Evidence Regarding the Effectiveness of Hearing Solutions in Older Adults

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Overview

• Types of Hearing Aid Outcome Measures
• Dimensions of Hearing Aid Outcome
• Explaining Individual Differences in Outcome
• Influence of Technology on Outcomes
Do Hearing Aids Help?

• Yes, but how can this be demonstrated—for the field and for individual patients?

  • “Hearing Aid Outcome Measures”

    • Used to demonstrate or document the benefits of hearing aids to consumers, clinicians, HA manufacturers, and various third-party payers
Hearing-Aid Outcome Measures

- Objective Performance and Benefit
- Subjective Benefit
- Satisfaction
- Usage
Objective Performance and Benefit

Aided and Unaided Speech Recognition

- **Materials**
  - Syllables, words, sentences

- **Listening Conditions**
  - Speech Level
  - Background
  - Azimuth
Subjective Performance

- Subjective Scales
- Aided Assessment
- Examples
  - Sound Quality
    - Gabrielsson et al.
  - Aided Performance
    - PHAP (Cox & Alexander)
  - Hearing Handicap
    - HHIE (Weinstein)
Subjective Benefit

- Subjective Scales
- Assessment of CHANGE from Unaided to Aided
- Examples
  - HAPI or SHAPIE
  - Benefit Profiles
    - PHAB, APHAB, COSI
  - Hearing Handicap
    - HHIE
Subjective Benefit

- Self-Report Scales
- Assessment of *CHANGE* from Unaided to Aided or “helpfulness” of HA
- Example
  - HAPI, Hearing Aid Performance Inventory
Example (HAPI)

• You are in a large business office talking with a clerk. There is the usual office noise (e.g., typing, talking, etc.)

• In this situation, my hearing aid is...

  very helpful  helpful  very little help
  no help  hinders performance  N/A
Hearing Aid Satisfaction

Rate your satisfaction with the following **HA features** (VS,S,N,D,VD)

- Overall fit/comfort
- Hearing aid size
- Visibility to others
- Ease of adjusting volume
- Whistling/feedback
- Clearness of sound

Rate your satisfaction with the HA in the following **listening situations**

- Conversation with 1 person
- In small groups
- Outdoors
- In large groups
- Watching TV
- On the telephone

*MarkeTrak series, S. Kochkin*
Hearing Aid Usage

• Objective Measures
  • “Datalogger”
  • Battery weight

• Subjective Measures
  • single reports of “typical usage”
  • diaries or use “logs”
  • average hours used per day vs. recommended hours
Overview

• Types of Hearing Aid Outcome Measures

• **Dimensions of Hearing Aid Outcome**

• Explaining Individual Differences in Outcome

• Influence of Technology on Outcomes
Many Outcome Measures

- How are they related?
- Do they all measure the same thing?
- Do they interact in a simple or complex manner?
- Are some more important than others?
- ????
Our Approach to Sorting this Out

• Obtain multiple measures of hearing-aid outcome from large numbers of hearing aid wearers at the same time

• Examine associations (correlations) among measures

• Determine if the large set of outcome measures can be reduced to a smaller set (factor analysis)
The IU Studies
(IU-1 to IU-4)

KEY COLLABORATORS:
Nathan Amos
Amy Arthur
Nancy Barlow
Gretchen Burk
Carolyn Garner
Lisa Goerner
Dana (Wilson) Kinney
Elizabeth Thompson
+ many students!
Common Features across IU Studies

• Shared set of 11 outcome measures
• Outcome measures completed at 4-6 weeks post-fit
• Strict protocol followed in each study, with many common features across studies
  • Older adults with typical bilateral sloping hearing loss as participants
  • Similar gain targets and real-ear verification
  • Bilateral fits
  • Same core team of clinicians in same clinic
Dimensions of Hearing Aid Outcome

Are all measures needed? NO (11 measures >>> 3 dimensions)

Relies on correlations and factor analysis

Large subjects/variables ratio needed (e.g., 368/11)

Humes & Krull (2012)
Overview

• Types of Hearing Aid Outcome Measures

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• Explaining Individual Differences in Outcome—Why do listeners differ in performance?

