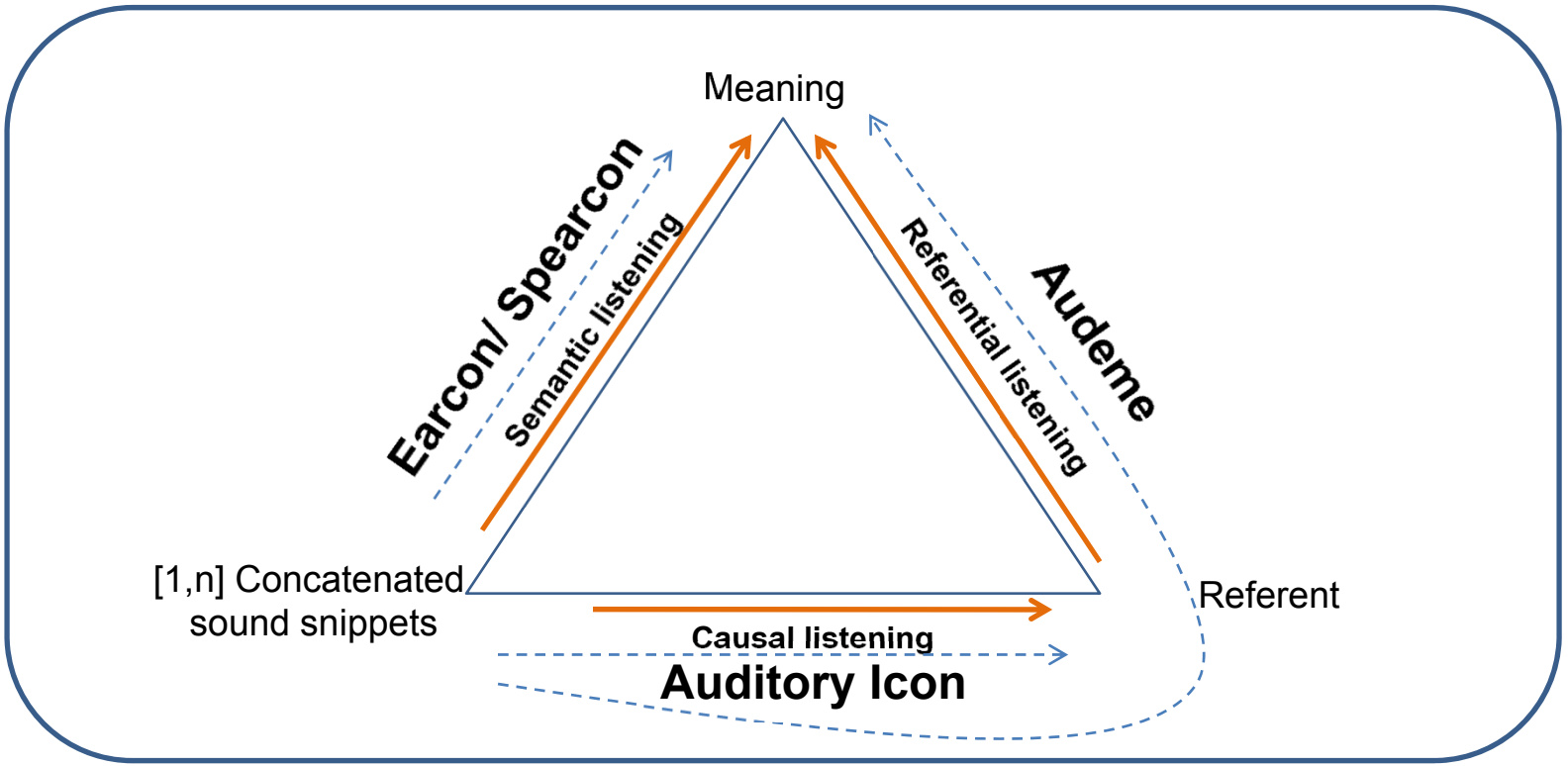
Modes of Listening



Semiotics, Modes of Listening and Non-speech Sounds



Ferati et al (submitted)

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At the same time the United States government decided to regulate the use of broadcast radio and the airwaves in America. Congress created the Federal Radio Commission to control broadcasting, and many years later this government agency evolved to become the Federal Communication Commission. In the beginning, most radio users were amateur broadcasters who built their own radios and communicated with other amateur users. When the government began to regulate broadcasting, this helped promote the growth of the commercial radio.

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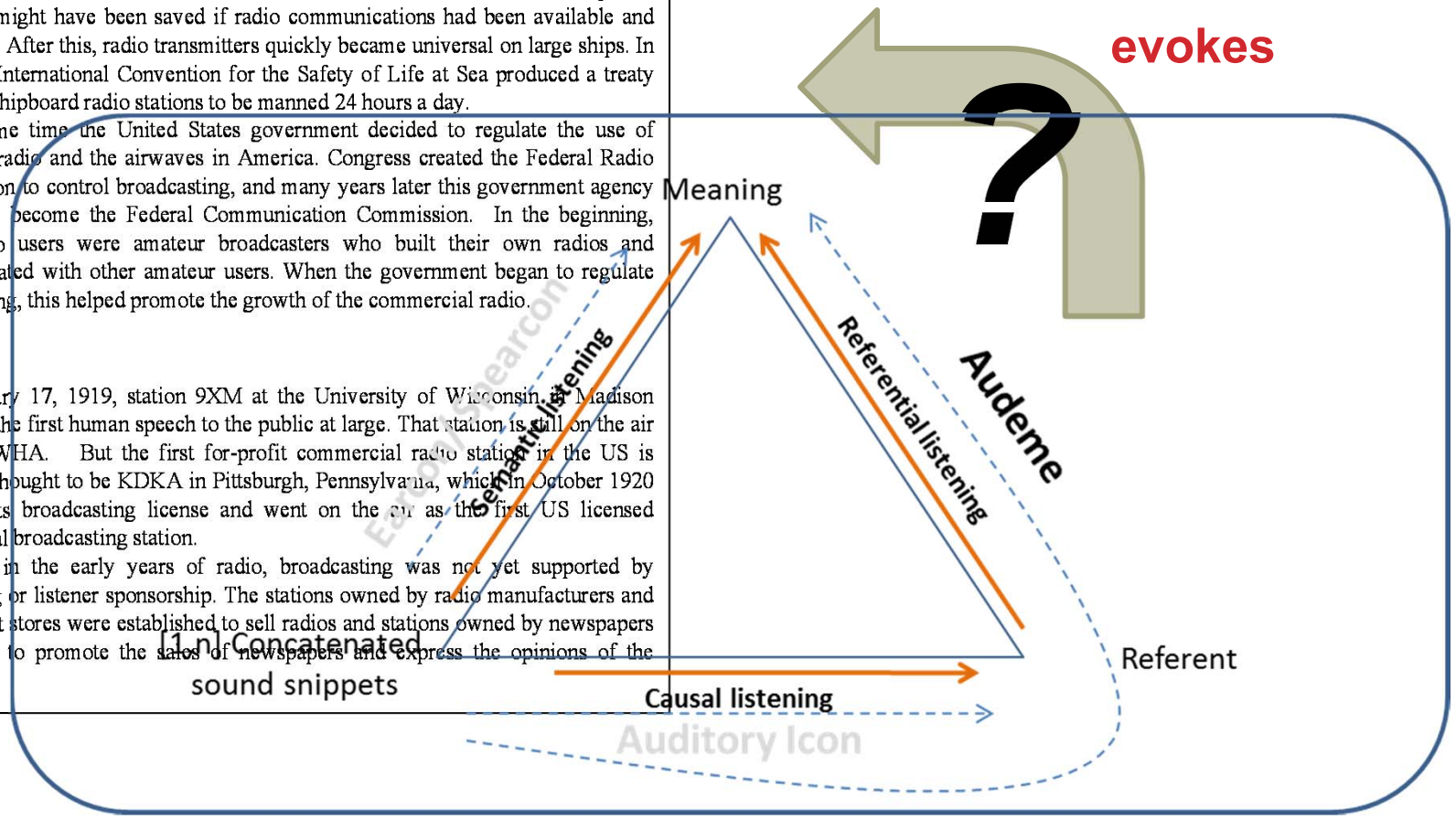


Experiment: Exploring Information Recognition using Audemes

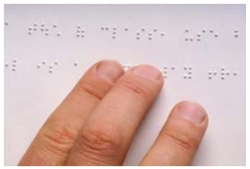
Purpose: Investigate how do audemes enhance learning in terms of recognition of large theme-based content

Participants:

(total 21)

8

13



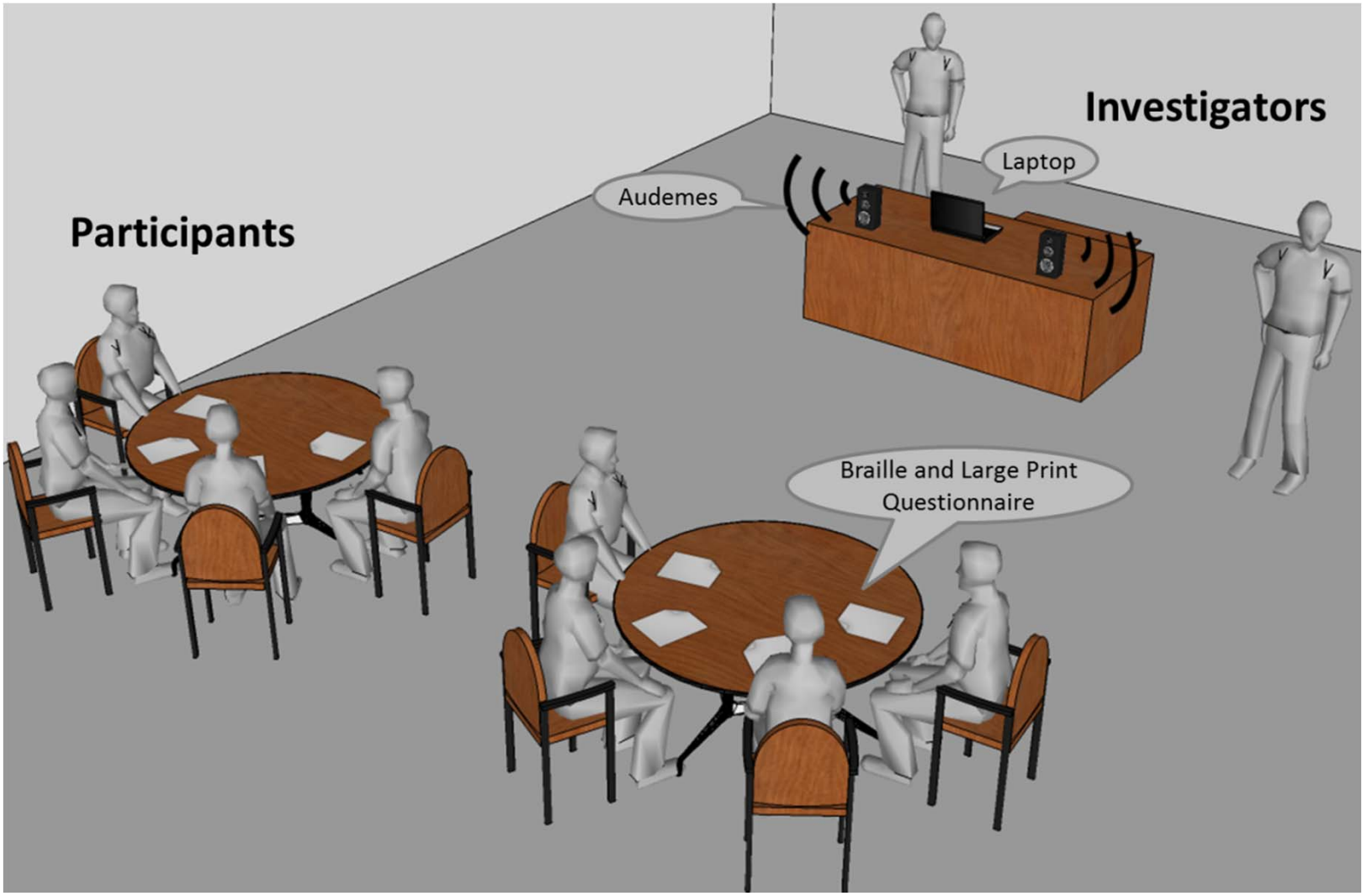
10

11

Groups:

- **Control** - was not exposed to the audeme; only the essay
- **Encode** - was exposed to audeme when hearing the essay but not when taking the posttest
- **Encode+recognition** - was exposed to the audeme when hearing the essay and also when taking the posttest

Experimental Setting at ISBVI



Stimuli

Three Essays:

- Radio
- U.S. Constitution
- Slavery

Independent Variables

- Audemes
- Essays

Dependent Variable

- Content Recognition Rate

Radio essay:

(760 words)

Play Radio audeme

Radio is a technology that uses electro-magnetic signals, sometimes called radio waves that travel through the air and many solid materials and can be detected by receivers, generally called radios. Although the basic principle of radio is simple, developing the complex technology for sending and receiving radio waves took almost a century to evolve. There are many military, communication and entertainment uses for radio, but most of us think of radio in terms of music and information broadcast by radio stations.

As the 19th century progressed with many advances in science and technology building on previous efforts, it was clear to many inventors that wireless communication was possible. Many people working in different countries throughout the century in different countries contributed various pieces of the complex technology that would become modern radio. Some of the more famous people were Michael Faraday, James Clerk Maxwell, Thomas Alva Edison, Nikola Tesla, Ernest Rutherford and Guglielmo Marconi, who was awarded a British patent for radio in 1896. Marconi received an American patent, and in 1901, he conducted the first successful transatlantic experimental radio communication. In 1909 Marconi won the Nobel Prize for his work with radio.

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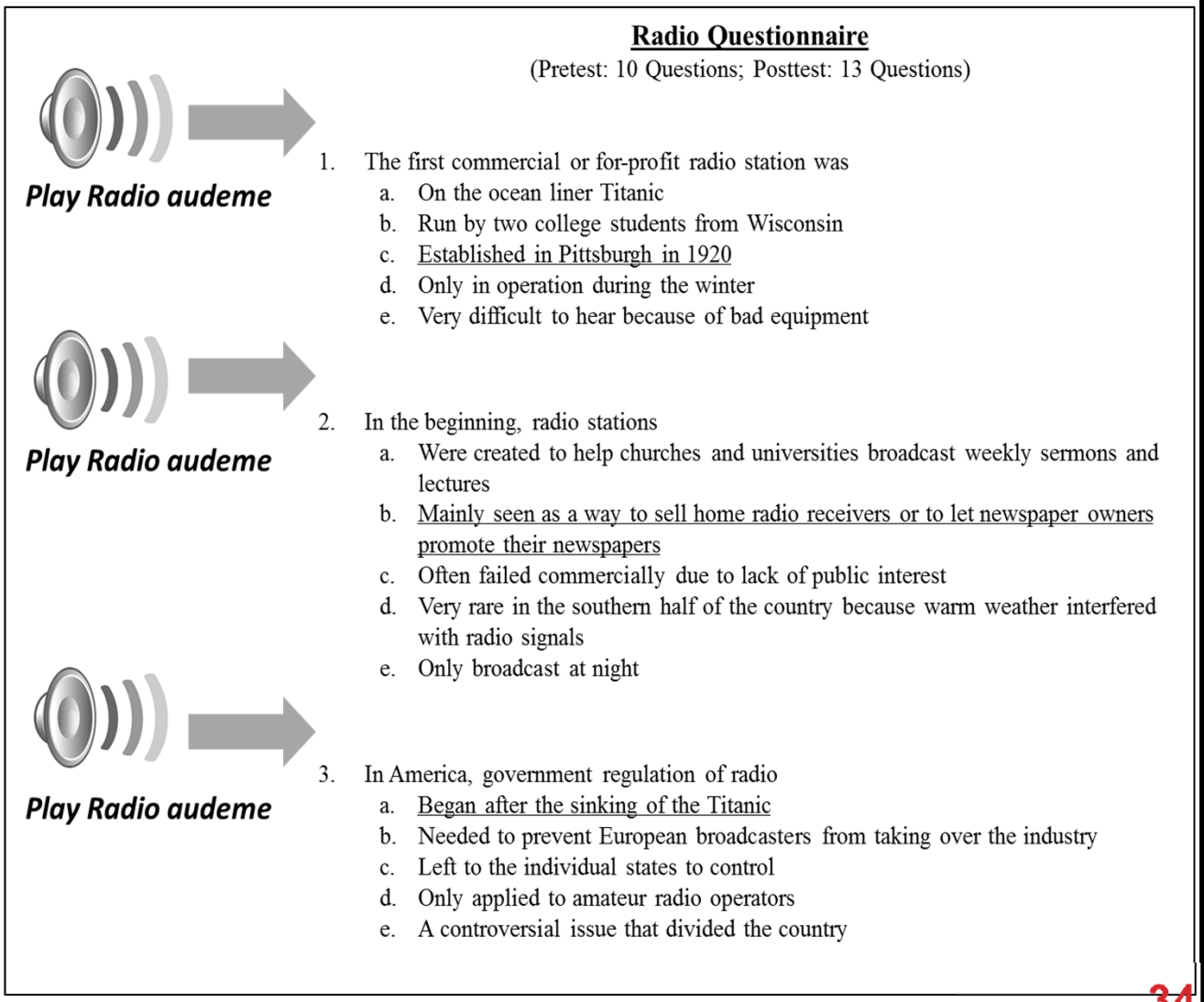
Testing after Two Weeks

