USER-LED ACCESSIBLE TECHNOLOGY RESEARCH FOR THE DEAF AND HARD OF HEARING IN HUMAN-COMPUTER INTERACTION

YUHKI SHIRAISHI, TSUKUBAI UNIVERSITY OF TECHNOLOGY, JAPAN

HTTPS://WWW.SHIRAISHI-LAB.ORG/

ACHI 2021, The Fourteenth International Conference on Advances in Computer- Human Interactions

PRESENTER

- Yuhki Shiraishi is an Associate Professor at Tsukuba University of Technology, Japan. His research interests include accessible technology, applied machine learning and Web information system. Currently, he is a committee member of SIG Assistive and Accessible of the Information Processing Society of Japan, and of Data Engineering of the Institute of Electronics, Information, and Communication Engineering. Also, he is a member of the IEEE, the Japanese Society of Artificial Intelligence, the Society of Instrument and Control Engineers and Japanese Association for Sign Language Studies. He received his PhD degree in information science from Kyushu University in 2007.

email: yuhkis(at)a.tsukuba-tech.ac.jp

TSUKUBA UNIVERSITY OF TECHNOLOGY

- Tsukuba University of Technology is the only national university corporation in Japan that provides services for people with hearing or visual disabilities.
- The presenter is teaching a class using sign language to deaf and hard-of-hearing (DHH) students.
- In my research activities, I am working on accessible technology with DHH students.

DHH PEOPLE IN THE WORLD

- Over 5% of the world's population (430 million people) require rehabilitation to address their 'disabling' hearing loss(*1) [1]

- DHH people consists of
  - 'hard of hearing': people who have hearing loss ranging from mild to severe, usually mild
  - 'deaf': people who have severe hearing loss, recognized as a medical term
  - 'Deaf': people who have a sense of belonging to the Deaf culture, usually using sign language
  - etc.

Diversity

(*1) 'Disabling' hearing loss refers to hearing loss greater than 35 decibels (dB) in the better hearing ear.

[1] Deafness and hearing loss https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss

DIVERSITY IN DHH

- Cochlear implants / hearing aids / None
  - Some people with DHH wear cochlear implants, wear hearing aids, and wear nothing based on Deaf culture.

- Sign Language / Signed Language / Pidgin Signed Language / Lipreading
  - Some people with DHH use sign language (which varies from country to country), signed language, pidgin signed language, and rely on lipreading.

Hard to consider DHH as a single category

CHALLENGES FACED BY DHH

- Communication barriers
  - Difficulty in smooth communication due to the different language used by the DHH people (Sign Language) and the hearing people or DHH's inability to hear the hearing person speaking.
- Unaware of sound information
  - In addition to language, hearing people rely on sound information for their daily lives.
    - alarm sound, notification sound, knock, walking, car, train, etc.

- Need accessibility for ALL information about sounds
- Method to convey information naturally to the hearing

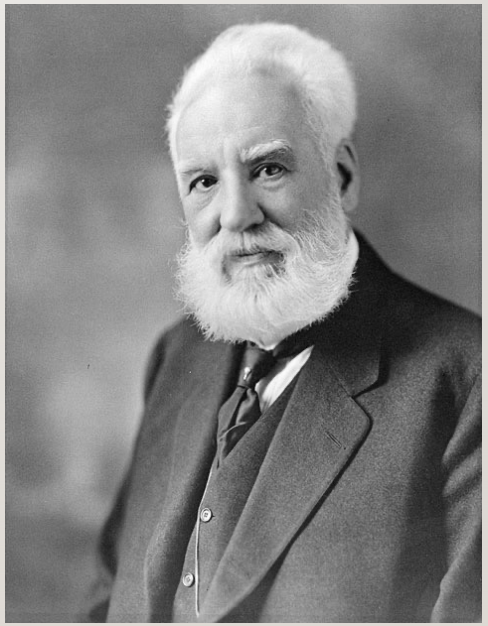
DHH AND HCI

- Use of residual hearing
  - Different DHH people have very other hearing characteristics.
  - Making the sound louder alone may not so helpful; many innovations are opened.
- Use of alternative perception
  - Some DHH people do not use hearing assistive devices; need to use other senses such as sight, touch, etc.
  - Many DHH people rely on visual information and need to be careful about disturbance and fatigue.

