

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

Sound awareness has wide-ranging impacts...



Safety-critical sounds



Mundane yet useful sounds



Social interactions with hearing people

Hearing aids



Cochlear implants



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

Our goal

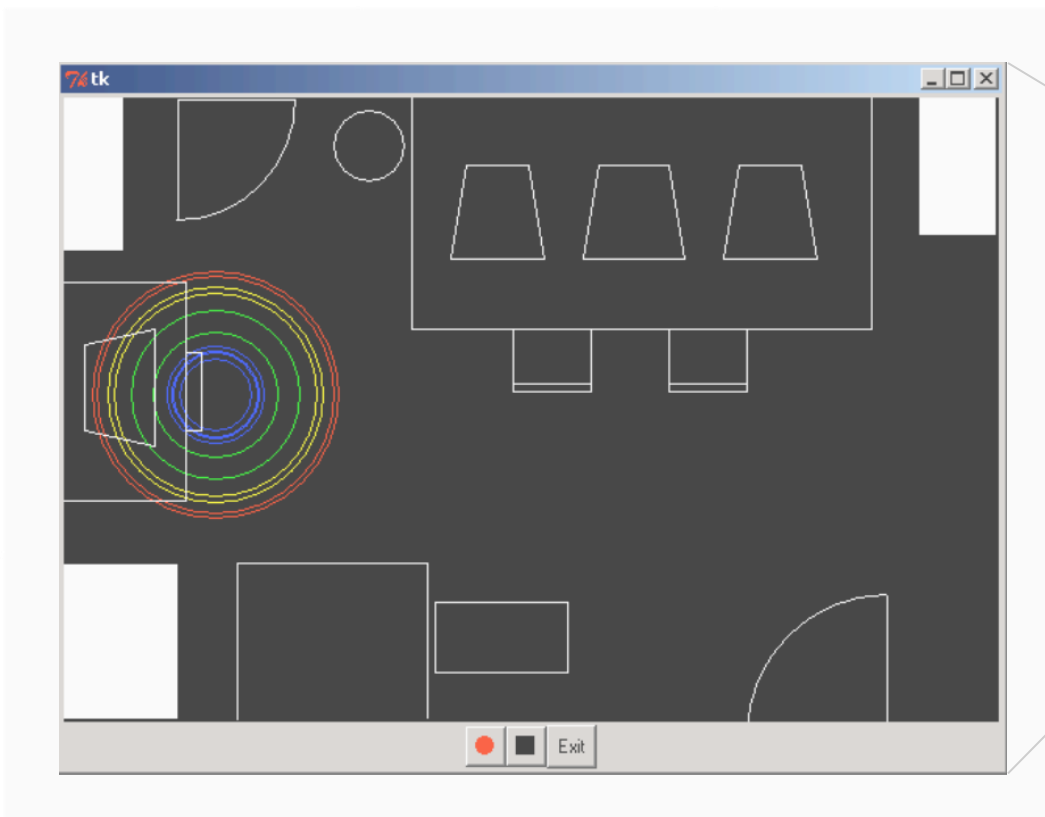
Always-available, private, and unobtrusive **sound sensing and feedback** that augments the user's existing sound awareness strategies

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?

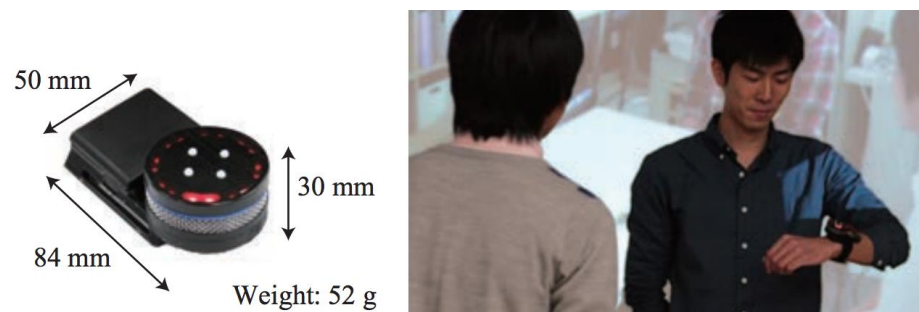
Early work on sound awareness needs



Sounds occurred around the room and were visualized on this display.

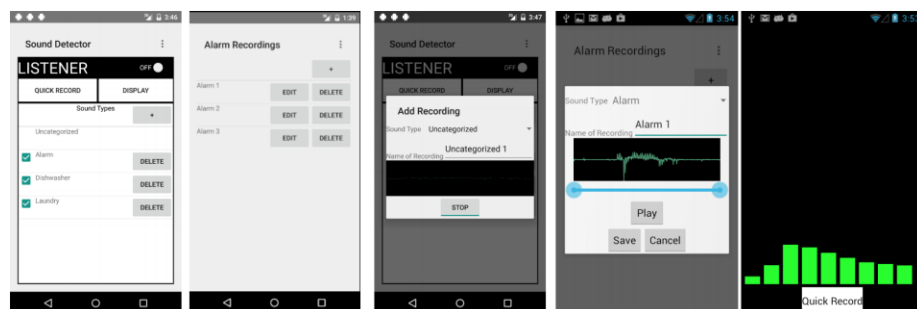
Also investigated which sounds are desired by DHH individuals.