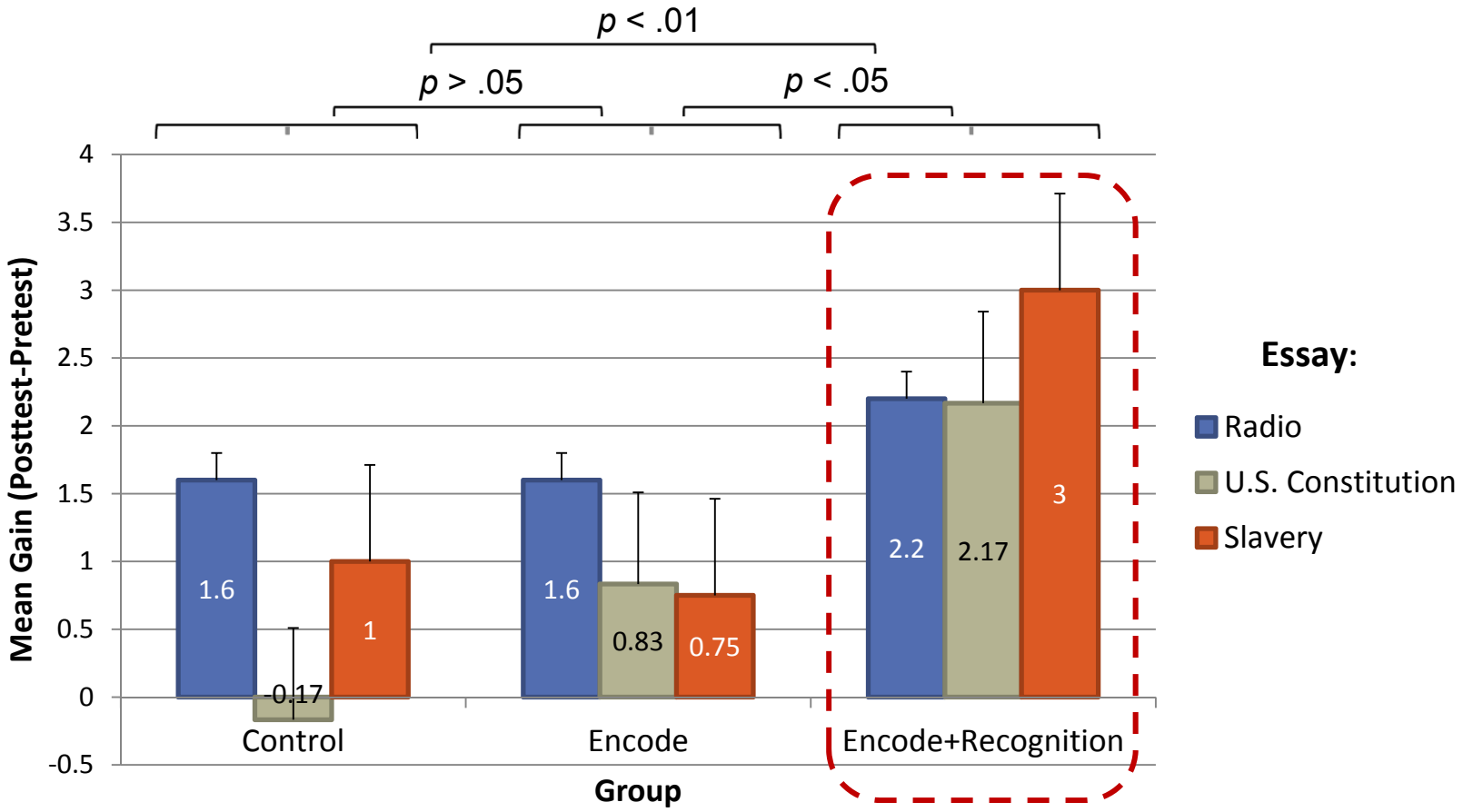
Groups:

- **Control** questionnaire without the audeme
- **Encode** questionnaire without the audeme
- **Encode+recognition** questionnaire *with* the audeme played between each question

An excerpt of the procedure shown here:



Results



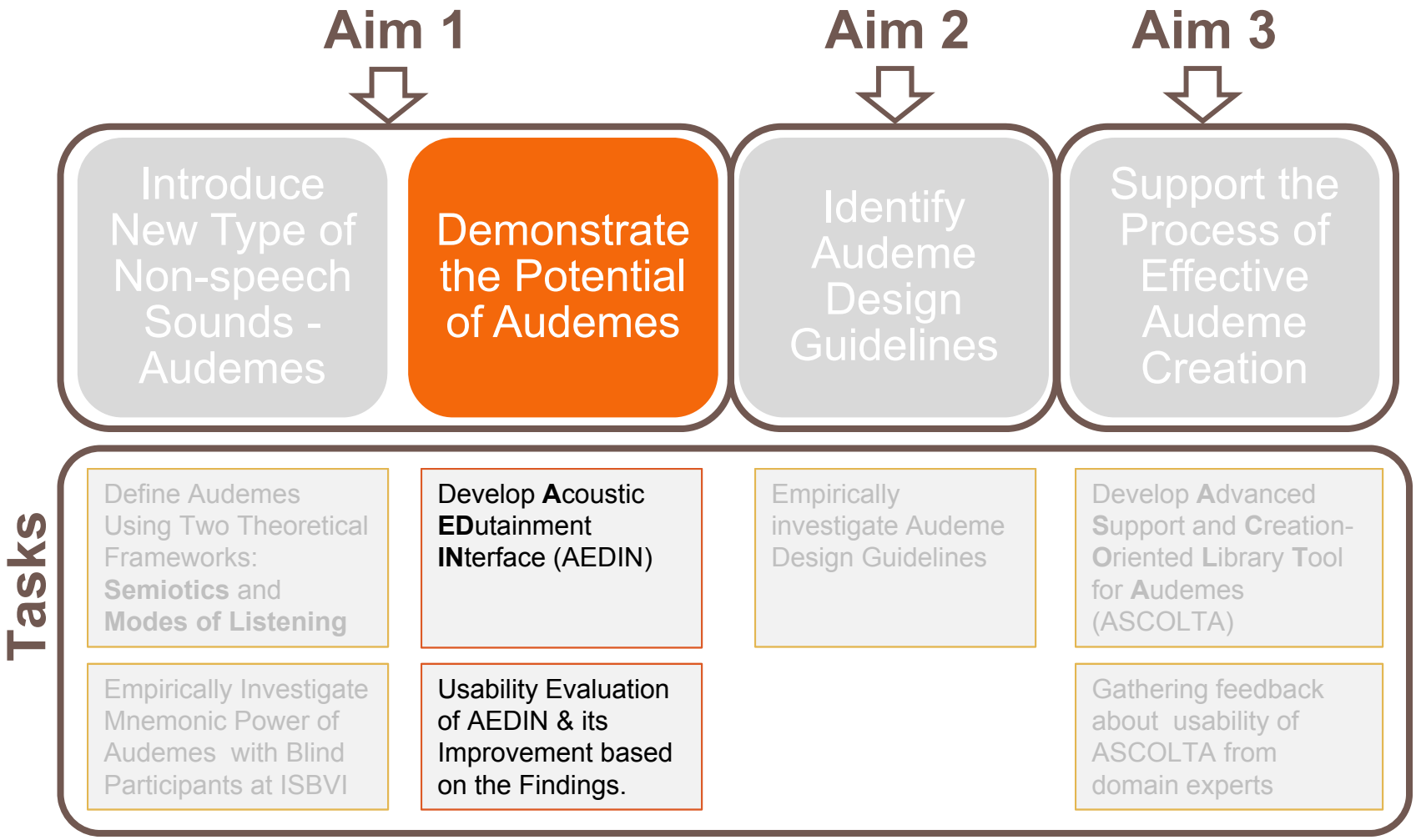
Gain = posttest – pretest scores

Overall significance:

- $F(2, 18) = 8.33$, $p < .005$, $\eta^2 = .481$

Mannheimer et al (2009)

Dissertation Aims



To investigate the function of audemes when integrated into a content-rich user interface

Acoustic Edutainment Interface – AEDIN

- AEDIN is an acoustic interface in which audemes were used as “aural covers” to anticipate large content, such as text-to-speech essays

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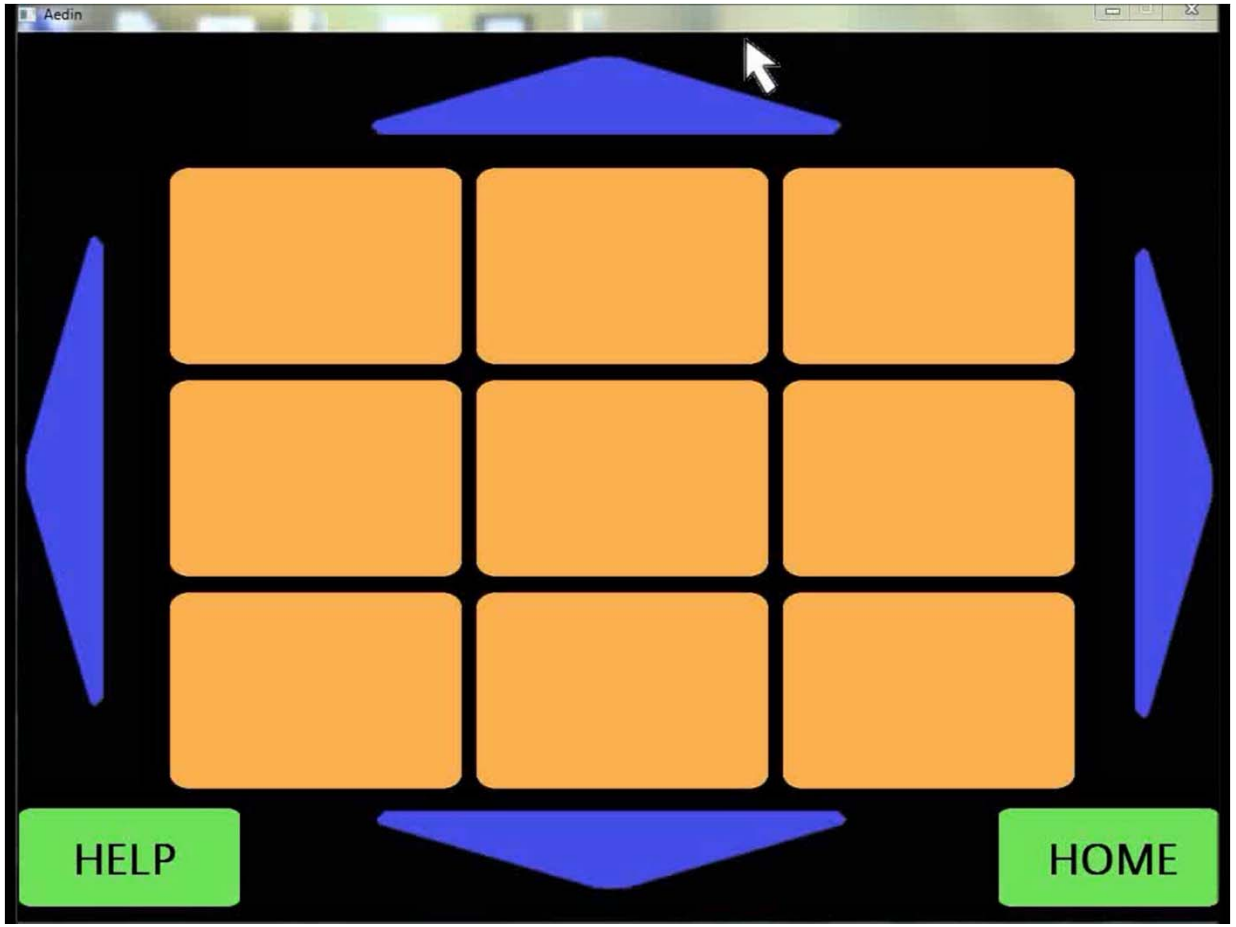
- Interface built on:
  - The *ability-based design* principle (user’s *ability* rather than disability drives the design process)
    - Leverages senses blind people mostly rely upon (hearing and touch)

AEDIN Demo



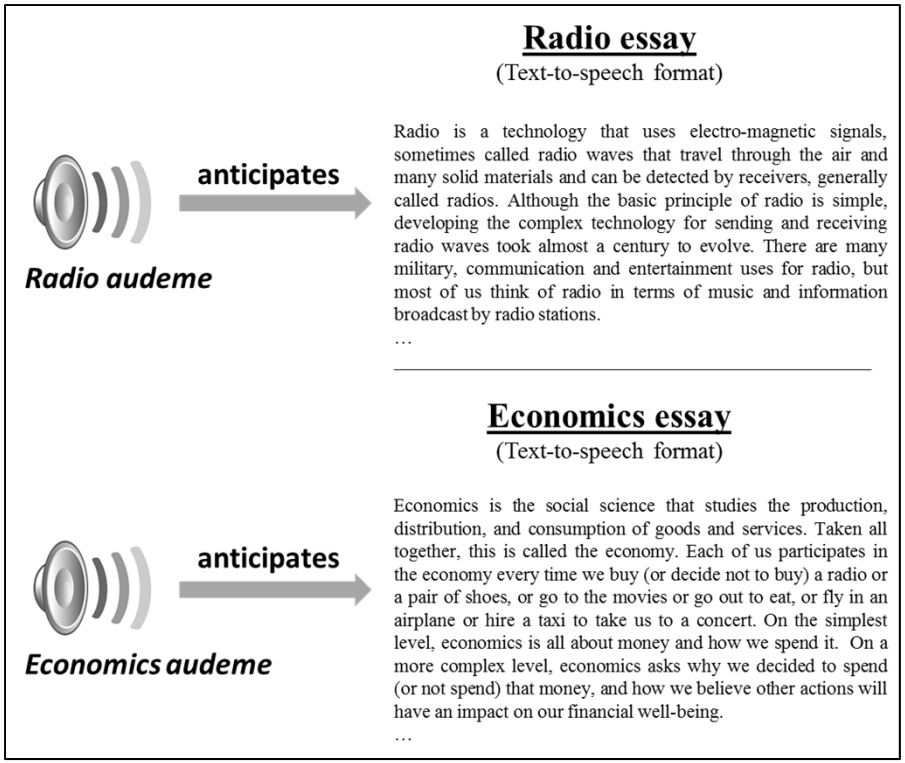
- AEDIN is based on exploring content by audemes.

- Audemes are non-speech sounds that serve as “aural covers” to browse large collection of content

- AEDIN is targeted to the BVI K12 students

- Evaluated with BVI participants from the Indiana School for the Blind and Visually Impaired (ISBVI)

Audemes as Content Anticipators



Content anticipation examples

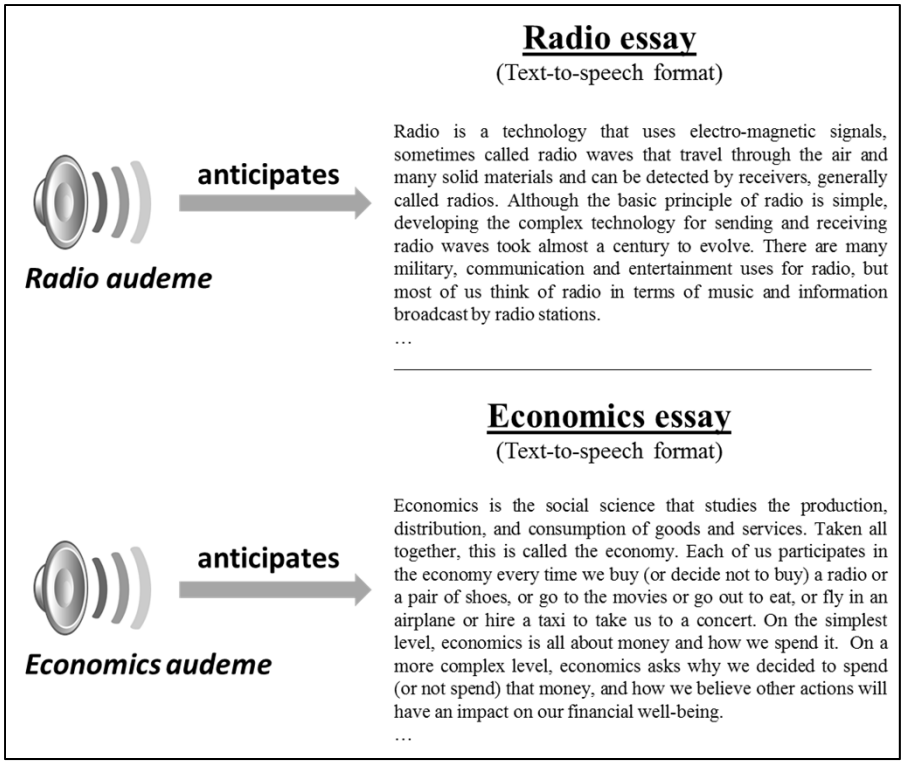
flickr from YAHOO!


From Katarina...


From Katarina...


From Katarina...

Audemes as Content Anticipators



Content anticipation examples

flickr from YAHOO!


From Katarina...


From Katarina...

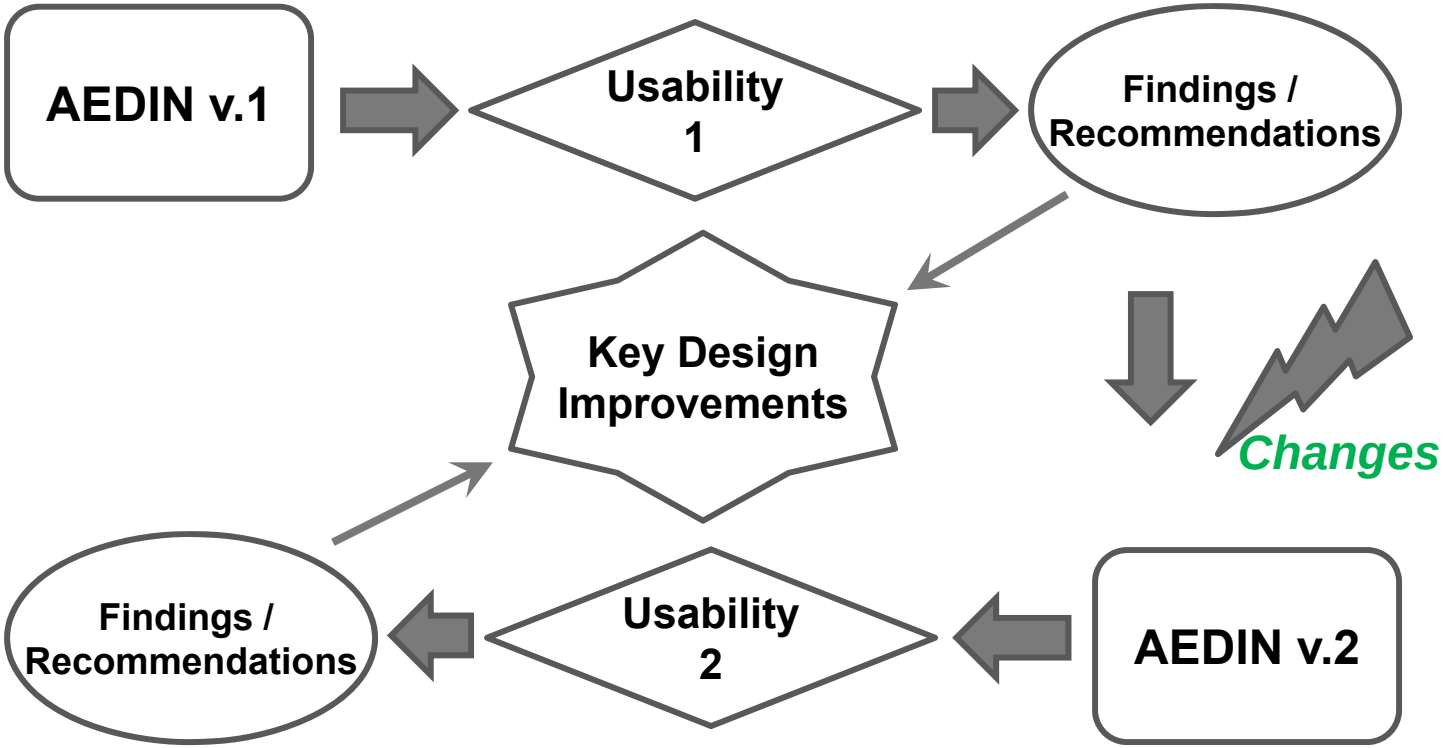

From Katarina...

