Functional Hearing Difficulties: Detecting What the Audiogram Misses

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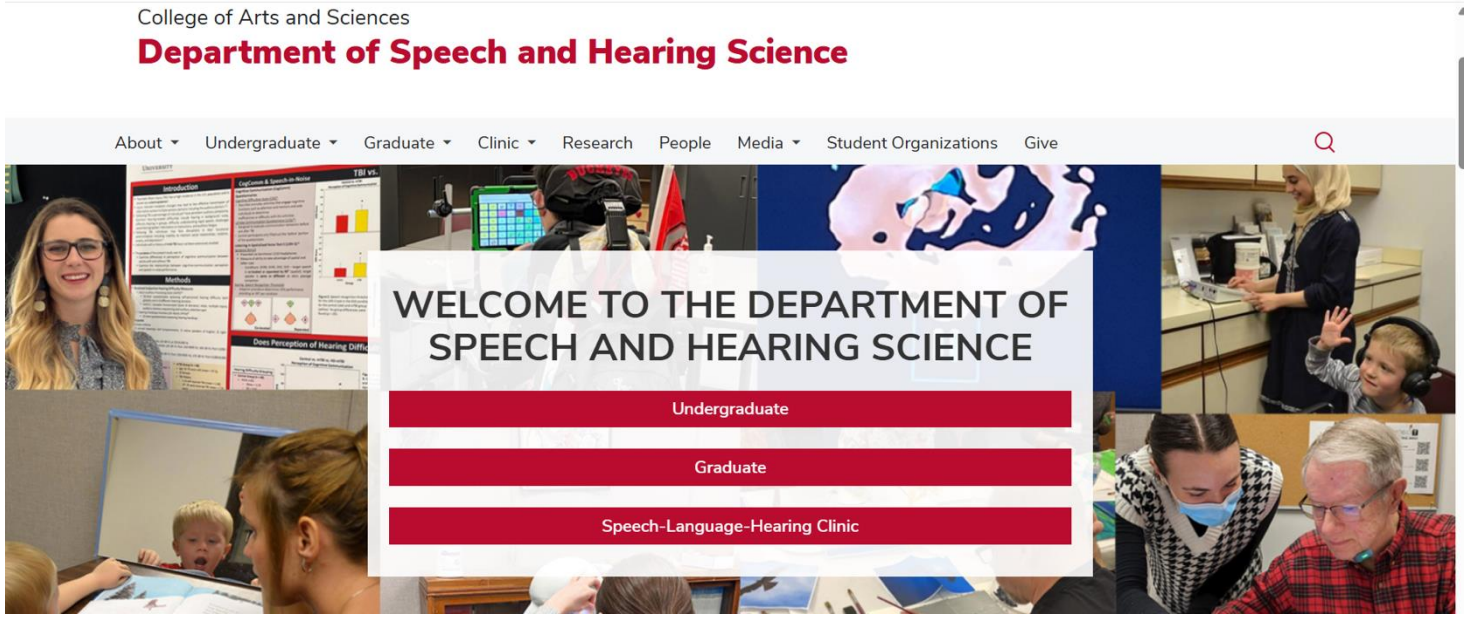
Disclosures

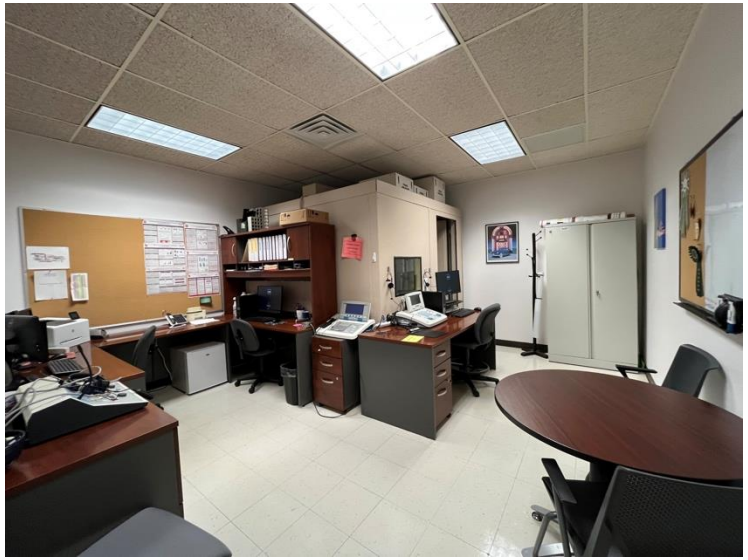
Relevant Financial/Non-Financial Relationships

1. Employed by The Ohio State University
2. Editor-in-Chief for the American Journal of Audiology
3. Co-Chair, American Academy of Audiology Guidelines Committee for the Management of Adult Hearing Loss

Department of Speech & Hearing Science



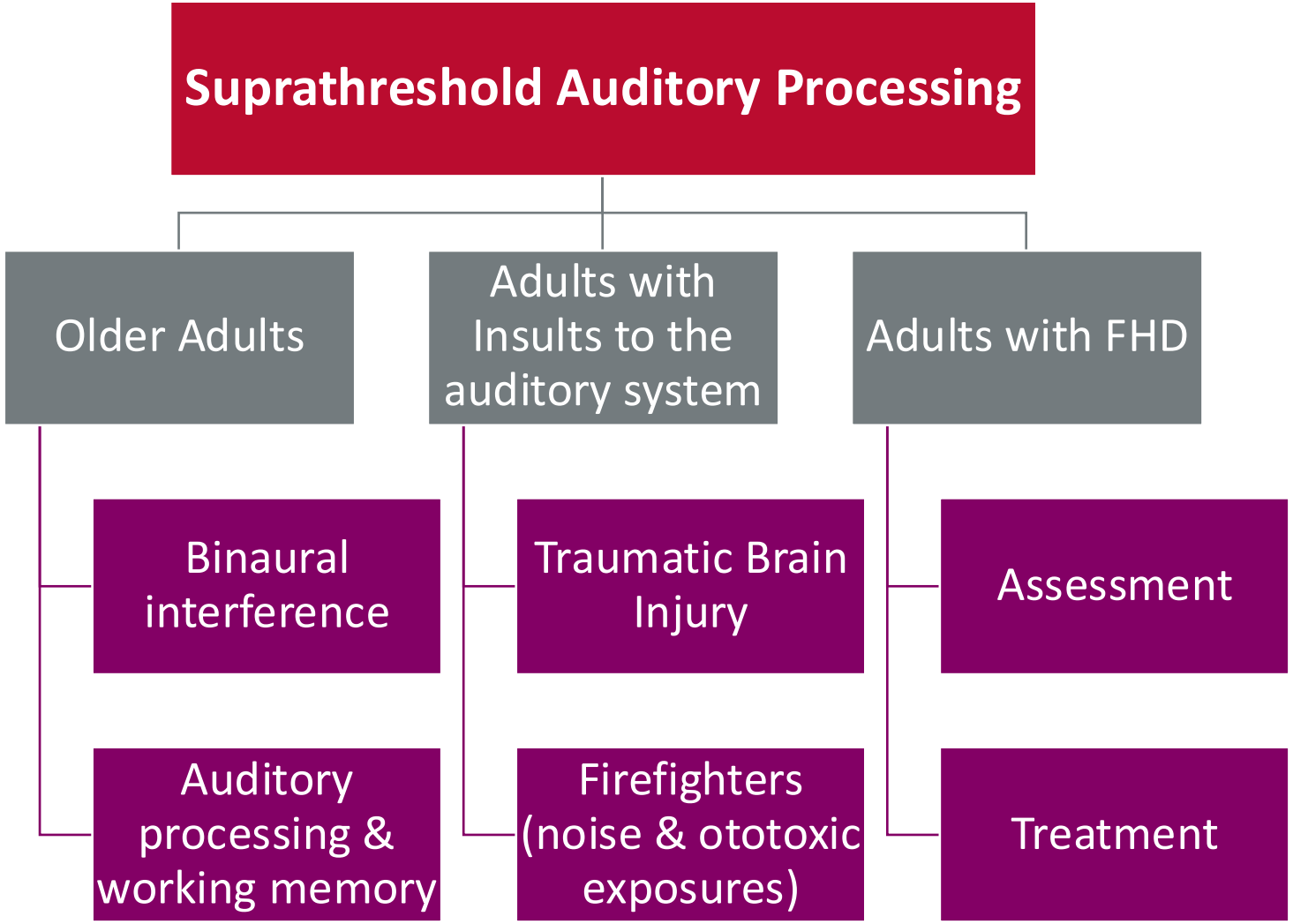
SRA Lab



OSU BrainCARE GRADUATE

Speech Recognition & Aging Lab at OSU

What we study . . .