More recent trend: mobile and wearable approaches



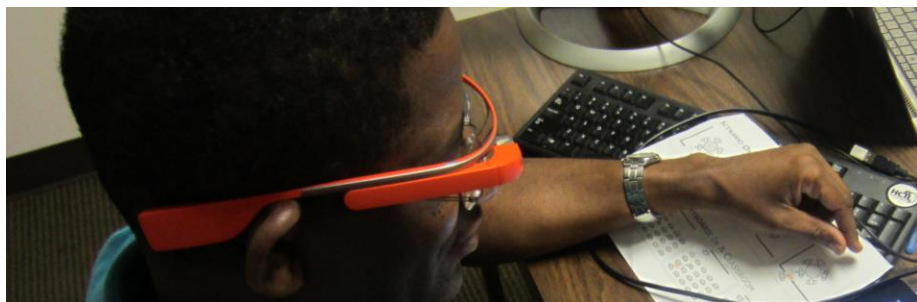
Wrist-worn "Sound Compass"

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](https://www.surveymonkey.com), and took up to 20mins.



Online survey

Hosted on [surveymonkey.com](https://www.surveymonkey.com), and took ~20 mins.

Closed- and open-ended questions

Demographics

Sound awareness interest

Imagining device designs: wearable and mobile

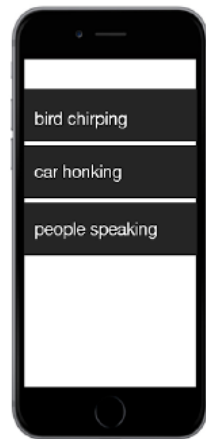
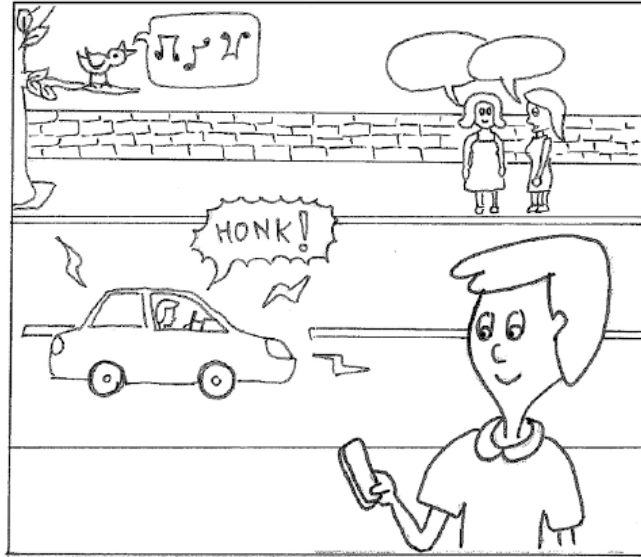
Oral conversation support