Dailymotion

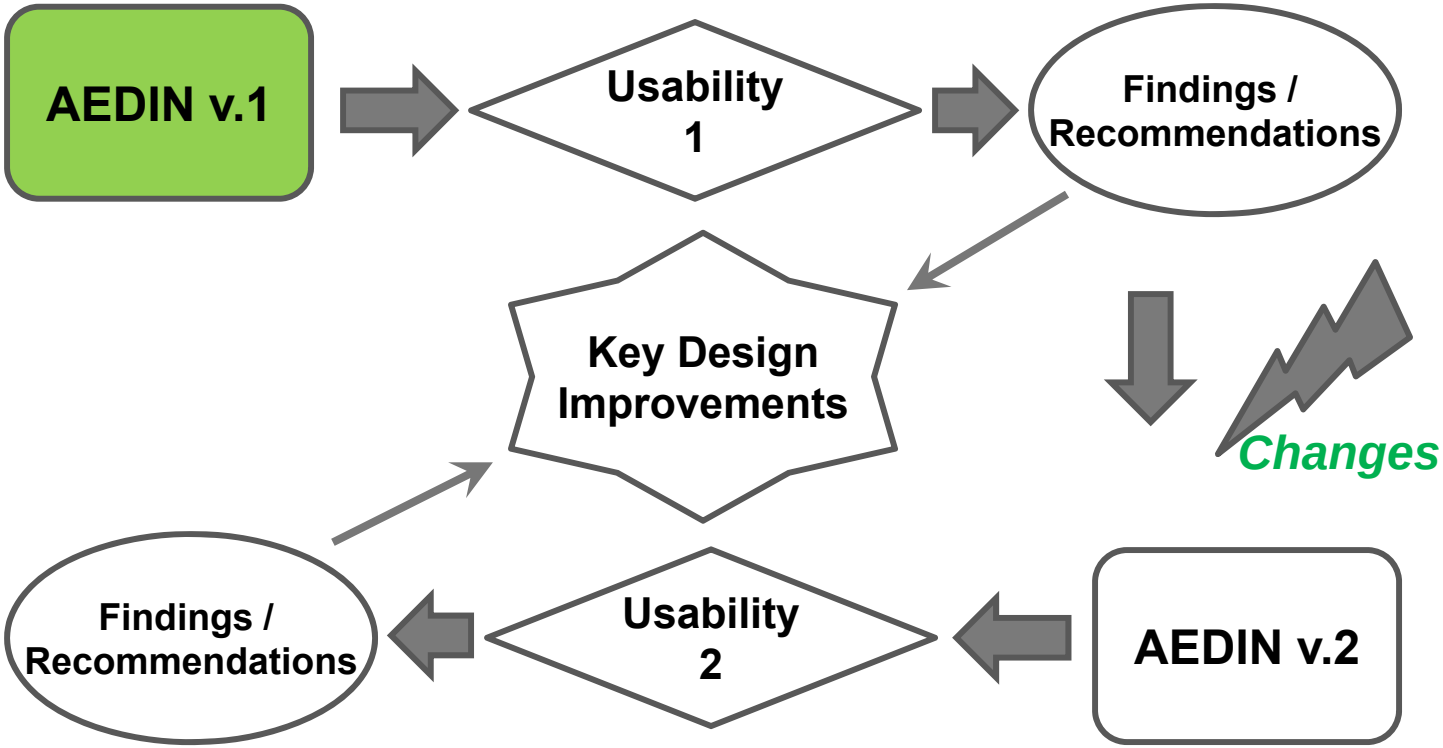
Super Bowl Weekend in indianapolis Indiana
By BBQSuperStars

indianapolis Motor Speedway
By LocalNews-GrabNetwork

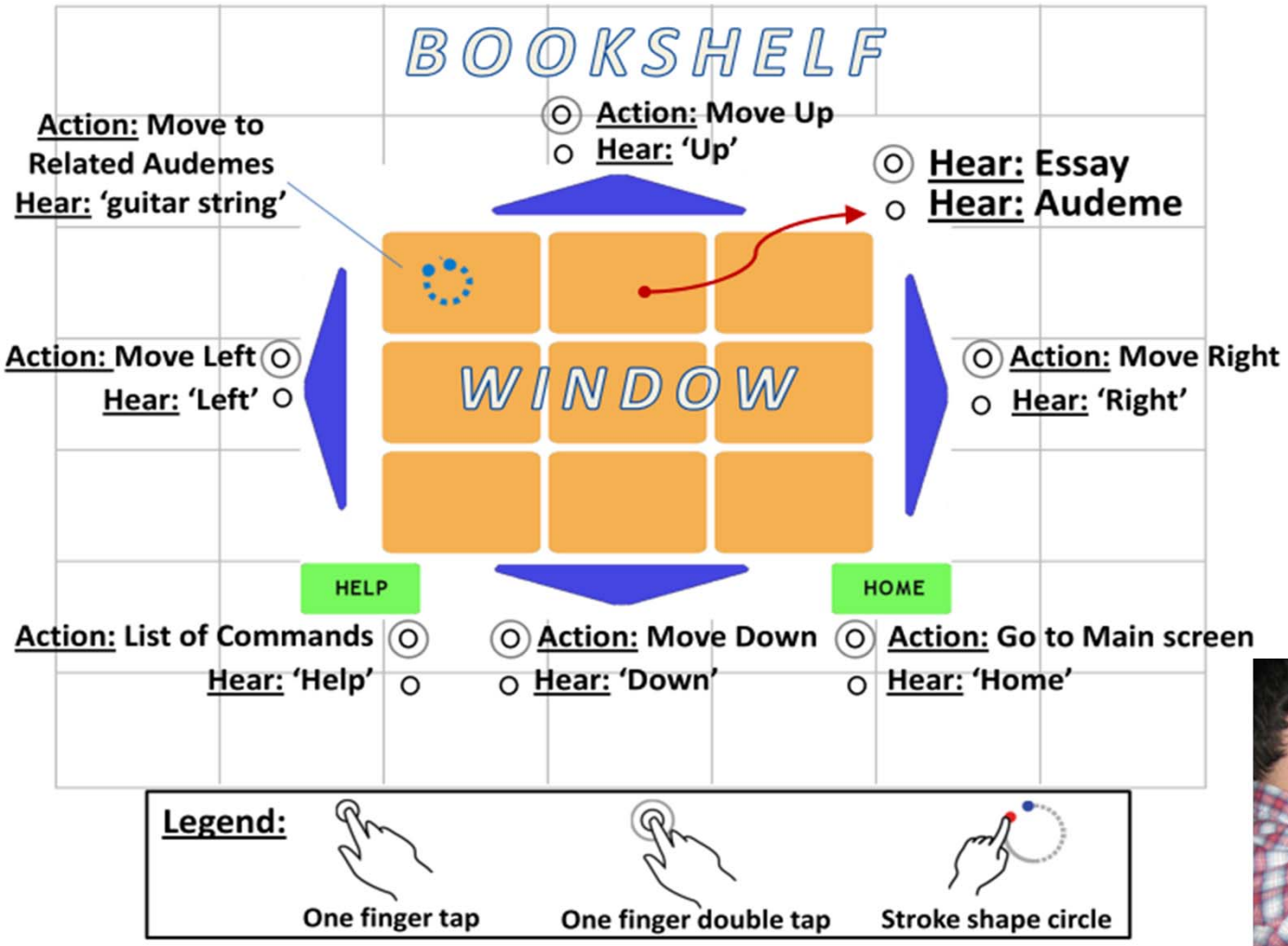
AEDIN Design and Iterative Evaluation



AEDIN Design and Iterative Evaluation



AEDIN

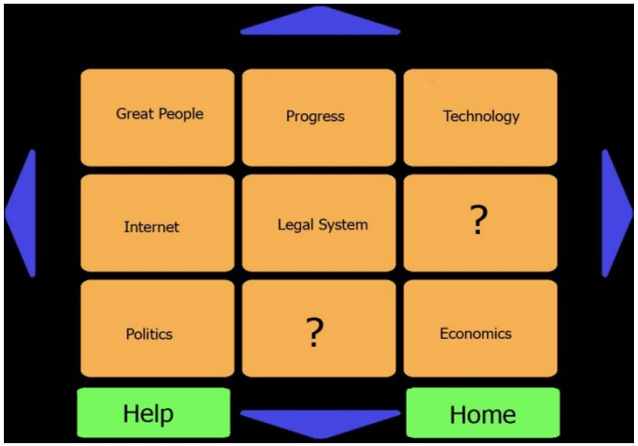


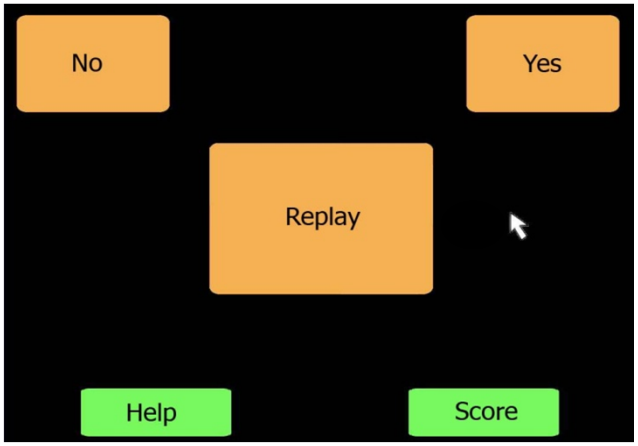
Ferati et al (2009)

AEDIN

Sound Categories

- ***Content Sounds***
  - *Audemes (manually created)*
  - *Essays (text-to-speech)*
  - *Quizzes (text-to-speech)*
- ***Feedback Sounds***
  - *Positional sounds (text-to-speech)*
  - *Background sounds (sound-effect)*





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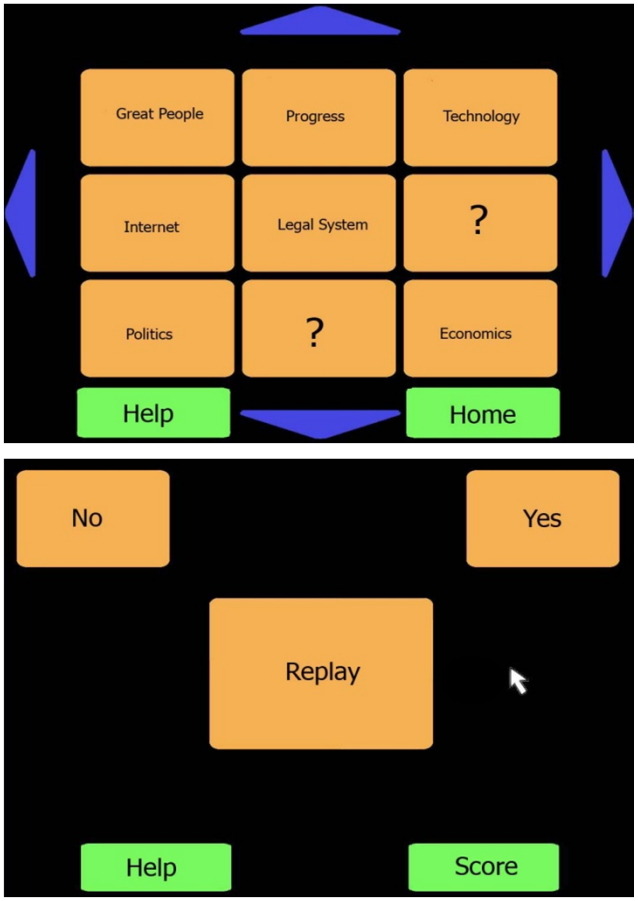

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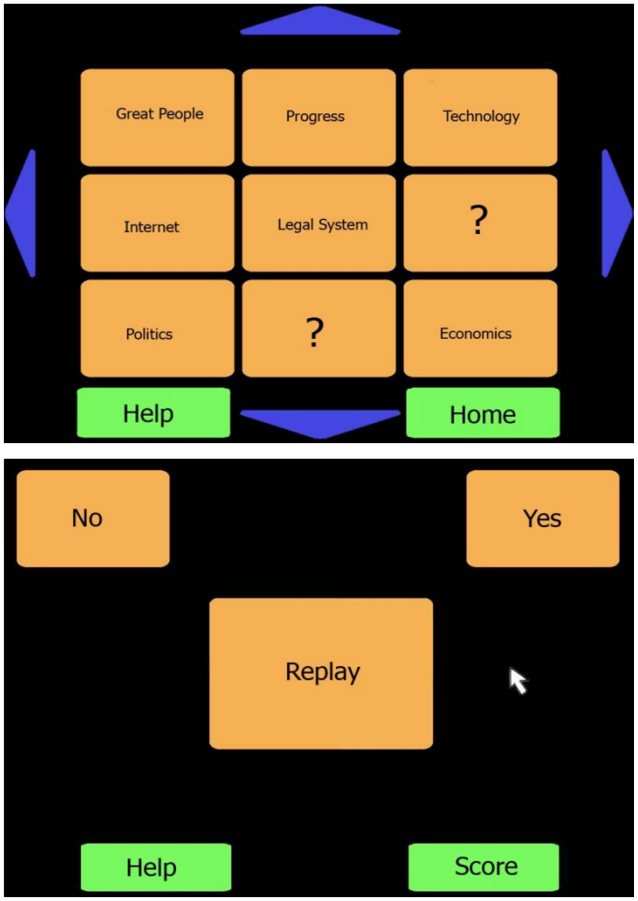

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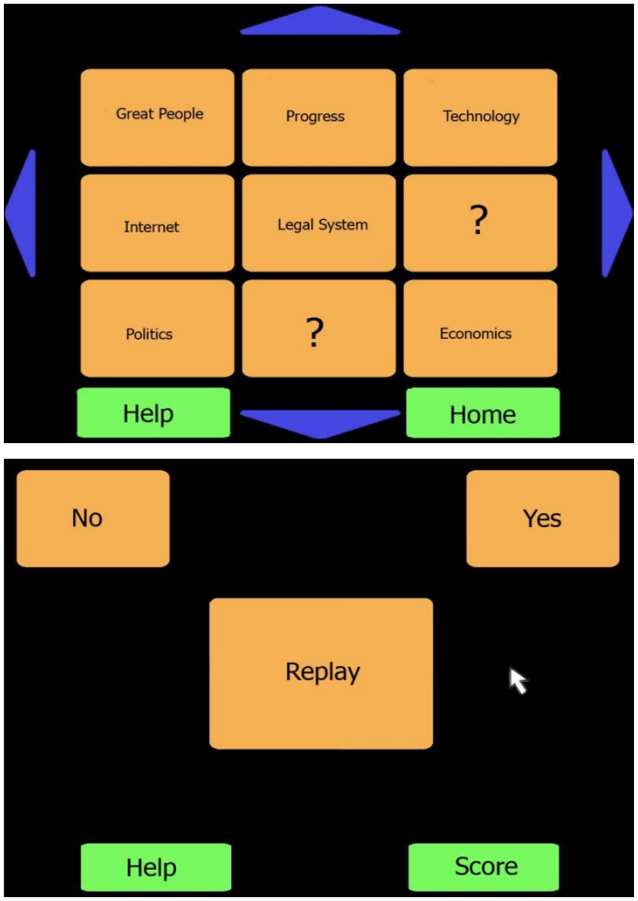

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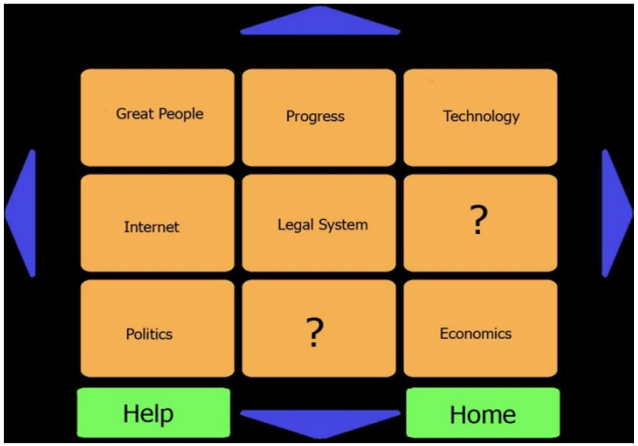