• Influence of Technology on Outcomes
SEM Results

IU-1 Study

N=173

Humes (2003)
Re: “Benefaction”: Thorough Reviews in Recent Years

• Wong, Hickson & McPherson (2003)

• Knudsen et al. (2010)

  • In addition to review, added two substantial studies of factors related to satisfaction
Singh et al. (2015)

• Study 1: 173 older adults, 55.5% using hearing aids for at least 5 years

• Study 2: 161 middle-aged adults, 35.4% using hearing aids for at least 5 years

• Some minor differences in variables, both predictor and outcome, across studies
Singh et al. (2015)

• Best predictor in both samples was self-reported social support (DUFSS)
  • S1: Total Rsq = 0.22, 0.08 due to DUFSS
  • S2: Total Rsq = 0.43, 0.25 due to DUFSS
  • No other shared predictors across samples

• APHAB included in S2 and correlation with SADL was $r = 0.46$ – “benefaction” (incl. as predictor in S2)

Despite wide range of variables examined, still only able to account for about 10-25% of variance in benefaction measures
Explaining Individual Differences in Speech Understanding—Unaided and Aided

Unaided Speech Recognition:

NU-6 Quiet
r = 0.75

WIN
r = 0.75
Explaining Individual Differences

Unaided Speech Recognition--Humes (2005)  N = 249
Explaining Individual Differences: AIDED Speech Recognition

Humes (2002)

N = 171

$r_m = 0.82$

$rms = 0.58$

Multiple Regression Analysis

Audibility Factor = 53.2%
Cog Factors = 12.5%

Humes (2002)
Our Most Recent Study of Individual Differences in *Aided* Speech Recognition (Humes, Kidd & Lentz, 2013)

**AGE:** $M = 69.2$ y, 60-86 y
- 50 females;
- 91 right ears tested;
- 91 not current HA users (88 never)
Potential Predictor Variables

• Cognitive/Linguistic Measures
  (all tests made use of visual stimuli)
  
  • 3 Measures of Verbal Processing Speed (AQT)

  • 3 Measures of Working Memory Capacity

  • Text Recognition Threshold (TRT)—using text of SPIN-PH sentences
Potential Auditory Predictor Variables

• Psychophysical Measures (14 measures)
  • Modulation Detection and MDI (5)
  • Dichotic Pure-Tone Masking (2)
  • Stream Segregation (3)
  • Informational Masking (“multi-burst masking”) (2)
  • Anisochrony (1)
  • Harmonic Mistuning (1)

• Except for stream segregation, standard-2AFC, adaptive tracking-7 reversals each, 5 estimates averaged

• Environmental Sound Identification (ESI)
Speech-Understanding Measures

• Coordinate Response Measure (CRM)—85 dB SPL
  • Simultaneous (same target & competing talker, 0-dB SNR)
  • 6 ST Fo separation
  • 6 ST Fo sep, reversed

• Speech Perception in Noise (SPIN)—85 dB SPL
  • Interrupted (8, 19-38 ms “glimpses” per target word; 50% proportion or duty cycle)
  • Babble (+8 dB SNR)
  • Time compressed (50% time compression; PL items only)

• Dichotic Syllable-Sequence Task
Spectral Shaping Applied--SPIN

![Graph showing the relationship between 1/3-OB Center Frequency (Hz) and Sound Level (dB SPL) for different hearing thresholds and spectral shaping techniques. The graph compares SPIN, LTASS, LTASS-shaped, Older-thr, and YNH-thr.](image)
Quick Summary of Group Differences

• Group means for YNH subjects were generally consistent with prior studies

• In the vast majority of cases (~80%), for auditory measures, older adults did not perform significantly worse than YNH subjects (*including speech understanding*)
Multiple-Reg & Dominance Analysis

• Regression analysis performed

• Independent Variables (Predictors)
  • Age
  • TRT
  • ESI
  • Cognitive Function
  • Modulation Detection
  • Dichotic Masked Threshold
  • Stream Segregation
  • Informational (Multi-Burst) Masking
  • Hearing Loss

