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

Sounds in HCI

Function-oriented

Content-oriented

Earcons

Problem & Background | Aim 1 - Audemes - AEDIN | Aim 2 - Guidelines | Aim 3 – ASCOLTA | Conclusion
Sounds in Human-Computer Interaction

Sounds in HCI

- Function-oriented
- Content-oriented

Earcons
Sounds in Human-Computer Interaction

- Sounds in HCI
  - Function-oriented
    - Earcons
    - Auditory Icons
  - Content-oriented

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  - Sonification

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- Audemes

Problem & Background | Aim 1 - Audemes - AEDIN | Aim 2 - Guidelines | Aim 3 – ASCOLTA | Conclusion
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

Aim 1
Introduce New Type of Non-speech Sounds - Audemes

Aim 2
Demonstrate the Potential of Audemes

Aim 3
Support the Process of Effective Audeme Creation

Tasks

Define Audemes Using Two Theoretical Frameworks: Semiotics and Modes of Listening

Empirically Investigate Mnemonic Power of Audemes with Blind Participants at ISBVI

Develop Acoustic EDutainment INterface (AEDIN)

Usability Evaluation of AEDIN & its Improvement based on the Findings.

Empirically investigate Audeme Design Guidelines

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

Gathering feedback about usability of ASCOLTA from domain experts
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

adapted from Peirce (1908)

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

adapted from Peirce (1908)
Meaning Generation in Audemes

Mannheimer et al (2009)
Meaning Generation in Audemes

Mannheimer et al (2009)
Modes of Listening

- Reduced Listening
  - abstract
  - quality-oriented

- Semantic Listening
  - language-dependent
  - convention-oriented

- Causal Listening
  - ecological
  - source-oriented

- Referential Listening
  - socio/cultural-dependent
  - context-oriented
Semiotics, Modes of Listening and Non-speech Sounds

Ferati et al (submitted)
In 1912, the famous ocean liner Titanic sank. This event made it clear to the public that lives might have been saved if radio communications had been available and monitored. After this, radio transmitters quickly became universal on large ships. In 1913, the International Convention for the Safety of Life at Sea produced a treaty requiring shipboard radio stations to be manned 24 hours a day.

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.

On February 17, 1919, station 9XM at the University of Wisconsin at Madison broadcast the first human speech to the public at large. That station is still on the air today as WHA. But the first for-profit commercial radio station in the US is generally thought to be KDKA in Pittsburgh, Pennsylvania, which in October 1920 received its broadcasting license and went on the air as the first US licensed commercial broadcasting station.

However, in the early years of radio, broadcasting was not yet supported by advertising or listener sponsorship. The stations owned by radio manufacturers and department stores were established to sell radios and stations owned by newspapers were used to promote the sales of newspapers and express the opinions of the owners.
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

#IRB-1009001883
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)

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:

1. The first commercial or for-profit radio station was
   a. On the ocean liner Titanic
   b. Run by two college students from Wisconsin
   c. Established in Pittsburgh in 1920
   d. Only in operation during the winter
   e. Very difficult to hear because of bad equipment

2. In the beginning, radio stations
   a. Were created to help churches and universities broadcast weekly sermons and lectures
   b. Mainly seen as a way to sell home radio receivers or to let newspaper owners promote their newspapers
   c. Often failed commercially due to lack of public interest
   d. Very rare in the southern half of the country because warm weather interfered with radio signals
   e. Only broadcast at night

3. In America, government regulation of radio
   a. Began after the sinking of the Titanic
   b. Needed to prevent European broadcasters from taking over the industry
   c. Left to the individual states to control
   d. Only applied to amateur radio operators
   e. A controversial issue that divided the country
Results

Gain = posttest – pretest scores

Overall significance:

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

Mannheimer et al (2009)
Dissertation Aims

**Aim 1**

Introduce New Type of Non-speech Sounds - Audemes

**Tasks**

- Define Audemes Using Two Theoretical Frameworks: Semiotics and Modes of Listening
- Empirically Investigate Mnemonic Power of Audemes with Blind Participants at ISBVI
- Develop Acoustic EDutainment INterface (AEDIN)
- Usability Evaluation of AEDIN & its Improvement based on the Findings.