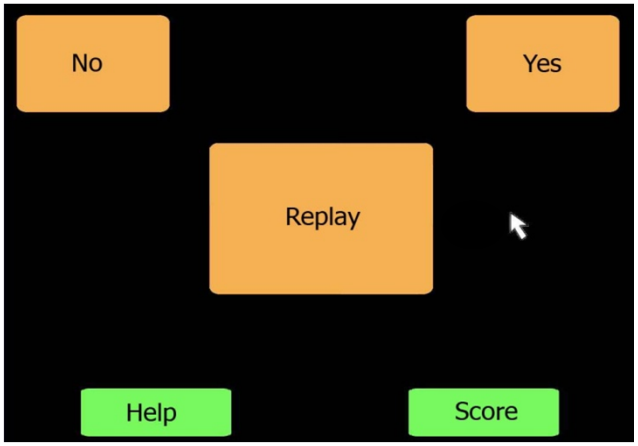

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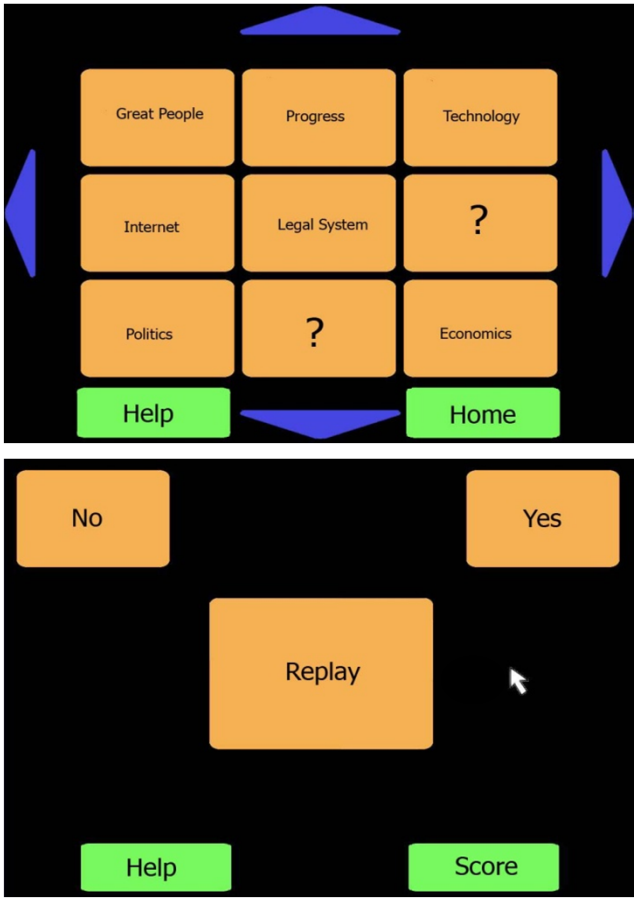
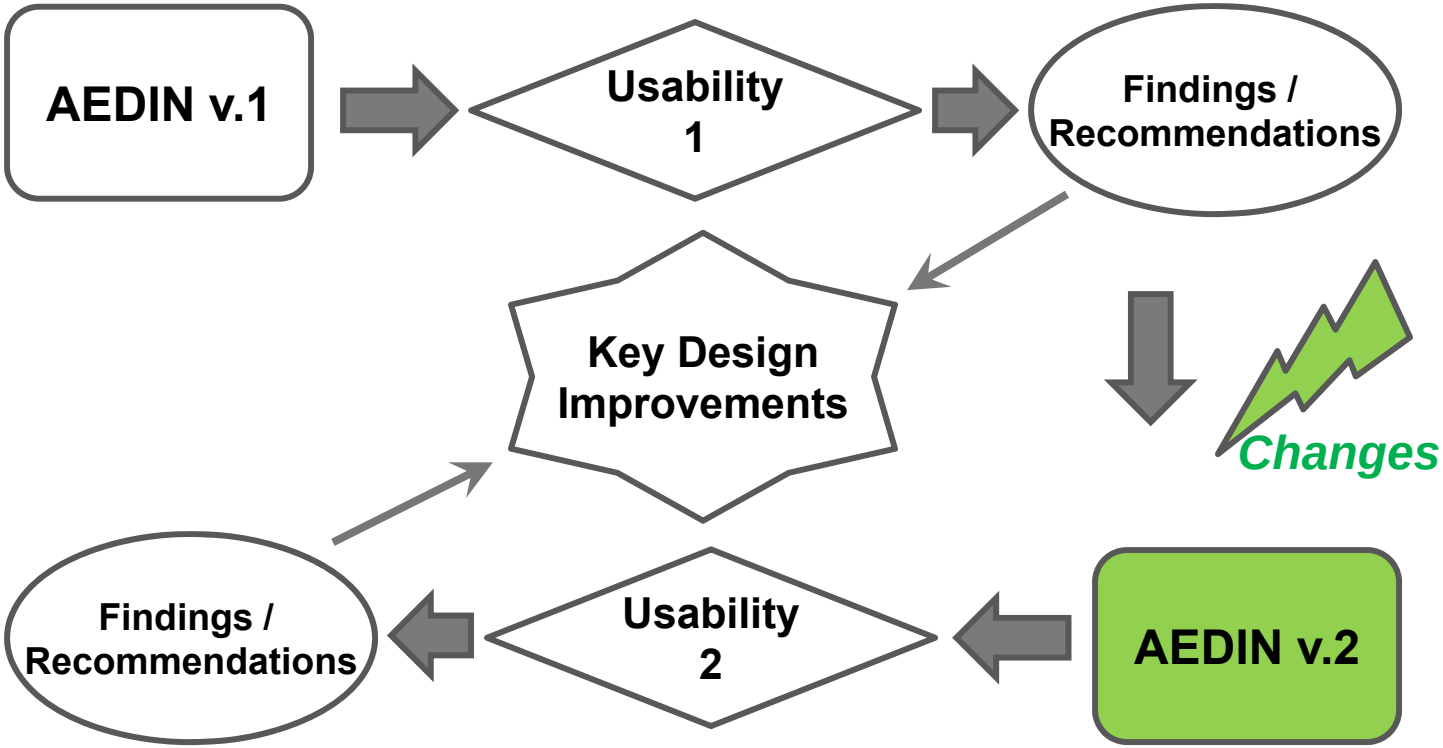


AEDIN Design and Iterative Evaluation



AEDIN V.2

64% Increased Speed of Reading Essays

AEDIN v.1 Essay

(160 word per min.)

AEDIN v.2 Essay

(250 word per min.)

AEDIN V.2

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AEDIN V.2

64% Increased Speed of Reading Essays

AEDIN v.1 Essay

(160 word per min.)

AEDIN v.2 Essay

(250 word per min.)

AEDIN V.2

Improved design for overlapping affordances

Traditional Design
(for Sighted Users)

AEDIN v.1

AEDIN Design
(for Blind and Visually Impaired Users)

AEDIN v.2

AEDIN V.2

Improved Feedback Sounds

Robotic Aural Label

AEDIN v.1

Humanlike Aural Label

AEDIN v.2

AEDIN V.2

Improved Feedback Sounds

Robotic Aural Label

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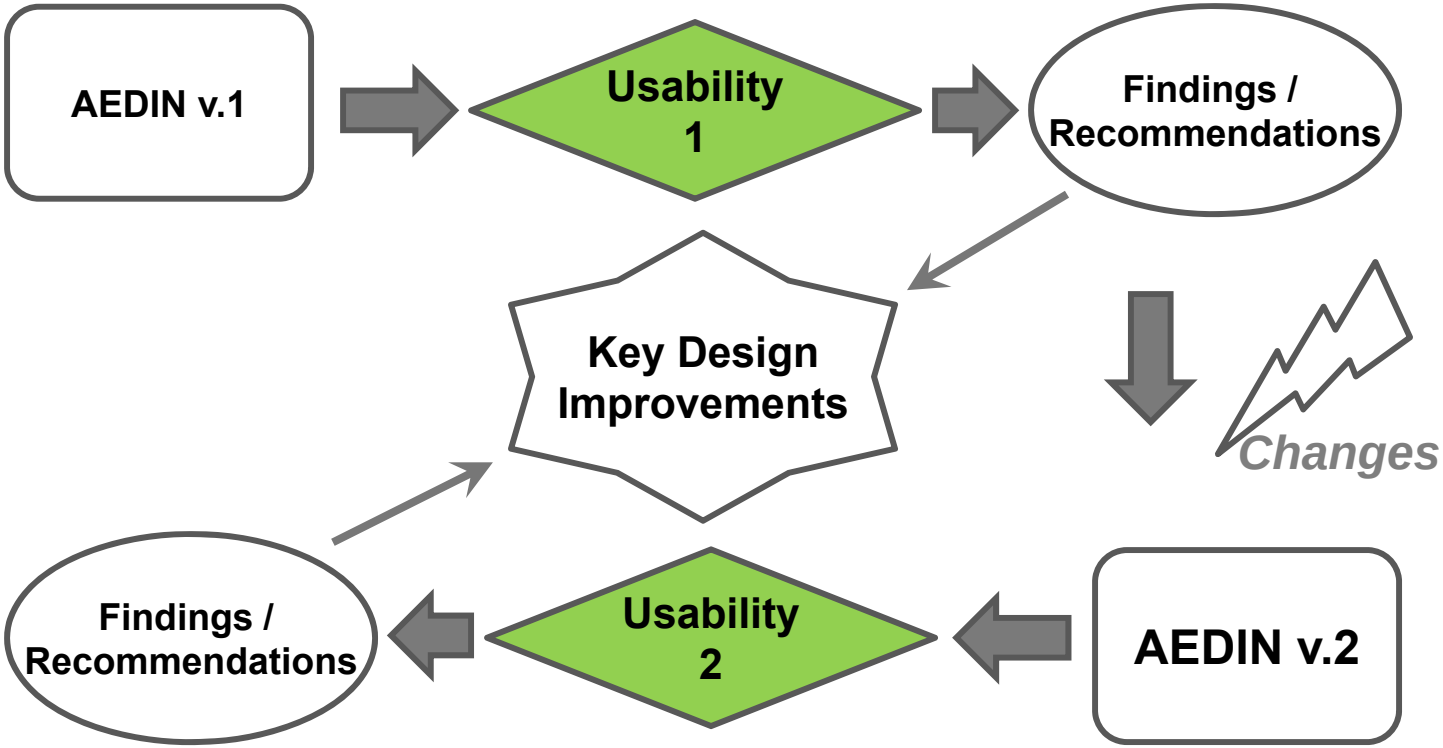
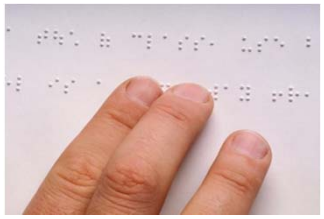
AEDIN Design and Iterative Evaluation



Usability Evaluation

Participants (total 20)






10 **10** **7** **13**

Usability test 1

AEDIN v.1




4 **5** **2** **7**

Usability test 2

AEDIN v.2




6 **5** **5** **6**

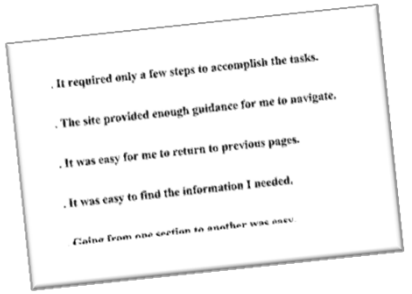
Usability Evaluation

Tasks and Data collection

Satisfaction Questionnaire

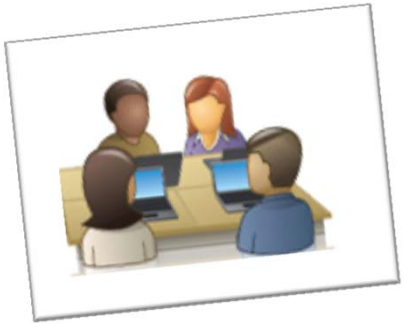
Tasks:

1. Play few audemes
2. Go to a related audeme
3. Play few essays
4. Answer the question heard *(by now a pop up question will be playing)*
5. Tell me your current Score
6. Describe buttons available on the screen



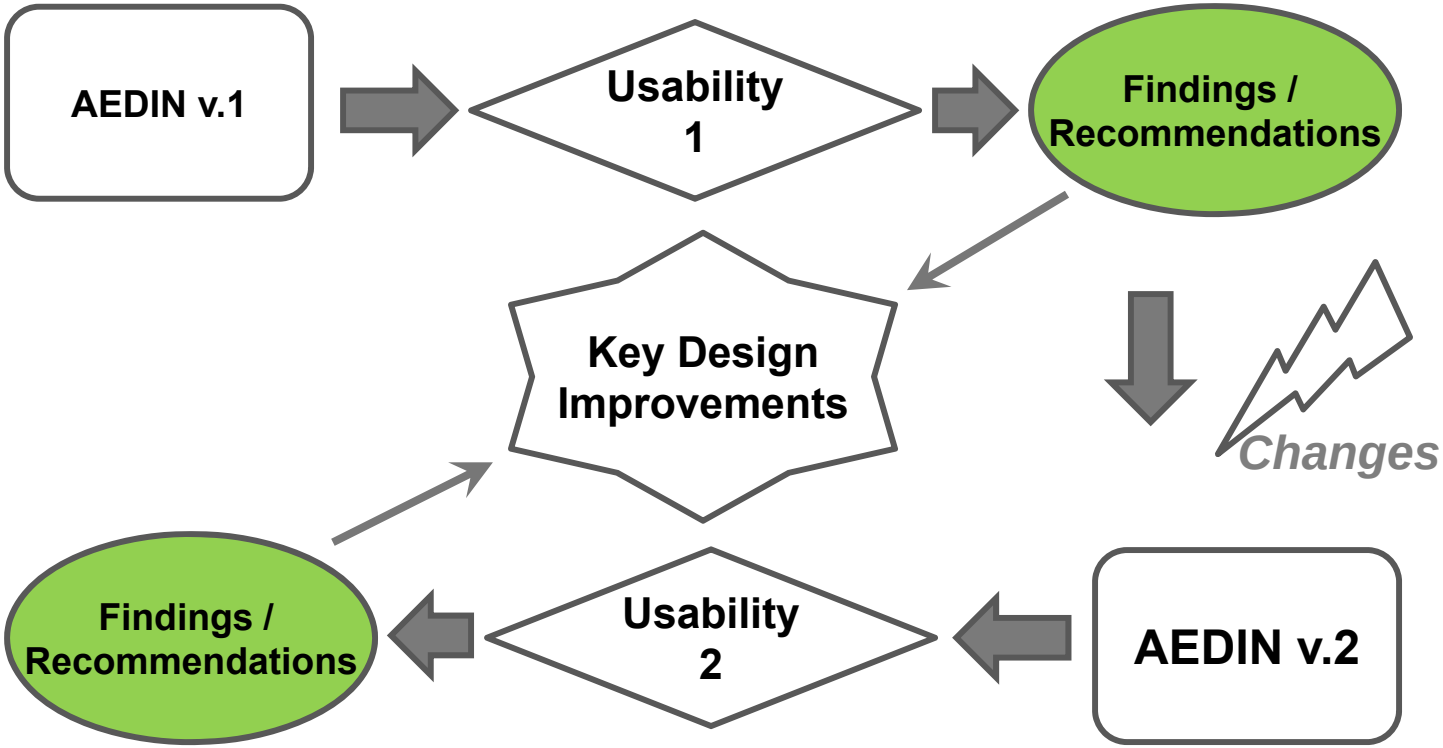
Open-Ended Questionnaire

Participant Comments



Observation

AEDIN Design and Iterative Evaluation



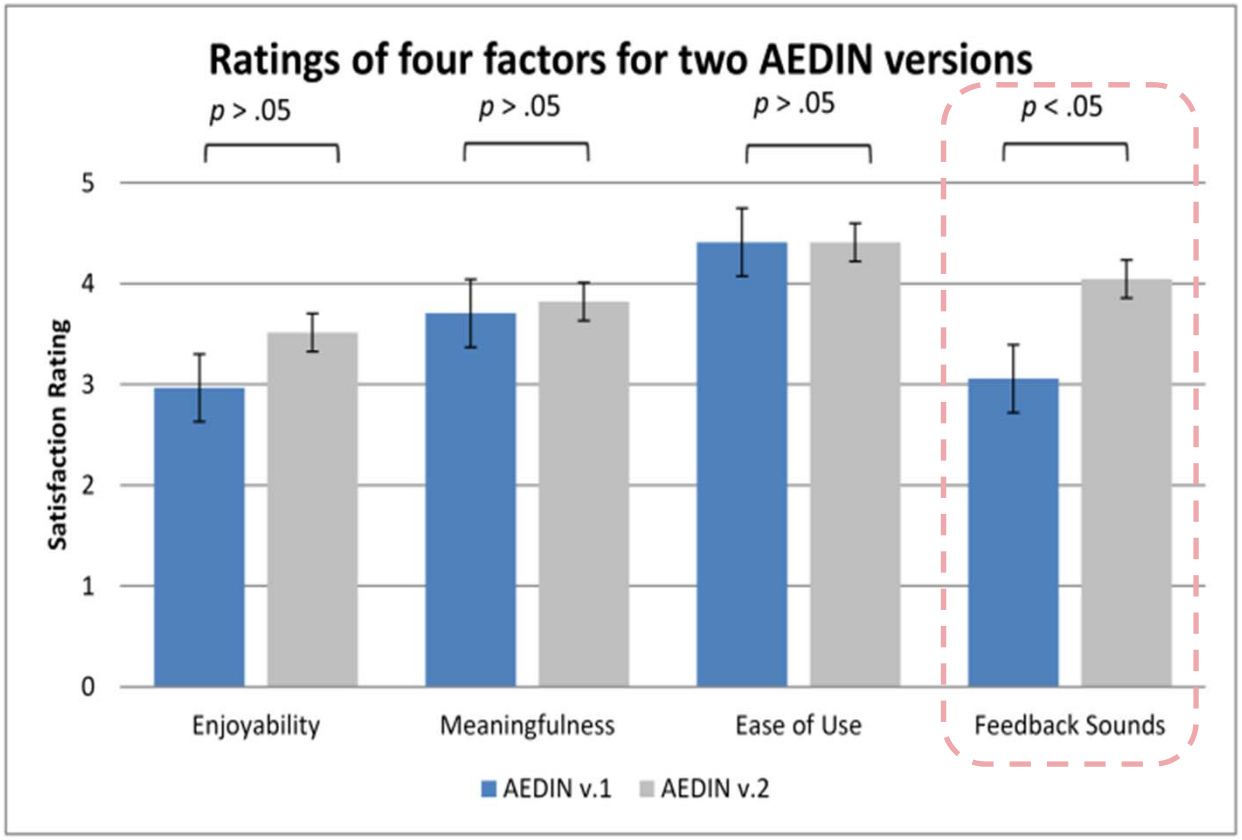
Results

Factor Analysis,

Cronbach's Alpha = .731

Factor	Questions	Loading
1. Enjoyability of AEDIN	Q16. The interface is fun to use. Q15. Using the interface is enjoyable. Q17. I would use this interface again.	.932 .855 .811
2. Meaningfulness of AEDIN	Q8. Audemes were meaningful. Q5. The bookshelf metaphor makes sense. Q4. Our explanation was sensible after you experienced the interface.	.915 .850 .815
3. Easiness of using the touchscreen	Q19. Using the touchscreen was comfortable. Q18. Using the touchscreen was easy.	.951 .950
4. Appropriateness of feedback sounds	Q11. Feedback sounds were meaningful. Q13. Feedback sounds were short enough.	.866 .855

Consistent Improvement



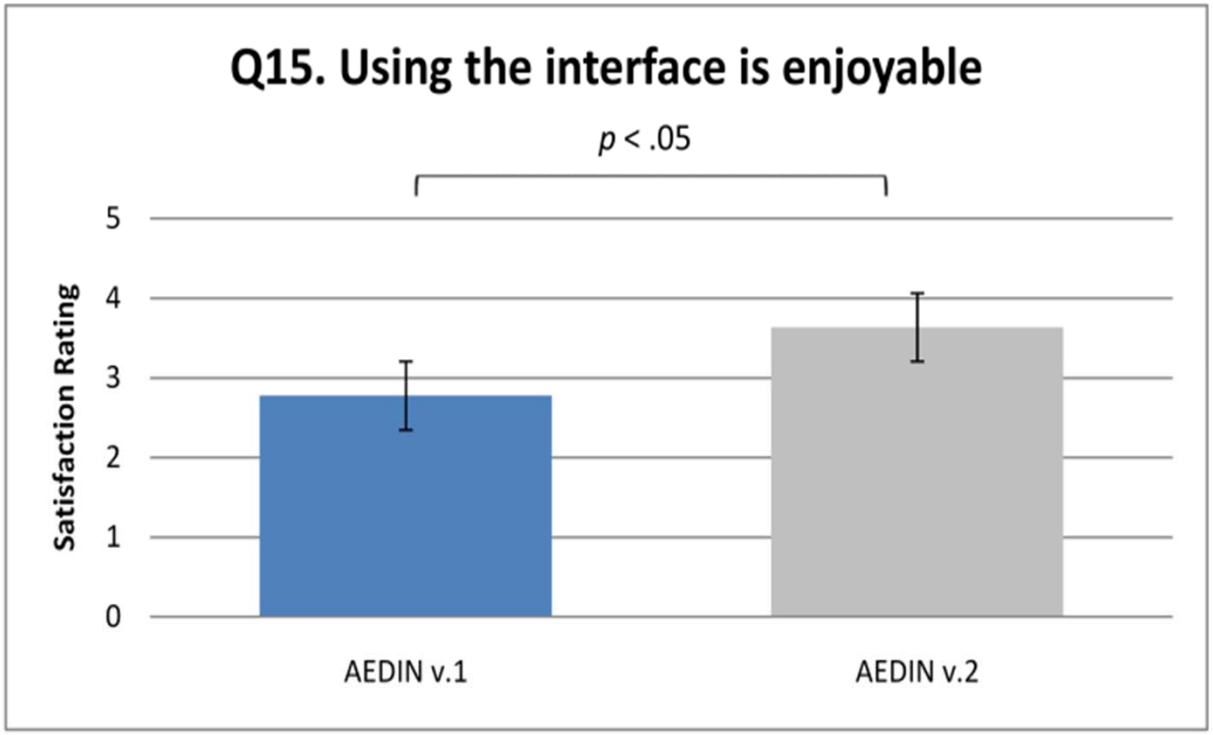
Feedback sounds: **AEDIN v.1** (*M* = 3.06, *SD* = 1.24) vs. **AEDIN v.2** (*M* = 4.05, *SD* = 0.88)
t(18) = 2.09, *p* < .05, *d* = .92.