My Clinical Collaborators

Gail Whitelaw, PhD

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Outline

- Introduction to FHD
- Redefining "Normal" Hearing
- Assessment of FHD
- Case Examples

3 Components of a Standard Assessment of Auditory Function: Theoretical & Clinical Framework

Patient Self-Perception of Hearing	Objective & Detection Measures of Hearing	Suprathreshold Behavioral Measures of Hearing

• Case history
• Maybe:
  • Standardized questionnaires or PROMS
	• Tympanometry & acoustic reflexes
	• Pure-tone thresholds
	• SRT
	• Maybe:
	  • OAEs / AEPs
		• Word recognition in quiet
		• Speech-in-noise
		• Maybe:
		  • Auditory processing test battery

?

3 Components of a Standard Assessment of Auditory Function: Theoretical & Clinical Framework

Do the test results align?

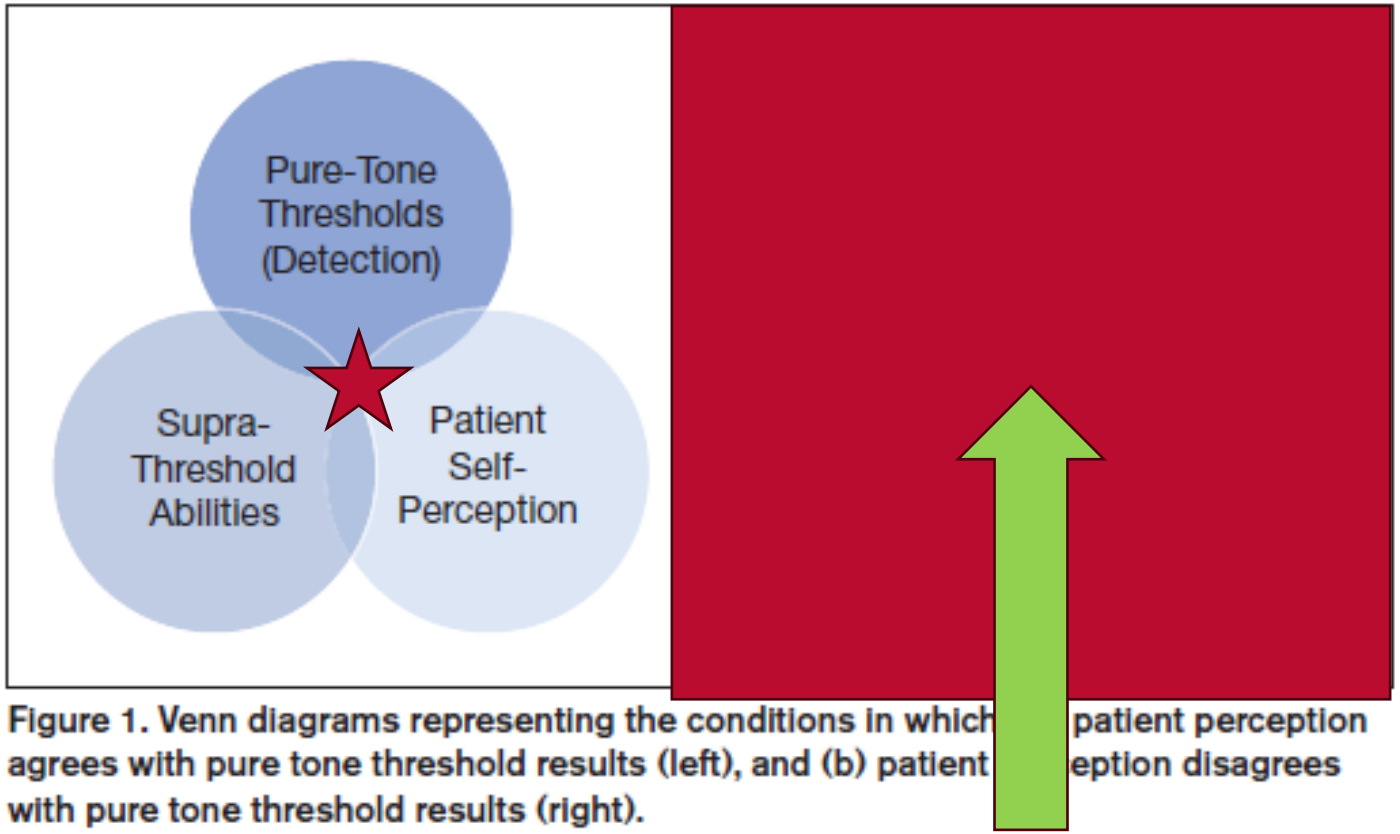
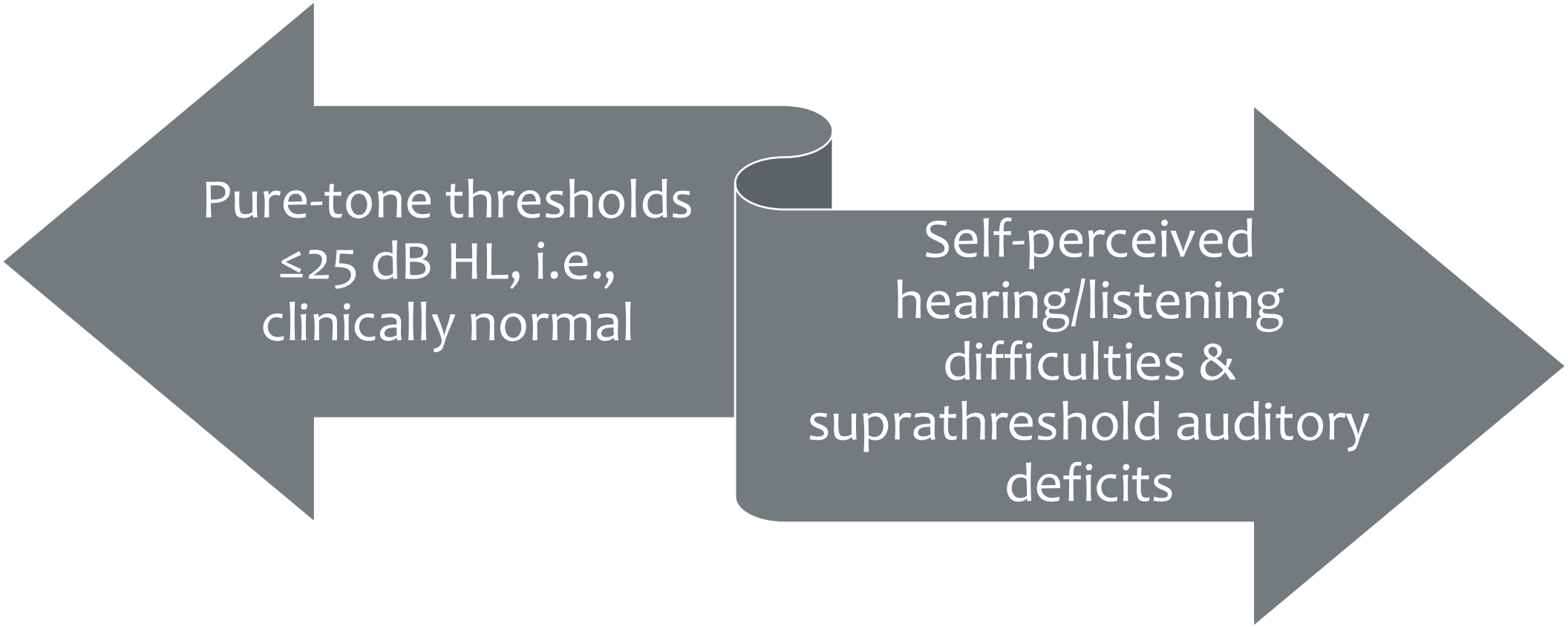