Visual and vibrational feedback

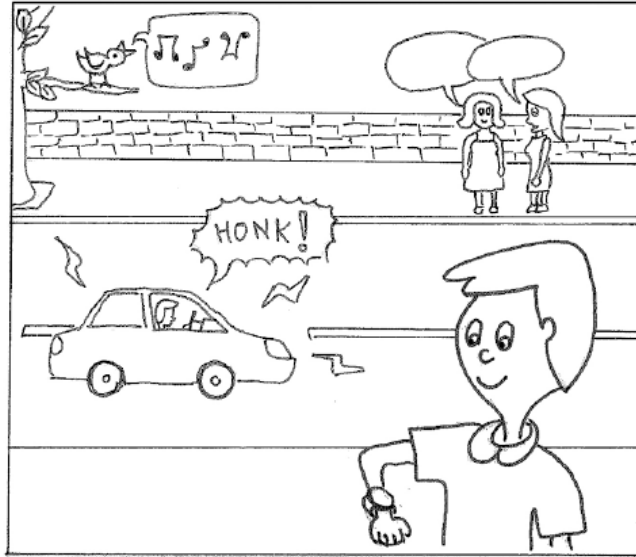
Filtering and notification

Social context

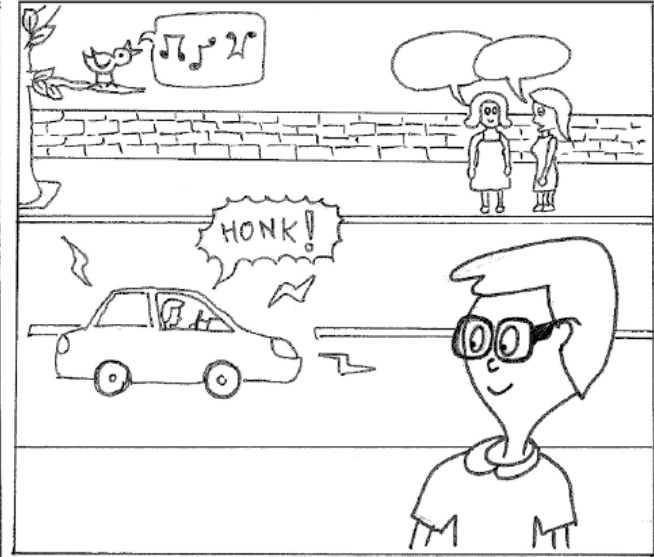
Smartphone

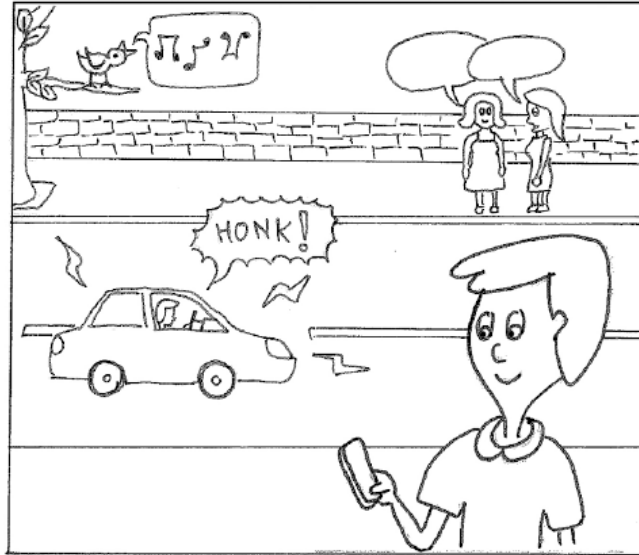
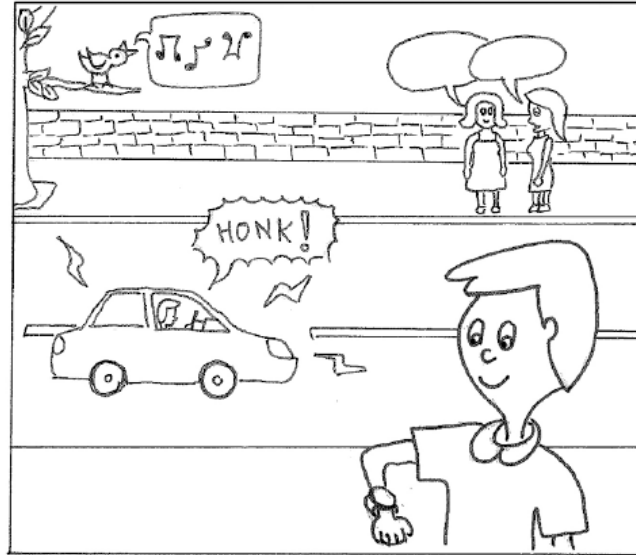
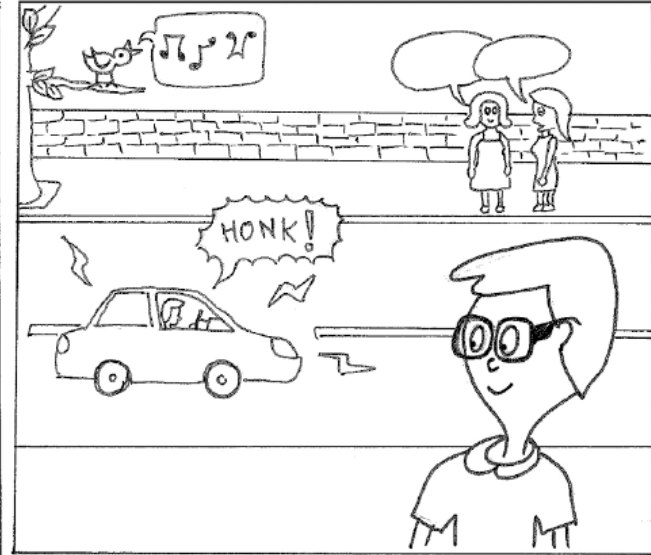


Smartwatch



Head-mounted display



Smartphone**Smartwatch****Head-mounted display**

“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

Deaf and hard of hearing

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

Discussed more in findings

Online survey

Closed- and open-ended questions

Main analysis includes 201 DHH participants

Qualitative and quantitative analysis

The diagram features a horizontal line with two brackets extending downwards from it. The left bracket is positioned under the word 'Qualitative' and points to a box containing 'Iterative coding process'. The right bracket is positioned under the word 'quantitative' and points to a box containing 'Descriptive statistics', 'Non-parametric tests', and 'Holm-Bonferroni corrections'.

