Will My Patient Benefit from Audiologic Rehabilitation? The Role of Individual Differences in Outcomes

Presented by:
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Moderated by:
Jason Galster, PhD, Starkey Hearing Technologies

Expert e-Seminar

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Individual Variability in Aided Outcomes

Individual Differences in Benefit from Directional Microphones
Jason Galster & Krishna Rodemark

Individual Variability in Recognition of Frequency Lowered Speech
Joshua M. Alexander

Individual Variability in Unaided & Aided Measurement of the Acceptable Noise Level
David A. Eddins

Will My Patient Benefit from Audiologic Rehabilitation?
Harvey Abrams & Theresa Hnath Chisolm

Individual Differences in Listening Effort With Hearing Aids
Erin Margaret Picou
Will My Patient Benefit from Audiologic Rehabilitation?  
The Role of Individual Differences in Outcomes

Theresa Hnath Chisolm, Ph.D.  
University of South Florida

Harvey B. Abrams, Ph.D.  
Starkey Hearing Technologies

Healthcare Research

› Is treatment ‘A’ better than treatment ‘B’?

Audiologic Rehabilitation Research

› Do those who use hearing aids have better outcomes than those who don’t?
› Is hearing aid ‘A’ better than hearing aid ‘B’?
› Does the newer signal processing feature yield better outcomes than the older version?
› Do those who participate in an auditory training program have better outcomes than those who don’t?
› Do those who participate in group aural rehabilitation have better outcomes than those who don’t?
Different treatments for the same disorder

- Individuals with the same disease respond differently to the same treatment
- Genomic research is taking us to new frontiers in the treatment of cancer, for example

Audiologic Rehabilitation: Individual Differences

- There is considerable individual variability associated with the outcomes of the two major approaches to AR

AR Approaches

- **Individualized Auditory Training**
  - Provision of auditory and/or auditory-visual speech perception training, currently typically implemented in computer-based programs
- **Counseling-Based Group AR**
  - Provision of educational counseling, most often in post–hearing aid fitting group sessions
Individualized Auditory Training

› A category of interventions designed to improve speech recognition through:
  • the implementation of exercises that range from a focus on small units of speech (phonemes or syllables – analytic approach) to larger elements of speech (sentences or phrases – synthetic approach)

Analytic Auditory Training

› Involves identifying a token nonsense syllable or word among other “foils” that become increasingly phonetically similar to the token as the patient’s performance improves

1. sat mouse door
2. sat map trap
3. sat fat chat

Synthetic Auditory Training

› Requires the listener to repeat a sentence in a background of noise.
  • As performance improves, the signal-to-noise ratio decreases.
  • The assumption is that improved task performance will generalize to improved speech understanding in the patient’s day-to-day communication situations
**What Does the Evidence Tell Us about Auditory Training?**

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants</th>
<th>Materials</th>
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<th>Findings</th>
<th>Conclusion</th>
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**Table 2: continued**

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**Summary:**
Auditory training is effective in improving auditory processing abilities, particularly in children with auditory processing deficits. Further research is needed to determine the most effective intervention strategies.
Results revealed a small, but reliable effect size of 0.35 (95% confidence interval [CI] = 0.13 to 0.58)

- Cohen’s $d$ effect sizes for the individual studies were quite varied, with relatively large confidence intervals

- Effect size is a measure of practical significance
  - the greater the effect size, the more likely the intervention is to have an impact, on average, for individuals

Conclusions
- Although AT, in general, will likely lead to an improvement in speech understanding for the average patient, there is a need for AT paradigms to be optimized for the individual
Counseling –Based Group AR

- Attempts to improve patient outcomes through group discussion and education as implemented via a counseling-based approach with an emphasis on information and psycho-social adjustment

Counseling–Based AR Generally Addresses:

- understanding communication problems associated with hearing loss
- use of strategies for managing difficult situations
- coping strategies
- problem solving
- assertiveness training
- quality of life (QoL)

What Does the Evidence Tell Us about Counseling–Based Group AR?
Meta-Analysis

- Results revealed a standardized mean difference of -0.35 (95% CI = -0.48 to -0.022) indicating a small, but reliable, improvement in the self-perception of improvements in outcomes related to hearing handicap and/or QoL as a result of group AR
- Cohen’s $d$ effect sizes for the individual studies were quite varied, with relatively large confidence intervals
- Chisolm and Arnold again concluded that there was a need for examining individual needs in determining the optimal intervention approach

Can the Data Help Us Predict Who Will or Will Not Benefit?