Two main findings:

1. Touchscreens highly usable, above 4 rating avg.
2. Significant improvements on the feedback sounds in AEDIN v.2

Ferati et al (2011)

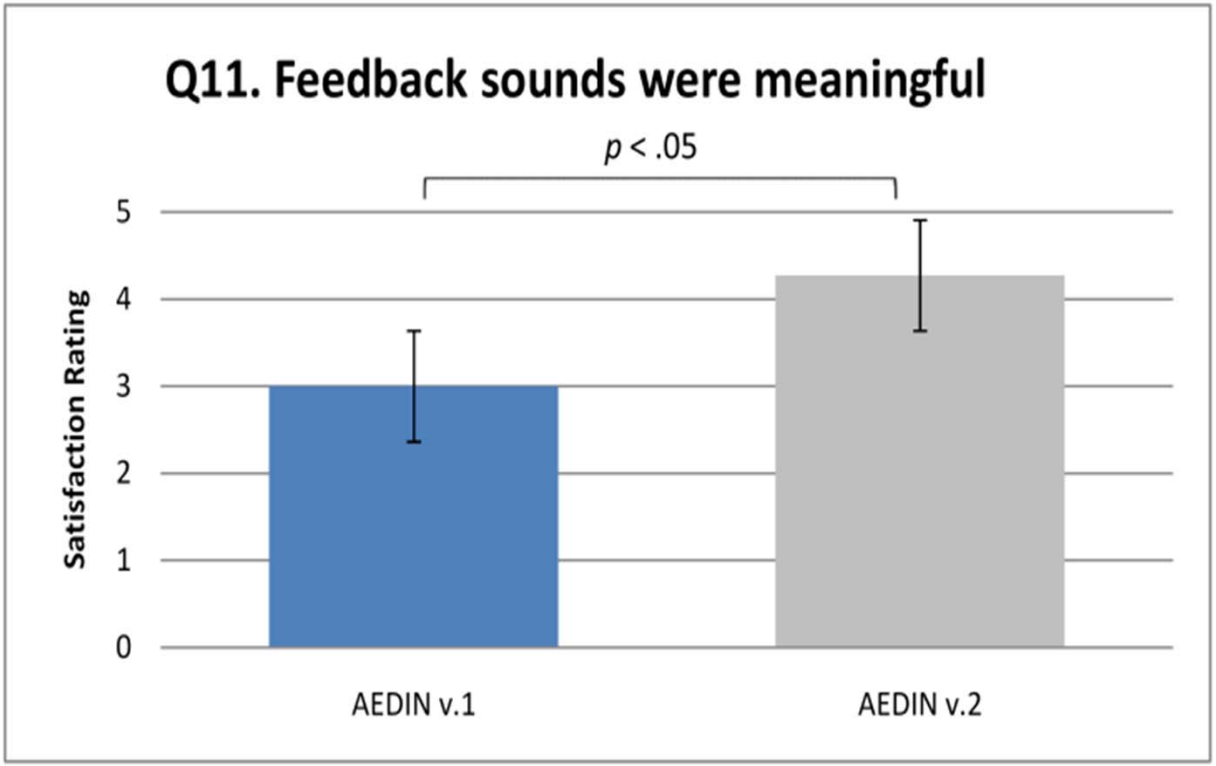
Interface Enjoyability



Interface enjoyability **AEDIN v.2** (*M* = 4.27, *SD* = 1.01) vs. **AEDIN v.1** (*M* = 3.00, *SD* = 1.50)
t(18) = 2.26, *p* < .05, *d* = .99.

Enjoyability significantly increased with minor design changes done within a week.

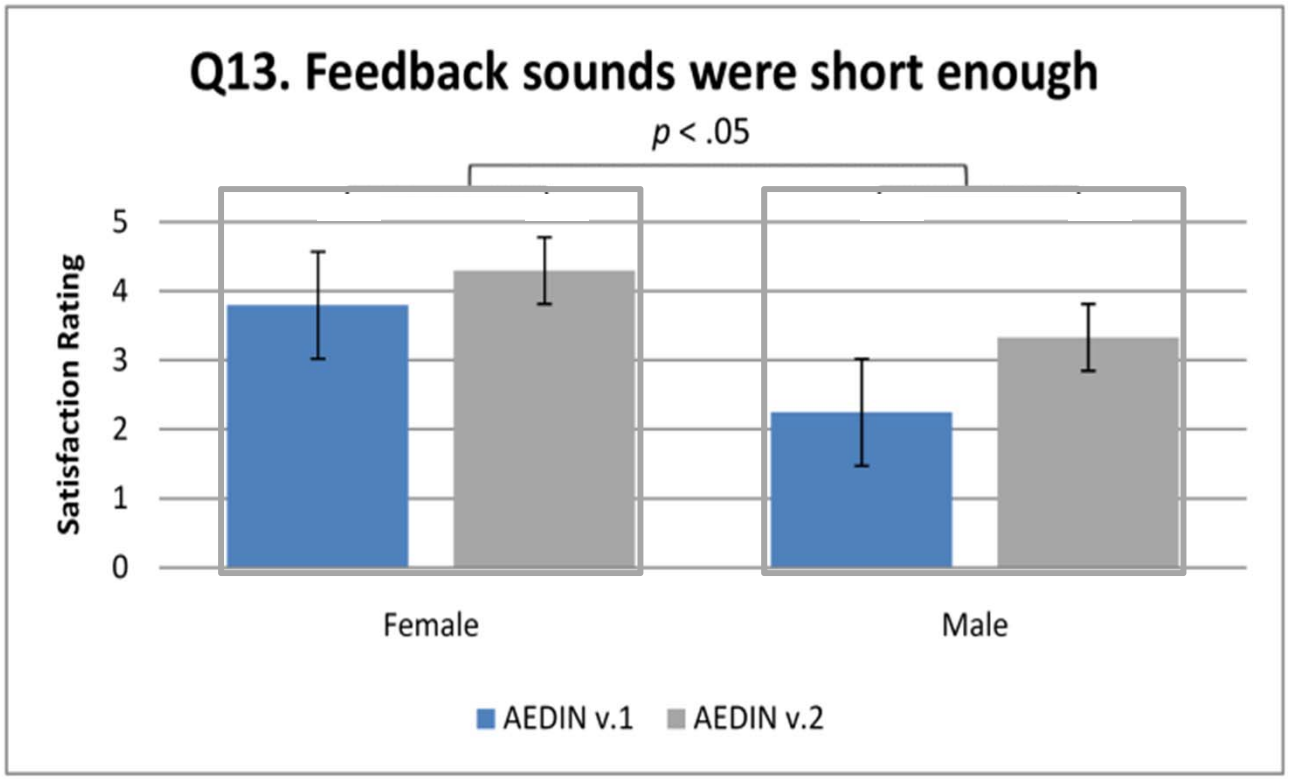
Feedback Sounds



Feedback sounds **AEDIN v.1** (*M* = 2.78, *SD* = 0.83) vs. **AEDIN v.2** (*M* = 3.64, *SD* = 0.92)
t(18) = 2.16, *p* < .05, *d* = .98.

Feedback sounds significantly improved with minor design changes done within a week

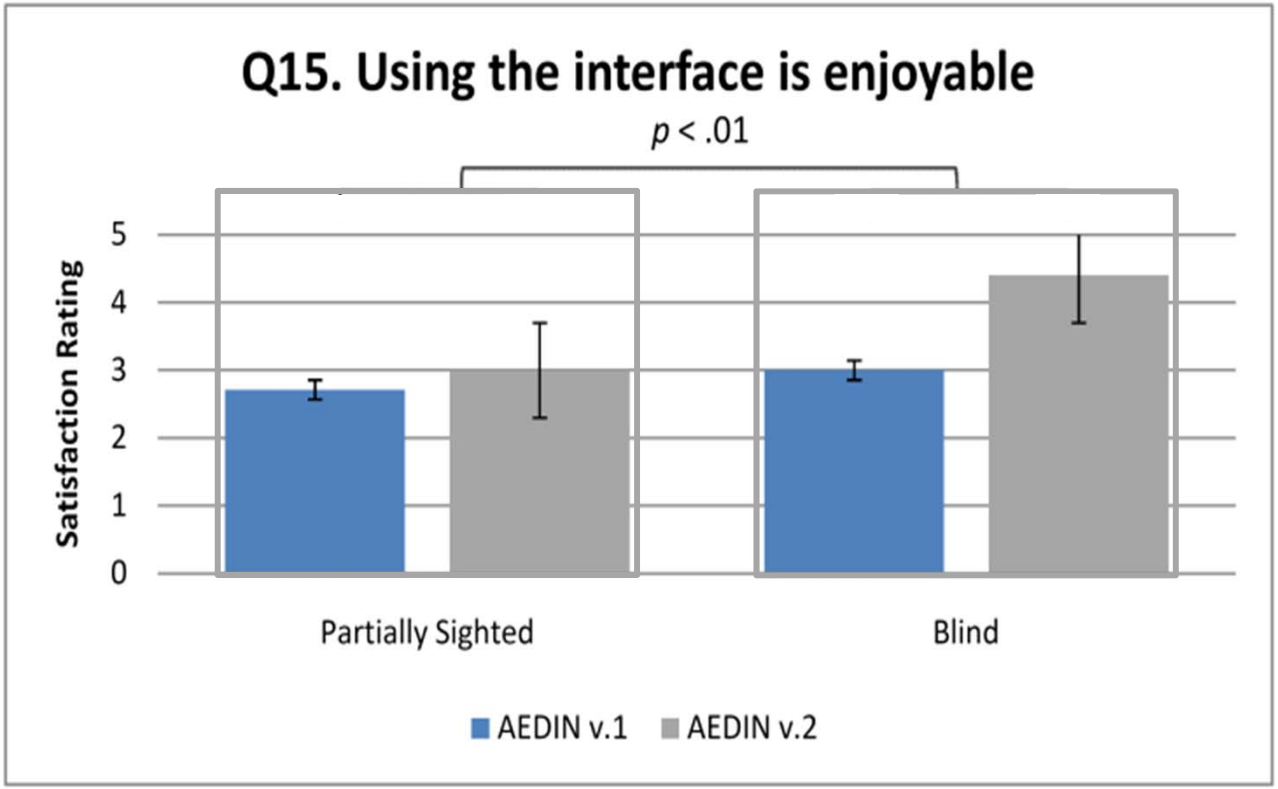
Gender Effect



Gender: **Female** (*M* = 4.10, *SD* = 0.88) vs. **Male** (*M* = 3.64, *SD* = 0.92)
t(18) = 2.16, *p* < .05, *d* = .98.

Female participants like feedback sounds to be short and succinct rather than long.

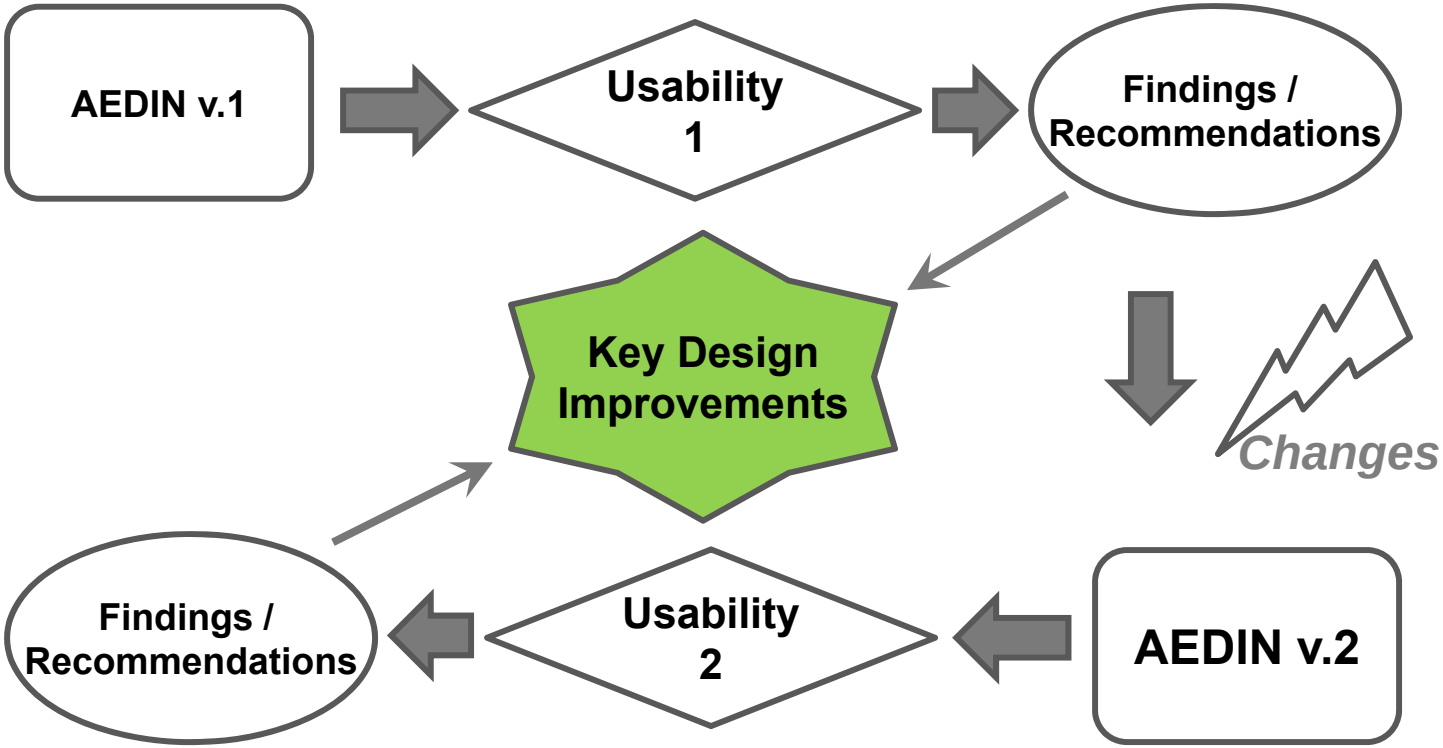
Impairment Effect



Impairment: **Blind** (*M* = 4.00, *SD* = 1.00) vs. **Partially sighted** (*M* = 2.85, *SD* = 0.69) *t*(18) = 3.05, *p* < .05, *d* = 1.34.

Blind participants rated the enjoyability of AEDIN significantly higher than partially sighted.

AEDIN Design and Iterative Evaluation



Findings Highlights

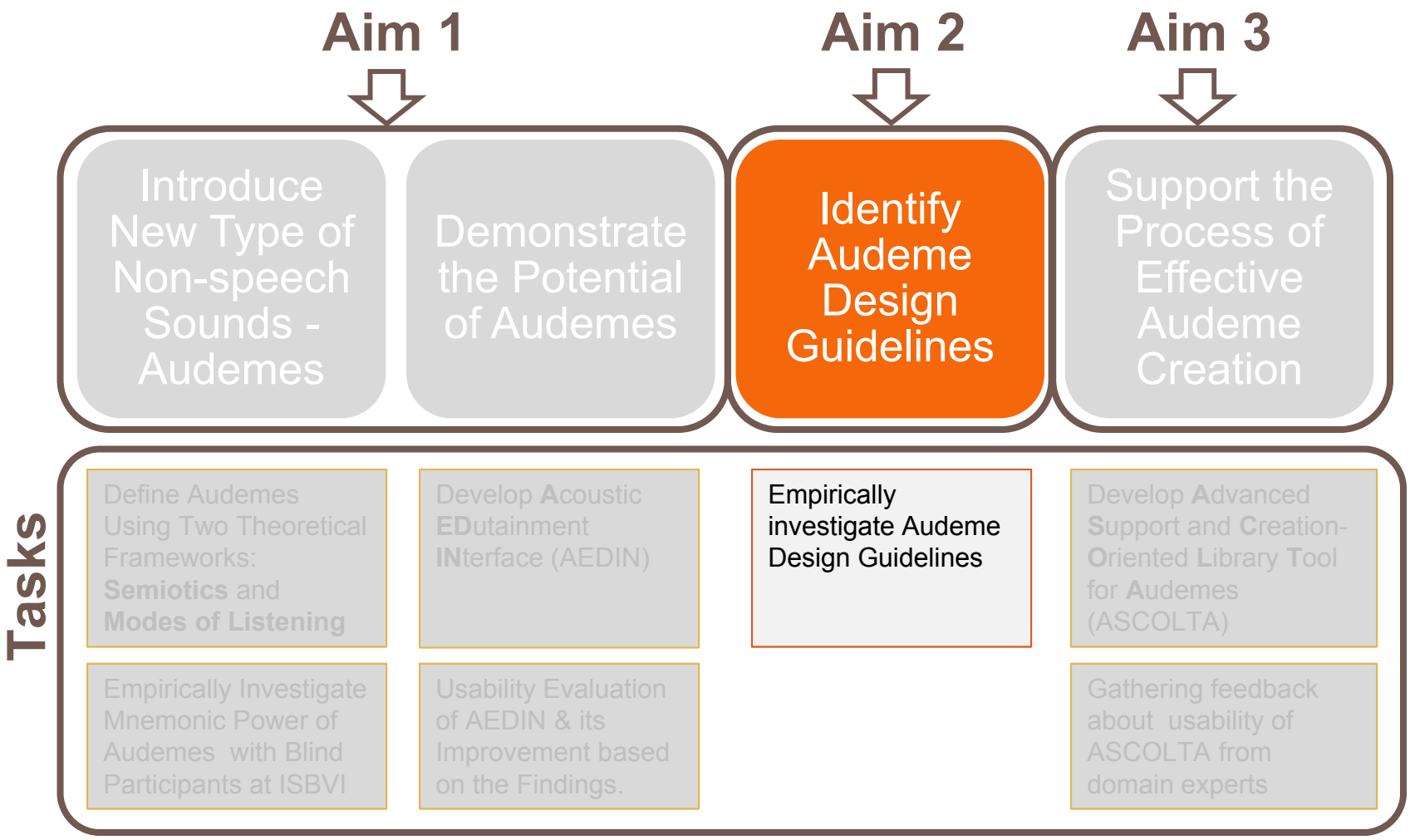
KEY DESIGN CHANGES

- 64% Increased speed of reading essays
- Overlapped but not congruent haptic and visual affordance
- Improved sound feedback

IMPROVED AURAL UX

- Significant increase of enjoyability
- Blind participants rate interface enjoyability higher than partially sighted
- Females rate feedback sounds higher

AIM 2: Need for Guidelines



Yet, designing well-formed audemes remains an ad hoc process!