**Aim 2**

Identify Audeme Design Guidelines

**Tasks**

- Empirically investigate Audeme Design Guidelines
- Develop Advanced Support and Creation-Oriented Library Tool for Audemes (ASCOLTA)
- Gathering feedback about usability of ASCOLTA from domain experts

**Aim 3**

Support the Process of Effective Audeme Creation

**Tasks**

- Develop Advanced Support and Creation-Oriented Library Tool for Audemes (ASCOLTA)
- Gathering feedback about usability of ASCOLTA from domain experts

To investigate the function of audemes when integrated into a content-rich user interface
AEDIN is an acoustic interface in which audemes were used as “aural covers” to anticipate large content, such as text-to-speech essays.
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

- 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 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

**Radio essay**
(Text-to-speech format)

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.

**Economics essay**
(Text-to-speech format)

Economics is the social science that studies the production, distribution, and consumption of goods and services. Taken all together, this is called the economy. Each of us participates in the economy every time we buy (or decide not to buy) a radio or a pair of shoes, or go to the movies or go out to eat, or fly in an airplane or hire a taxi to take us to a concert. On the simplest level, economics is all about money and how we spend it. On a more complex level, economics asks why we decided to spend (or not spend) that money, and how we believe other actions will have an impact on our financial well-being.

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Audemes as Content Anticipators

### Content anticipation examples

**Radio essay**
_(Text-to-speech format)_

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AEDIN Design and Iterative Evaluation

AEDIN v.1 → Usability 1 → Findings / Recommendations → Key Design Improvements → Usability 2 → AEDIN v.2

Changes

Findings / Recommendations

Problem & Background | Aim 1 - Audemes - AEDIN | Aim 2 - Guidelines | Aim 3 – ASCOLTA | Conclusion
AEDIN Design and Iterative Evaluation

AEDIN v.1 → Usability 1 → Findings / Recommendations

Findings / Recommendations → Key Design Improvements → Changes

Key Design Improvements → Usability 2 → AEDIN v.2

Changes → AEDIN v.2
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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AEDIN

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  • Background sounds *(sound-effect)*
AEDIN Design and Iterative Evaluation

AEDIN v.1 → Usability 1 → Findings / Recommendations → Key Design Improvements → Usability 2

Changes

Findings / Recommendations → 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.)
64% Increased Speed of Reading Essays

AEDIN v.1 Essay

(160 word per min.)

AEDIN v.2 Essay

(250 word per min.)
64% Increased Speed of Reading Essays

AEDIN v.1 Essay

(160 word per min.)

AEDIN v.2 Essay

(250 word per min.)
Improved design for overlapping affordances

Traditional Design
(for Sighted Users)

Visual and Haptic Affordance Areas

AEDIN Design
(for Blind and Visually Impaired Users)

Visual Affordance Area

Haptic Affordance Area

AEDIN v.1

AEDIN v.2
Improved Feedback Sounds

Robotic Aural Label

Humanlike Aural Label
**AEDIN V.2**

**Improved Feedback Sounds**

Robotic Aural Label

Humanlike Aural Label
Improved Feedback Sounds

Robotic Aural Label

Humanlike Aural Label
AEDIN Design and Iterative Evaluation

AEDIN v.1 → Usability 1 → Findings / Recommendations → Key Design Improvements → Findings / Recommendations

Usability 2 → AEDIN v.2

Changes
Usability Evaluation

Participants (total 20)

<table>
<thead>
<tr>
<th>Usability test 1</th>
<th>Usability test 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AEDIN v.1</strong></td>
<td><strong>AEDIN v.2</strong></td>
</tr>
<tr>
<td>4</td>
<td>6</td>
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<tr>
<td>5</td>
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<tr>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Participants: 10 for AEDIN v.1, 10 for AEDIN v.2

IRB-1009001883
Usability Evaluation

Tasks and Data collection

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

Satisfaction Questionnaire
Open-Ended Questionnaire
Participant Comments
Observation
AEDIN Design and Iterative Evaluation

AEDIN v.1 → Usability 1 → Findings / Recommendations

Key Design Improvements

Findings / Recommendations → Usability 2 → AEDIN v.2

Changes
## Results

### Factor Analysis,

Cronbach’s Alpha = .731

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

**Q15. Using the interface is enjoyable**

$$p < .05$$

![Graph comparing satisfaction ratings between AEDIN v.1 and AEDIN v.2](image)

*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 significantly improved with minor design changes done within a week.

