Rethinking Hearing Aids as Recommender Systems

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Hearing Loss

By 2050 hearing loss will have disabling hearing loss

In 2019 33% of people over 65 have disabling hearing loss

By 2050 10% of the world’s population will have disabling hearing loss

1 WHO (https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss)
Treating Hearing Loss
Complex device configuration
Multiple parameters influence the experience of hearing-impaired users

Hearing is a subjective sense
Users perceive the sounds differently and might benefit from a fully personalized hearing aid configuration

Constantly changing sound environment
Users might have different preferences in different situations

Learning user preferences
How to effectively gather them in multiple real-world situations?
1. Fitting Space
It’s the space defined by the different possible combinations of settings that can be applied to a hearing aid, based on the audiogram of the user.
Rethinking Hearing Aids as Recommender Systems

1. Fitting Space
   It’s the space defined by the different possible combinations of settings that can be applied to a hearing aid.

2. Default Configuration
   The default configuration is a combination of medium settings, adopted when user preferences are not known. Previous research showed that people have different characteristics and hearing preferences. 

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Rethinking Hearing Aids as Recommender Systems

1. Fitting Space
   It’s the space defined by the different possible combinations of settings that can be applied to a hearing aid.

2. Default Configuration
   The default configuration is a combination of medium settings, adopted when user preferences are not known.

3. Recommended Configuration
   A personalised configuration can be recommended, based on some specific characteristics and preferences of the single user.

HOW TO RECOMMEND A PERSONALISED CONFIGURATION?

✓ Simplifying the complex **audiological space**
✓ Gathering user preferences in **real-world** situations
The Study Participants

Experience with Hearing Aids

Years

User

A
B
C
D
E
F
G

0 20 40

Gender

1
6

15
16
7
5
19
20
19
The Study Timeline

Week 1
Evaluation of Parameter A
Noise reduction and directionality

Week 2
Evaluation of Parameter B
Brightness

Week 3
Evaluation of Parameter C
Soft gain

Week 4
Final test of preference

Level 1
Noise reduction and directionality

Level 2
Noise reduction and directionality

Level 3
Noise reduction and directionality

Level 4
Noise reduction and directionality

Level 1
Brightness

Level 2
Brightness

Level 3
Brightness

Level 4
Brightness

Level 1
Soft Gain

Level 2
Soft Gain

Level 3
Soft Gain

Level 4
Soft Gain

Personalized Configuration

Prescribed Configuration
What is the perceived usefulness of the parameters?
Usefulness of the 3 Parameters

Average usefulness of the 3 parameters

- Noise Reduction and Directionality (n=94)
- Brightness (n=98)
- Soft Gain (n=103)
Do people have different preferences?
Does the same person have different preferences?
Noise Reduction and Directionality

User preferences when the parameter is considered to be useful (Usefulness > 2 out of 5)
Brightness

User preferences when the parameter is considered to be useful (Usefulness > 2 out of 5)
**Soft Gain**

User preferences when the parameter is considered to be useful *(Usefulness > 2 out of 5)*

<table>
<thead>
<tr>
<th>Preference</th>
<th>A (n=6)</th>
<th>B (n=16)</th>
<th>C (n=4)</th>
<th>D (n=0)</th>
<th>E (n=11)</th>
<th>F (n=6)</th>
<th>G (n=37)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in Soft Gain</td>
<td>Lev. 4</td>
<td>Lev. 3</td>
<td>Lev. 2</td>
<td>Lev. 1</td>
<td>Lev. 4</td>
<td>Lev. 3</td>
<td>Lev. 2</td>
</tr>
</tbody>
</table>

**Preferred Soft Gain Levels**

100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
4

Is real-world personalization preferred to how hearing aids are fitted in a standard clinical workflow?
Test of Preference

✓ 6 out of 7 users preferred the Personalized Configuration
✓ Some users fine-tuned the hearing aids for speech situations
✓ Participants liked to have more than one configuration
Conclusions

- Item
  - We simplified the audiological design space and isolated the most important parameters.

- User
  - Users exhibited different audiological preferences.

- Context
  - The same user exhibited different preferences in different contexts.

- Rating
  - The device configuration learned in multiple real-world environments was preferred to a traditional configuration.
Thank you