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- Email customerservice@AudiologyOnline.com

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Vanderbilt Audiology Journal Club: *Hearing Aid Research with Clinical Implications*

Erin M. Picou, AuD, PhD
&
Todd A. Ricketts, PhD
May 29, 2019

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Disclosures

- Employed by Vanderbilt University Medical Center
- AO contributes financial support for VUMC DHSS student travel
- Received research funding
  - Sivantos
  - Oticon
  - Phonak / Sonova
  - Resound
  - Starkey
  - NIH NIDCD
  - NIDRR
  - NSF
  - VA RR&D
  - ASHFoundation

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Learner Outcomes

1. List new key journal articles on the topic of hearing aids that have implications for audiology clinical practice.
2. Describe the purpose, methods and results of new key journal articles on hearing aids that have implications for audiology practice.
3. Explain some clinical takeaway points from new key journal articles on hearing aids.

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What today's focus could have been…

- Examination of hearing aid benefits that are beyond speech recognition
  - Hearing aid use slows the progression of cognitive decline
    - Maharani et al (2018) *Journal of the American Geriatrics Society, 66,* 1130-1136
  - Hearing aid users go to the doctor less often
    - Mahmoudi et al (2018) *JAMA Otolaryngology–Head & Neck Surgery, 144*, 498-505
  - Hearing aid use is associated with high life-space mobility; inconsistent hearing aid use and hearing aid non-use is associated with less space
    - Polku et al (2018) *Journal of Aging and Health, 30,* 408-420
  - Hearing aids improve disease-specific and general quality of life
    - Kitterick & Ferguson (2018) *JAMA, 319,* 2225 - 2226

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What today's focus could have been…

- Identification of factors that affect hearing aid adoption/use
  - Hearing aid users' perceptions of problems
    - Bennett et al (2018) *Ear and Hearing, 40,* 77-87
  - Identification of traits associated with barriers to hearing aid use using big data – race, low SES, qualitative factors
    - McKee et al (2018) *Gerontologist*
  - Time to hearing aid acquisition is about 9 years and is influenced by ethnicity, hearing disability in social situations, speech recognition performance
    - Simpson et al (2019) *Ear and Hearing, 40,* 468-476

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Time of Day and Hearing Aid Adoption

Gurjit Singh
Stefan Launer

Trends in Hearing, 2018, 22, 1-14

Author Affiliations:
- Phonak
- University of Toronto
- Ryerson University
- UHN Toronto Rehabilitation Institute
- Sonova
- The University of Queensland - Australia

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What they did and found…

- Hearing aid adoption rates are low and we can only explain some of the variability
- Analyzed 24,842 patient records based on appt time
  - Hearing aid adoption
  - Hearing aid return rate
- Hearing aid adoption rates lowest at 12:00 and 4:00
- Hearing aid return rates lowest at 12:00 and 4:00
- Why? People are risk averse when hungry
  - Lower adoption rates
  - When do adopt, they pushed through the hunger

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Cost-Benefit Analysis of Hearing Care Services: What Is It Worth to Medicare?

Willink A, Reed NS, Lin FR. J Am Geriatr Soc. 2019 Jan 14. doi: 10.1111/jgs.15757. [Epub ahead of print]

Johns Hopkins Medicine

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What they did and found…

- Compared Medicare expenditures for those wearing and not wearing hearing aids.
- Estimated that 4.97 million use hearing health care services and 3.12 million do not.
- Matched samples for age, sex, race, education, # of chronic conditions, presence of helper, activity level and self reported trouble hearing.
- Per-person Medicare expenditures were approximately $2,500 lower for those accessing hearing health services.

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Why is this important…

- A note of caution: Even though the study is very well controlled – we do not know if those seeking hearing health care are in some way different (e.g. being more proactive about healthcare could have benefits).
  - In addition, results rely on self reported use of hearing healthcare.
- However, this study minimally suggests that Medicare coverage of hearing healthcare services may provide a net-positive, rather than a net negative, for Medicare.

