A truly self-fitting hearing aid: need, concept, and feasibility

Gitte Keidser¹, Elizabeth Convery¹, Harvey Dillon¹, Andrea Caposecco², De Wet Swanepoel³, and Lena Wong⁴

¹ National Acoustic Laboratories and the HEARing CRC, Australia
² University of Queensland and the HEARing CRC, Australia
³ University of Pretoria, South Africa
⁴ University of Hong Kong, Hong Kong

Advances in Audiology, December 2012, Las Vegas
Background

- Truly self-fitting devices
  - No professional input
  - No computer support
  - No telephone access
  - No ear impressions

- Self-fitting hearing aid concept patented in 1984 (Köpke et al.)
Background

- Developing countries
  - Deficit in both the provision of hearing aids and the number of hearing health care providers who are skilled to fit them

- Developed countries
  - Unreliable services to remotely located populations (indigenous people in particular)
Self-fitting hearing aid (concept)

- Automated in-situ audiometry
- Prescribed fitting
- Fine-tuning in real life

Re Convery et al., 2011
Objective

- Understand the concept
  - Management
    - Preparations
      - Assembly
    - Automated in-situ audiometry
  - Contraindications to fitting
    - Asymmetry
    - Conductive component
  - Fine tuning (training)
Assembly Instructions

- Designed in accordance with best practice health literacy principles ("ability to read, use and understand health information")

Parts of the hearing aid
1. The parts for the right hearing aid are in the red bag. The parts for the left hearing aid are in the blue bag.
2. Open the blue bag and take out the parts.
3. Check you have all the parts:
   - Hearing aid body
   - Three (3) tubes
   - Three (3) domes
   - Battery

4. Now you will put the parts together. Please follow the steps shown on the next few pages. This is how the hearing aid will look when you are finished.

Hearing aid body
Tube
Dome

line drawings paired with text to reinforce the message

Re Caposecco et al., 2011
Assembly instructions

• An instruction booklet for each ear
• Left/right color coded
• Defined steps:
  – Tube selection
  – Dome selection
  – Attach dome to tube
  – Attach tube to HA body
  – Insert battery
  – Insert device into ear
  – Troubleshooting (tube and dome sizes)
  – Button press
• Hearing-impaired participants with partner

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Australia (N = 80)</th>
<th>South Africa (N = 40)</th>
<th>Hong Kong (N = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructions</td>
<td>English Version 1.0</td>
<td>English Version 2.0</td>
<td>Mandarin Version 2.0</td>
</tr>
<tr>
<td>Age (years)</td>
<td>73</td>
<td>67</td>
<td>74</td>
</tr>
<tr>
<td>Occupation (rating)</td>
<td>Manager</td>
<td>Unemployed</td>
<td>Labourer</td>
</tr>
<tr>
<td>Vision (self-rating)</td>
<td>Excellent/good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Reading (self-rating)</td>
<td>Excellent</td>
<td>Good</td>
<td>Moderate</td>
</tr>
<tr>
<td>Cognition (score)</td>
<td>26/30</td>
<td>22/30</td>
<td>22/30</td>
</tr>
<tr>
<td>Health literacy (score)</td>
<td>34/36</td>
<td>27/36</td>
<td>26/36</td>
</tr>
<tr>
<td>Dexterity (sec)</td>
<td>101</td>
<td>116</td>
<td>108</td>
</tr>
</tbody>
</table>

(Convery et al., in preparation)

Monitor independence and accuracy
- More people in the AUS population managed task on own
- Health literacy primary determining factor
- More managed task on own the second time (all populations)
- SA population most accurate – revised instructions
- Health literacy and cognition were contributing factors
- 58% of HK subjects did not read the instruction booklet fully, or at all
Conclusion:
Task seems manageable by a wide cross section of the population provided instructions are carefully designed taking low health literacy into account
Audiometry

• Reliability and validity of automated in situ audiometry fundamental for the SFHA

• Automated audiometry verified (e.g. Ho et al., 2009; Margolis et al., 2010; Swanepoel et al., 2010)
  – Automated (Auto) and manual (Man) audiometry by a clinician on 117 ears (Convery et al., in preparation)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Test-retest</th>
<th>Auto-Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 Hz</td>
<td>r = 0.98</td>
<td>r = 0.98</td>
</tr>
<tr>
<td>1000 Hz</td>
<td>r = 0.98</td>
<td>r = 0.98</td>
</tr>
<tr>
<td>2000 Hz</td>
<td>r = 0.98</td>
<td>r = 0.99</td>
</tr>
<tr>
<td>4000 Hz</td>
<td>r = 0.99</td>
<td>r = 0.98</td>
</tr>
</tbody>
</table>
In situ audiometry through a hearing aid attached to different instant-fit tips is valid and reliable provided transducer and coupling specific REDD’s are applied (O’Brien et al., 2010)
Audiometry