*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.
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)

- Exposed to:
  - 35 audemes
  - 105 concepts
  (Week 1)

- **T1:**
  - 35 audemes
  - 105 concepts
  (After 1 Week)

- **T2:**
  - 35 audemes
  - 105 concepts
  (After 4 Weeks)

- **T3:**
  - 35 audemes
  - 105 concepts
  (After 7 Weeks)

IRB-10070474B
Stimuli

Audeme Attributes:

Source:
- Music
- Sound effect

Semiotic:
- Causal
- Referential
- Reduced

Syntactic:
- Serial
- Parallel

IV: Audeme Combinations

DV: Concept Recognition Score

- 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
Results

T1 (after 1 week)
T2 (after 4 week)
T3 (after 7 week)

Ferati et al (submitted)

F (2, 14) = 17.32, p < .001, η² = .71.
Results

The difference among audeme types fades over time
Results

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

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

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

F (6, 36) = 3.12, p < .05, η² = .34.
Results

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

F (6, 36) = 3.12, p < .05, η² = .34.
Females recognized audemes more accurately than males.

Audemes created of serially concatenated sounds better than parallel concatenation.
Results

\[ t(6) = 3.95, r = .85. \]

\[ t(7) = 5.32; r = .89. \]

Music+SFX
Music+Music
SFX+Music
SFX+SFX
Causal+Causal
Causal+Referential
Referential+Referential
Referential+Causal
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

**Aim 1**
- Introduce New Type of Non-speech Sounds - Audemes

**Aim 2**
- Demonstrate the Potential of Audemes
- Identify Audeme Design Guidelines

**Aim 3**
- Support the Process of Effective Audeme Creation
- Empirically investigate Audeme Design Guidelines
- Develop Advanced Support and Creation-Oriented Library Tool for Audemes (ASCOLTA)
- Gathering feedback about usability of ASCOLTA from domain experts

**Tasks**
- Define Audemes Using Two Theoretical Frameworks: Semiotics and Modes of Listening
- Empirically Investigate Mnemonic Power of Audemes with Blind Participants at ISBVI
- Develop Acoustic Entertainment Interface (AEDIN)
- Usability Evaluation of AEDIN & its Improvement based on the Findings.

**To operationalize the audeme design 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

Advanced Support and Creation-Oriented Library Tool for Audemes

How to create an audeme:

**Step 1**
Enter few keywords from a book’s end of the chapter.

**Step 2**
Play or Edit the given audemes. E.g., delete any of the sounds within the audeme, or change their order.

**Step 3**
Save the audeme to your computer or USB flash drive.
Designing ASCOLTA

Mockups

Audemes matching your keywords:

1. Audeme 1
   - Play
   - Edit
   - Save

2. Audeme 2
   - Play
   - Edit
   - Save

3. Audeme 3
   - Play
   - Edit
   - Save

Hear audeme

Export audeme to local storage

Modify the audeme

Sounds composing the audeme:

1. Sound 1
   - Play
   - Remove
   - Order 1

2. Sound 2
   - Play
   - Remove
   - Order 2

3. Sound 3
   - Play
   - Remove
   - Order 3

Update Order

Hear sound

Remove the sound from the audeme

Order of the sound in the audeme

Update sound ordering

Save Changes

Technical Architecture

Teacher inputs keywords from the end-of-the chapter vocabulary

Match the keywords with sound meta names

Database of sounds

Based on the sounds extracted from the database, the program applies the guidelines for effective audeme creation and generates few audemes

Display audemes to the user
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

Aim 1
- Introduce New Type of Non-speech Sounds - Audemes
- Define Audemes Using Two Theoretical Frameworks: Semiotics and Modes of Listening
- Empirically Investigate Mnemonic Power of Audemes with Blind Participants at ISBVI

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- Demonstrate the Potential of Audemes
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Aim 3
- Identify Audeme Design Guidelines
- Empirically Investigate Audeme Design Guidelines
- Develop Advanced Support and Creation-Oriented Library Tool for Audemes (ASCOLTA)
- Gathering feedback about usability of ASCOLTA from domain experts

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

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

3. **What characteristics of audemes help BVI users recognize audeme meaning?**
   - **ANSWER:** 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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**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.**

**Ferati, M., Mannheimer, S., Bolchini, D., Acoustic Interaction Design through "Audemes": Experiences with the Blind in Proc. of the 27th ACM International Conference on Design of Communication (SIGDOC), 23-28, Bloomington, IN, 2009.**