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Today's Focus

- Hearing aid research with direct clinical implications
- Selection decisions
  - Open canal instruments for kids
- Fitting considerations
  - NAL-NL2 versus first fit
  - Automatic probe microphone measures
- Feature benefits
  - Noise reduction and directionality

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Today's Agenda

- What they asked
- A little background
- Why it matters
- What they did
- What they found
- Why is this important
- Does it matter clinically

CONTINUED

Open-Fit Domes and Children with Bilateral High-Frequency Sensorineural Hearing Loss: Benefits and Outcomes.

Johnstone P, Yeager K, Pomeroy M, Hawk, N. (2018)
J Am Acad Audiol 29: 348-356.

What they asked…

- Will the localization benefits of open fit hearing aids observed in adult hearing aid users also be present in children?
- If so, are benefits affected by degree of hearing loss, age, and/or duration of use of conventional earmolds with limited venting.

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A little background…

- Adults with high frequency hearing loss (an normal or near normal low frequency hearing) demonstrate poorer localization in the horizontal plane aided than unaided when using conventional earmolds with limited venting (Van den Bogaert et al, 2006).
- In comparison, this same decrement is not observed when these listeners are fitted with open eartips (Alworth et al, 2010) because they gain access to unaided and unaltered low frequency sound energy at the two ears.
- When compared to closed fittings, open fittings also provide benefits such as improved hearing aid sound quality (Goode and Krusemark, 1999; Alworth et al, 2010), improved own-voice quality (Alworth et al, 2010) and improved externalization of sound (Boyd et al, 2012).
- While expected, similar benefits for children have not yet been demonstrated.

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Why it matters…

- Eliminating the localization decrements associated with conventional earmolds with limited venting is clearly desirable for children.
- Particularly given that it appears that localization practice early in life is important to improve accuracy for children with a wide range of hearing loss (e.g. Sebkova and Bamford, 1981; Godar and Litovsky, 2010; Van Deun et al, 2009).

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What they did…

- Eighteen children who had high frequency hearing loss (no more than mild loss <1000 Hz) and 18 age-matched controls with normal hearing participated.
  - Within each group, half were older (10–16 yr) and half were younger (6–9 yr).
- All participants that completed the study were current users of the same brand of BTE hearing aid (several different models) that could be retro-fitted with an open eartip.
  - These listeners had used these instruments with conventional earmolds for between 4 months and 12 years.

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What they did…

- Conventional earmold venting was typically fairly limited: SAV and fixed venting ranging in size from 0.9 mm to 2.1 mm with one exceptions (3mm).
- The hearing aids were originally fitted to DSL and used omnidirectional microphones.
  - Since only the original programming was used, gain was approximately 10 dB lower in the low frequencies and 5-10 high in the high frequencies for the open fit (Equal SII).
- Localization accuracy was measured in the horizontal plane for the spondee "baseball" using a horizontal array of 15 loudspeakers (radius of 1 m; separation 10o) within a sound treated booth. The average presentation level was 60 dB SPL (randomly roved +/-8 dB).
  - Response was to click on a picture that corresponded to pictures on the loudspeakers.

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What they found…

- Localization error was greater in younger children than older children and in children with hearing loss compared to children with normal hearing.
- 94% (17/18) of the participants offered unsolicited positive comments regarding improvement in own-voice quality.
- Despite virtually no experience, some children received immediate localization benefits for the open fittings, although this was affected by duration of experience with conventional earmolds.

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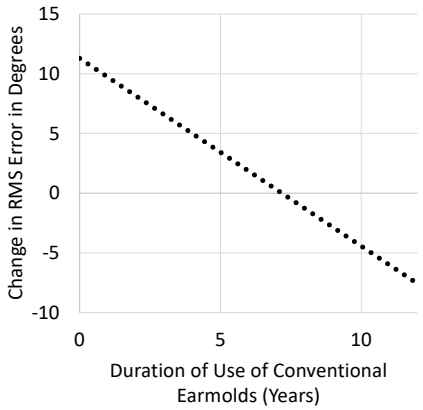
What they found…



- Considerable individual variability, but on the average the open fitting resulted in less localization error than the closed fitting in children with less experience with conventional earmolds.