- **Baseline Performance:**
  - Several studies indicate that the poorer the baseline performance the more likely that improvement will occur
  - Across the studies reviewed in Tables 1 and 2, baseline performance appears to be most consistent indicator of post-training benefit

- **Age:**
  - Data from several studies suggested that older subjects tended to improve more than younger subjects
  - Older participants had poorer baseline scores and a higher level of motivation
  - This relationship was not consistently found, however, as several investigations failed to find an association between age and improved outcomes
Hearing Loss:
- Hearing loss severity did not appear to be a factor in predicting post-training performance

Other predictor variables:
- verbal intelligence
- motivation
- increased willingness to guess
- involvement of a significant other in the AR process

What to do?
- Given the limited information currently available
  - How can the clinician advise their patients concerning the most appropriate post-fitting AR intervention?
- Tinnitus management offers a model
  - Progressive Audiologic Tinnitus Management (PATM) (Henry et al, 2008)
Case Study

- JS, a 67 year old retired public school teacher, complains that he has to turn up the TV louder than his wife would prefer
- He denies any difficulty understanding his wife and, as the couple is not particularly socially active, he denies any other significant communication problems
- JS’s primary (and only) treatment goal is to be able to hear and understand the TV at a volume level that is comfortable for his wife

Which is the most appropriate level?

Level 5
  Ind. AT
Level 4
  Group AR
Level 3
  Virtual AR
Level 2
  Hearing Aids & ALDs
Level 1
  Counseling, PSAPs

Which is the most appropriate level?

Level 5
  Ind. AT
Level 4
  Group AR
Level 3
  Virtual AR
Level 2
  Hearing Aids & ALDs
Level 1
  Counseling, PSAPs
JS returns 5 years later with complaints of increasing communication problems. He and his wife have moved into a retirement complex and he wants to take part in the many social events that the center offers but he is finding it almost impossible to participate in most of the activities due to his hearing problems.

Which is the most appropriate level?

- Level 5: Ind. AT
- Level 4: Group AR
- Level 3: Virtual AR
- Level 2: Hearing Aids & ALDs
- Level 1: Counseling, PSAPs
JS and his wife return for their 30 day follow-up. He reports considerable improvement in one-on-one situations but is still struggling to keep up with conversations in small groups such as in the dining room where he and his wife share a table with another couple.

---

Which is the most appropriate level?

1. **Level 5**
   - Ind. AT
2. **Level 4**
   - Group AR
3. **Level 3**
   - Virtual AR
4. **Level 2**
   - Hearing Aids & ALDs
5. **Level 1**
   - Counseling, PSAPs

---

Progressive Audiologic Rehabilitation Management (PARM)

1. **Level 5**
   - Ind. AT
2. **Level 4**
   - Group AR
3. **Level 3**
   - Virtual AR
4. **Level 2**
   - Hearing Aids & ALDs
5. **Level 1**
   - Counseling, PSAPs
Our Work with Computer-Based Auditory Training Programs
A Tale of Two Studies
VA Merit Review Grants

The contents do not represent the views of the Department of Veterans Affairs or the United States Government

Evidence Based Practice (EBP)
- Requires the integration of the best research evidence with our clinical expertise and our patient's unique values and circumstances.

Study Types & Levels of Clinical Evidence
- Control for bias
- Demonstrate cause & effect in humans

Our findings demonstrate that published evidence for the efficacy of individual computer-based auditory training for adults with hearing loss is not robust and therefore cannot be reliably used to guide intervention at this time.

We identify a need for high-quality evidence to further examine the efficacy of computer-based auditory training for people with hearing loss.
Study #1:
Evaluation of Approaches to
Auditory Rehabilitation for mTBI

Study funded by VA RR&D grant #: C7054R
(G. Saunders, PI)
and Phonak who provided study equipment

James A. Haley VA,
Tampa, FL, U. South
Florida: Terry Chisolm,
Paula Myers, Michelle

Why are we interested in this?