Experiment: Audeme-based Content Recognition over Time

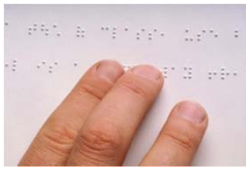
Purpose: Investigate what characteristics of audemes make them most effective for content recognition

Participants:

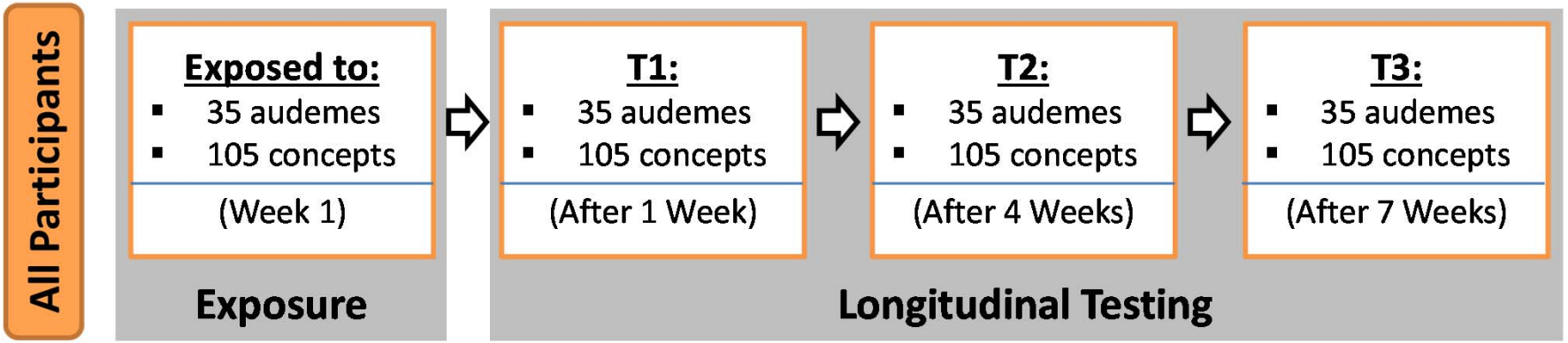
(total 8)


4


4


5


3



Stimuli

Audeme Attributes:

Source:

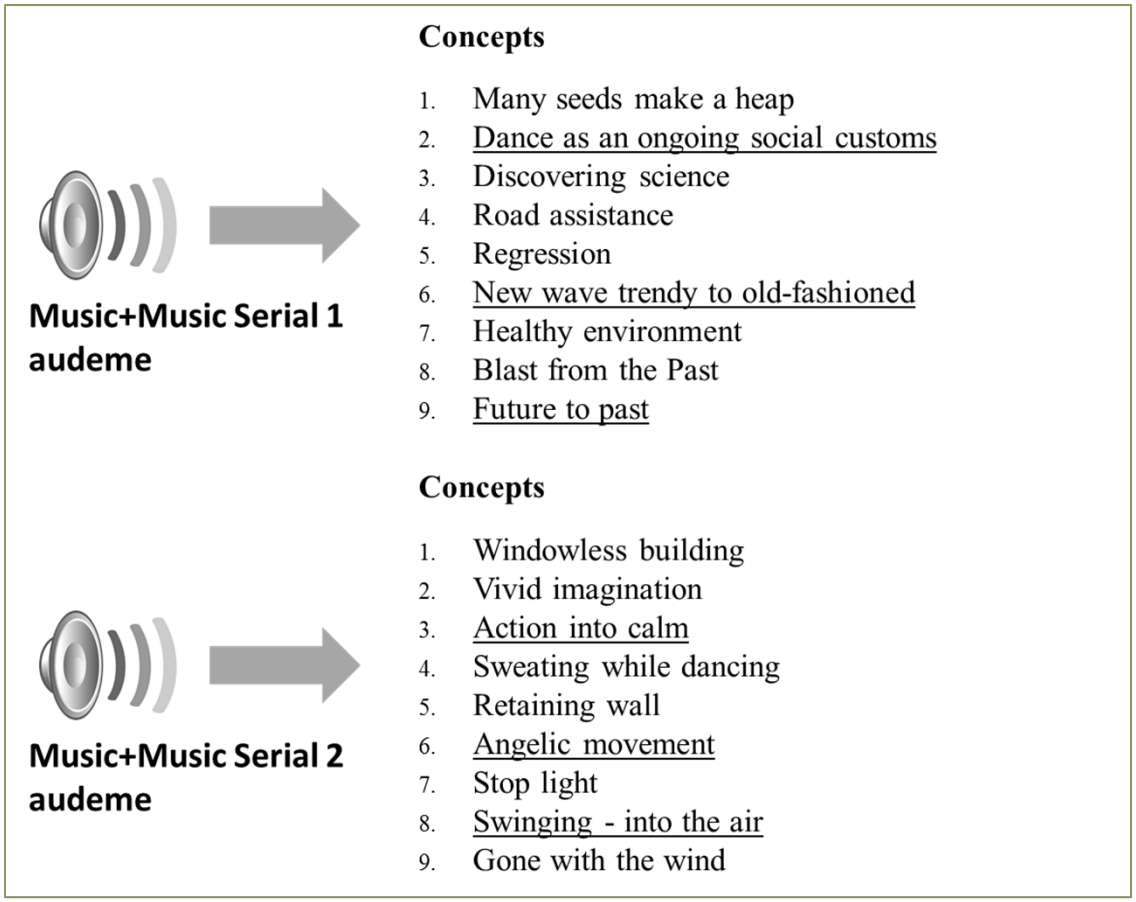
- Music
- Sound effect

Semiotic:

- Causal
- Referential
- Reduced

Syntactic:

- Serial
- Parallel

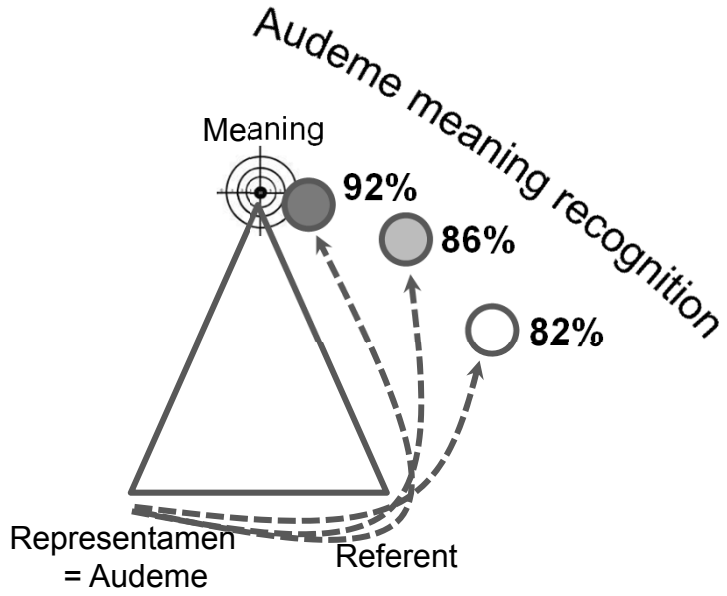


- More feasible to test 35 audemes with 105 (3x35) concepts than 35 essays
- An essay could be considered as a set of concepts with unifying theme

IV: Audeme Combinations

DV: Concept Recognition Score

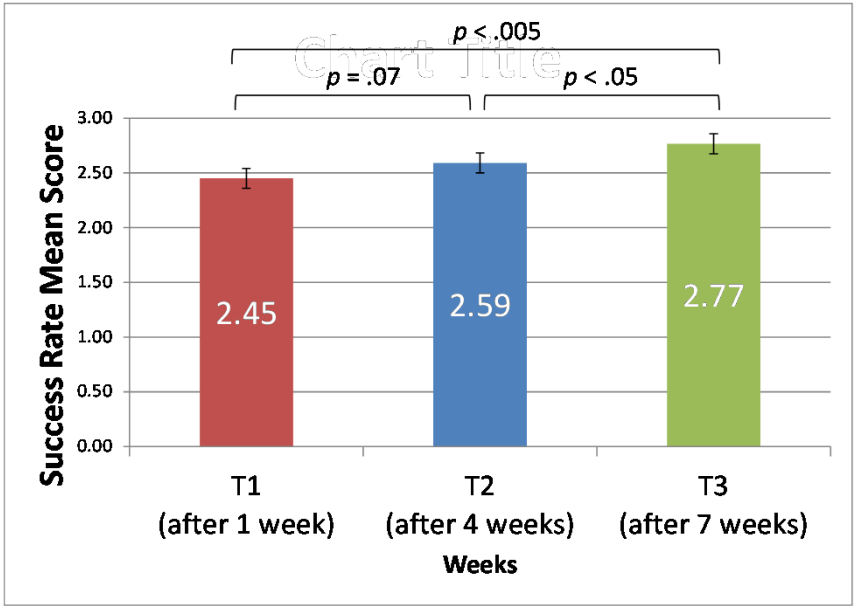
Results



T3 (after 7 week)

T2 (after 4 week)

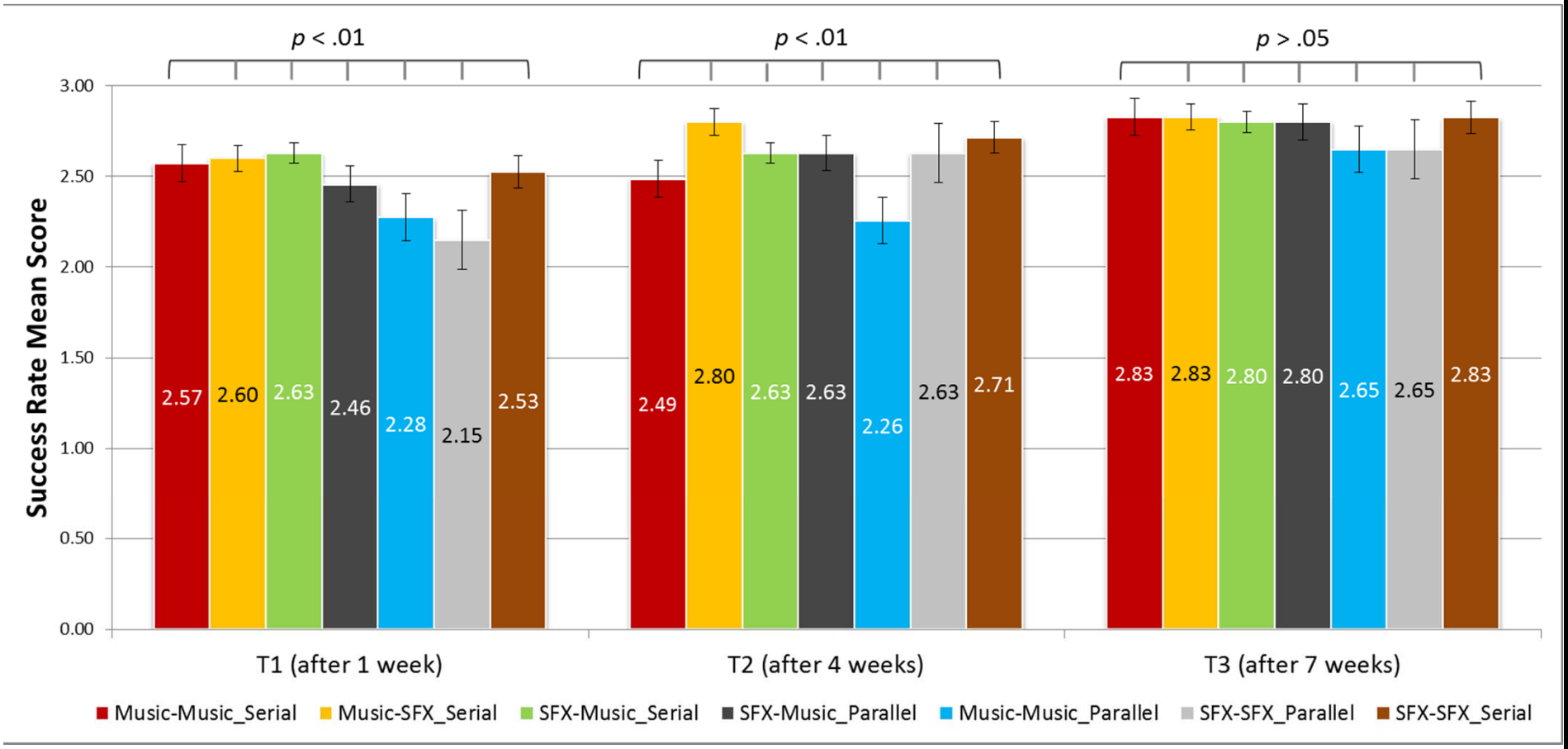
T1 (after 1 week)



F (2, 14) = 17.32,
p < .001, η^2 = .71.

Ferati et al (submitted)

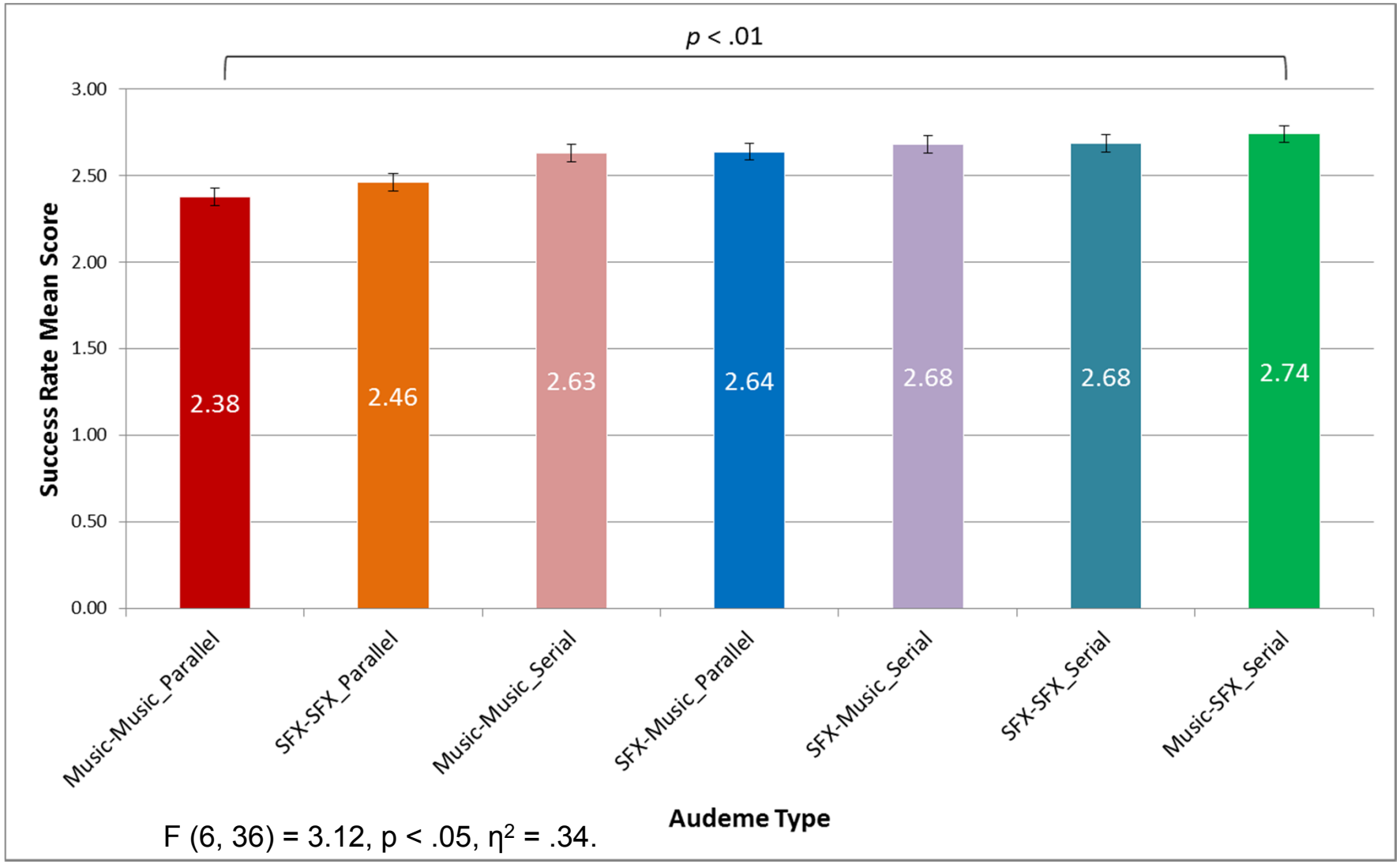
Results



F (6, 36) = 3.54, η^2 = .38 F (6, 36) = 4.24, η^2 = .41 F (6, 36) = 1.59, η^2 = .21