Need a light physical and mental load based on various DHH cultures

ALEXANDER GRAHAM BELL

- Inventor of the world's first practical telephone
- It is said that
  - His mother's hearing loss led him to study acoustics, which led to the invention of the telephone.
  - He dislike sign language because he believed that hearing loss people should be overcome the disability using technology.
- This suggests that
  - Research on accessibility technology may advance the world.
  - However, it can also lead to tragedy without the people involved.



USER-LED APPROACH

- A user-led organization is defined in [1] as
  - An organisation that is run and controlled by people who use support services including disabled people, people who use mental health services, people with learning disabilities, older people, and their families and carers."
- It is also reported that in [2]
  - *In developing sign language processing, Deaf community involvement is essential at all levels, in order to design systems that actually match user needs, are usable, and to facilitate adoption of the technology.*
- I believe that user-led research can provide a deeper level of awareness.
  - However, if DHH alone conducts the research, it may lead to biased viewpoints and lack of manpower.

Collaboration between DHH and hearing people is the key

[1] Social Care Institute for Excellence, 2009
[2] D. Bragg, et.al., Sign Language Recognition, Generation, and Translation: An Interdisciplinary Perspective, Proceedings of ASSETS 2019, Pittsburgh, PA, USA, 2019

EXAMPLE OF USER-DRIVEN ACCESSIBILITY RESEARCH

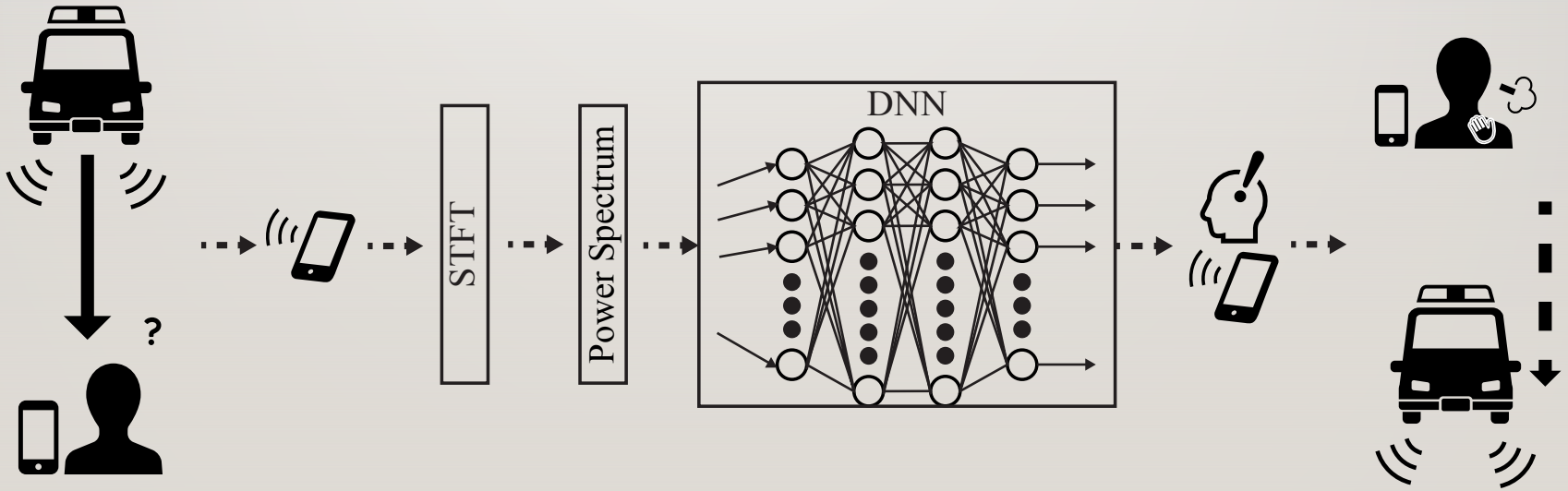
1. Sound Recognition
2. Sign Language Recognition
3. Sports Support
4. Conversational User Interfaces
5. ISeee Project

1. SOUND RECOGNITION

- Many DHH people is unaware of sound information
  - alarm sound, notification sound, knock, walking, car, train, etc.
- Many DHH people are unaware of the existence of various kinds of sound information in the first place because of hearing loss.