Data show that:

◦ About 300,000 Operation Enduring Freedom
(OEF)/Operation Iraqi Freedom (OIF) Veterans
have some form of traumatic brain injury
(TBI)

◦ About 75% of wounds are due to exposure to
a blast(s)


Gaby Saunders,
Melissa Frederich,
Shilenfei Silverman

NCRAR, Portland
OR

11/15/2013
66% of Veterans with deployment-related TBI and blast complained of auditory difficulties. Of these:

- 35-54% have SNHL
- 7% conductive (ruptured TM)
- 20% have ‘normal or almost normal’ thresholds


Subjective impacts

- Hearing in background noise
- Following rapid speech
- Following instructions
- Following long conversations
- Tinnitus
- Hyperacusis

_i.e. indicative of auditory processing problems_

Reported difficulties:

- Hearing in background noise
- Signal-to-noise ratio (SNR)
- Following rapid speech
- Temporal processing
- Following instructions and long conversations
- Working memory
Interventions

**FM system**
- Will be effective at improving SNR, if used correctly
- A prop rather than a ‘fix’; requires an external device

**Auditory Training**
- Potential for sustainable change (a fix) for processing difficulties.
- Requires discipline and time commitment before any benefit may be realized.

Brain Fitness Program - computer-based training program developed by Merzenich et al., distributed by Posit Science.
- Designed to train:
  - Temporal processing
  - Auditory working memory
- 40 sessions, 60 min/day

The Brain Fitness Program: Training Tasks
- High or Low?
- Tell Us Apart
- Match It!
- Sound Replay
- Listen and Do
- Story Teller
Participants

- OEF/OIF Veterans
- Normal or near normal peripheral hearing sensitivity
- Reported blast exposure during deployment
- Self-reported functional hearing difficulties

2-site RCT

Consenting, Screening
Baseline Testing

Random assignment to intervention

Counseling (Control)
Counseling + Auditory Training
Counseling + FM System
Counseling + Auditory Training + FM System

8-12 weeks

Post-intervention testing

Outcome Measures: Performance

<table>
<thead>
<tr>
<th>Test measure</th>
<th>Rationale for Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gap detection - Adaptive Tests of Temporal Resolution ATTR</td>
<td>Trained with AT</td>
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<td>Speech-in-noise - HINT</td>
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Self-Report Outcome Measures

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<th>Rationale</th>
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<tr>
<td>Speech Spatial and Qualities Questionnaire - comparative (SSQ-C)</td>
<td>Likely to improve with FM; may improve with AT</td>
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<tr>
<td>Cognitive Self-Report Questionnaire (CSRQ)</td>
<td>Some scales likely to improve following one or both interventions</td>
</tr>
<tr>
<td>Psychosocial Impact of Assistive Devices Scale (PIADS)</td>
<td>May improve following either intervention</td>
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Results

Data collected from 86 participants.

<table>
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<tr>
<th>FM+AT</th>
<th>AT</th>
<th>FM</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>22</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Age</td>
<td>33.1</td>
<td>34.8</td>
<td>33.9</td>
</tr>
<tr>
<td>4F-PTA</td>
<td>13.4</td>
<td>11.0</td>
<td>12.1</td>
</tr>
<tr>
<td>Gender</td>
<td>Male: 22 Female: 0 Male: 12 Female: 3 Male: 19 Female: 5 Male: 22 Female: 3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results

Did the participants use the interventions?
Compliance with intervention Auditory Training

- Participation breakdown:
  - <10 sessions: 10 participants (5.7%)
  - 10-19 sessions: 15 participants (8.6%)
  - 20-29 sessions: 20 participants (10.9%)
  - 30-40 sessions: 30 participants (16.7%)
  - 50% - 75%: 50 participants (26.7%)
  - 75% - 100%: 70 participants (36.9%)

Percentage of Auditory Training Completed

Compliance FM System

- 1 individual did not use FM at all
- 13 wore it hardly ever
- 25 wore it a few times a week
- 7 used it every day

Average use per day = 2.9 hr, range: 0-9

Analyses of the Preliminary Data

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</table>
Gap detection - All subjects

Within-channel

Across-channel

Speech-in-Noise - HINT

Better
Benefit [dB SNR]

Better

Self-Report Outcome Measures

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Cognitive Self Report Questionnaire (CSRQ)

- A 64-item questionnaire assessing daily functioning on 8 subscales: Attention, Executive function, Memory, Language, Vision, Hearing, Energy, Satisfaction.