Iterative coding process

Descriptive statistics
Non-parametric tests
Holm-Bonferroni corrections

FINDINGS

High interest in sound awareness

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

Communication
Preference

Age

Gender

Hearing
Level

Prelingual

(N=201, except for gender N=200)

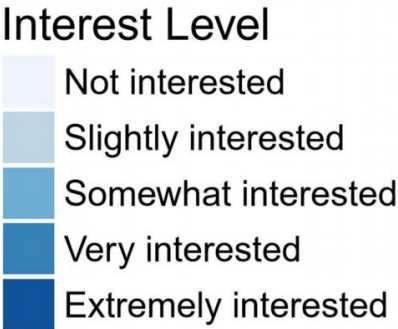
High interest in sound awareness

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

**Communication
Preference**

High interest in sound awareness

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



No clear pattern

Communication
Preference

Age

Gender

Hearing
Level

Prelingual

(N=201, except for gender N=200)

Most important demographic factor for interest: communication preference

Logistic regression

Communication preference

Age

Gender

Hearing level

Prelingual hearing loss

Communication preference significantly predicts sound interest level ($p < .001$)

No other factors significant after controlling for communication preference

Age and communication preference are highly related

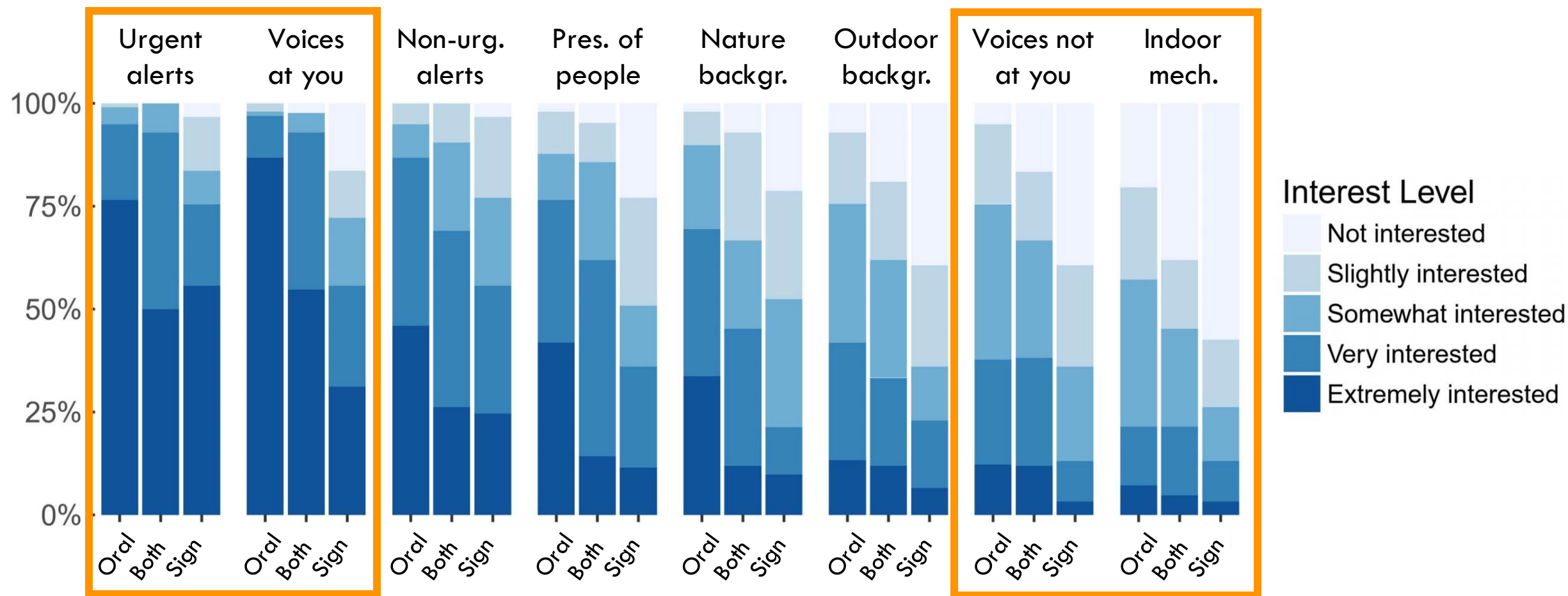
We focus on communication preference in our subsequent analysis.

