## **Exploring Sound Awareness in the Home** for People who are Deaf or Hard of Hearing

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# The home environment is filled with a rich diversity of sounds



These sounds inform us about the **home** and the **occupants** within it.

However, in many situations, sound is **inaccessible** to **people who are deaf or hard of hearing (DHH).** 

### Fortunately, DHH people use **visual** or **vibratory** alternatives...





### Flashing Doorbell

### VIBRATORY BED ALARM

### Fortunately, DHH people use **visual** or **vibratory** alternatives...

While useful for their applications, these products **do not** offer a **general awareness** about sounds in the home.

Flashing Doorbell

VIBRATORY BED ALARM

### 11:29 \* 79°

29 9° TRENDING TOPICS Video: 200-mile-wide cosmic rock hints to mysterious 'Planet

Try "Alexa, play the Cosmic Rock video"

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Recent proliferation of screen-based smarthome devices and advances in machine learning for sound offer a new opportunity to design for DHH people...

## QUESTIONS

What information about sound do DHH people want in the homes?
How do they want this information to be conveyed?
How would a sound awareness system integrate into the homes of DHH people?
What concerns may arise when using such a system in the home? (e.g., privacy)

## AIMS

To investigate the **sound awareness needs and preferences of DHH people** in the home

To explore the design of in-home sound awareness system for the DHH people.









(Bragg et al., ASSETS 2016)



## Our Paper

- Study 1: A semi-structured interview with 12DHH participants to explore experiences with sounds in the home.
- 2. Study 2: A Wizard of Oz study with 10 DHH participants to explore our three sound awareness prototypes.

## OUR PAPER

- Study 1: A semi-structured interview with 12DHH participants to explore experiences with sounds in the home.
- 2. Study 2: A Wizard of Oz study with 10 DHH participants to explore our three sound awareness prototypes.



### OUTLINE

### A brief overview of Study 1 ---> Study 2 (Formative interview)

Design of sound  $\longrightarrow$  Wizard-of-Oz  $\longrightarrow$  Findings awareness prototypes

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## QUESTIONS

## What information about sound do DHH people want in the homes?

## How do they want this information to be **conveyed**?

ry "Alexa, play the Cosmic Rock video



### Goal

 To assess the needs and preferences of DHH individuals with respect to a sound awareness system in the home

### **Participants** o 12 DHH individuals

### **Study Method**

- o Semi-structured formative interview
- o Design probe



### Goal

 To assess the needs of DHH individuals with respect to a sound awareness system in the home

## • 12 DHH individuals

### Study Method

Semi-structured formative interviewDesign probe

All participants emphasized the **need for a sound awareness system** in the home.

"I have [a] flashing doorbell... But, one day I was sleeping and somebody came at night [and] rang the doorbell, and I couldn't see the light. So, I had to get a bed shaker [for the doorbell...] How many devices should [I] keep?"

- P11



### Goal

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## • 12 DHH individuals

### **Study Method**

- Semi-structured formative interview
- o Design probe

## Design Space for In-Home Sound Awareness

### FORM FACTOR







TABLET

Smart Watch





Smart Home

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#### Ambient

### **OUTPUT MODALITY**



#### **DISPLAY ELEMENTS**

- 1. Sound type,
- 2. Sound location
- 3. Temporal history
- 4. Length of occurrence
- 5. Physical characteristics of sound
- 6. Importance of sound





### Sound type specificity



## Design Space for In-Home Sound Awareness

### FORM FACTOR







Smart Watch







Ambient

#### **DISPLAY ELEMENTS**

- 1. Sound type,
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#### Sound location specificity



## A brief overview of Study 1 $\longrightarrow$ Study 2 Design of sound awareness prototypes $\longrightarrow$ Wizard-of-Oz evaluation $\longrightarrow$ Findings



### Goal

• To gain further insight into in-home sound awareness, particularly to investigate themes that are central to the home (*e.g.*, privacy, issues with activity tracking)

### **Participants**

- o 10 DHH individuals
- o Recruited through email and snowball sampling

### **Study Method**

- o Built three sound-awareness prototypes
- Evaluated the prototypes using a scenario-based
   Wizard-of-Oz study

## A brief overview of Study 1 $\longrightarrow$ Study 2 Design of sound awareness prototypes $\longrightarrow$ Wizard-of-Oz evaluation $\longrightarrow$ Findings

## THREE INITIAL PROTOTYPES





### WIZARD'S INTERFACE



## THREE INITIAL PROTOTYPES



## THREE INITIAL PROTOTYPES



## QUESTIONS

What information about sound do DHH people want in the homes?How do they want this information to be conveyed?How would a sound awareness system integrate into the homes of DHH people?What concerns may arise when using such a system in the home? (e.g., privacy)

## QUESTIONS



How would a sound awareness system integrate into the homes of DHH people?

What **concerns** may arise when using such a system in the home? (e.g., privacy)
#### A brief overview of Study 1 → Study 2 Design of sound awareness prototypes → Wizard-of-Oz evaluation → Findings

#### WIZARD OF OZ EVALUATION

(conducted in a studio on campus that looked like a home)



#### WIZARD OF OZ EVALUATION

#### 1. Introduced prototypes

Using short demos of some example sounds (e.g., coffee pouring, door knock)

#### 2. Scenarios-based evaluation

Three scenarios to explore themes central to the home.