- Therefore, collaboration between DHH and hearing people is important.
  - *Hearing:* what kinds of sounds exist?
  - *DHH:* what kinds of sounds information is needed?
  - *DHH:* what notification methods are appropriate?
  - *Both:* developing an optimal solution.

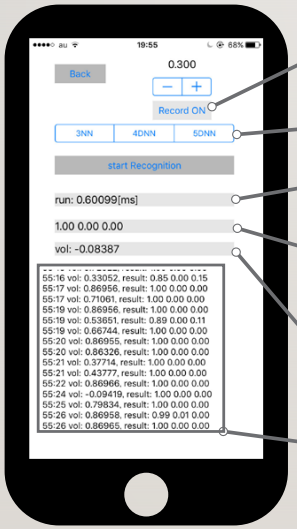
ALARM SOUND CLASSIFICATION SYSTEM IN SMARTPHONES FOR THE DEAF AND HARD-OF-HEARING USING DNN[1]



- Develop an alarm sound classification system in smartphone using deep neural network (DNN)
- As a result, the DHH can go out safely using this system

[1] Y. Shiraishi, et.al., Alarm Sound Classification System in Smartphones for the Deaf and Hard-of-Hearing Using Deep Neural Networks, Proceedings of ACHI 2020, pp.148-151, Valencia, Spain, 2020

DEVELOPMENT SYSTEM



Recording function

Can select 3NN, 4DNN and 5DNN

Recognition Time

Classifition ratio for each class
ex)Ambulance Siren, Horn, Chari bell

Volume

Logs of classifition result

- The classification and transmission application run on a smartphone without connecting the internet.
- The basic flow of the proposed system
  1. Collect environmental sounds with a smartphone
  2. Notify smartphone when an alarm sound is identified
- Deep Learning (DL) is used for classification
  - Keras was used for implementing DL
- The system works in iPhone now

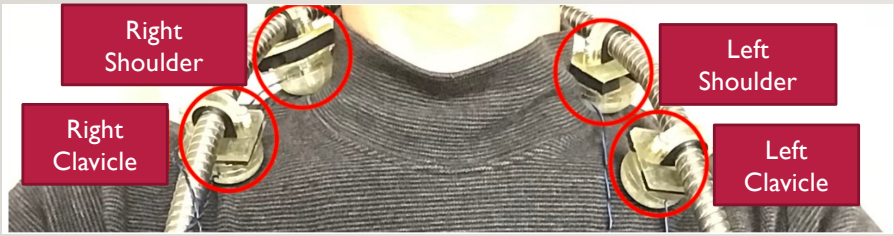
CALCIFICATION ALGORITHM

- The alarm classifying flow
  1. Continuous collection of environmental sounds
  2. If volume data exceeding the threshold is detected, record audio data for a certain period.
  3. Specify the alarm class (horns, bicycle bells, ambulance sirens, etc.) of the recorded audio data.

- Because the nature of the alarm sound tends to be monotonous, we apply the short-time Fourier transform (STFT)

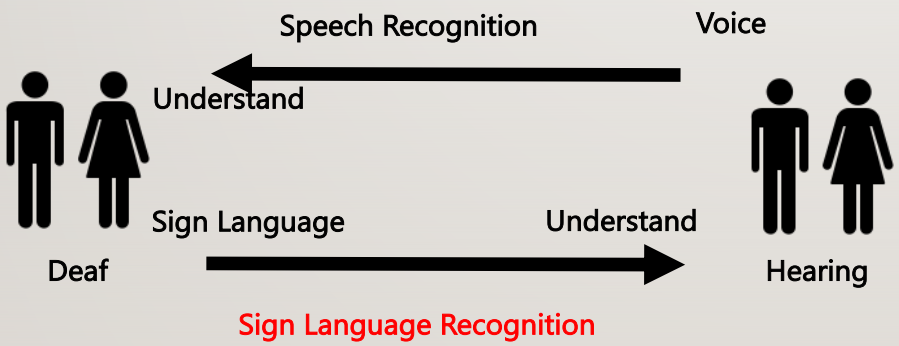
$$STFT(t,\omega) = \int_{-\infty}^{\infty} x(\tau)h(\tau - t)e^{-j\omega\tau}d\tau,$$

DEVELOPMENT OF NEW INTERFACE FOR THE DHH



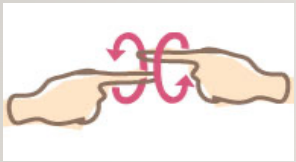
- Tapping the shoulder is a natural transmission method for many DHHs
- Type of vibration transmits the kind of sound
- Transmits the direction of the sound source by using four oscillators

2. SIGN LANGUAGE RECOGNITION



- Voice recognition technology is advancing.
- However, communication is a two-way street.
- Therefore, sign language recognition is strongly required.
- Collaboration between DHH and hearing people is needed to communicate with each other in the first place.