The difference among audeme types fades over time

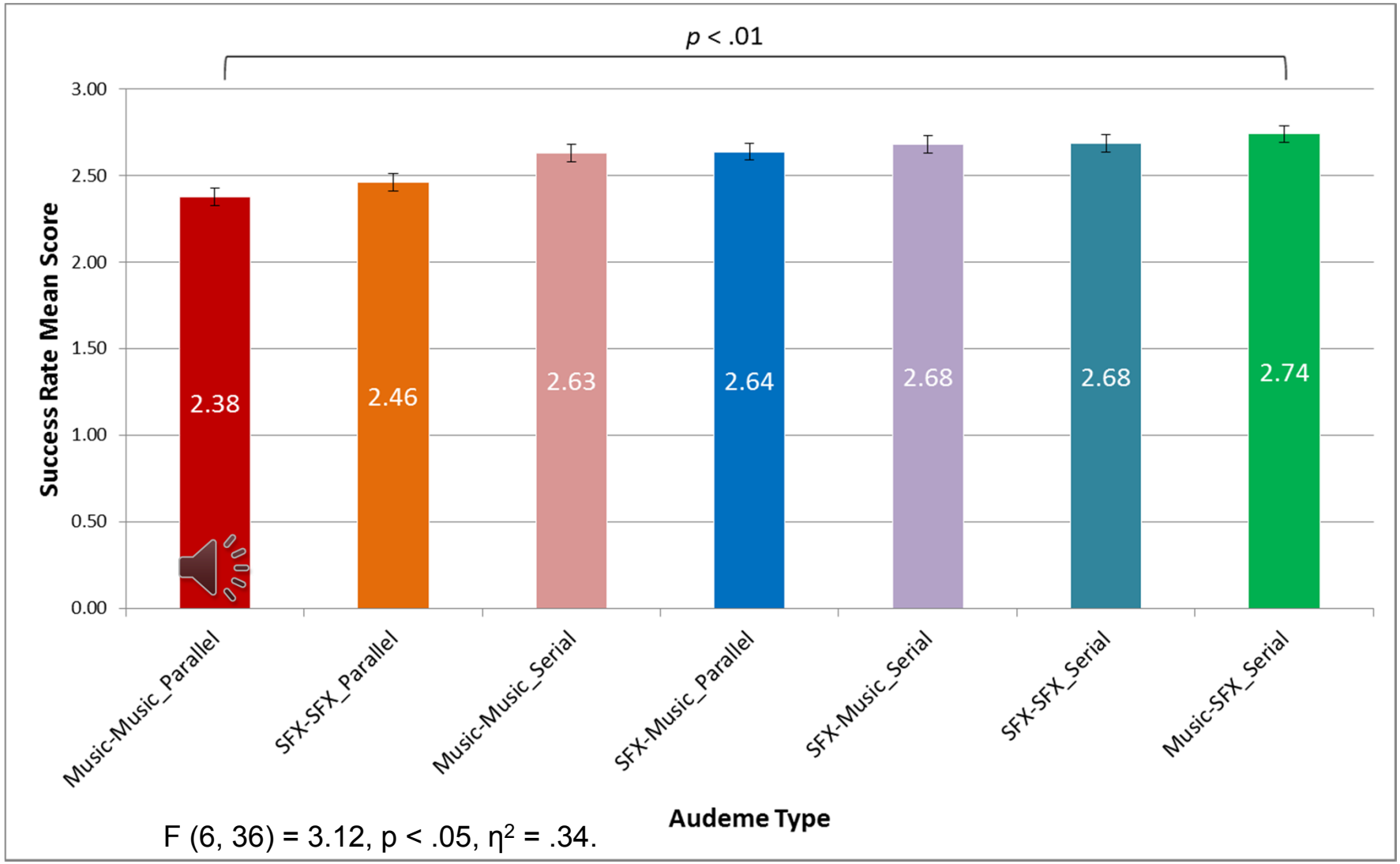
Results



$F(6, 36) = 3.12, p < .05, \eta^2 = .34.$

The best audeme Music+Sound effect Serial; the worst Music+Music Parallel

Results



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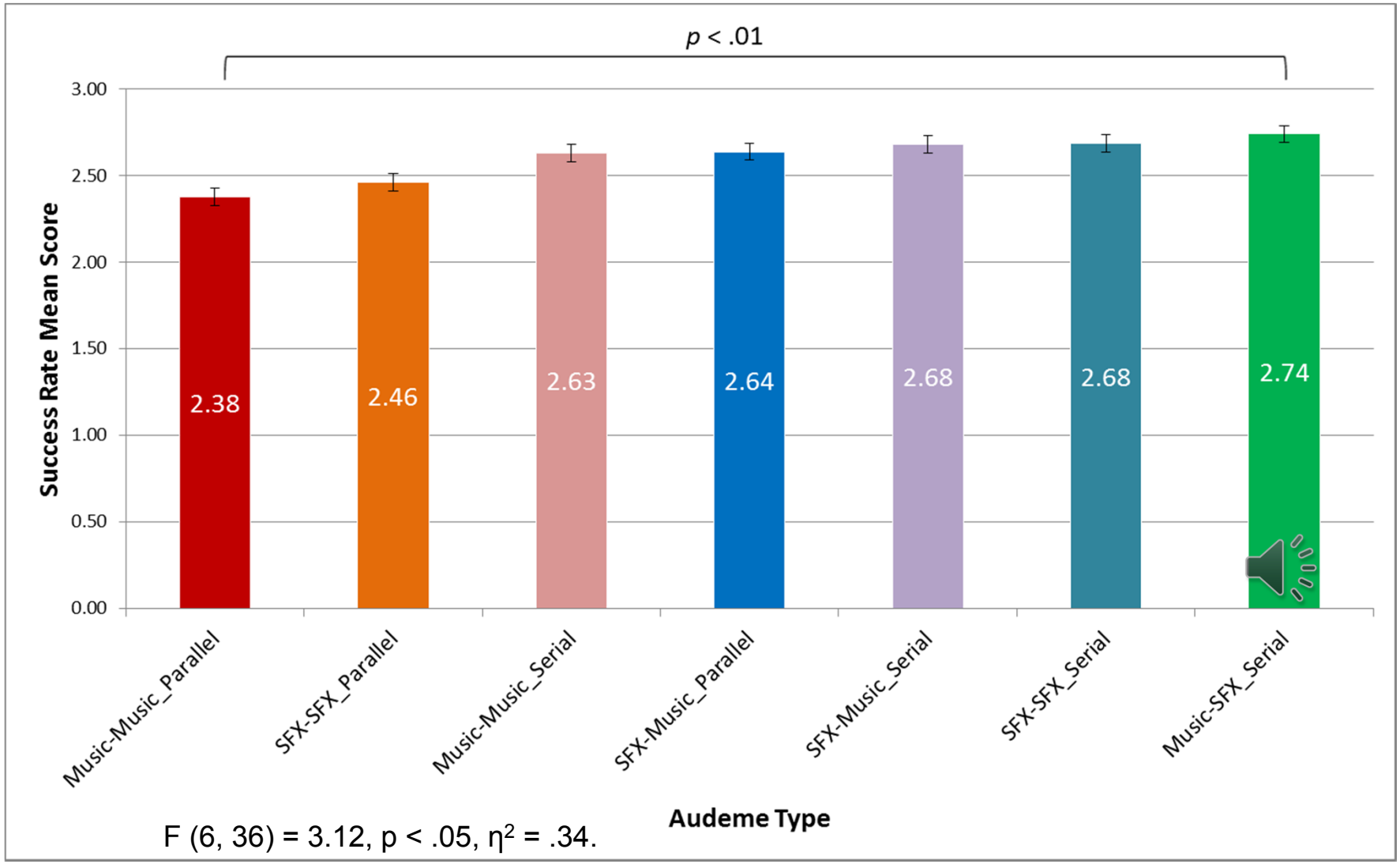

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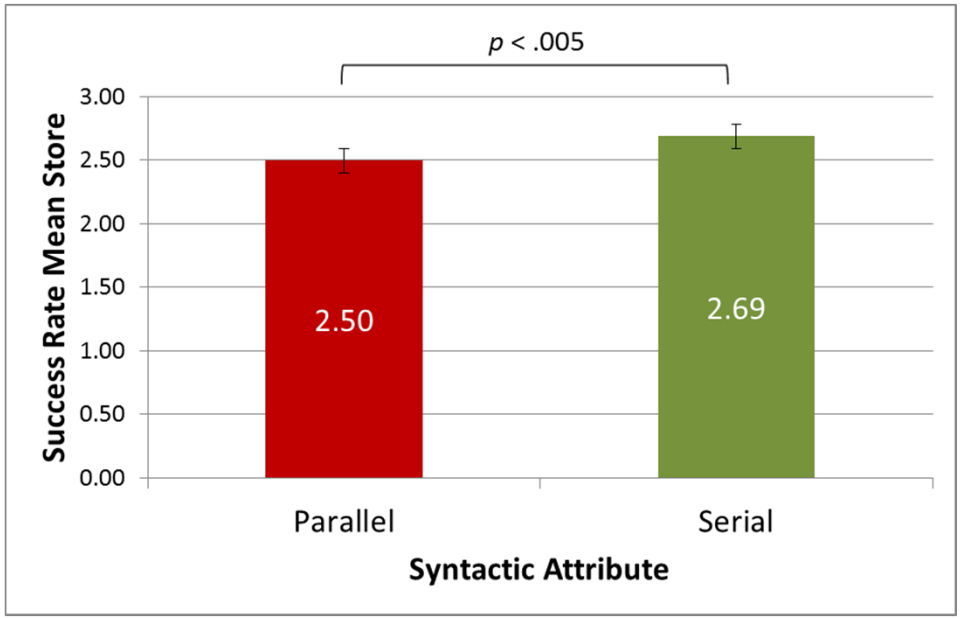
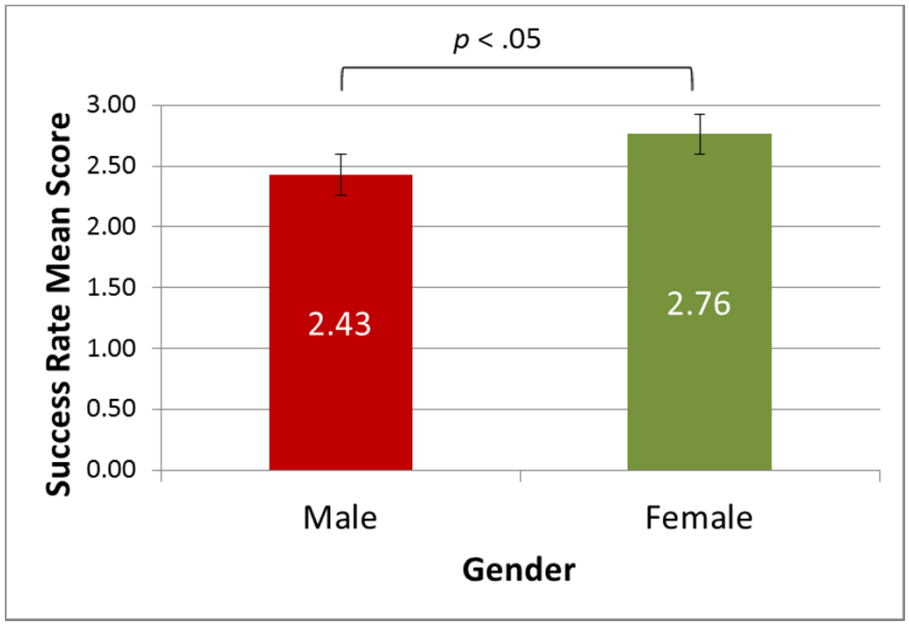


t(7) = 4.71, r = .87.

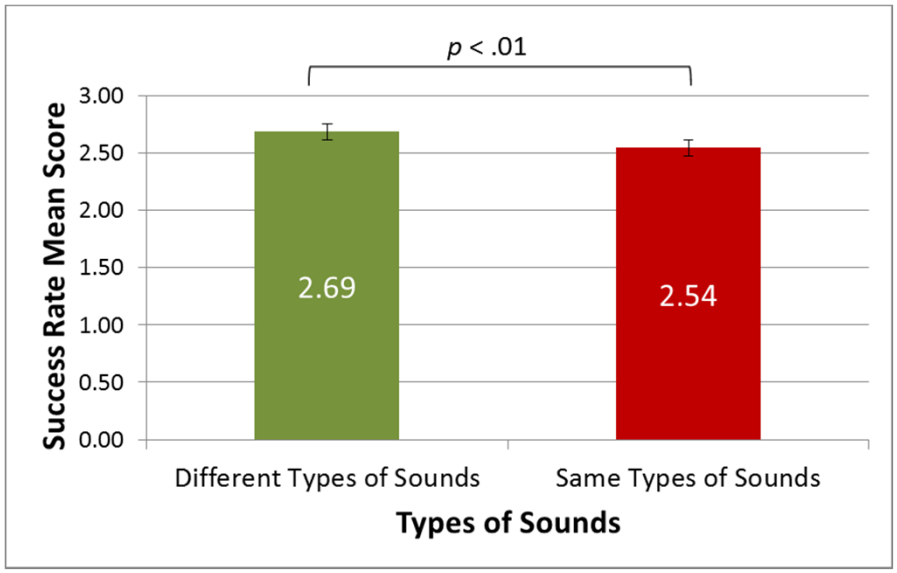
Audemes created of serially concatenated sounds better than parallel concatenation



t(6) = 3.62, r = .83.

Females recognized audeme meanings more accurately than males

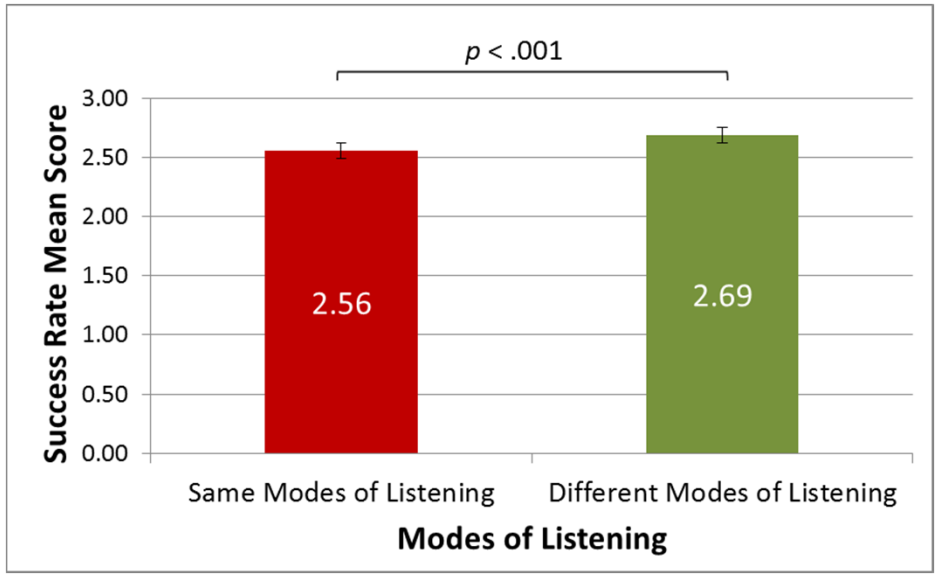
Results



t(6) = 3.95, r = .85.

Music+SFX **Music+Music**

SFX+Music **SFX+SFX**

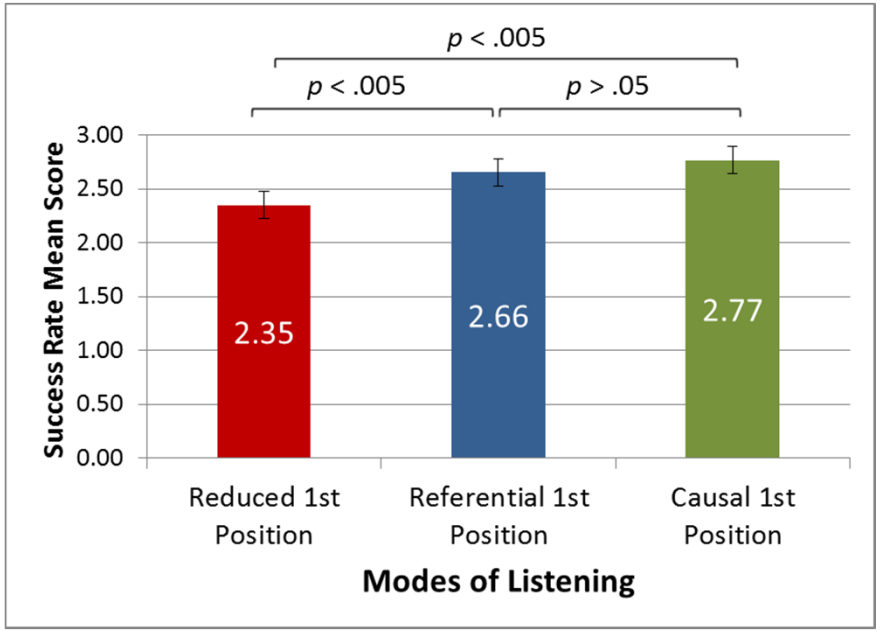


t(7) = 5.32; r = .89.

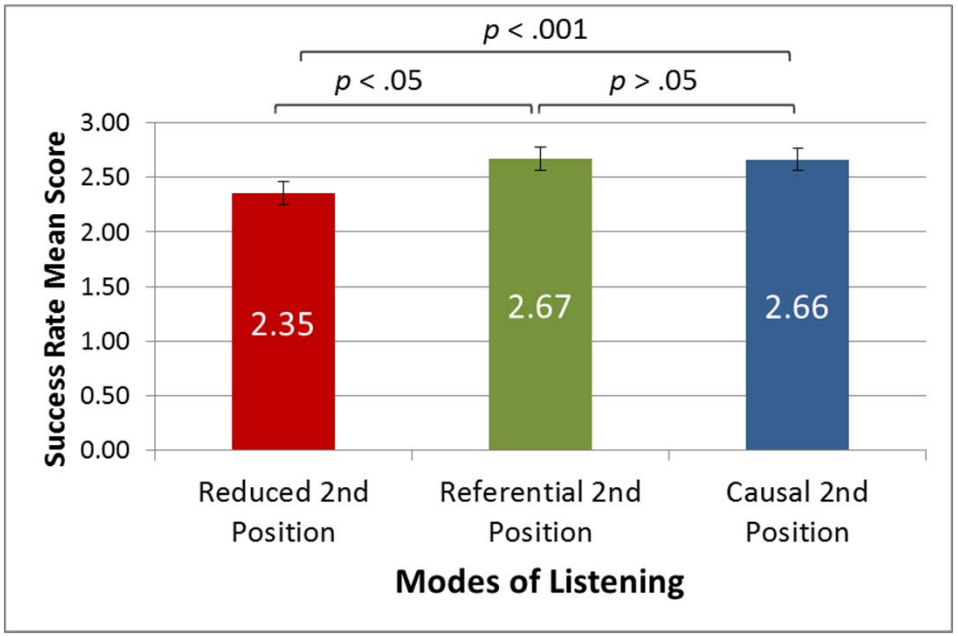
Causal+Causal **Causal+Referential**

Referential+Referential **Referential+Causal**

Results



$F(2, 14) = 22.25$, p , .001, $\eta^2 = .76$.



$F(2, 14) = 25.87$, $p < .001$, $\eta^2 = .79$.

Audemes created with sounds (both first and second position) used in the causal and referential mode of listening are better than audemes used with sounds in the reduced mode of listening.

