COMPARISONS AMONG DIFFERENT TYPES OF HEARING AIDS

Fang Fu and Yan Luximon
School of Design, The Hong Kong Polytechnic University
yan.luximon@polyu.edu.hk
Dr. Luximon is an Associate Professor in School of Design at The Hong Kong Polytechnic University. She also serves as Lab Leader for Asian Ergonomics Design Lab and Deputy Discipline Leader for BA Product Design. Her research interests include ergonomics in design, anthropometry and its application in design, 3D digital human modeling and CAD, design tool and visualization, head and face related products, human computer interaction, cultural difference, statistical and mathematical models.
1. Introduction
2. Methods
3. Results and Discussion
4. Conclusion and Future Work
INTRODUCTION
Hearing aids are used to amplify collected sound for people with hearing loss.

Different types of hearing aids are designed for specific demands.
- Behind-The-Ear (BTE) aids,
- In-The-Ear (ITE) aids,
- In-The-Canal (ITC) aids,
- Completely-In-The-Canal (CIC) aids.

(Different hearing aids © Siemens)
Fit evaluation of hearing aids

• Fit evaluation has been studied for various ergonomics designs, such as shoes (Au&Goonetilleke, 2007) and chairs (Helander&Zhang, 2010).

• Most of fit studies focused on ear anthropometry (Jung&Jung, 2003; Chiou et al., 2016), auditory performance (Rallapalli et al., 2019; Vroegop et al., 2018), and cognition (Convery et al., 2019).

• Evaluation methods:
  - Computer Aided Design (CAD) simulation;
  - Virtual reality;
  - Mock-up evaluation;
  - Prototype evaluation.
RESEARCH AIM

Research gap:
• The association between anthropometric data and design patterns of hearing aids has not been sufficiently evaluated.
• To address the design problem, there is a need to evaluate the fit for various hearing aids.

Aim:
• This paper aimed at comparing sizes and shapes among the widely-used types of hearing aids, including BTE, ITE, and ITC aids, based on the user experience of fit and comfort.
• As a work-in-progress study, the findings can be useful to study fit evaluation of hearing aids in future research.
METHODS
PRODUCT MEASUREMENTS

- In the study, BTE Fun P, ITE Vibe Mini 8, and ITC Vibe Nano 8 aids (Siemens®) were selected.
- Product parameters, including length, width, height, and weight, were measured to evaluate the product, which were compared with anthropometric data to seek proper fit.
• Participants were asked to wear each hearing aid for 5 minutes.
• Fit and comfort perception of the participant was recorded with a Likert-Scale questionnaire.
• Contact area with the human ear was marked for further discussion on association between anthropometric data and product design.
RESULTS AND DISCUSSION
Differences among Commercial Hearing Aids

- Selected commercial product were measured for product length, width, height, and weight.

<table>
<thead>
<tr>
<th>Type</th>
<th>Hearing Aids</th>
<th>Components contacting with human ear</th>
<th>Size</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTE</td>
<td>[Image]</td>
<td>Round earplug in soft plastic material; Tubing contacting the ear root.</td>
<td>Earplugs were designed with selectable sizes.</td>
<td>7.16g</td>
</tr>
<tr>
<td>ITE</td>
<td>[Image]</td>
<td>Special shape in direct contact with ear concha.</td>
<td>Width:8.71mm Height:12.97mm Length:19.88mm</td>
<td>1.42g</td>
</tr>
<tr>
<td>ITC</td>
<td>[Image]</td>
<td>Special shape in direct contact with ear canal.</td>
<td>Width:5.72mm Height:12.52mm Length:17.28mm</td>
<td>0.97g</td>
</tr>
</tbody>
</table>
DIFFERENCES AMONG COMMERCIAL HEARING AIDS

• Wight and size: BTE aids > ITE aids > ITC aids.

• Users’ satisfaction on fit and comfort perception: BTE aids > ITE aids > ITC aids.

• As for the product weight, load analysis can be conducted in specific ear region for the specific type of hearing aids.

• The parameters were difficult to compare directly, considering different aids need to fit with distinct ear region. Hence, there is a need to associate the product dimensions with anthropometric data to examine the comfort and fit.
ANTHROPOMETRY FOR HEARING AID DESIGN

• Based on the contacting area, BTE, ITE, and ITC aids should be designed to match with specific ear regions individually.

Ear reference area for designing hearing aids:

Ear root (A) and back part of the ear (B) associated with BTE aids;

Ear concha (C) associated with ITE aids;

Ear canal (D) associated with ITC aids.
ANTHROPOMETRY FOR HEARING AID DESIGN

• To seek proper fit, anthropometric data were essential for designing distinct types of hearing aids.

• According to definitions of ear dimensions in the literature (Lee et al., 2018), different dimensions were chosen for specific hearing aids.
  - ear protrusion and pinna flare angle can be used for designing BTE aids;
  - cavum concha length, center of concha to incisura intertragic length, and ear canal entrance circumference can be valuable for designing ITE aids;
  - ear canal entrance height, ear canal entrance width, ear canal entrance to 1st bend length, and ear canal 1st bend circumference can be applied in ITC aid design.
CONCLUSION AND FUTURE WORK
CONCLUSION

• This pilot study tried to compare the shapes and sizes of different hearing aids, and examined the application of ear anthropometry in hearing aid design from comfort and fit perspective.

• Generally, BTE aids have the largest size and weight but the highest fit and comfort perception, while ITC have the smallest size and weight but the lowest fit and comfort perception.

• Different contact areas on the external ear were recorded with diverse types of hearing aids. Accordingly, anthropometric dimensions were selected for different hearing aids based on the literature.
With the preliminary findings in the study, next step is to apply CAD simulation to examine the fit of different hearing aids, and use prototypes to explore the users’ experience.

Future research can be conducted with larger sample size and more hearing aids in different markets to improve the fit of ear-related products with the use of CAD simulation technique.
REFERENCES


Thank You !