SENSOR GLOVE APPROACH FOR JAPANESE FINGERSPELLING RECOGNITION SYSTEM USING CNNS[1]



Hello!

DHH

Sign Language

Recognition

Computer
(Deep Learning)

Caption or Voice

Hearing

[1] T. Tsuchiya, et.al., Sensor Glove Approach for Japanese Fingerspelling Recognition System Using Convolutional Neural Networks, Proceedings of ACHI 2020, pp.152-157, Valencia, Spain, 2020

WHY SENSOR GLOVE?

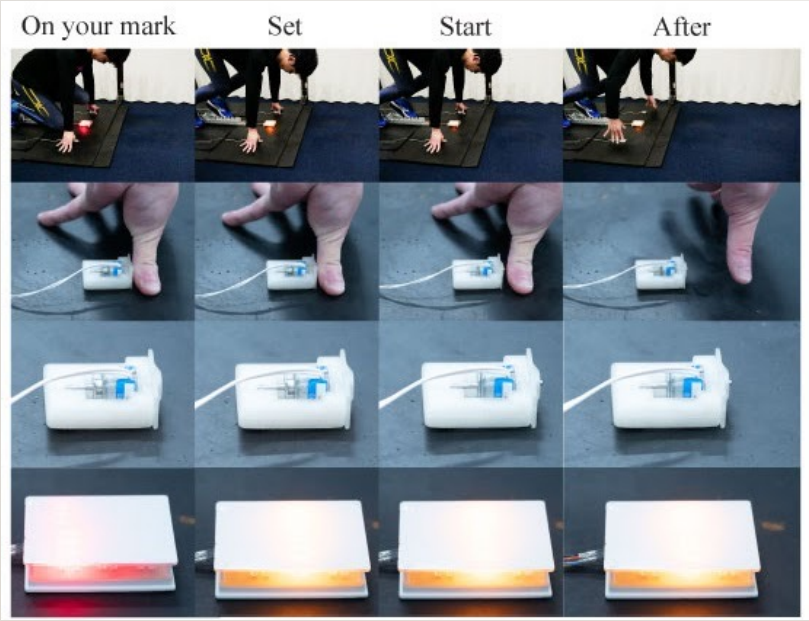
- Advantage in HCI
  1. Location Free
     - Can be used freely anywhere without concern for cameras or other capture devices.
  2. Haptic feedback
     - Can provide feedback such as recognition start and end; Can be used as a controller for AR/VR.
- Disadvantage / Limitation
  1. Need to wear
     - Will become thinner in the future; Possibility of implantable devices.
  2. Cannot get face information
     - Sign language cannot be recognized only by hand information; Face information is necessary using other devices.

3. SPORTS SUPPORT

- Being DHH can be a disadvantage in sports.
- Deaflympic is a quadrennial global sports competition for DHH, and the first international sports competition for the disabled people.

- In order to compete on equal terms with hearing people, a variety of assistive technologies are needed.

HAPTSTARTER:
HAPTIC STIMULUS START SYSTEM FOR DHH SPRINTERS[1]



- DHH sprinters use LED-type visual stimulus generating a light.
- However, the recognition visual stimulus is slower than auditory stimulus (about 30 ms).
- Therefore, “HaptStarter” that start signal interface using haptic stimulus is newly developed as shown in the left figure.