### CSRQ

**I lose my train of thought...**

<table>
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<th>Same as before</th>
<th>Worse</th>
<th>Does not apply</th>
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<tbody>
<tr>
<td>Less often</td>
<td>More often</td>
<td></td>
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**My ability to pay attention to more than one thing at a time is...**

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**My ability to remember phone numbers is...**

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**My ability to hear things clearly is...**

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### Benefit [Range: -8 to +8]

- Significant differences across treatment arms for all scales except energy & satisfaction.
- **FM**, **AT**, **Control**.
Summary of Study #1 – Preliminary Analyses

- Interventions are showing some small but positive outcomes for
  - temporal processing
  - speech-in-noise
  - Reported cognitive processing
- Combination of AT and FM appears to be most effective

Summary (cont.)

- Many more analyses to conduct:
  - Relationships between compliance and outcome
  - Predictors of outcome (individual differences)
  - Baseline deficit on outcome
- Many individual differences in outcome

Clinical take-home message

- Consider FM+AT for blast-exposed patients
- Make sure patient is open to using the interventions – or they likely won’t use them

Check out the new format for running Brain Fitness from Posit Science: https://brainhq.positscience.com/octnl-free/start

Format allows user to direct their own training
Study #2: Supplementing Hearing Aids with Computerized Auditory Training

VA RR&D Merit Review Grant C6303R (Chisolm & Wilson, Co–PIs)

LACE Training

- Comprehension of Degraded Speech
  - Speech-in-babble
  - Time-compressed speech
  - Competing speaker

- Enhancement of Cognitive Skills
  - Auditory working memory
  - Missing word identification using context

- Use of Communication Strategies
  - Helpful hints
Multi-site randomized controlled trial (RCT)

- \( n = 65 \) (mostly) experienced hearing aid users
- Ages 28-85 years old

Randomized to an Immediate Treatment or a Control, Delayed Treatment Group

Positive Treatment Outcomes at the Group Level
- Speech perception tests
- Cognitive tests
- Subjective measures of residual hearing difficulties and use of communication strategies

Greater gains were made by:
- Greater hearing loss
- Poorer baseline scores, particularly for:
  - Recognition of Degraded Speech
  - Recognition of Speech with a Competing Speaker
- Greater degrees of self-perception of hearing handicap
Factors which might influence LACE outcomes

- Veteran population
  - Higher pre-fitting expectations for hearing aid use
  - More severe unaided self-report of problems associated with hearing loss
  - Poorer physical and mental health than non-veteran age equivalents (Cox et al, 2005)

Overview of Study

- Large scale ($n = 279$), Parallel Group Randomized Clinical Trial
- Veterans
- New and Experienced Hearing Aid Users
- All hearing aids < 2 years old

Overview of Study

- Interventions:
  - Hearing Aid Use
    - + Standard-of-care educational counseling (Control)
    - + Directed Listening (Placebo)
  - Directed Listening to Books on computer for equivalent training period
Overview of Study

- **Interventions:**
  - Hearing Aid Use
  - + LACE Computer Training (20, ½ hour sessions)
  - + LACE DVD Training (10, ½ hour sessions)

Baseline testing

Control (standard care)

LACE-C
20 days, 30 min/day

Directed listening
20 days, 30 min/day

LACE-DVD
10 days, 30 min/day

Random assignment to intervention

4-6 weeks

Post-intervention testing

6-month follow-up

Participants
Screening Criteria

- **Normal Cognitive Function**
  - MiniMental State Exam (Age and Education Norms)

- **No Greater than a Mild Vision Loss** (corrected)
  - Smith-Kettlewell Institute Low Luminance (SKILL) Card (Snellen Equivalent 20/63)

- **Read at 5th Grade Level or Higher**
  - Woodcock-Johnson Letter-Word Identification; Reading Fluency; Passage Comprehension Subtests

Baseline testing

Groups equivalent on demographics, audiometrics, and on all outcome measures

Directed listening

**Baseline testing**

Groups equivalent on demographics, audiometrics, and on all outcome measures

30 min/day

4-6 weeks

Post-intervention testing

6-month follow-up

Distribution of Experience Across Groups: NS

<table>
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<tr>
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<th>Number of Participants</th>
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<tr>
<td>Control</td>
<td>30</td>
</tr>
<tr>
<td>LACE-DVD</td>
<td>30</td>
</tr>
<tr>
<td>LACE-C</td>
<td>30</td>
</tr>
<tr>
<td>Placebo</td>
<td>30</td>
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Outcome Measures