Each scenario was in-acted by an actor who made sounds. The wizard then listened to those sounds and clicked on the interface to transmit the sound information to the participant's screen.





#### QUESTIONS



How would a sound awareness system integrate into the homes of DHH people?

What **concerns** may arise when using such a system in the home? (e.g., privacy)

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#### WIZARD OF OZ EVALUATION

#### 1. Introduced prototypes

Using short demos of some example sounds (e.g., microwave beep, door knock)

#### 2. Scenarios-based evaluation

Three scenarios to explore themes central to the home.



#### 3. Interview on the experience

#### A brief overview of Study 1 $\longrightarrow$ Study 2 Design of sound awareness prototypes $\longrightarrow$ Wizard-of-Oz evaluation $\longrightarrow$ Findings

Study 2: Findings

## **PROTOTYPE PREFERENCE**



Most preferred

Least preferred

#### Study 2: Findings

#### **PROTOTYPE PREFERENCE**

Time	Sound	Location
10:07:45	Microwave beep	Kitchen
10:08:01	Bird chirp	Outside
10:08:32	Clap	Dining

#### **PROTOTYPE PREFERENCE**



Integrate waveform in the list prototype as a column

- 1 Privacy
- 2 Contextualized Feedback
- **3** Trust and Confidence

Study 2: Findings

#### THEMES CENTRAL TO HOME USAGE

1 Actionability

2 Privacy

3 Information Overload
4 Contextualized Feedback
5 Trust and Confidence

# Actionability

All participants emphasized that a sound awareness system could help them perform the desired task, and gave suggestions for increasing actionability.

For example, the following quote shows a participant emphasizing how showing the tone of important sounds (such as her daughter's voice) could help her discern the situation:

Study 2: Findings



"If my 9-year old daughter is sitting down in her room and talking normally, I am not concerned. If she's sobbing because she's in pain, then I need to know that."

#### Intimate sounds

# 1 Privacy -

Activity tracking

#### - Intimate sounds

System could show intimate sounds (e.g., toilet flushing)

Activity tracking

Privacy

1

STUDY 2: FINDINGS

"I don't want to know if someone is using toilet or whatever they are doing in the bathroom... It's their privacy, you know?"

- R8

#### - Intimate sounds

# 1 Privacy -

- Activity tracking

#### - Intimate sounds

# 1 Privacy –

#### Activity tracking

System may provide insight into other household members' activities

Study 2: Findings

"People [would] avoid coming to my house because they're been monitored each and every moment..." - R10



# 1 Privacy

# 2 Contextualized Feedback

System should customize what is shown based on participant's activities or daily rhythm.

STUDY 2: FINDINGS

"Restrict to important sounds only when there's a large guest party, [because] I don't want to be distracted at that time" - R4

"For night time you might want to [show] crying if the kids are in the other room. You wouldn't worry about siren outside or street noise or the air conditioning running. Those are daytime things."

- R5

# Privacy Contextualized Feedback Truct and Confidence

# **3** Trust and Confidence

# 2 Contextualized Feedback3 Trust and Confidence

1 Privacy

Because sound classification algorithms are probabilistic, we also asked participants about **possible ways to handle uncertainty in sound detection**.

# 1 Privacy

# 2 Contextualized Feedback

# **3** Trust and Confidence

All participants said they would use the system even if it just shows the sound's location but not its identity (e.g., bathroom but not toilet flush).

Most participants also felt that other uncertain information can be useful as well such as a **general category** (e.g., "an alarm-like sound", R8) or a **list of possible sounds** (e.g., "this sound could be a clock alarm or a microwave beep", R4).

- 1 Privacy
- 2 Contextualized Feedback
- **3** Trust and Confidence

- 1 Privacy
- 2 Contextualized Feedback
- 3 Trust and Confidence
- 4 Actionability
- 5 Trust and Confidence
- 6 System Installation

# THEMES CENTRAL TO HOME USAGE

# 1 Privacy

- Contextualized Feedback
   These considerations give direct guidance for design for future in-home systems for the DHH people.
- 4 Actionability
- 5 Trust and Confidence
- 6 System Installation

# Reflections

#### 11:29 • 79°

#### 9° TRENDING TOPICS Video: 200-mile-wide cosmic rock hints to mysterious 'Planet

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#### 11:29 • 79°

#### TRENDING TOPICS

510

# Video: 200-mile-wide **cosmic rock** hints to mysterious 'Planet

Try "Alexa, play the Cosmic Rock video"

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We hope that you **use this opportunity** to increase access for DHH people.

# CONSIDERATIONS

Home is a shared space. Be mindful of what sound information is being listened to, and where the displays are installed.

2 System should interweave into the domestic lives of people. Use context cues such as daily rhythm (*e.g.*, night vs. day), user's location and activity (*e.g.*, not doing high-focused tasks) to select what to record and display.

3 Handle uncertainty of sound recognition by displaying additional cues such as location, possible list of sounds, or a general category (e.g. alarm-like sound).

# **Exploring Sound Awareness in the Home** for People who are Deaf or Hard of Hearing

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