Guidelines for Well-formed Audemes that can Optimize Content Recognition

G1. Serially concatenate sounds

G2. Mix different sounds

G3. Follow a music with a sound effect

G4. Use the sound of the real object causing it

G5. Frequent exposure has great impact on the recognition of the audeme meaning

G6. Recognition of the audeme meaning works well with a broad range of rhythms

G7. Recognition of the audeme meaning works well with a broad range of timbres

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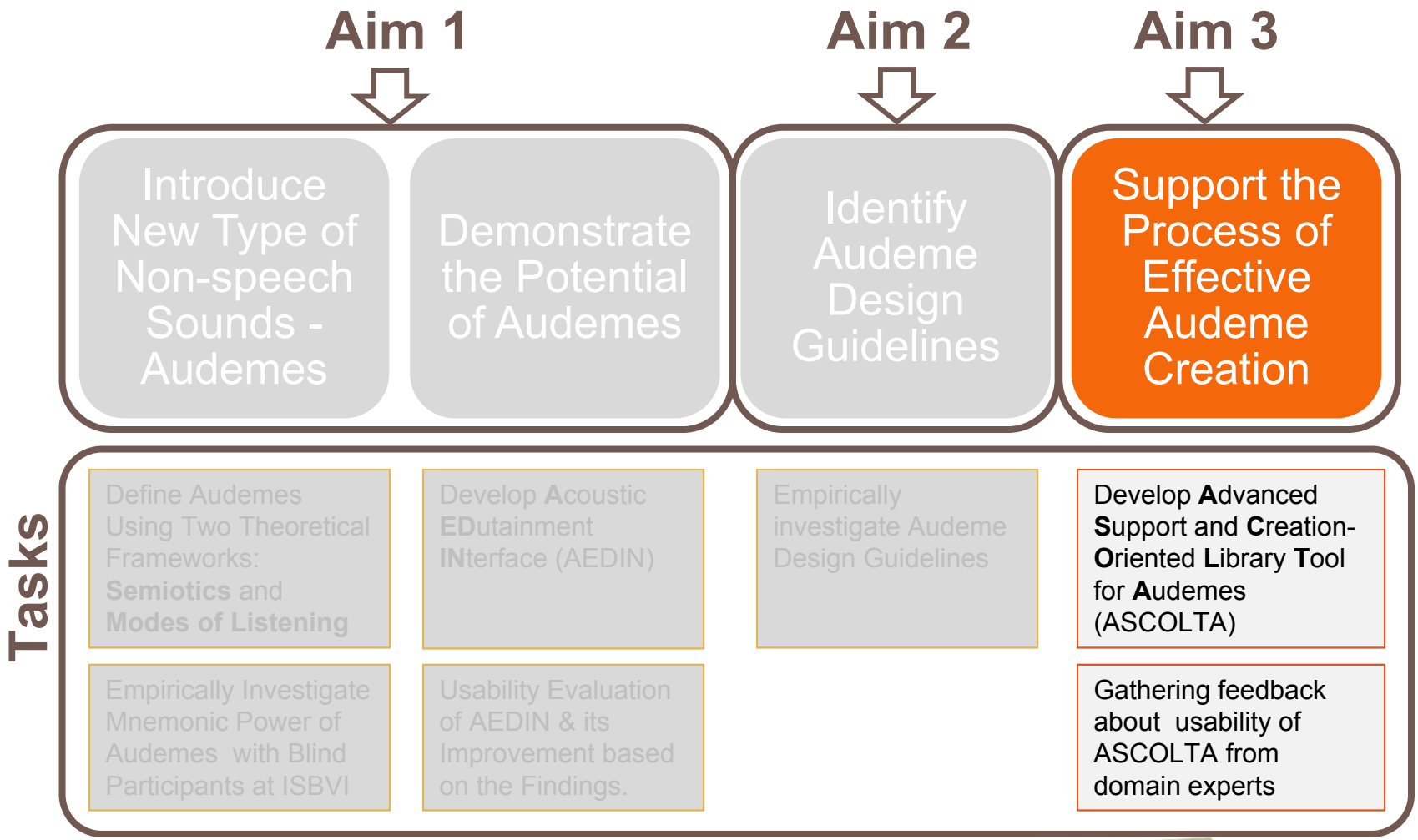
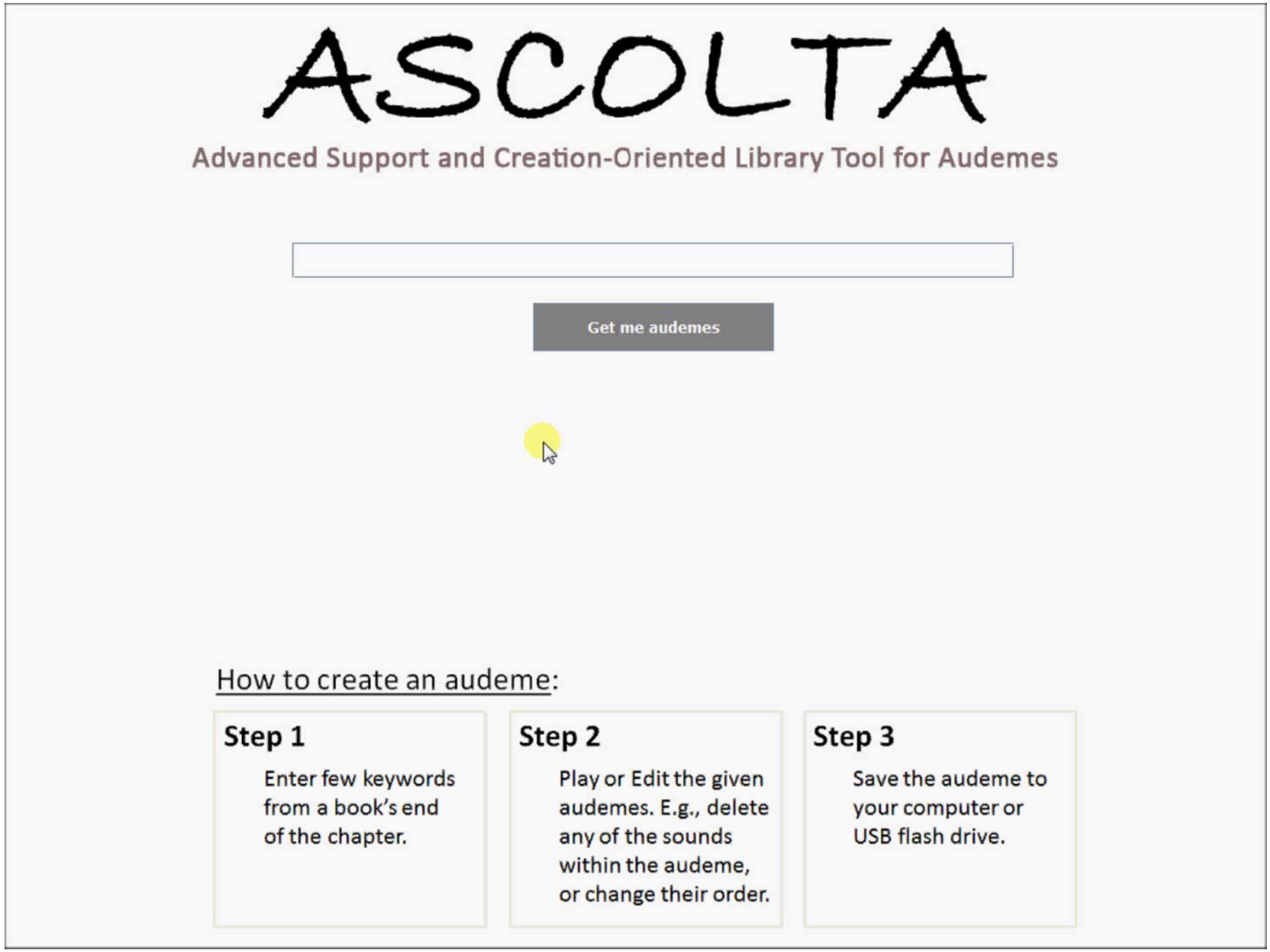
Aim 3: Operationalize Guidelines into a Tool



Advanced Support and Creation-Oriented Library Tool for Audemes (ASCOLTA)

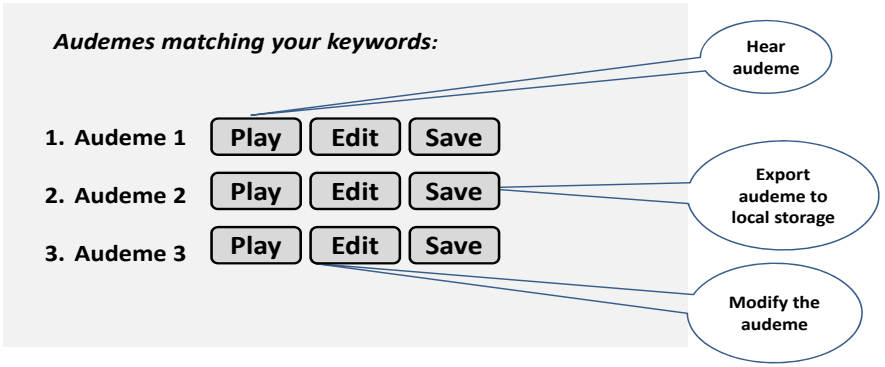
- ASCOLTA is an interactive application that enables individuals without an audio design background to create effective audemes
- It is built for the teachers of the BVI students to enhance their teaching experience
- ASCOLTA operationalizes the guidelines derived empirically in the experiments in Aim 2, which ensures the creation of well-formed audemes

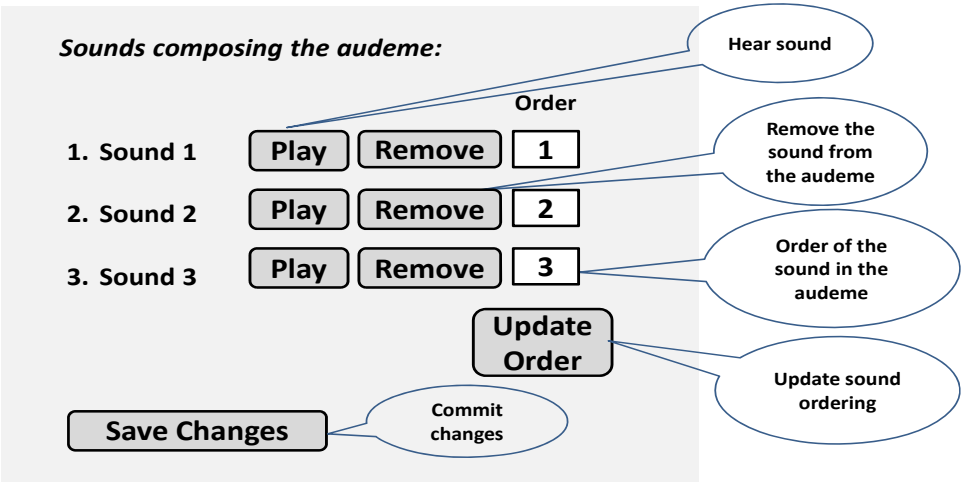
ASCOLTA Demo



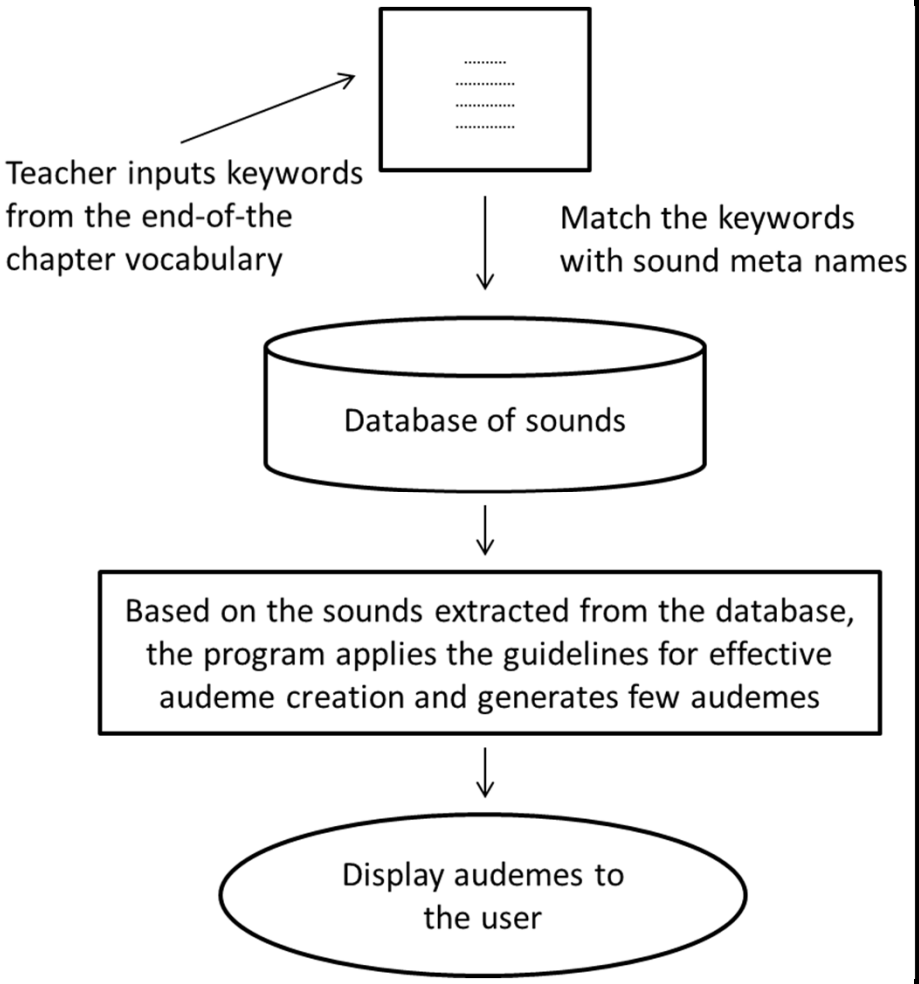
Designing ASCOLTA

Mockups





Technical Architecture



ASCOLTA Evaluation

Purpose: Gather feedback about:

- the usefulness of ASCOLTA to teachers to enhance their lecturing experience
- ways to improve it

Individual interviews conducted with 3 teachers from the ISBVI

Procedure:

1. ASCOLTA demonstration
2. Participants performed four tasks using the ASCOLTA interface
3. Interview using 10 open-ended questions

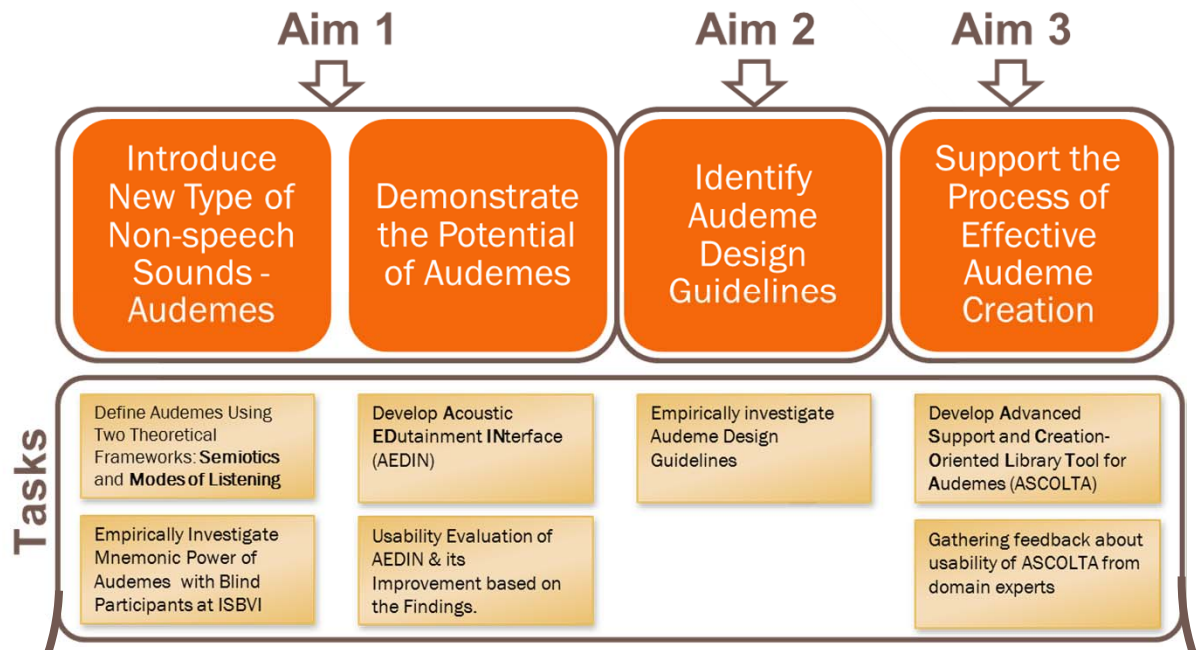
Results on the Value of ASCOLTA to Teachers of the ISBVI

- **Simple User Interface, but with Limited Accessibility**
  - P2: *"It's simple; it's good that you get just few audemes as a result, not too many."*
  - P1: *"It should be made accessible, as we do have blind teachers in the school."*
- **Freedom to Explore Users' Creativity, but Limited Collaboration**
  - P3: *"I like the choice of being able to change the individual sounds."*
  - P1: *"Could you make it possible for the users to share the created audemes with their friends?"*
- **Users Anticipate using the ASCOLTA in Teaching their Classes**
  - P1: *"We can use the ASCOLTA to offer a nine-week rotation class in which students will create audemes."*
  - P2: *"Audemes from the environment are very useful, so with the ASCOLTA I can create audemes to explain to my students what a residential environment is."*
  - P3: *"I could use this tool to create audemes while I teach the lesson. The audeme will be created with suggestions from the kids.*

Discussion on ASCOLTA evaluation

- From the results we can learn:
  - To consider broader spectrum of user profiles: BVI teachers and students
  - To provide collaborative environment to support the co-creation and evaluation of generated audemes

Revisit Aims & Contributions



Contributions

1. First work that establishes audemes as a new type of non-speech sound aimed at conveying theme-based content
2. Enriches Multimedia Learning principle by using audemes as non-verbal representations

It demonstrates audemes as aural covers in an acoustic interface built for BVI K-12 users

It introduces novel and empirically validated guidelines for effective creation of audemes

First work to operationalize the guidelines into a tool aimed at generating well-formed audemes

Limitations

Sample

1. Size of the sample: Convenience-limited sample (8-21 participants)

2. Characteristics of the sample:

   a. impairment level (only blind and visually impaired)

   b. education level (only K-12 education level)

Content Domain

1. Audemes and essays were created within the theme of U.S. history keyed to the Indiana K-12 education standard.

Research Questions Revisited

1. **When a new type of non-speech sound (*audeme*) is played along with theme-based information, does it help to <u>better memorize content</u>?**
   - <u>ANSWER:</u> Audemes function as *memory catalysts* that help users to better memorize theme-based content when they are played along with the content.

2. **<u>What is the function(s)</u> of audemes in content-rich interfaces for the BVI?**
   - <u>ANSWER:</u> Audemes serve as *content anticipators* when used in content-rich interfaces for the BVI.

3. **<u>What characteristics</u> of audemes help BVI users recognize audeme meaning?**
   - <u>ANSWER:</u> Numerous audeme characteristics, such as the serial concatenation of sounds and a mixture of different sound types, help BVI users recognize the meaning of the audemes.

Future Research Directions

- **Devising further guidelines for the audeme design**
  - Length of audemes
  - Pause between the sounds creating the audeme

- **Use audemes to communicate a process to sighted people**
  - Natural disaster - an alarm sound along with an audeme created of sounds: basement, bathtub and table.
  - Kids in the bathroom - water getting flushed down the toilet, sound of brushing the teeth, and washing hands.

- **Studying the process of co-creation of audemes to enhance learning and content recognition.**

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NINA MASON PULLIAM CHARITABLE TRUST

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NSF

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- Microsoft Imagine Cup '11

Thanks & Related Publications

thank you ju falemnderit grazie शुक्रिया با تشکر از شما

شکرا 谢谢 ви благодарам danke merci 감사합니다

Ferati, M., Pfaff, M., Mannheimer, S., and Bolchini, D., Audemes at Work: Investigating Features of Non-speech Sounds to Maximize Content Recognition, International Journal of Human-Computer Studies *(submitted)*

Ferati, M., Mannheimer, S., Bolchini, D., Usability Evaluation of Acoustic Interfaces for the Blind. in Proc. of the 29th ACM International Conference on Design of Communication (SIGDOC), 9-16, October 3-5, Pisa, Italy, 2011.

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Ferati, M., Bolchini, D., Mannheimer, S., Towards a Modeling Language for Designing Auditory Interfaces, in C. Stephanidis (Ed.): Universal Access in HCI, Part III, HCII 2009 Proceedings, Springer-Verlag LNCS 5616, 502–511, San Diego, CA, 2009.

Mannheimer, S., **Ferati, M.,** Bolchini, D., Palakal, M., Educational Sound Symbols for the Visually Impaired, in C. Stephanidis (Ed.): Universal Access in HCI, Part I, HCII 2009 Proceedings, Springer-Verlag LNCS 5614, 106–115, San Diego, CA, 2009.

Mannheimer S., **Ferati M.,** Huckleberry D., and Palakal M., Using Audemes as a Learning Medium for the Visually Impaired, Proceedings of HEALTHINF 2009, 175-180, Porto, Portugal, 2009.