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<th>Outcome measure</th>
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<tr>
<td>Speech-in-babble</td>
<td>NU-6 tasks presented in multi-talker babble at 7 SNRs (+24 to 0 dB), compute 50% correct SNR</td>
</tr>
<tr>
<td>Time-compressed speech</td>
<td>NU-6 words 45% and 65% compressed. Presented in quiet. Compute % correct.</td>
</tr>
<tr>
<td>Competing speaker</td>
<td>Female voice, NU-6 words in carrier phase, sentence masker spoken by single male. Presented at 9 SNRs (+24 to -8 dB). Compute 50% correct SNR</td>
</tr>
<tr>
<td>Auditory word memory</td>
<td>Digit span, Backwards (WIM) Forward (STM)</td>
</tr>
<tr>
<td>Missing word identification</td>
<td>SPIN-LA sentences presented in multi-talker babble at 10 SNRs (+23 dB to -4 dB). Compute 50% correct SNR</td>
</tr>
<tr>
<td>Subjective ratings</td>
<td>HHIE/A: Social and Emotional scales</td>
</tr>
<tr>
<td></td>
<td>APHAB: Ease of Communication, Reverberation, Background Noise, Aversiveness.</td>
</tr>
</tbody>
</table>

Compliance With Training

- Sweetow & Henderson Sabes (2010)
  - Compliance with LACE training by clinical patients was less than 30%

<table>
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<tr>
<th>Intervention</th>
<th>Assessed By</th>
<th>Complete Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>No Formal Assessment</td>
<td>Completed 50% of 10 sessions</td>
</tr>
<tr>
<td>AT10</td>
<td>Daily Training Logs</td>
<td>Completed 30-100% of the 10 sessions</td>
</tr>
<tr>
<td>AT20</td>
<td>DTL+ Computer Logs</td>
<td>Completed 0-100% of the 20 sessions</td>
</tr>
<tr>
<td>Placebo</td>
<td>DTL+ Computer Logs</td>
<td>Completed 10-100% of the 20 sessions</td>
</tr>
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~ 70% of Ss completed training in each arm
### Outcome Measures

**LACE TASK**

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<td>Subjective ratings</td>
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**HHIE/A:** Social and Emotional scales

**APHAB:** Ease of Communication, Reverberation, Background Noise, Aversiveness.

### @ Baseline

**LACE TASK**

<table>
<thead>
<tr>
<th>Outcome measure</th>
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<tbody>
<tr>
<td>Speech-in-babble</td>
</tr>
<tr>
<td>Time-compressed speech</td>
</tr>
<tr>
<td>Competing speaker</td>
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**RESULTS**
Effects of Type of Intervention

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<td>Speech-in-babble</td>
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<tr>
<td>WIN: Identify, multi-talker babble at 7 SNRs (+20 dB)</td>
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<tr>
<td>Time-compressed speech</td>
</tr>
<tr>
<td>NU-6 words in 45% and 65% compressed in quiet.</td>
</tr>
<tr>
<td>Compute % correct</td>
</tr>
<tr>
<td>Competing speaker</td>
</tr>
<tr>
<td>NU-6 CM: C1, C2, C3, C4, C5, C6, C7, C8, C9, C10,</td>
</tr>
<tr>
<td>sentence mask, carrier phase, presented at 5 SNRs</td>
</tr>
<tr>
<td>Compute 50% correct SNR</td>
</tr>
<tr>
<td>Auditory word memory</td>
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<tr>
<td>Digit span 65% correct SNR</td>
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<tr>
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Compressed Speech 65% CR

Implication?

