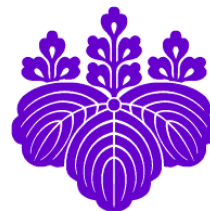


# Music for Deaf and Hard of Hearing Persons: on Beat

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**KTH: Royal Institute of Technology, Sweden**  
**University of California San Diego, USA**

# Deaf and Hard of Hearing Students @ Tsukuba University of Technology

- hearing acuity over 60dBs
- hearing aids / cochlear implants / none
- speech-centered listening training
- varieties of hearing ability



# MIBURI play by a student



# MIBURI play by a student



# Tsukuba University of Technology

## Research Themes by Students

- **Music visualization**
- **Practice system for rhythm —to enjoy Karaoke**
- **Music game for hearing-impaired persons**
- ...
- **Practice system for speech**
- **Speech visualization**
- **Alarm detection system**
- ...
- **Practice system of Environmental Sound with sound visualization**
- **Effect of timber on Rhythm Perception**
- **Vibration system to detect beat**

# Deaf and Hard of Hearing Persons (DHH)

**Love Music!**

Listen to, Karaoke, Dance, Taiko, Game, ...

**Difficulties in Music**

Pitch discrimination, Detect timing, ...

**Music ... is not ... by **hearing acuity****

appreciation

limited

perception

restricted

enjoyment

impeded

# Research Questions

- How do DHH enjoy music?
- What are the defects of music assessments for hearing people when we use them to DHH?
- How could we increase their **hearing ability** with IT?





# Past Research

*Ise*



perception of **emotion** in music performance  
improvisation by a professional percussion  
player

- **timbre**
- **harmony**
- **Tapping Game**
- **Music Puzzle**

*harmony*

*Tonic* 🎵

*Dominant* 🎵

# Beat

- Rhythm: critical element of music perception for DHH students
- Beat: basic pattern of rhythm
- Beat tapping game

for improving hearing ability

play with music only / music and visual information

visual information improves the tapping accuracy

- Beat recognition with different timbres
- Beat alignment tests (BAT)

**Research proposed by a deaf student**

# DHH enjoy music more

Research proposed by a deaf student

- with **audible** timbre

>> music classes for DHH children

Is a piano good?

Is a recorder good?

- The student: profoundly deaf, plays Music Puzzle like experienced hearing persons.

# Beat Tapping Experiment with Different Timbres by DHH

- tap a display along with the beat sound while listening (BAT)
- Sound data

C4, quarter notes, 16 beats, 90BPM, 20 instrumental sounds





# Instruments

Family	Instruments
String Plucking	Mandolin (MDN), Class. Guitar (CGT), Elec. Guitar (EGT), Harp (HRP)
String Rubbed	Violin (VLN), Cello (VCL)
Hammer	Piano (APF), Clavinet (CVN)
Brass	Trumpet (TRP), Trombone (TRB), Tuba (TUB), Horn (HRN)
Woodwind	Bassoon (BSN), Clarinet (CLN), Flute (FLT), Recorder (REC)
Others	Accordion (ACC), Harmonica (HMC), Shamisen (SHM), Sou (SOU)

# Beat Tapping Experiment

- Participants: nineteen DHH  
with Hearing Aids (HA): eleven (M:3)  
Cochlear Implanter (CI): eight (M:4)

- Procedure

Practice

Tap with beats, twice for each instrumental sound

Subjective evaluation

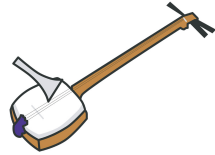
Interval

↑  
repeat for 20 instrumental sounds  
↓

# Subjective Evaluation

marked from 1 (Strong No) to 5 (Strong Yes)

1. Was the sound easy to hear? (EASY)
2. Did you hear sounds at higher pitches? (HIGH)
3. Was it easy to tap with the beats? (BEAT)
4. Did you like the instrumental sound? (LIKE)



# Results

## Differences between Instrumental Sounds

		HA	CI
EASY	**	-	The subjective evaluations are different between DHH with HA and CI
	*	REC (2.36) and SHM (4.18)	
HIGH	**	CGT (2.27) and REC (4.45)	CGT (2.13) and TRP/TUB/SOU (4.25)
	*	CVN (2.8), SHM (2.45) and REC (4.45)	
BEAT	**	-	-
	*	-	REC (2.38) and HRP (4.59)/EGT (4.63)/SHM
LIKE	**	Recorder sounds higher than other instruments and not easy to listen to.	Shamisen does not sound high and easy to listen to.

\*:  $p < .05$ , \*\*:  $p < .01$



# What are pitches?

- Calculate pitch

with MIRToolbox (Matlab)/iOS app1/iOSapp2

- REC: 131/C5/104(G)
- SHM: 261/C3/130

- Subjective evaluation of “HIGH” by Hearing People  
(four participants, average)

Recorder sounds higher

- REC: 4.0
- SHM: 2.5

Shamisen does not sound high

DHH with HA and Hearing People  
feel similar to pitch of REC and SHM

# Results

## Differences between Participant Groups

- EASY

\*\* VCL: HA(2.9) CI (4.6)

\* EGT: HA(3.6) CI(4.8)

- LIKE

\*\* VCL: HA (2.6) CI (4.0)



\*:  $p < .05$ , \*\*:  $p < .01$



# Discussion

- Differences in subjective evaluation between two DHH groups
- Which instruments are good to understand?

HI children can enjoy music classes at elementary school?

- No instrument was found commonly good for HI
- How about the combination of several instruments?



# Discussion

# Future Work

- The effect of sound features
- The relationship between the subjective evaluation and an objective evaluation (tapping accuracy)
- Future music assistive technology for DHHs ...  
personalized music recommendation system



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**Fine**