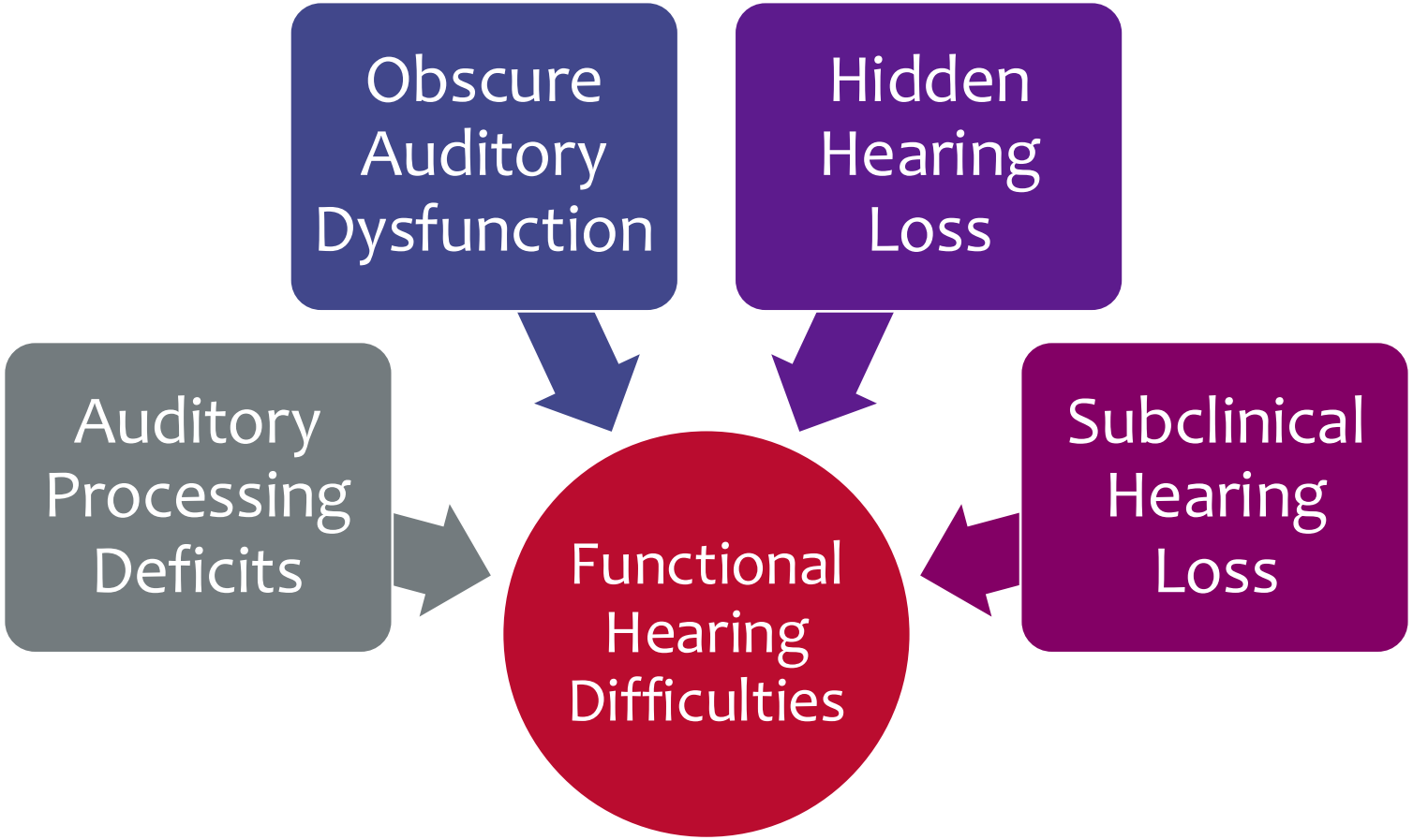
Figure 1. Venn diagrams representing the conditions in which patient perception agrees with pure tone threshold results (left), and (b) patient eption disagrees with pure tone threshold results (right).

Functional Hearing Difficulties

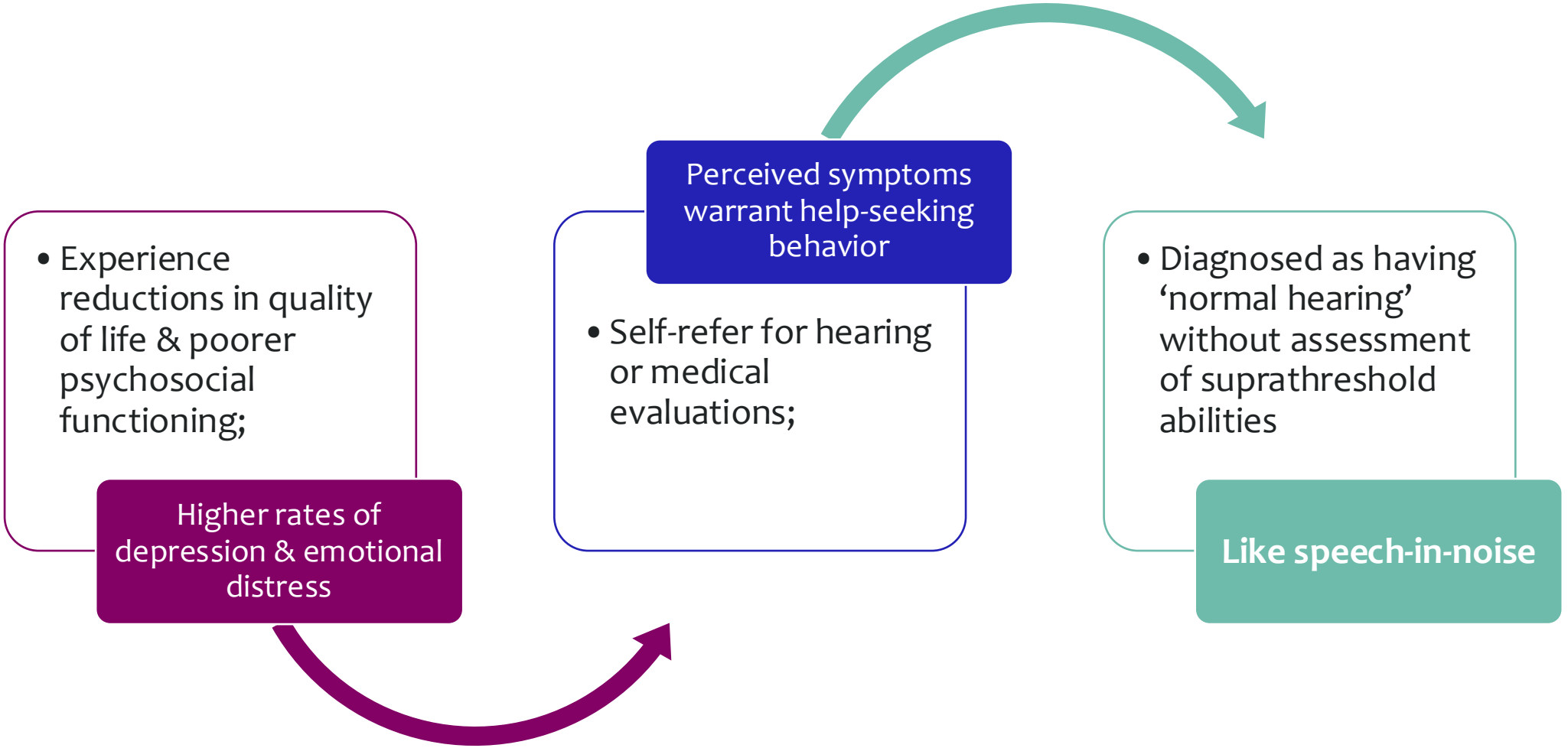
Defining FHD: Clinical Presentation



Defining FHD: Other Common Terms



FHD: Why is this population important?



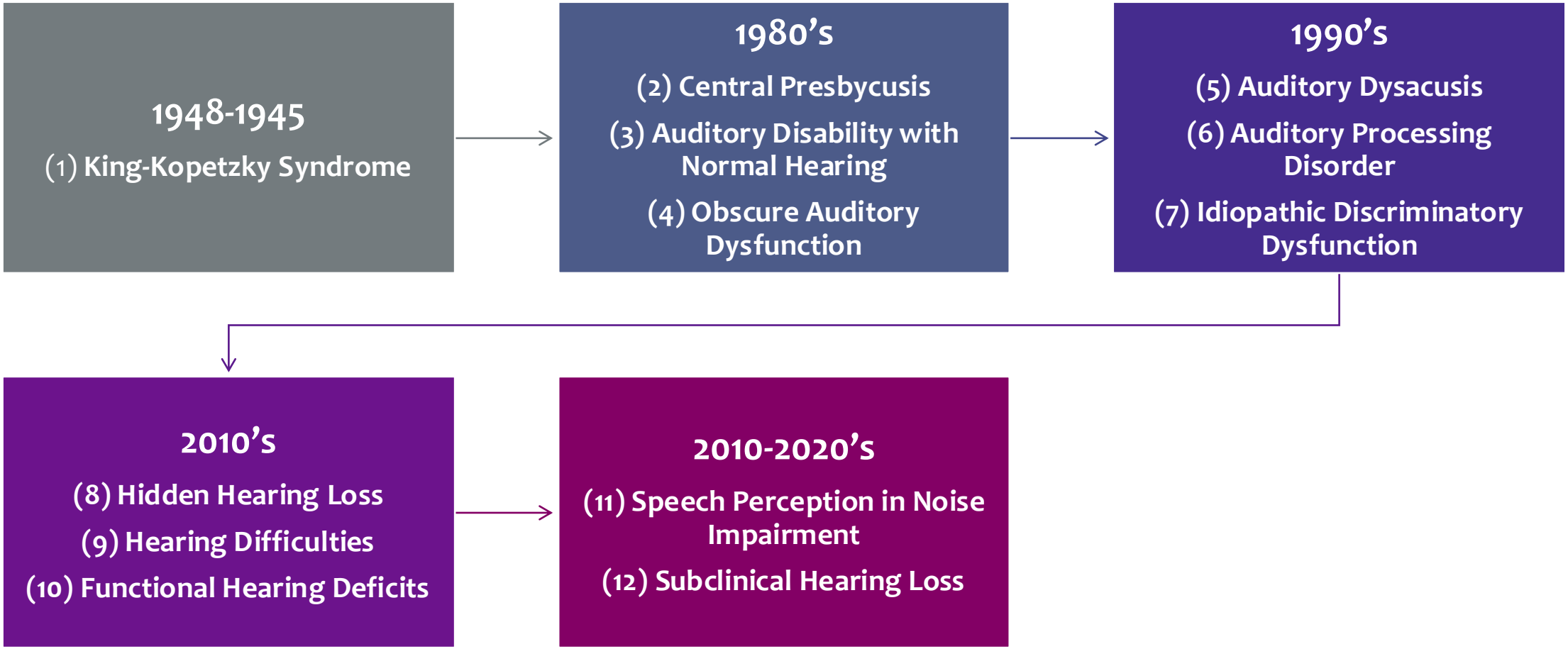
Saunders & Haggard (1989); Zhao & Stephens (2000); Tremblay et al. (2015)

‘Functional Hearing Difficulties’ (FHD)

Audience!