• Dependent Measures
  • Aided Speech Understanding

How do differences in THESE measures

Explain differences in THIS measure
Regression Analysis:

*Why Individual Differences in AIDED Speech Understanding?*

Variables NOT Entering:
- Mod Detection
- Stream Segregation
- Age

- ESI: 14.9%
- Cog: 11.4%
- Info. Mask: 10.0%
- TRT: 9.6%
- H Loss: 8.8%
- Dich. Mask: 4.8%
- Higher Level Cognitive & Linguistic Processes: 59.5%
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<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>AGE (M, sd)</th>
<th>BHFPTA*</th>
<th>%MALE</th>
<th>%NEW users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Ch, Linear</td>
<td>53</td>
<td>74.0 (6.7) y</td>
<td>48.4 dB HL</td>
<td>66</td>
<td>74</td>
</tr>
<tr>
<td>2-Ch, WDRC</td>
<td>52</td>
<td>74.6 (7.0) y</td>
<td>48.3 dB HL</td>
<td>66</td>
<td>74</td>
</tr>
<tr>
<td>4-Ch, Omni</td>
<td>53</td>
<td>75.4 (6.4) y</td>
<td>50.3 dB HL</td>
<td>60</td>
<td>67</td>
</tr>
<tr>
<td>4-Ch, Dir</td>
<td>56</td>
<td>74.5 (7.6) y</td>
<td>50.9 dB HL</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>Open Fit BTE**</td>
<td>35</td>
<td>73.6 (8.0)y</td>
<td>44.0 dB HL</td>
<td>51</td>
<td>80</td>
</tr>
</tbody>
</table>

*BHFPTA = Bilateral pure-tone average at 1000, 2000 and 4000 Hz
**6-channel, WDRC, Directional mic
Audiograms
Speech-Recognition Performance (CST)

![Graph showing speech-recognition performance for different conditions.

- **Condition**: Unaided, Aided, Benefit
- **Performance Scores**: 0% to 100%
- **Devices**:
  - 1-Ch, Linear
  - 2-Ch, WRDC
  - 4-Ch, Omni
  - 4-Ch, Dir
  - Open Fit BTE

Significant differences marked with asterisks (*)
Benefaction and Usage

SUMMARY:
Not many differences in outcomes across various technologies, ALL fit following best practices
Johnson, Xu & Cox (2015)

• Outcome domains for lab tests and questionnaires (as used in daily life) from 45 older adults
  • Speech understanding
  • Listening effort
  • Localization
  • Sound acceptability

• Hearing aid fittings
  • Bilateral, with appropriate coupling
  • Fitted using best-practice protocols, starting with NAL targets
  • Features set to manufacturers’ recommendations

• Compared “basic” to “premium” technology—2 brands
<table>
<thead>
<tr>
<th>Feature</th>
<th>Premium A</th>
<th>Basic A</th>
<th>Premium B</th>
<th>Basic B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of compression channels</td>
<td>16</td>
<td>8</td>
<td>20</td>
<td>6</td>
</tr>
<tr>
<td>Directional Microphone</td>
<td>Automatic multi-channel adaptive</td>
<td>Automatic single-channel adaptive</td>
<td>Automatic multi-channel adaptive</td>
<td>Automatic single-channel adaptive</td>
</tr>
<tr>
<td>Environmental adaptation</td>
<td>more</td>
<td>less</td>
<td>more</td>
<td>less</td>
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<tr>
<td>Binaural data streaming</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
<tr>
<td>Automatic learning of preferred volume</td>
<td>yes</td>
<td>no</td>
<td>yes</td>
<td>no</td>
</tr>
</tbody>
</table>
Influence of Technology on Outcomes

• When audiology best practices followed, differences in outcomes across technologies are relatively small.

• This appears to be true across a wide range of technologies.

• Shared aspects of “best practices” across studies:
  • Bilateral fits
  • REM used to match Rx targets
  • Counseling and HA orientation included
Acknowledgements

• Special thanks to the hundreds of participants in these projects

• This research was supported, in part, by NIH research grant R01 AG008293.