[1] A. Shitara, et.al., Tactile Stimulus Start System Proposal for Deaf and Hard of Hearing Sprinters, Proceedings of The 7th International Conference for Universal Design in Bangkok 2019, pp.185-192, Yokohama, Japan: IAUD, 2019

METHODOLOGY

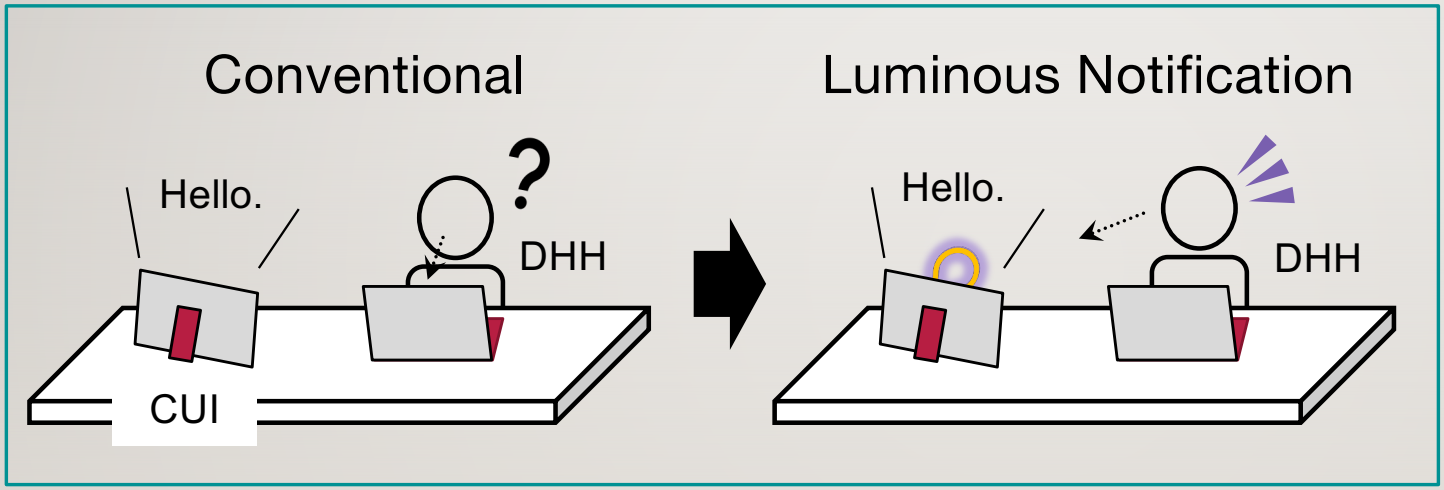
- One researcher is a Deaflympic 400m relay gold medalist and a graduate of my university.
- When I dealt with the topic of considering the use of tactile stimuli in a class on embedded computer systems, he came up with the idea based on his experience.
- He is still working on the practical application and further extension to a disability-independent universal system.

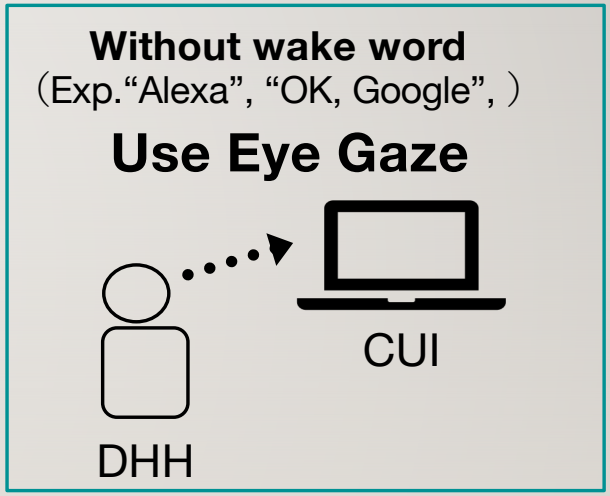
4. CONVERSATIONAL USER INTERFACES

- The recent proliferation of voice-based interaction devices (Amazon Alexa, Google Assistant, etc.) has created new accessibility barriers for many DHH people.
  - Many DHH do not speak.
  - Many DHH do not hear.

- Collaboration between DHH and hearing people is important.
  - *Hearing:* how to communicate with the device using voice?
  - *Hearing:* how is it convenient to use?
  - *DHH:* what communication methods are convenient?
  - *Both:* developing an optimal solution.

SIGN LANGUAGE CONVERSATIONAL USER INTERFACES USING LUMINOUS NOTIFICATION AND EYE GAZE FOR DHH[1]





- Considering how to utilize light and eye contact, which are natural means of information transmission for DHH.