LACE Training might provide processing speed benefits under difficult listening conditions.
Long-Term Outcomes

Benefits, but not clear that LACE training improves outcomes more than Directed Listening

Comparison to Published Data

- Findings not as robust as previously reported by (Sweetow & Sabes, 2006; Sweetow & Sabes, 2007)
- Difference in design
  - Delayed Treatment Crossover
  - Between-Groups Design
- Differences in outcome measures (e.g., QuickSIN vs. WIN)
  - Equivalence of performance established (Wilson, McArdie & Smith, 2007)
  - But some outcome measures the same (e.g., HHIE)

Differences in Participant Groups: Non-Veterans vs. Veterans
Differences in Participant Groups:

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<tr>
<th>Factor</th>
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<td>Hearing Aids</td>
<td>Unknown</td>
<td>&lt; 2 years old</td>
</tr>
<tr>
<td>Age</td>
<td>28–92 years old</td>
<td>55–85 years old</td>
</tr>
<tr>
<td>Hearing Loss (PTA)</td>
<td>1.7 dB – 102 dB</td>
<td>5.0 dB – 57.0 dB</td>
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Need to Examine Individual Differences in Trial Outcomes
Can Predictors be Identified?
Baseline demographic characteristics
- Age
- 3-Frequency PTA (Better Ear)
- High Frequency PTA (Better Ear)
- Word recognition in quiet (NU-6; Binaural)
- Word recognition in noise (Unaided)
- Education
- Motivation to improve hearing

Basic Hearing Aid Characteristics
- Hearing Aid Experience
- Length of time of current hearing aid use
- Aided Audibility Index (Better Ear)

Baseline performance for the outcome measure

Treatment Arm
- Control
- AT10
- AT20
- Placebo

Results
- After trimming for outliers, and transforming categorical variables to similar "groupings"
- Significant models for all Outcomes
  - Not surprising given our n
- Account for ~15-40% of the variance
- For all Outcomes, "Baseline Performance" strongest predictor
  - Similar to Sabes Henderson & Sweetow (2007) poorer performers at Baseline showed greatest gains
Results

- For all Outcomes, some aspect of "hearing" (i.e., PTA, HF-PTA, word recognition quiet, word recognition noise) was a significant predictor
  - As hearing loss increased, outcomes improved
- Depending on Outcome, other demographic and/or hearing aid related variables were significant predictors
- Intervention Arm significant in 3 models

Compressed Speech 65%

Rerun analyses, new analyses
**What can I do for the individual patient?**

**Limitations of RCTs for Individual Patient Care**

- RCTs are gold standard for assessing efficacy of interventions at the **group level**
- RCT results, however, are not as easily applied to **individual patients**

**Example**

- Kelley & Kaptchuk (2010)

- Recently completed trial of sham acupuncture in irritable bowel syndrome
  - Waitlist Control Group
  - Acupuncture with limited clinician involvement
  - Acupuncture with augmented clinician involvement
Example

9 controls exceeded mean of Augmented Group

Note: Symptom improvement levels are presented as t-scores, with an overall mean of 50 and a standard deviation of 10.
13 controls exceeded mean of Limited Acupuncture Group

- Natural History
- Regression to the mean
- Response bias

- n-of-1 trials
  - Multiple cross-over design to tease apart placebo effects from true treatment effects
  - Particularly for chronic conditions
  - Identify disease and treatment combinations in which individual response occurs

Recommendation
One size doesn’t fit all

Summary & Conclusions
• Era of EBP must demonstrate that:
  - RCTs are the “gold-standard” of intervention studies
  - Effective for drawing reliable inferences at the group level
• However, inferences at the level of the individual cannot be made with the same confidence
• n-of-1 studies to determine disease and treatment combinations which work

Some Final Thoughts
What little attention has been paid to individual differences appears to highlight baseline performance and or baseline needs as the primary determinant of who might benefit from AR.

From a clinical perspective, assessing individual goals and matching treatment alternatives to meet those goals as suggested by the PAR model proposed here is a reasonable approach.

Clearly, future studies are needed to assess the relationship between individual differences and AR success.

ONE SIZE DOES NOT FIT ALL.

KEEP TRYING…
One size does not fit all.
Keep trying...

And eventually you will find the perfect fit.

Thank You

Individual Variability in Aided Outcomes

Individual Differences in Benefit from Directional Microphones
Jason Galster & Krishna Rodemark

Individual Variability in Recognition of Frequency Lowered Speech
Joshua M. Alexander

Individual Variability in Unaided & Aided Measurement of the Acceptable Noise Level
David A. Eddins

Will My Patient Benefit from Audiologic Rehabilitation?
Harvey Abrams & Theresa Hnath Chisolm

Individual Differences in Listening Effort With Hearing Aids
Erin Margaret Picou