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Why is this important…

- Children with experience with conventional earmolds immediately noticed improvements in own voice quality when fitted with open earmolds. Own voice quality can be important for hearing aid acceptance in adults and likely is an important factor for children.
- Children with hearing loss demonstrated localization accuracy in the horizontal plane that lagged far behind their peers with normal hearing.

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Does it matter clinically?

- Although in no way conclusive, this study suggests the following possibilities:
  - Open fittings have the potential to provide better localization than conventional earmolds in children.
  - Less experience with conventional earmolds may lead to better localization outcomes.
  - Poor own voice sound quality when using conventional earmolds may be far more important/noticeable in children than previously assumed. Open fittings have considerable potential to improve own-voice sound quality.

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Differences in Word and Phoneme Recognition in Quiet, Sentence Recognition in Noise, and Subjective Outcomes between Manufacturer First-Fit and Hearing Aids Programmed to NAL-NL2 Using Real-Ear Measures

Michael Valente
Kristi Oeding
Alison Brockmeyer
Steven Smith
Dorina Kallogjeri

*J Am Acad Audiol, 2018, 2*9, 706–721

Washington University in St. Louis

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What they asked…

- Are there differences between manufacturer's "first fit" and verified, prescriptive target fittings?
  - Word and phoneme recognition
  - Sentence recognition in noise
  - Perceived hearing aid benefit (APHAB)
  - Perceived speech intelligibility, spatial abilities, sound quality

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A little background…

- "First fit" versus verified fit
  - Probe microphone the "gold standard" and part of best practice guidelines by ASHA and AAA
  - 20-30% of audiologists routinely verify and program using probe microphone measures
  - Without verification, don't know if fitting to a validated prescription and risk providing sub-optimal audibility

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A little background…

Sanders et al (2015) *Hear Rev, 21*, 24-26, 28, 30, 32

- Evaluated difference between "first" fit and NAL-NL2 in 5 RICs from 5 manufacturers on 8 participants with high frequency sloping hearing losses
  - 74% of cases below NAL-NL2 at 55 dB SPL input
  - 55% of cases below NAL-NL2 at 65 dB SPL input
    - About 7-10 dB below
  - Cases at or above NAL-NL2 at 75 dB SPL input

Similar results reported over last several decades

- Swan & Gatehouse (1995) *Br J Audiol, 29,* 271 – 277
- Hostler et al (2004) *BSA News, 43,* 32 - 35
- Aarts & Caffee (2005) *Int J Audiol, 44,* 293 - 301
- Aazh & Moore (2007) *J Am Acad Audiol, 18,* 653 - 664
- Aazh et al (2012) *Am J Audiol, 21*, 175 – 180

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A little background…

- Using first fit might have negative consequences
  - Speech understanding in noise
    - Leavitt & Flexer (2012) *Hear Rev, 19,* 20 – 23
  - Perceived hearing aid benefit (and patient preference)
    - Abrams et al (2012) *J Am Acad Audiol, 23,* 768 - 778

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Why it matters…

- Substantial validation behind NAL-NL2 and DSL targets
- Deviation from target, especially without knowing what the deviation is, could reduce audibility, intelligibility, and ultimately hearing aid benefit

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What they did…

- Participants
  - 24 adults (*M* = 72 years), new hearing aid users, symmetrical, sensorineural loss
- Research design
  - Double-blinded, crossover
- Hearing aids
  - Custom, RIC hearing aids with earmolds
  - "Premium" aids with 16 channels, adaptive, multichannel directionality
  - Randomly assigned to "first fit" or "verified fit" group first