Sound types of interest reflect past work

[Matthews et al., 2006]

[Bragg et al., 2014]

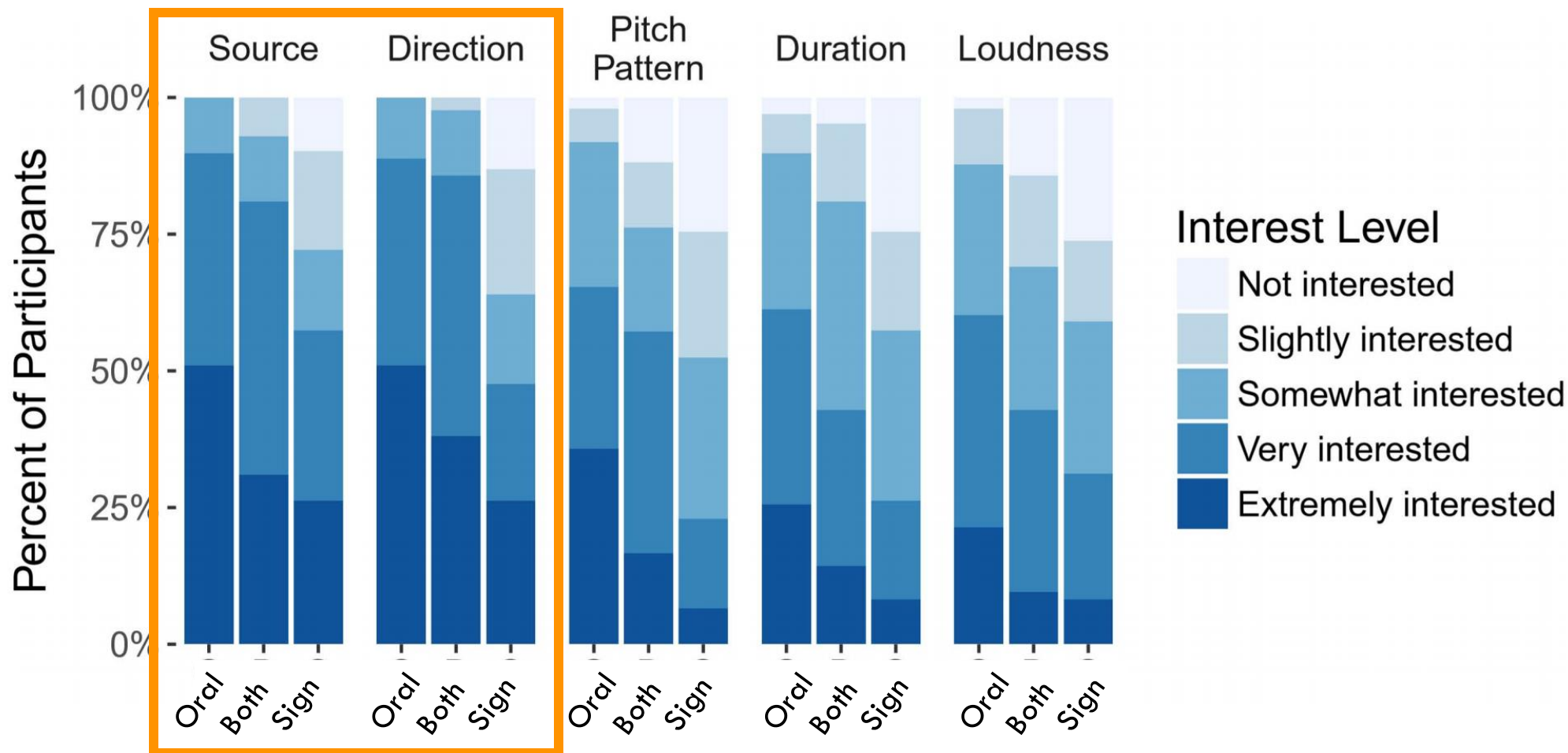
However, we provide statistically significant conclusions...



3x8 (communication preference x sound type) ANOVA with ART:
main and interaction effects all significant ($p < .05$)

(N=201)

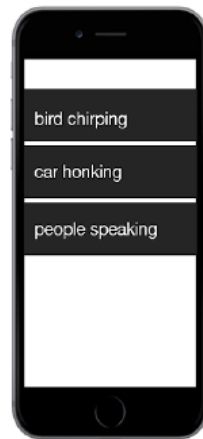
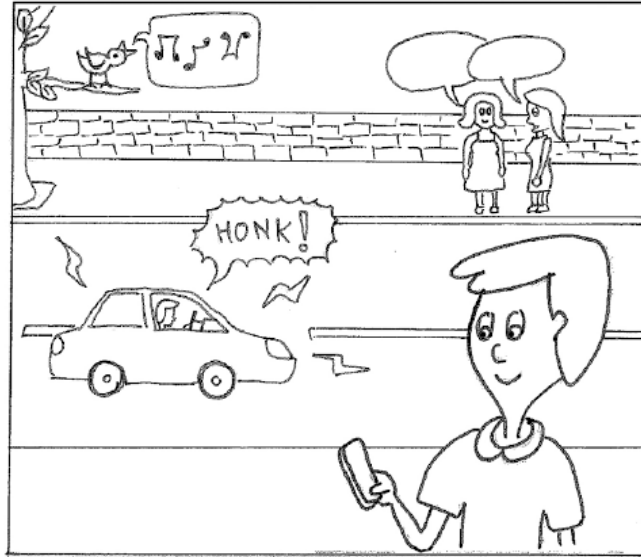
Sound characteristics of interest reflect past work