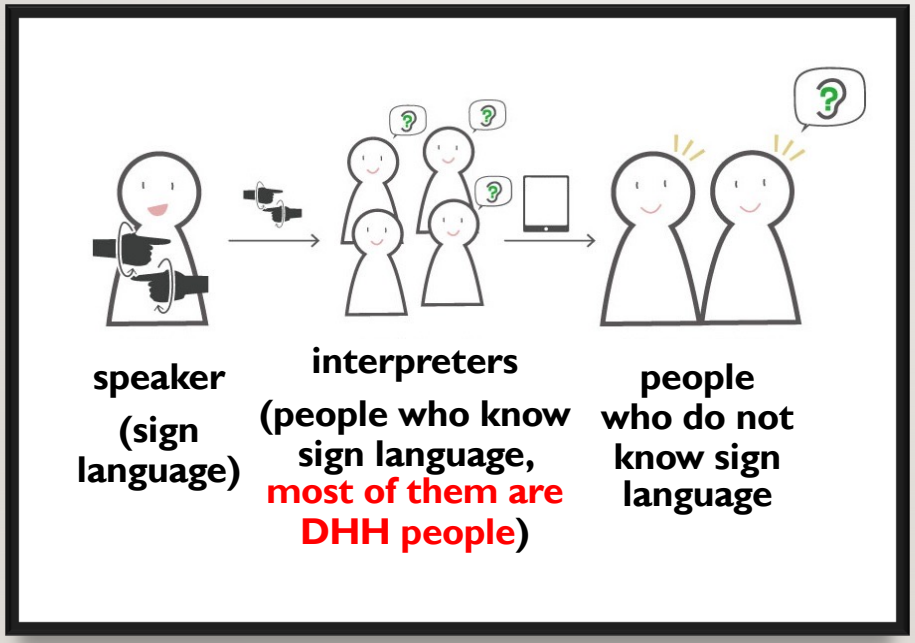
[1] T. Kato, et.al., Sign Language Conversational User Interfaces Using Luminous Notification and Eye Gaze for the Deaf and Hard of Hearing, Proceedings of ACHI 2021, Nice, France, 2021

5. ISEEE PROJECT[1]

- ISeee is an abbreviation of "Information Support of Everyone, by Everyone, for Everyone."
  - Information Support (People with disabilities acquire information using alternative means)
  - of Everyone
  - by Everyone (Everyone provides information support)
  - for Everyone (Everyone receives information support)
- Realize a society where everyone can say "I see."

[1] https://crowd4u.org/en/projects/ISeee

CROWDSOURCED REAL-TIME CAPTIONING OF SIGN LANGUAGE BY THE DHH[1]



- Helping DHH people
  - from receivers of information support
  - to providers of information support
- Implementing a crowdsourced real-time captioning system, that enables groups of DHH people to collaboratively interpret a speech or lecture given by sign language to text.

[1] Y. Shiraishi, et.al., "Crowdsourced Real-Time Captioning of Sign Language by Deaf and Hard-of-Hearing People", International Journal of Pervasive Computing and Communications, Vol. 13, No. 1, pp.2-25, 2017.

ISEEE TIMELINE: INFORMATION SUPPORT FOR THE DHH WHILE WATCHING REAL SPORTS GAME[1]

- ISeee TimeLine (ISeeeTL) is a web application for people who participate in sports events and watch them in real life to exchange and guarantee information on a timeline (TL).
- In addition to text and images, the application allows users to post in a variety of ways, including languages other than English, Japanese, audio, video, etc.
- By doing so, an environment where information on real sports events can be guaranteed to the disabled, the elderly, and foreigners.

- Not only DHH people but people with vison loss
  - from receivers of information support
  - to providers of information support

ISeee Project
Know Each Other. Support Each Other.

R. Hiraga, et.al., First Evaluation of Information Support of everyone by everyone for everyone TimeLine (ISeeeTL) applied to Deaf and Hard of Hearing People Watching Sport, Proc. of AAATE 2019, pp.S135-S136, Bologna, Italy, August 2019.

SUMMARY

- In HCI, accessibility studies for DHH are a must.
- DHH is particularly diverse, and research based on the only assumptions of the hearing people can lead to a trap.
- A user-led approach is important to create something truly useful.

Thank you for your attention!