1. How many of you have heard of functional hearing difficulties – maybe by another term?
2. How many FHD patients have you seen clinically?

FHD: Is this something new?



(1) Hinchcliffe (1992); (2) Welsh et al. (1985); (3) Stephens & Rendell (1988); (4) Saunders & Haggard (1989); (5) Jayaram et al. (1992); (6) Jerger et al. (1990); (7) Rappaport et al. (1993); (8) Schaette & McAlpine (2011); (9) Tremblay et al (2015); (10) Phatak et al. (2018); (11) Guest et al. (2018) (12) Golub et al. (2020)

FHD: What populations are affected?

(1) Helfer & Vargo (2009); (2) Leigh-Paffenroth & Elangovan (2011); (3) Dubno et al. (2002); (4) Hannula et al. (2011); (5) Musiek et al. (2005); (6) Vignesh et al. (2016); (7) Roup et al. (2023); (8) Lander et al. (2024); (9) Kumar et al (2012)

FHD: How prevalent is this condition?

25.3M

Adults in the U.S.

Edwards (2020); Tremblay et al. (2015)

10-33%

Young to middle-aged adults

Demeester et al. (2012); Dragon et al. (2023); Tremblay et al. (2015)

51%

Older adults

Hannula et al. (2011)

Self-report hearing difficulties or speech-in-noise problems

FHD: What is the impact on clinical audiology?

10%

Referrals to ENT clinics

Saunders & Haggard (1989);

Billings et al. (2018)

1-3

Audiology patients per month

Koerner et al. (2020)

=

Motivated to seek treatment as adults with mild to moderate HL

Alicea & Doherty (2017)

FHD: What's the clinical implication?

Patients with FHD who seek audiologic assessment frequently report:

- Dissatissfaction with their clinical experience[1]
- Being 'dismissed' by healthcare providers[1,2]
- Not having their symptoms taken seriously by the audiologist[1]
- Lack of alignment between patient concerns and assessment protocols[2]
- Doctor shopping[2]

(1) Pryce & Wainwright (2008); (2) Kamerer et al. (2025)

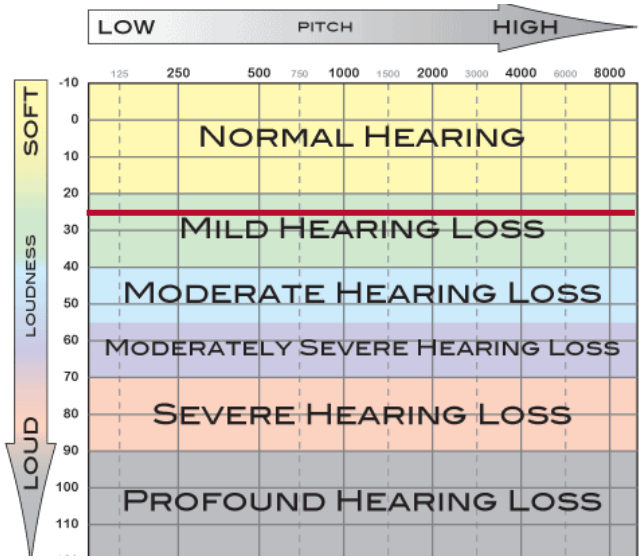
Outline

- Introduction to FHD
- Redefining “Normal” Hearing
- Assessment of FHD
- Case Examples

What does it mean to have 'normal hearing'?

Normal Hearing

≤20-25 dB HL



Common 'Degree' of HL Descriptors *(Goodman, 1965)*

OR, "categories of convenience"

Assumption: The degree of HL reflects the degree of communication difficulty

Evidence: Generally, as degree of hearing loss increases, so do deficits in speech recognition[1] and self-reported hearing handicap[2,3]

Inherently Problematic!

1. Failure to accurately predict supratheshold abilities or hearing handicap for many adults – *especially those in the "normal" threshold range*
2. Fails to consider the contribution of extended high-frequency hearing (>8000 Hz)

(1) Hornsby et al. (2011); (2) Ventry & Weinstein (1982); (3) Wiley et al. (2000)

Does threshold elevation within the ‘normal’ range matter?

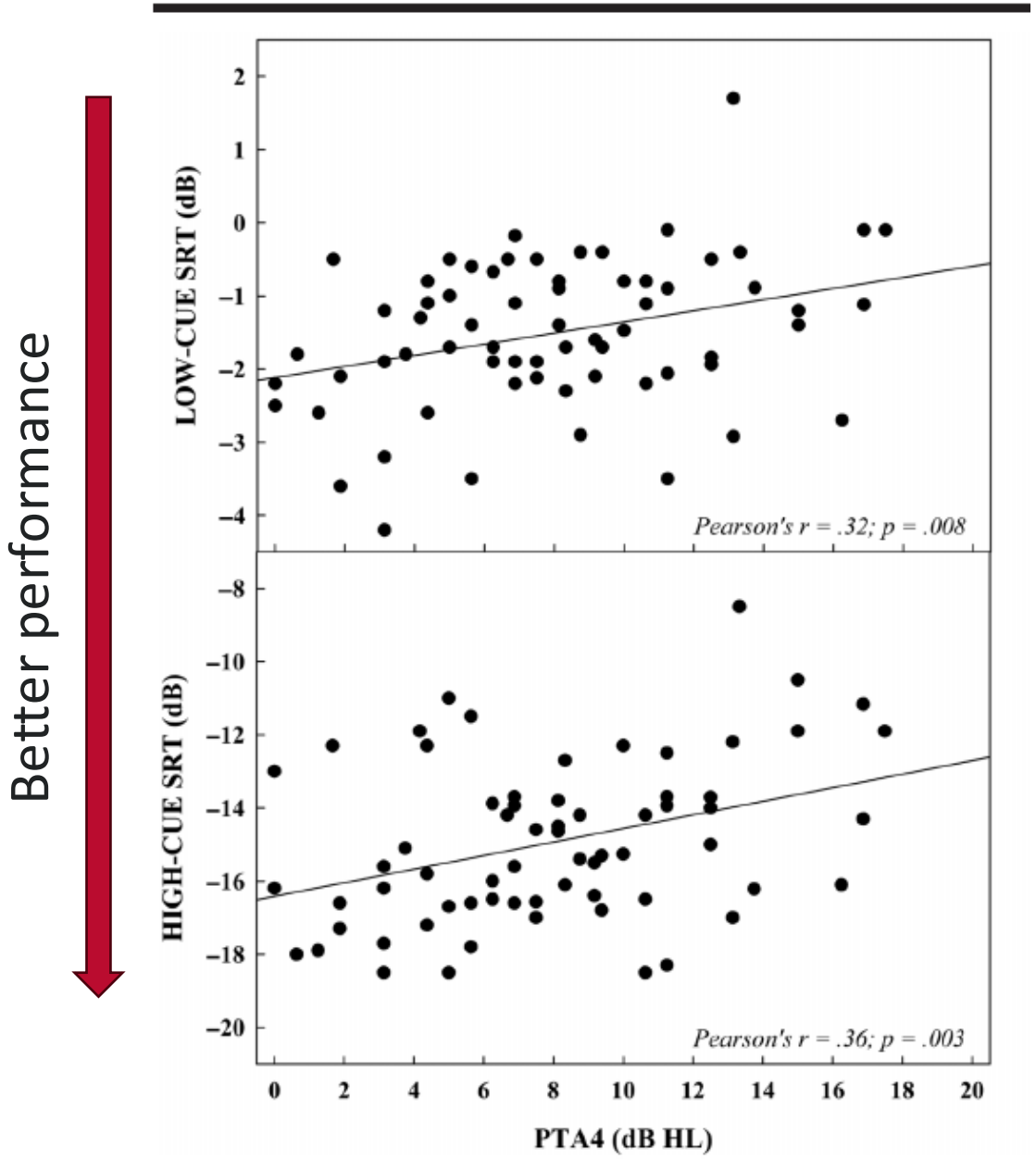
Influence of Threshold Elevation in the "Normal" Range

Speech-in-noise performance

vs.