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What they did …

ANSI and dmic

1st visit	2nd visit	3rd visit (4 wk)	4th visit (4 wk)
▪ Comprehensive audio ▪ SRTs in quiet ▪ WRSs in quiet with recorded speech ▪ LDLs for "loud but okay" ▪ Selection (EMIs, color, wire)	▪ Info entered into Auricle ▪ Info entered into NOAH for "first fit" ▪ Measured REIG for 3 inputs ▪ Changed programming for "verified fit" ▪ No fine tuning	▪ Aided speech testing in quiet and in noise using R-space ▪ Questionnaires (APHAB and SSQ) ▪ Interview questions (what did you like? Not like?) ▪ Fit next setting	▪ Testing from 3rd visit in alternative condition

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What they found…

- REIGs
  - First-fit under target by 5 – 20 dB at 4000 Hz, larger differences at lower input levels
  - Programmed-fit under target by 5 dB at 4000 Hz and matched for moderate and higher input levels
- Preference
  - 79% preferred programmed-fit, more than half of these elected to purchase the hearing aids

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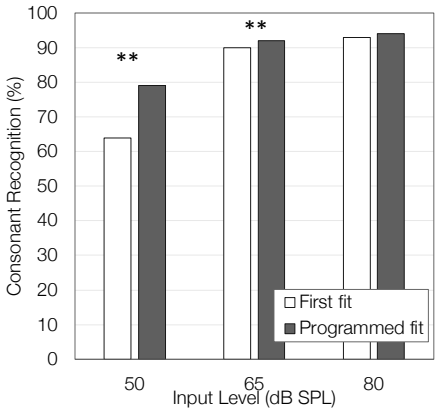
What they found…

- CNC in quiet
  - Benefit of programmed-fit for soft and moderate input levels
- Phonemes in quiet
  - Benefit of programmed-fit for soft inputs
- Speech in noise
  - No difference in fits



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What they found…

- APHAB
  - Problems in background noise 34% (first fit) versus 22.8% (programmed fit)
  - No other subscales demonstrated effect
- SSQ
  - No differences between first fit and programmed fit

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Why is this important…

- Programming to NAL-NL2 targets and verifying the settings provide more benefit in listening situations where patients need the most help
- Effects might be greater if participants had more hearing loss (most had normal low frequency hearing)
- Verification and use of validated prescriptive targets provides more hearing aid benefit

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Does it matter clinically?

- Yes
  - Effects are modest, but encouraging
  - Future work is warranted with different manufacturer first fits – they're proprietary and change all the time
  - Benefits in noise reduced because the instrument didn't become directional until background noise greater than 70 dB SPL
  - Benefits might be more dramatic if used a different methodology (one that didn't rely on retrospective patient reports)

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A preliminary investigation into hearing aid fitting based on automated real-ear measurements integrated in the fitting software: test–retest reliability, matching accuracy and perceptual outcomes.

Denys, S., Latzel, M., Francart, T., & Wouters, J. (2019). International journal of audiology, 58(3), 132-140.

A Comparison of Automated Real-Ear and Traditional Hearing Aid Fitting Methods

Folkeard, P; Pumford, J; Abbasalipour, P; Willis, N & Scollie, S. (2018). Hearing Review, November

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What they asked…

- Denys et al., (2019) - How does autoREMfit compare to manufacturer first fit and clinician fit of NAL-NL2 and DSL v. 5 in one hearing aid brand (Phonak) using one probe mic system (Otometrics Aurical).
- Folkeard et al., (2019) – How does autoREMfit compare to manufacturer first fit and clinician fit of DSL v. 5 in one hearing aid brand (Oticon) using one probe mic system (Audioscan Verifit 2).