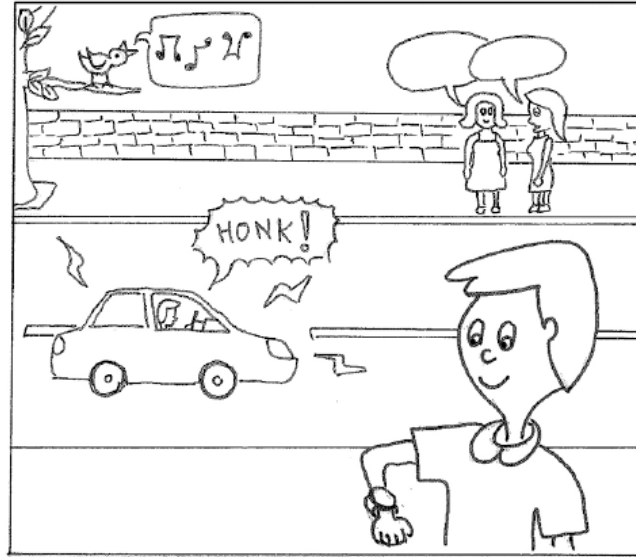
3x5 (communication preference x sound characteristics) ANOVA with ART:
main and interaction effects all significant ($p < .05$)

Form factor tradeoffs

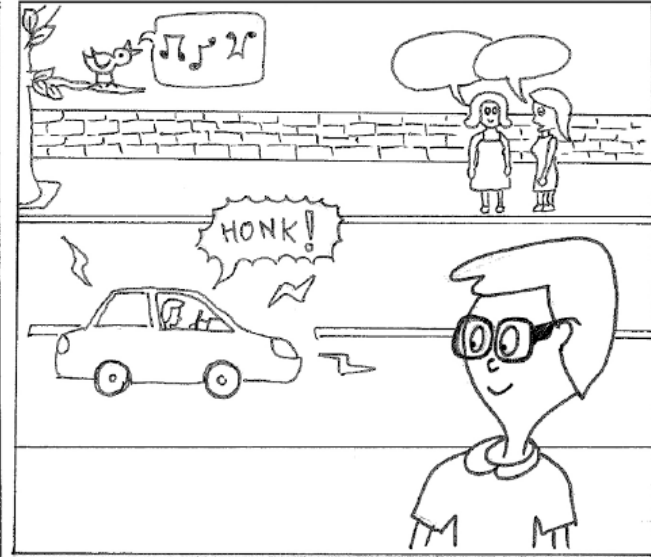
Smartphone



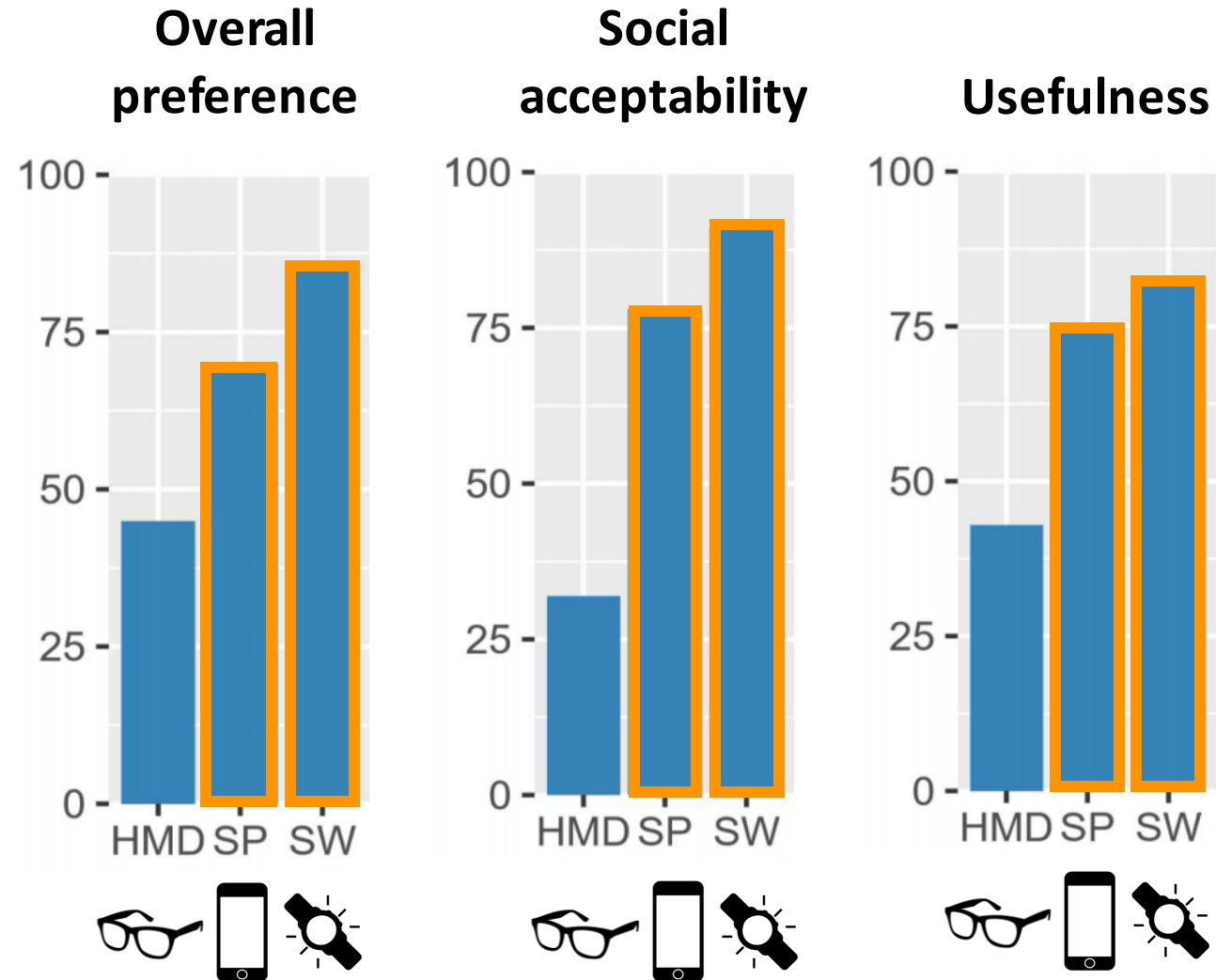
Smartwatch