PTA4

(500-4000 Hz)



Roup, Custer, & Powell (2021)

Influence of Threshold Elevation in the "Normal" Range

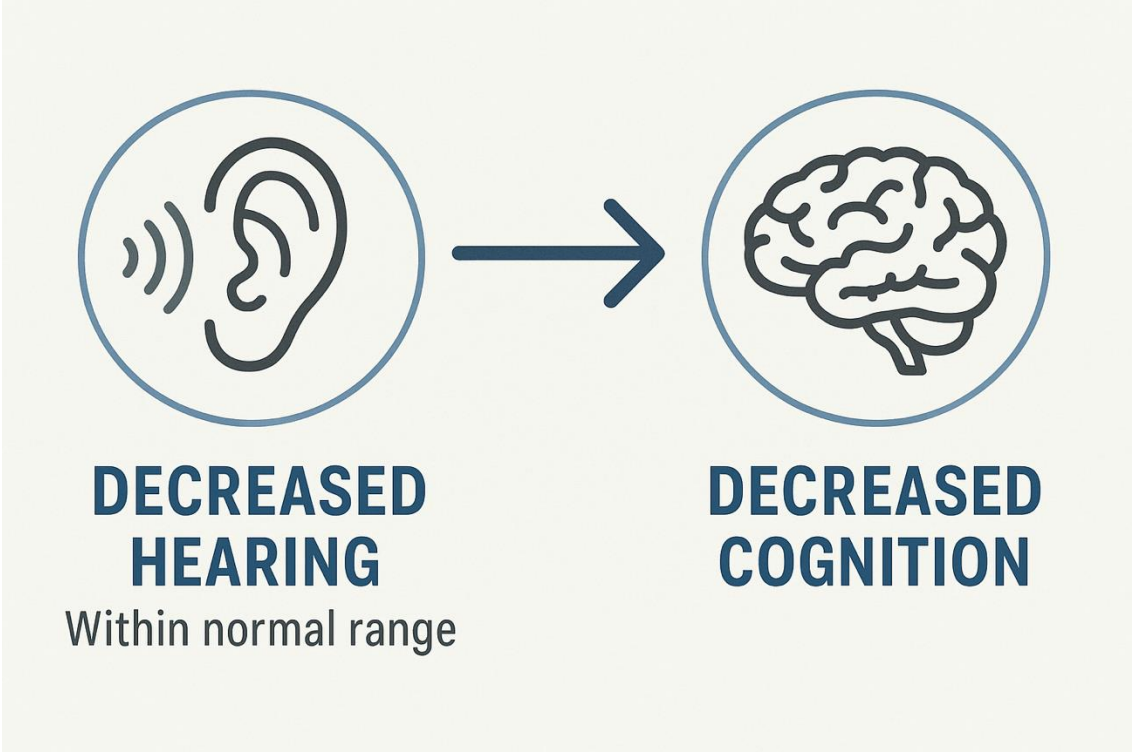
On cognitive performance

Adults from the (n = 6451, 50+ years):

- Hispanic Community Health Study
- National Health and Nutrition Examination Study
- PTA4 ≤25 dB HL

Association of Subclinical Hearing Loss With Cognitive Performance

Justin S. Golub, MD, MS; Adam M. Brickman, PhD; Adam J. Ciarleglio, PhD; Nicole Schupf, PhD; José A. Luchsinger, MD, MPH



Influence of Threshold Elevation in the "Normal" Range

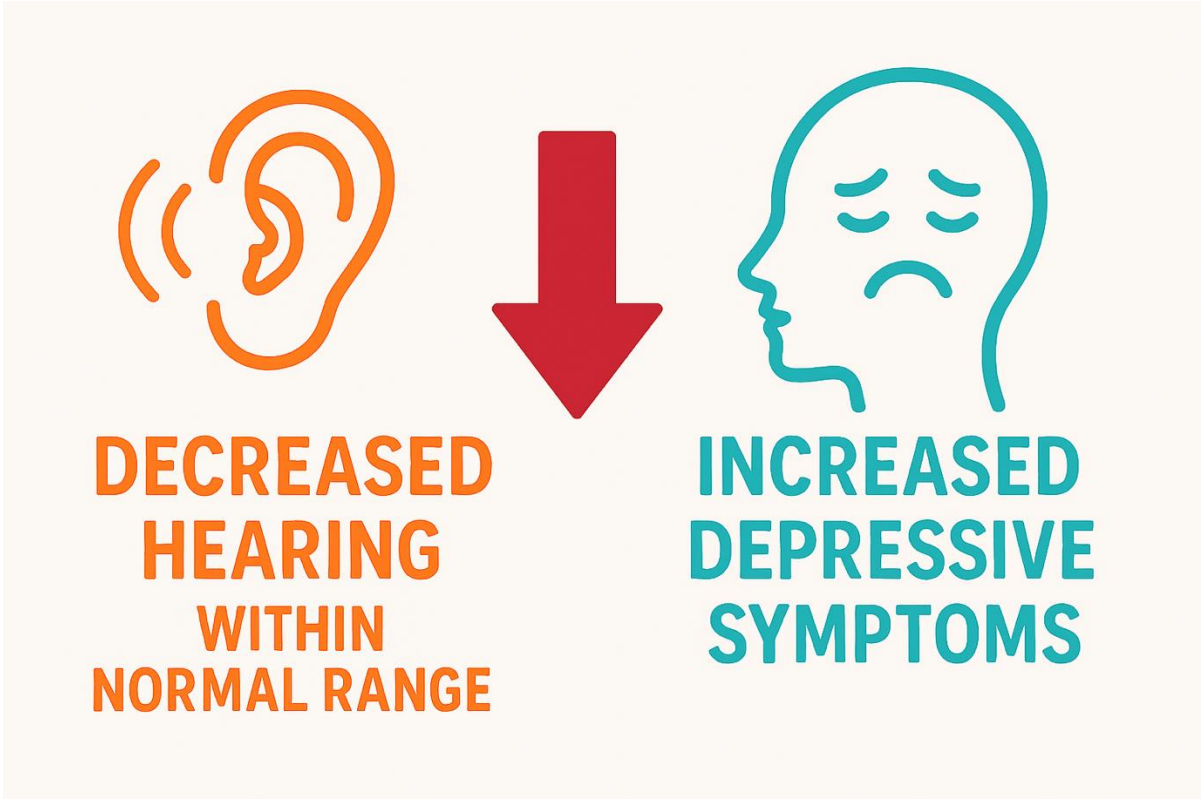
On depressive symptoms

Adults from the :

- Hispanic Community Health Study
- (n = 5499, 50+ years)
- PTA4 ≤25 dB HL

Subclinical Hearing Loss is Associated with Depressive Symptoms

Justin S. Golub, MD, MS[1], Katharine K. Brewster, MD[2], Adam M. Brickman, PhD[3], Adam J. Ciarleglio, PhD[5], Ana H. Kim, MD[2], José A. Luchsinger, MD, MPH[4,6], Bret R. Rutherford, MD[2]



Redefining ‘normal hearing’

Clinical Implication?

Reconsideration of the upper limit of normal hearing to **15 dB HL** *(Martin & Champlin, 2000)*

Reconsidering the Limits of Normal Hearing

Frederick N. Martin*
Craig A. Champlin*

20Q: What Exactly is “Normal” Hearing?

Christopher Spankovich, AuD, PhD, MPH

October 7, 2024

Articles / 20Q with Gus Mueller / Hearing and Hearing Loss / 20Q: What Exactly is “Normal” Hearing?

Audiologyonline/20q-what-exactly-normal-hearing

Why?

- *Slight threshold elevation matters!*
- ***Functional Impact:*** *People with thresholds in the 15–25 dB range often experience difficulties in noisy environments or with hearing speech.*

Mysteries of the Hearing Brain: What is Normal Hearing?

By Samira Anderson, AuD, PhD

Canadian Audiologist/mysteries-of-the-hearing-brain

Outline

- ✓ Introduction to FHD
- ✓ Redefining “Normal” Hearing
- Assessment of FHD
- Case Examples

Assessment Protocol

Managing Adults with Subjective Hearing Difficulties

By Christina M. Roup, PhD; Gail M. Whitelaw, PhD; and Jodi Baxter, AuD

CAREFUL CASE HISTORY

AUTHENTIC SUBJECTIVE ASSESSMENT

STANDARD AUDIOMETRIC ASSESSMENT

SUPRATHRESHOLD AUDITORY PROCESSING ASSESSMENT

Roup, CM, Whitelaw, GM, & Baxter, JM. (2019). Managing adults with subjective hearing difficulties. The Hearing Journal, 72(2), 34, 36-37.

Careful Case History

Specific to hearing difficulty:

1. Situations or situational difficulty
2. Duration of difficulty
3. History of insults
   - Head injury (e.g., TBI or concussion), noise exposure (ie., hidden hearing loss), etc.
4. Co-morbidities
   - Tinnitus or sound tolerance disorders
   - Other diagnoses (e.g., autism, ADHD), mental health, psychosocial functioning, etc.