- Investigate validity and reliability of self-managed, automated in situ audiometry
  - Assisted automated in situ audiometry
  - Self-managed automated in situ audiometry
Audiometry

• Investigate validity and reliability of self-managed, automated in situ audiometry

• The challenges of self-administered automated in situ audiometry:
  – Placement of tip
  – Distortion free tones and dynamic range
  – Ambient noise
  – Transducer and coupling specific calibration
  – Response time and false positives
Conclusion:
Implementation of automated in situ audiometry viable
• self-management of task to be fully investigated
Contraindications to hearing aid fitting

- Contraindications to hearing aid fitting
  - Asymmetry – masking (wireless)
  - Conductive component?
    - Tone test in quiet (TIQ) and in modulated noise (TIN)

Re Keidser et al., 2011
Prediction of CHL
Prediction of CHL

The accuracy of prediction is best
- at low frequencies
- for larger air-bone gap

Re Convery et al., in preparation
Conclusion:
Accuracy of identification of air-bone gap in at least 80% of cases using air conduction tone tests presented in quiet and in noise
• feasibility of identifying asymmetry using wireless connection to be investigated
### Fine-tuning

- 18 participants (median age = 79 years; PTA = 53 dB HL)
- Siemens prototype BTE (training of the compression characteristic in four frequency bands and six environmental sound classes)

<table>
<thead>
<tr>
<th></th>
<th>3 weeks</th>
<th>3 weeks</th>
<th>2 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half</td>
<td>NAL-NL2</td>
<td>Training 1</td>
<td>Compare</td>
</tr>
<tr>
<td>Half</td>
<td>Training 1</td>
<td>NAL-NL2</td>
<td>Compare</td>
</tr>
<tr>
<td>Fitting</td>
<td>SRTₙ</td>
<td>SRTₙ</td>
<td>Interview</td>
</tr>
<tr>
<td></td>
<td>Loudness GHABP</td>
<td>Loudness GHABP</td>
<td>Diary</td>
</tr>
</tbody>
</table>

*creating sound value™*
Trained parameters

(LF gain, HF gain): gain variation at 65 dB input

(LF CR, HF CR): difference in gain variation at 40 and 90 dB input
Efficacy of training

- Preferences:
  - 8 no preference
  - 8 trained response
  - 2 NAL-NL2

  5.1 adj/day - trained in 2.4 sound classes
  8.7 adj/day - trained in 3.5 sound classes

- No effect of training on outcome measures

- Those who preferred the trained response were more satisfied (8.1 vs 7.0 in rating)

Re Keidser & Alamudi, submitted
Conclusion:
Training is effective for those who want a change to prescription
Overall conclusion and clinical implications

• A truly self-fitting hearing aid:
  – Is feasible, but outcomes are unknown
  – Is a viable solution for those who do not have reliable access to audiological services

• Implications for clinicians:
  – Anticipated to be negligible
    • Many need and prefer the services of clinicians
    • Increasing demand due to population aging
    • Increasing market size due to hearing aids becoming more effective in noise for milder hearing loss
Conclusion

- Data on the feasibility of a truly self-fitting hearing aid are generally promising;
  - **Assembly**: manageable by a wide cross section of the population provided instructions are carefully designed taking low health literacy into account
  - **Automated in situ audiometry**: implementation viable
    - Technical issues to be addressed
    - self-management of task to be fully investigated
  - **Contraindications to fitting**: accuracy of identification of air-bone gap in at least 80% of cases using air conduction tone tests presented in quiet and in noise
    - feasibility of identifying asymmetry using wireless connection to be investigated
  - **Fine-tuning**: training effective for those who want a change to prescription
  - **Delivery model?**
    - Supply of instant-fit ear tips and batteries
Acknowledgements

We would like to thank Lisa Hartley, Katrina Freeston, and Karima Alamudi (NAL), Faheema Mahomed and Analicia Pretorius (University of Pretoria), and Eed Shen (University of Hong Kong) for helping out with data collection.

For further information: Trends in Amplification (2011), or contact Gitte.Keidser@nal.gov.au

This research was financially supported by the HEARing CRC established and supported under the Australian Government’s Cooperative Research Centres Program.