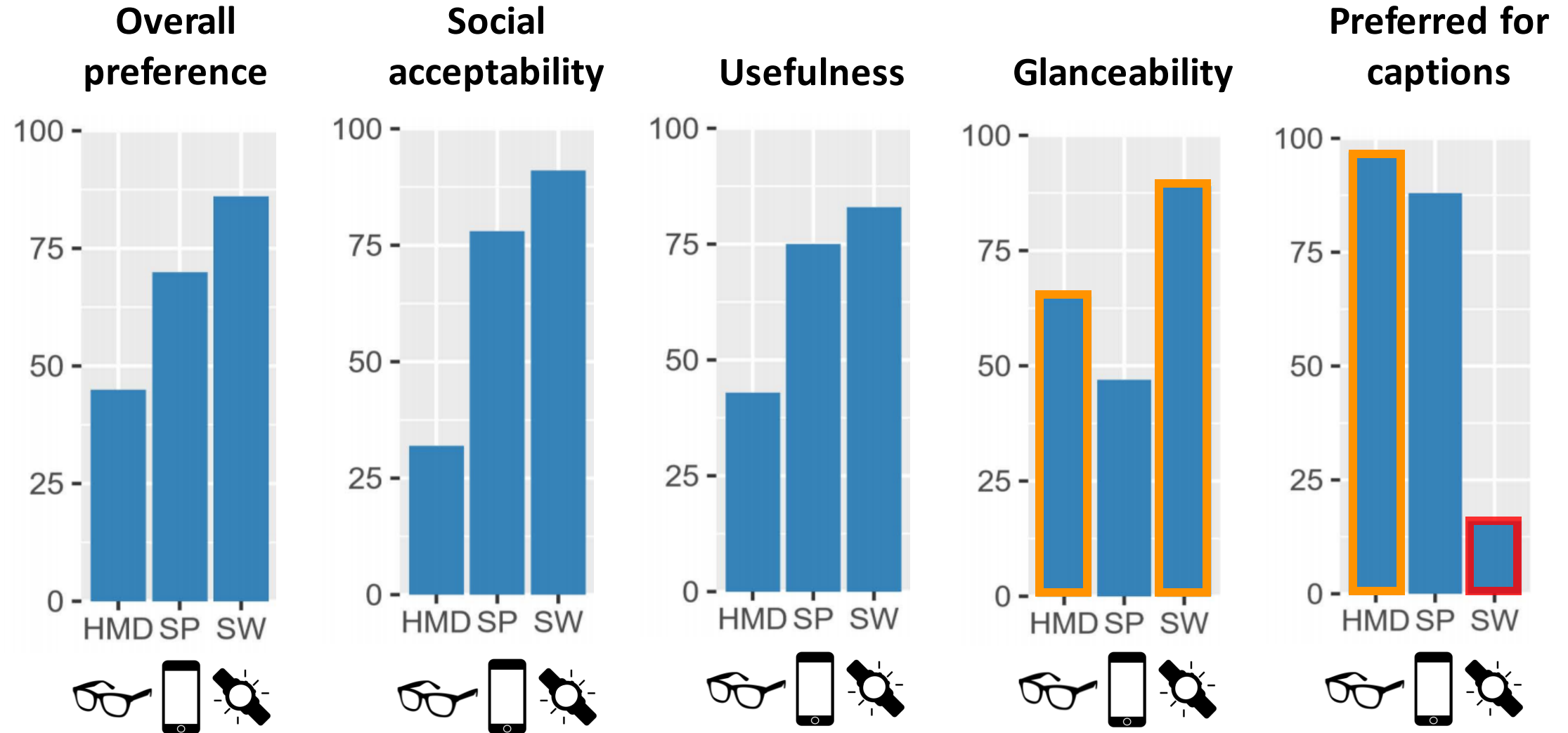
Head-mounted display



Form factor tradeoffs



Form factor tradeoffs



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)

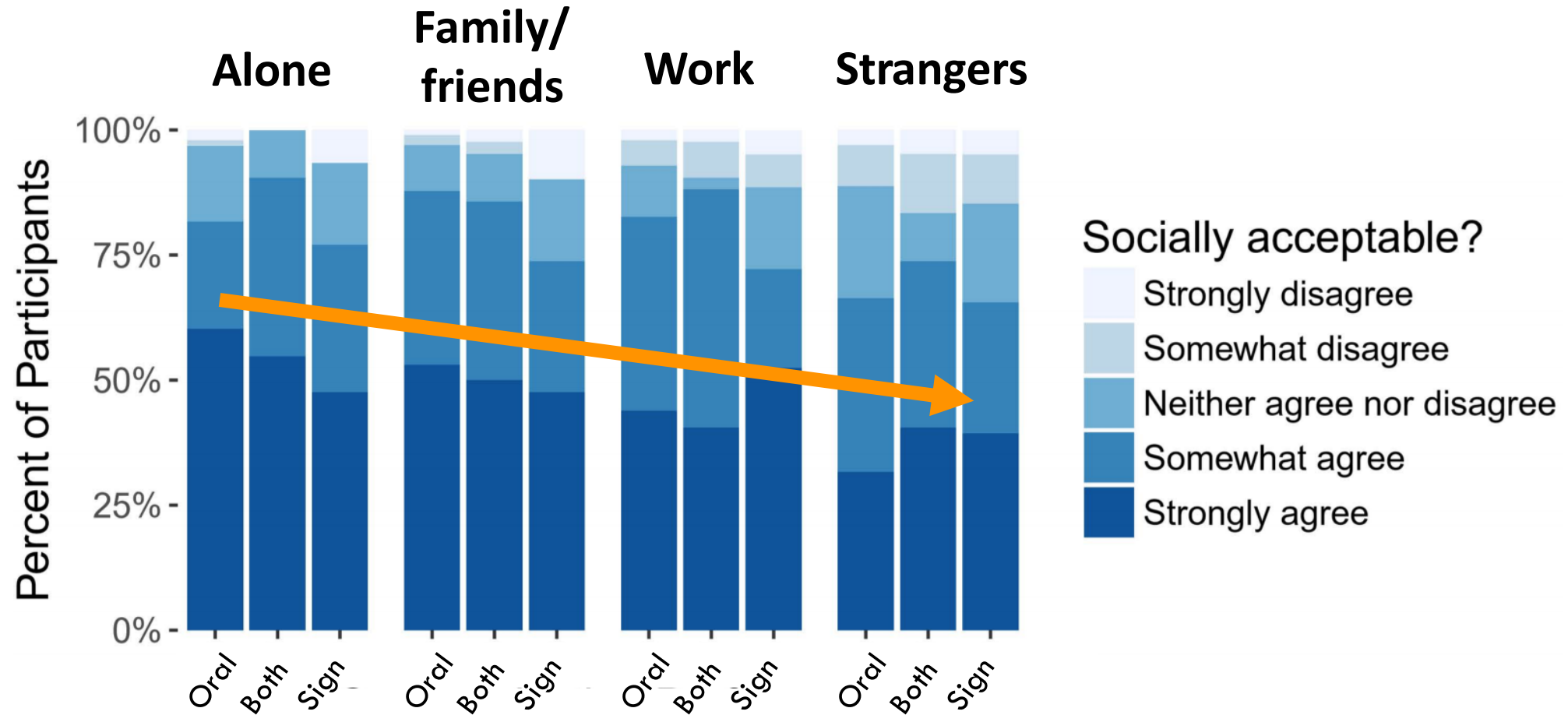


Smartphone
(39% of 201)

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

Would social context impact willingness to use?

50% said YES

31% said NO

Others unsure

“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)

“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)

“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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