Authentic Subjective Assessment

Further **quantification and validation** of symptoms through the use of:

- Standardized questionniares or Patient-reported outcome measures (PROMS)
  - Why?
    - *“Hearing threshold data are not particularly predictive of self-perceived hearing handicap . . .” (Palmer et al., 2009)*

- Consideration of cognitive status . . . Why?
  - Cognitive screening & scope of practice

Cognitive Screeners

Mini Mental State Examination (MMSE)[1]
Montreal Cognitive Assessment (MoCA)[2]
SAGE: Self-Administred Gerocognitive Exam[3]

(1) Folstein et al. (1975); (2) Nasredinne et al. (2005); (3) Scharre et al. (2010)

Authentic Subjective Assessment: Tools

Lots of questionnaires to choose from!

- **Hearing Handicap Inventory for Adults/Elderly (HHIA/E)** *(Ventry & Weinstein, 1982; Newman et al., 1990)*
  - Plus, a more recent revised version *(Cassarly et al., 2020)*
- Speech, Spatial, and Qualities of Hearing Scale (SSQ) *(Gatehouse & Noble, 2004)*
- Abbreviated Profile of Hearing Aid Benefit (APHAB) *(Cox & Alexander, 1995)*
- Functional Hearing Questionnaire (FHQ) *(Saunders et al., 2015)*
- Client Oriented Scale of Improvement (COSI) *(Dillon et al., 1999)*
- University of Cincinnati Auditory Processing Inventory (UCAPI) *(Keith et al., 2019)*
- **Adult Auditory Performance Scale (AAPS)** *(Roup et al., 2021)*

- *To name just a few!*

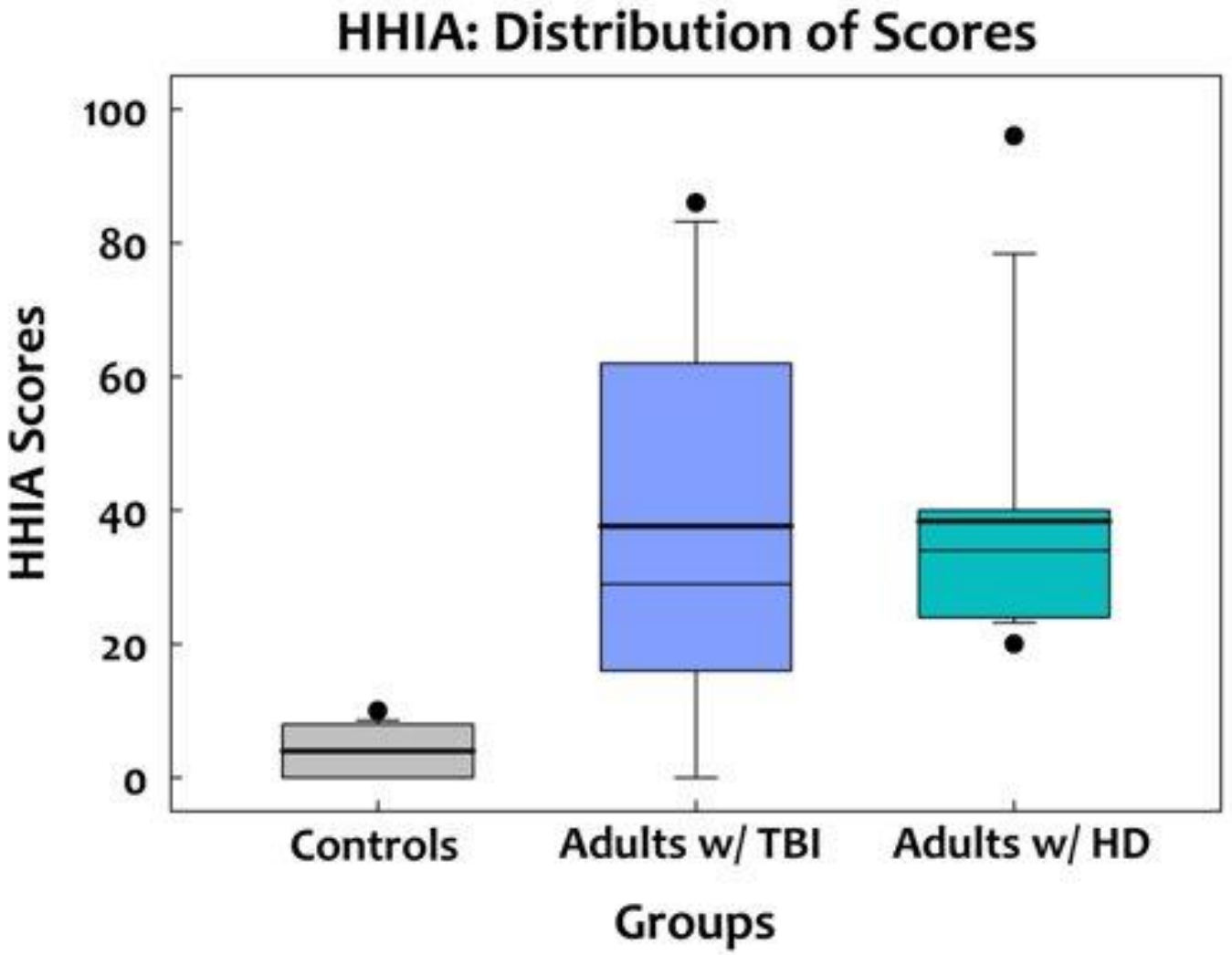
Authentic Subjective Assessment:

Hearing Handicap Inventory

Hearing Handicap Inventory for Adults/Elderly/Revised

- 25-item full-version
- 10-item screening version
- Revised version = 18-items

Does the HHIA/E differentiate adults with FHD vs. those without?



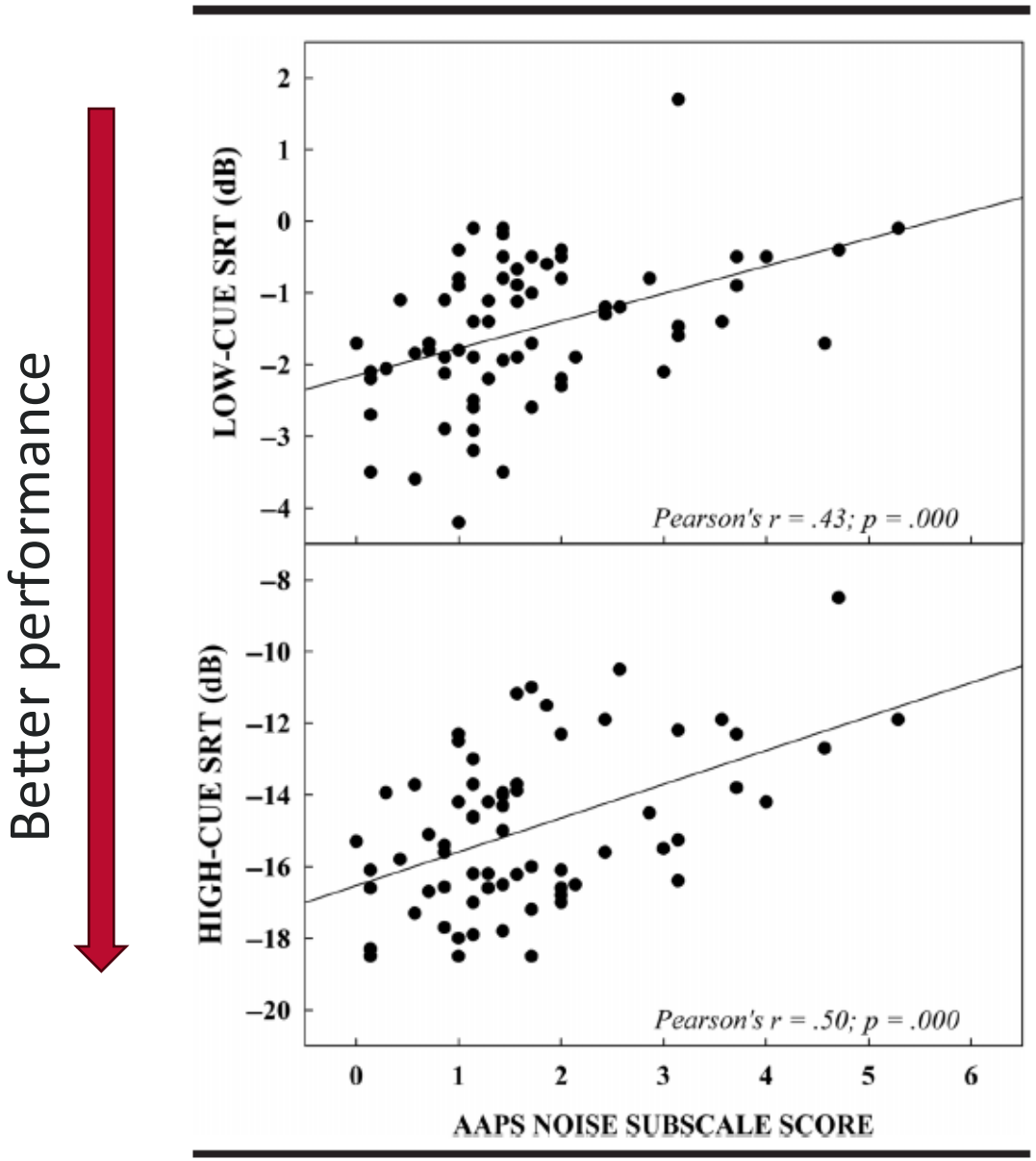
Roup, Post, & Lewis (2018); Roup et al. (2023)

Authentic Subjective Assessment: AAPS

Self-perceived hearing in noise

vs.