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Why it matters…

- AutoREMfit procedures have been around for a while and are used clinically – knowing reliability and validity is important!
- Clinical time is valuable, any time saved when completing a procedure is likely a good thing as long as…
  - Quality is not compromised
  - Accuracy is not compromised
  - Building patient rapport is not compromised

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What they did…

- Denys et al., (2018)
- 10 participants (20 ears)
- Clinician experience unknown, but perhaps limited.
  - Guided probe depth through REUR
- Standard BTEs with appropriately vented earmolds
- Compared fit to target and test re-test

- Folkeard et al., (2019)
- Twenty two participants
- Experienced clinician
- RIC style hearing aid with appropriate dome.
- Measured individual RECD
- Compared fit to target and test re-test

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What they did…

- Denys et al., (2018)
- Fittings completed over multiple weeks
- Two, two-week home trials to compare First Fit and AutoREMfit only
  - Speech recognition in quiet and noise, SSQ12
  - Generally underpowered statistically. No significant differences.

- Folkeard et al., (2019)
- Completed all three measures without moving probe tube.
- Calculated SII
- Measured time spent

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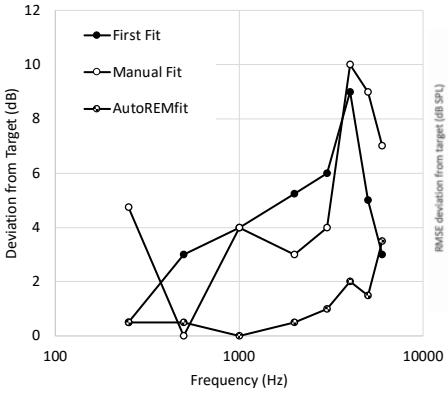
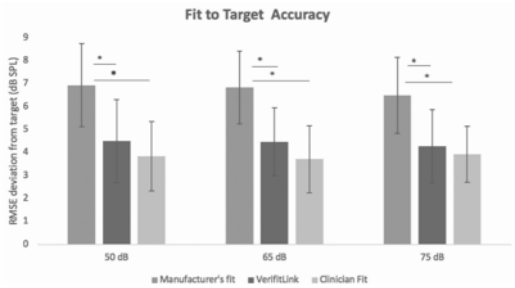
What they found…



Denys et al., (2018)



Folkeard et al., (2019)

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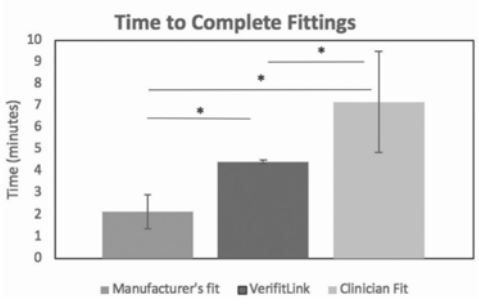
- AutoREMfit appears to be as accurate and at least as reliable (SD < 3 dB) as an experienced clinician using manually fitting.
  - Also leads to equivalent SII.
- Inexperienced clinicians may be rather inaccurate.
- Bilateral autoREMfit took about 4 1/2 minutes with little variation.
- Clinician fit took about 2 ½ - 3 minutes longer, but with much more variability (in some cases nearly 10 minutes with an experienced clinician).

Why is this important…



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Does it matter clinically?

- Three minutes in a busy clinic is pretty substantial. It frees up significant time to do other important tasks.
- Some methods also include probe tube depth guides which can improve reliability, particularly for inexperienced clinicians.
- Some methods force you to use an individualized REUR (essentially fitting to REIG targets) which may be an issue for some clinicians.

Efficacy and Effectiveness of Advanced Hearing Aid Directional and Noise Reduction Technologies for Older Adults With Mild to Moderate Hearing Loss

Yu-Hsiang Wu
Elizabeth Stangl
Octav Chipara
Syed Shabih Hasan
Sean DeVries
Jacob Oleson

Ear and Hearing, publish-ahead-of-print

The University of Iowa

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What they asked…

- How do premium directional microphones and noise reduction compare to basic directional microphones and noise reduction in terms of:
  - Efficacy – how well does something work in the best possible scenario
  - Effectiveness – how well does a feature actually work in a "real world" setting

