Deaf and Hard-of-hearing Individuals’ Preferences for Wearable and Mobile Sound Awareness Technologies

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BACKGROUND
“Some trouble hearing”

15% of US adults

“Disabling hearing loss”

2% of adults aged 45 to 54

50% of those 75 and older

[National Institute on Deafness and Other Communication Disorders, 2016]
Sound awareness has wide-ranging impacts...

- Safety-critical sounds
- Mundane yet useful sounds
- Social interactions with hearing people

[Matthews et al., Behaviour and Information Technology, 2006]
**Hearing aids**

- Can improve sound and speech recognition
- Do not eliminate hearing loss
- Success varies
  (e.g., based on hearing loss level, linguistic abilities, training)

**Cochlear implants**

[Dillon, 2008; NIDCD, 2014]
Our goal

Always-available, private, and unobtrusive sound sensing and feedback that augments the user’s existing sound awareness strategies.
But how do we get there?

What interest do deaf and hard of hearing users have in sound awareness?

What information do they want and how would they want it conveyed?
Early work on sound awareness needs

Sounds occurred around the room and were visualized on this display.
Also investigated which sounds are desired by DHH individuals.

[Ho-Ching et al., CHI ’03; Matthews et al., BIT ’04; Matthews et al., ASSETS ’05]
More recent trend: mobile and wearable approaches

Wrist-worn “Sound Compass”
  e.g., Kaneko et al, IEEE SMC ‘13

Smartphone-based detection
  e.g., Bragg et al, ASSETS 2016

Localization on a head-mounted display
  e.g., Jain et al, CHI 2015

These studies tend to be qualitative and have not examined social acceptability.
EXPLORATORY STUDY WITH 201 DHH PEOPLE
RESEARCH QUESTIONS

Who is interested in sound awareness?

What are form factor and feedback preferences?

What are predicted social implications?

CONTRIBUTIONS

Examine the influence of demographic factors

Compare mobile and wearable devices, output modalities, and speech vs. non-speech sounds

Assess utility and comfort across social contexts
METHOD
Online survey

Hosted on surveymonkey.com, and took up to 20mins.
Online survey

Hosted on surveymonkey.com, and took ~20 mins.

Closed- and open-ended questions

Demographics

Sound awareness interest

Imagining device designs: wearable and mobile

Oral conversation support

Visual and vibrational feedback

Filtering and notification

Social context
“Imagine that each device has the ability to constantly monitor and identify the sounds around you, and to inform you about those sounds, either through visual or vibrational feedback.”
Online survey

Closed- and open-ended questions

Main analysis includes 201 DHH participants

Someone who communicates primarily in sign language with their family might be less interested in sounds than an older adult who has age-related hearing loss and has relied on spoken communication their entire life.

Communication preference
- 49% oral (spoken)
- 30% sign language
- 21% both oral and sign

Deaf and hard of hearing

Discussed more in findings
Online survey
Closed- and open-ended questions
Main analysis includes 201 DHH participants

Qualitative and quantitative analysis

- Iterative coding process
- Descriptive statistics
- Non-parametric tests
- Holm-Bonferroni corrections
High interest in sound awareness

73% \(^{(N=147)}\) “very” or “extremely” interested in sound awareness

<table>
<thead>
<tr>
<th>Communication Preference</th>
<th>Age</th>
<th>Gender</th>
<th>Hearing Level</th>
<th>Prelingual</th>
</tr>
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\(^{(N=201, \text{except for gender } N=200)}\)
High interest in sound awareness

73% \((N=147)\) “very” or “extremely” interested in sound awareness

\((N=201, \text{except for gender } N=200)\)
High interest in sound awareness

73% (N=147) “very” or “extremely” interested in sound awareness

**No clear pattern**

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(N=201, except for gender N=200)
Most important demographic factor for interest: communication preference

<table>
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<tr>
<th>Logistic regression</th>
<th>Communication preference significantly predicts sound interest level ($p &lt; .001$)</th>
</tr>
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<tbody>
<tr>
<td>Communication preference</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>No other factors significant after controlling for communication preference</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Hearing level</td>
<td></td>
</tr>
<tr>
<td>Prelingual hearing loss</td>
<td>Age and communication preference are highly related</td>
</tr>
</tbody>
</table>

We focus on communication preference in our subsequent analysis.
Sound types of interest reflect past work

However, we provide statistically significant conclusions...

3x8 (communication preference x sound type) ANOVA with ART: main and interaction effects all significant (p < .05)
Sound characteristics of interest reflect past work

3x5 (communication preference x sound characteristics) ANOVA with ART: main and interaction effects all significant (p < .05)
Form factor tradeoffs

Smartphone

Smartwatch

Head-mounted display
Form factor tradeoffs

Overall preference

Social acceptability

Usefulness

(N=201)
Form factor tradeoffs

Overall preference

Social acceptability

Usefulness

Glanceability

Preferred for captions

(N=201)
Envisioning an ideal setup

92% of 201 wanted haptic and visual feedback

Most common ideal setup involved two devices

**Haptic**

- Smartwatch (66% of 201)

**Visual**

- HMD (41% of 201)
- Smartphone (39% of 201)
Utility across social contexts

Most participants “strongly” agreed would be useful across all contexts
Socially acceptability across different contexts

Most “somewhat” or “strongly” agreed would be acceptable across all contexts

Context significantly impacted social acceptability (main effect ANOVA with ART)

…social acceptability lower with strangers

(N=201)
Would social context impact willingness to use?

50% said YES

“Most definitely. I would feel the need to explain why I have the device when I’m around someone I don’t know”
(P58, male, age 46, sign and oral communication)

31% said NO

“Might not need as much with friends and family. May need more in work meetings, and most in unfamiliar situations, such as running errands, traveling.”
P164 (male, 45, oral communication)

Others unsure

“Being a member of Deaf Culture, I would’ve thought that it’d be considered rude if I am to place sounds above visual cues available to everyone. With Hearing people, I think they’d insist on sounds being available to me.”
(P95, female, age 29, prefers sign language)
CONCLUSION
Takeaways

High interest in sound awareness, modulated by communication preference

Support both visual and haptic feedback, possibly even on two devices: smartwatch + HMD or smartphone

Social context affects perceived usefulness and comfort with using a sound awareness device
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