Speech-in-noise performance



Roup, Custer, & Powell (2021)

Assessment Protocol

Audience!
How many of you consistently use a subjective assessments, or standardized questionnaires (PROM) with your patients?

CAREFUL CASE HISTORY

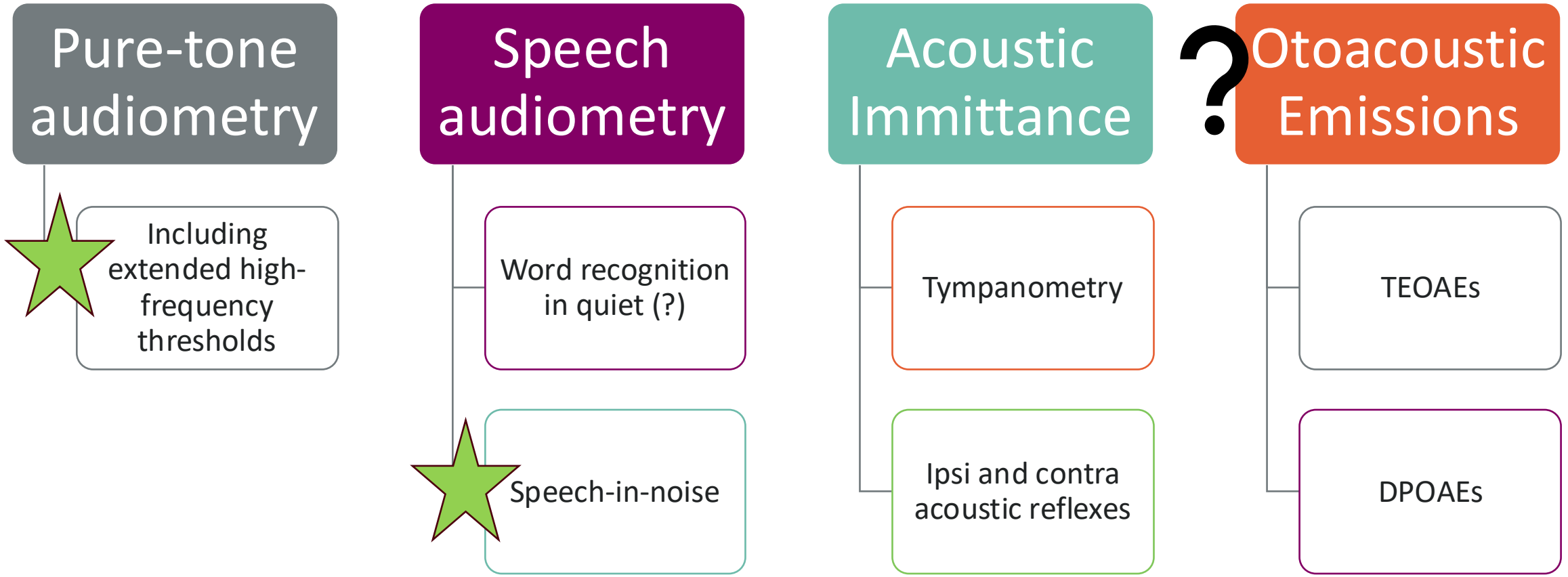
AUTHENTIC SUBJECTIVE ASSESSMENT

STANDARD AUDIOMETRIC ASSESSMENT

SUPRATHRESHOLD AUDITORY PROCESSING ASSESSMENT

Roup, Whitelaw, & Baxter (2019)

Standard Audiometric Assessment



Pure-Tone Audiometry

Standard Frequencies
250-8000 Hz

Extended High-Frequencies 10-16 kHz

FHD & Extended High-Frequency Thresholds

What does the evidence tell us?

Individuals with FHD have poorer EHF thresholds compared to controls

- *Shaw et al. (1996);*
- *King & Stephens (1992);*
- *Badri et al. (2011);*
- *Yeend et al. (2019)*
- *Kamerer et al. (2021)*

Recent Studies

Auditory filter shapes and high-frequency hearing in adults who have impaired speech in noise performance despite clinically normal audiograms[a)]

Rohima Badri, Jonathan H. Siegel, and Beverly A. Wright[b)]
School of Communication, Department of Communication Sciences and Disorders, Northwestern University, 2240 Campus Drive, Evanston, Illinois 60208

Working Memory and Extended High-Frequency Hearing in Adults: Diagnostic Predictors of Speech-in-Noise Perception

Ingrid Yeend,[1,2,3] Elizabeth Francis Beach,[2,3] and Mridula Sharma[1,3]

Understanding Self-reported Hearing Disability in Adults With Normal Hearing

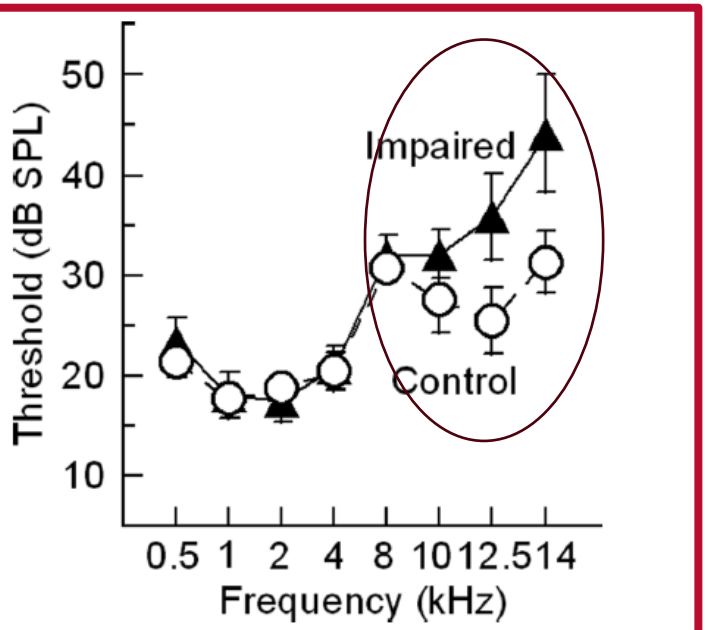
Aryn M. Kamerer, Sara E. Harris, Judy G. Kopun, Stephen T. Neely, and Daniel M. Rasetshwane

FHD & Extended High-Frequency Thresholds: Badri et al. (2011)

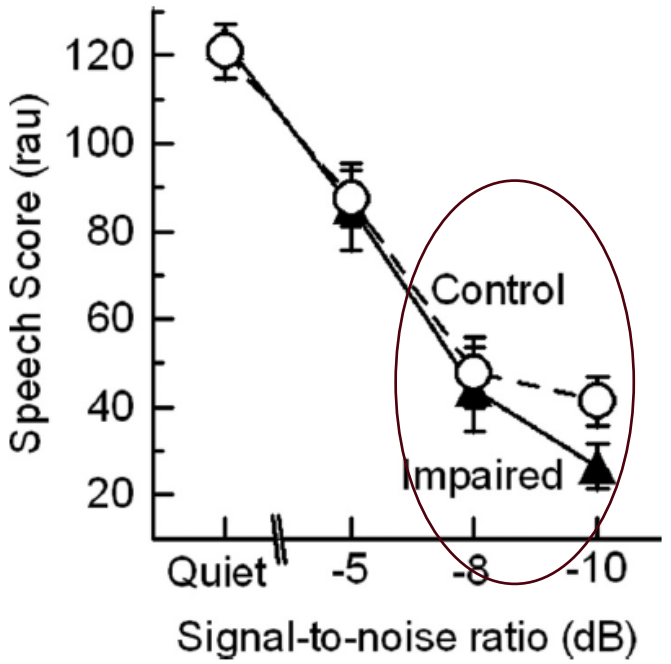
Impaired (aka: FHD): N = 14 20-50 years

Controls: N = 10 18-47 years

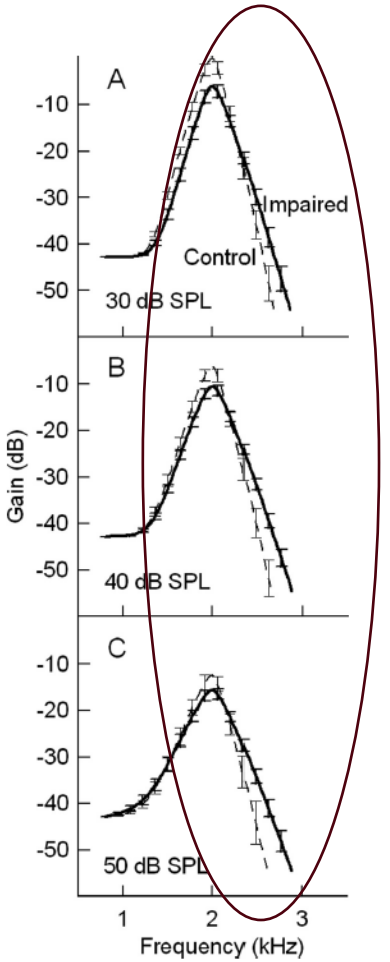
- **Pure-tones <15 dB HL**



*Poorer EHF thresholds



*Poorer sentence-in-noise performance



- Poorer frequency resolution
  Significantly wider auditory filters

FHD & Extended High-Frequency Thre

Yeend et al. (2019)