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A little background…

- Directional microphones are becoming more advanced
  - Fixed directionality that cannot change polar pattern
  - Multichannel, adaptive directionality that can steer the null towards the noise independently for each channel
    - Bilateral beamformers
    - Speech-seeking directional microphones
- Digital noise reduction is becoming more advanced
  - Single channel, slow
  - Multiple channels, fast
  - Detect and reduce broader range of sounds
    - Reverberation, impulse noise, wind noise

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A little background…

- Feature benefits evident in laboratory studies
  - Directional microphones can improve speech recognition performance in noise
  - Digital noise reduction can increase ease of listening

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A little background…

- Feature benefits less consistent in "real world"
  - Results with directional microphones are mixed
  - Studies with noise reduction are scarce

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A little background…

- How should we measure efficacy (feature benefits in best case scenario)?
  - In sound fields with multiple noise sources of different frequencies
  - When talker is not in the front
  - With sounds that reflect algorithm's maximum effectiveness (wind, impulse, steady state)

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A little background…

- How should we measure effectiveness (how well a feature actually works in real-world settings)?
  - Standardized questionnaires (retrospective self-reports)
    - Might be prone to recall bias
  - Ecological momentary assessment (EMA)
    - Also known as "experience sampling" or "ambulatory assessment"

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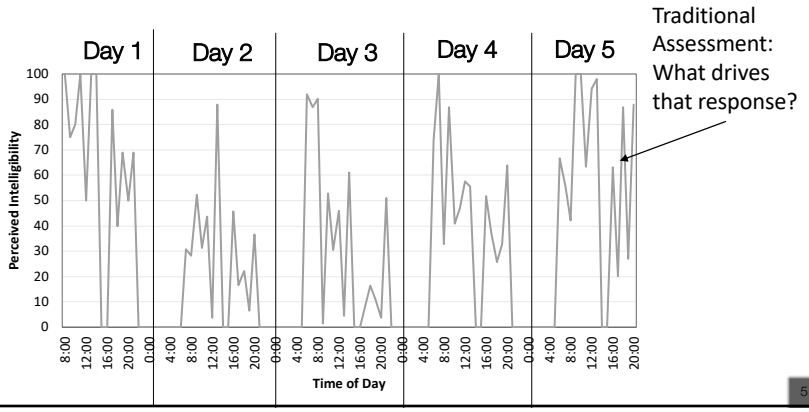
A little background…

- What is "EMA"?
  - Ecological momentary assessment



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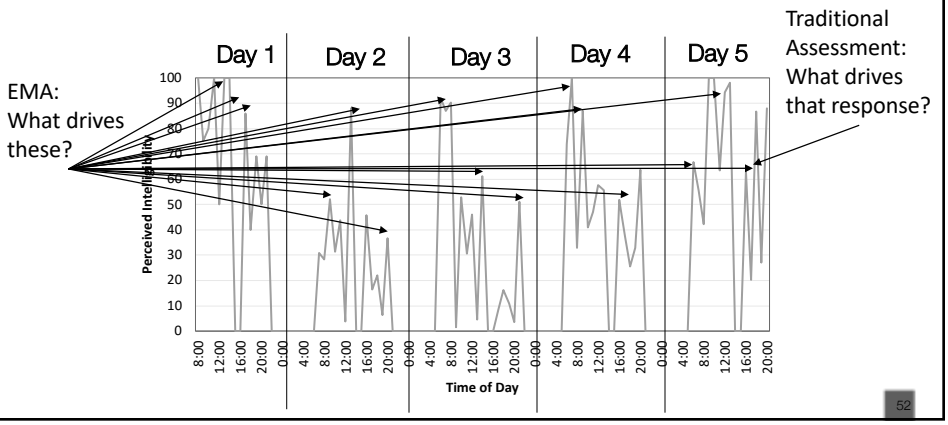
A little background…

- What is "EMA"?
  - Ecological momentary assessment



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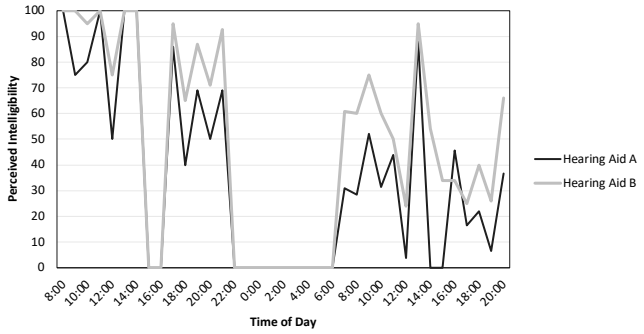
A little background…

- What is "EMA"?
  - Ecological momentary assessment



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Why it matters…

- Need to understand realistic expectations for feature benefits, both on/off and basic/premium
  - In the laboratory
  - In the real world

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What they did…

- Design
  - Single-blinded, crossover repeated measures
- Participants
  - 54 participants; 65 – 88 year old
  - Eastern Iowa and northwestern Illinois (city, town, farms)
  - Post-lingual, bilateral, SNHL, PTA better than 65 dB HL

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What they did…

Hearing aids

- Basic ($1500 / pair)
  - Automatic adaptive directionality
  - 1 beamforming channel
  - 12 channel, gain reduction, digital noise reduction
- Premium ($5000 / pair)
  - Automatic adaptive directionality
  - 33 beamforming channels
  - Manually-active, speech-seeking directionality
  - 20 channel, gain reduction, digital noise reduction
  - Impulse noise reduction
  - Reverberation reduction
  - Spatially-based noise reduction

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What they did…

Laboratory measures

- Speech recognition (HINT)
  - Adaptive speech, 65 dB background noise, low reverberation
  - S0Ndiffuse, S0Ndiscrete, S0Ndiffuse, S90Ndiffuse, S180Ndiffuse
- Paired comparisons (listening effort, naturalness, annoyance)
  - Stimuli recorded through hearing aids and played to participants
  - S0N0 babble, S0reverberation, S0N0transient, S0N180wind, S0N180babble
- Scale rating (listening effort, naturalness, annoyance)
  - 21 point rating scale
- Localization
  - Front/back localization (0 or 180 degrees)

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What they did…

Retrospective self-reports

- Abbreviated Profile of Hearing Aid Benefit (APHAB)
  - Cox & Alexander (1995)
  - Ease of communication, background noise, reverberation, aversiveness
- Speech, Spatial, and Qualities Hearing Scale (SSQ)
  - Gatehouse & Noble (2004)
  - Understand speech, localize events, auditory experience of music and naturalness
- Satisfaction with Amplification in Daily Life (SADL)
  - Cox & Alexander 1999
  - Positive effect, personal image, negative features, service / cost

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What they did…

Ecological momentary assessment (EMA)

- Completed surveys approximately every 2 hours
- Answered questions about experiences over the last 5 minutes
  - Where you listening to speech? How noisy was it? Were you using hearing aids?
  - How much speech did you understand? (0-100%)
  - How much effort was required to listen effectively? (very easy-very effortful)
  - Were you satisfied with loudness (not good at all-just right)
  - Could you tell where sounds were coming from? (not at all-very satisfied)
  - Were you satisfied with your hearing aids? (not at all-very satisfied)

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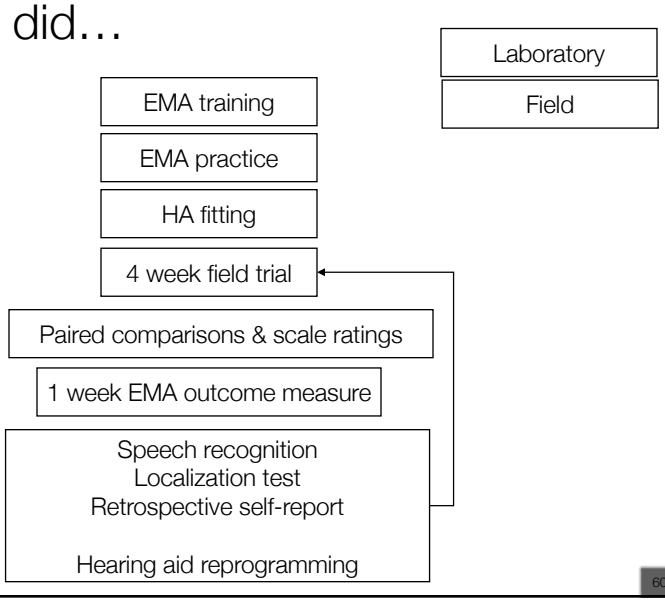
What they did…



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What they found (laboratory)…

- Speech recognition in noise
  - No differences between "premium off" and "basic off"
  - More benefit from premium features than basic features
  - Basic on *reduced* speech recognition for S180Ndiffuse
- Localization
  - Feature benefits with premium device only

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What they found (laboratory)…

- Paired comparisons
  - Listening effort –basic / premium equivalent
    - On better than off in some conditions (e.g., S0N0)
  - Sound quality – on/off and basic / premium equivalent
    - Premium worse for wind as a result of artifacts

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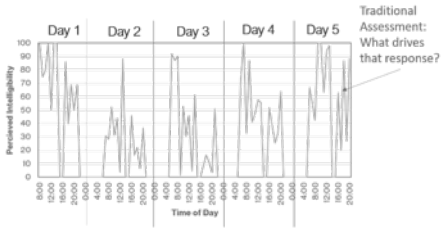
What they found (retrospective)…

- Features improved satisfaction speech understanding and satisfaction with basic and premium instruments
- Other retrospective surveys were equivalent



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What they found (EMA)…

- 7579 surveys (!) – participants completed surveys between 5 and 6 times a day
- Only 11% of surveys were “noisy” or “very noisy”
- In quiet, speech recognition scores were high
- In noise, scores for “feature on” were
  - 14% points higher with premium
  - 9% points higher with basic

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What they found (EMA)…

- Speech understanding: premium = basic
- Loudness: features help, premium better
- Listening effort: features similar, basic better
- Localization: features help in noise, basic better
- Satisfaction: features help, premium better

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Why is this important…

- All features help in the lab
  - Effects are robust
  - Premium instruments outperform basic instruments
- All features help in the retrospective reports
  - Benefits are small
  - Insensitive to premium versus basic
- All features help in the "real world"
  - Effects are strong
  - Benefits of premium versus basic are weak

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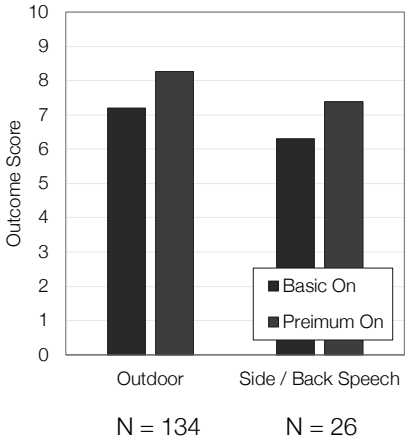
Does it matter clinically…

Yes, but…

- Noted benefits in laboratory might be imperceptible in "real world"
- Patients might not be in situations where benefit would be expected very often (especially in Iowa?)
  - Premium features work better in specific environments
- Highlights the need for instrument-specific counseling
  - Training for orientation
  - Training for switching to access "speech seeking" directionality



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Summary and Conclusions

- Noise reduction and directionality help patients in the "real world." Premium, noise reduction features further help in laboratory situations, but their benefits might be less noticeable:
  - Situation-specific expected benefits
  - Need for user training
- Verification and use of validated prescriptive targets provides more hearing aid benefit
- Matching to target can be done reliably and quickly with automated REM systems, but watch out for systems that require REUG measurements

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Summary and Conclusions

- Open fittings in children provide for better localization and own voice ratings than conventional earmolds
- Patients who use hearing health care services spend less Medicare money
- Hearing aid adoption rates are lowest right before lunch and right before the end of the day (12 and 4)

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Thank You!

Questions?