Preditors of the CSS?
(1) EHF thresholds
(2) Working memory

Participants

N = 122 30-57 years

Grouped by a Composite Speech-in-Noise Score (CSS)

- High – Mid – Low

Based on:

- SSQ speech items
- LiSN-S high-cue SRT
- NAL Dynamic Conversations Test

CSS Groups

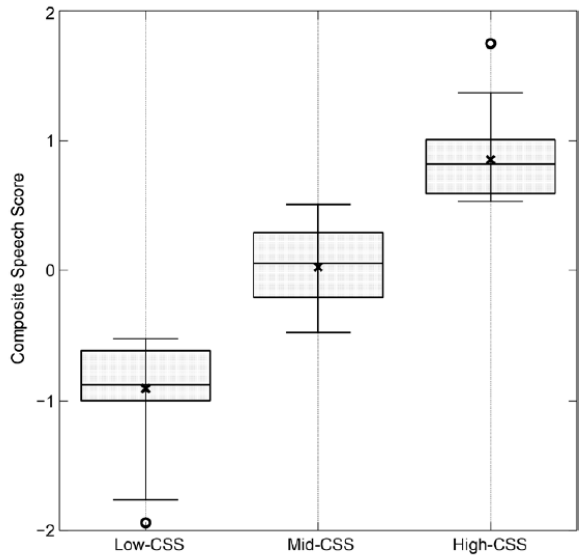


Fig. 1. The distribution of composite speech-in-noise scores for participants with the highest composite speech-in-noise scores (high CSS group; n = 30), those with the lowest scores (low CSS group; n = 30), and the remaining participants (mid CSS; n = 62).

gram

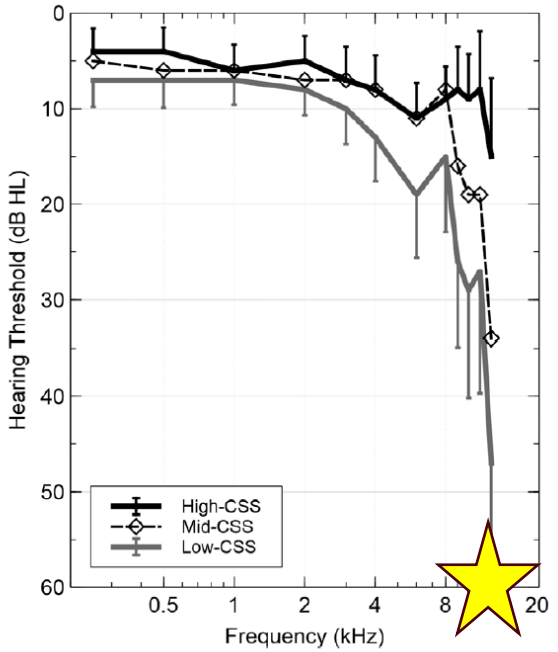


Fig. 2. Mean audiograms from 0.25 to 12.5 kHz for participants with the highest composite speech-in-noise scores (high CSS group; n = 30), those with the lowest scores (low CSS group; n = 30), and the remaining participants (mid CSS; n = 62). Error bars are 1 SD.

FHD & Standard Pure-Tone Thresholds: Kamerer et al. (2021)

Participants

N = 111 19-74 years

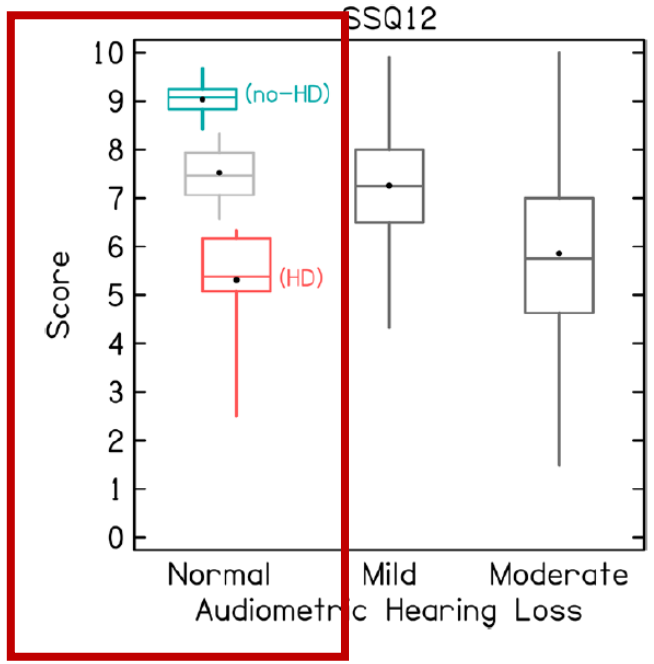
Inclusion criteria: pure-tone thresholds ≤ 25 dB HL

- 250-8000Hz

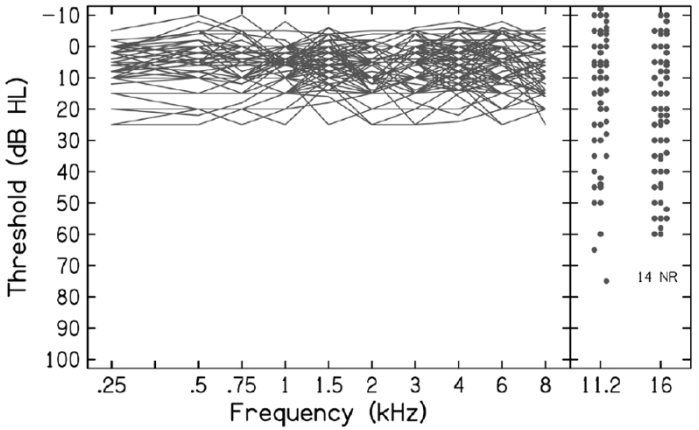
Grouped by the SSQ12 score

- HD = hearing disability
- No-HD = no hearing disability

Groups



Audiogram



FHD & Standard Pure-Tone Thresholds: Kamerer et al. (2021)

Test Battery

SSQ

Extended high-frequency thresholds

Word recognition

Speech intelligibility index (SII)

Impulse Noise Exposure Hx

Tinnitus Hx

FM Detection

MoCA

DPOAEs

ABR

Results

SSQ significantly correlated with PTA4, low-frequency & high-frequency averages

Variables that predicted 40% of the SSQ score:

1. Hx of impulse noise exposure
2. FM detection thresholds
3. SII (speech intelligibility index)

Audiogram by HD v. no-HD Groups

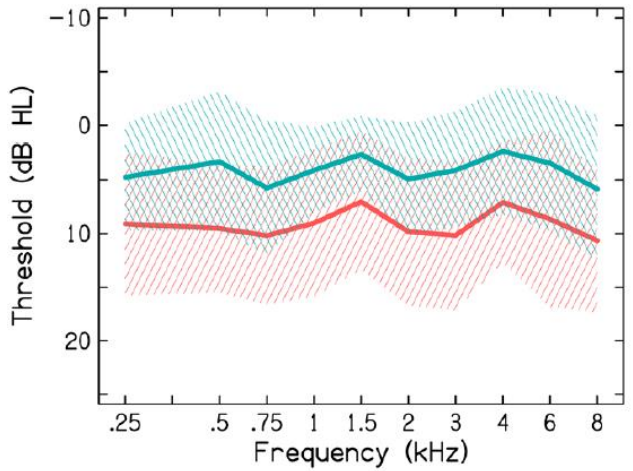


Fig. 5. Mean (solid line) and SDs (diagonal lines) of audiometric thresholds for groups with reported HD (red) and no-HD (blue).

Summary: Pure-Tone Audiometry

Threshold elevation in the 'normal range':

- Greater degrees of self-perceived hearing difficulty
- Associated with poorer SIN performance, cognitive function, and depressive symptoms
- **Clinical Recommendation:** Use 15 dB HL as the cutoff for "normal hearing"

EHF threshold elevation is associated with FHD

- Indication of auditory dysfunction
- **Clinical Recommendation:** Measure EHF thresholds as part of the standard evaluation

Speech Audiometry

- Speech Recognition Threshold (SRT)
- Word Recognition in Quiet

Preliminary Guidelines for Replacing Word-Recognition in Quiet With Speech in Noise Assessment in the Routine Audiologic Test Battery

Matthew B. Fitzgerald,[1] Steven P. Gianakas,[1,2] Z. Jason Qian,[1] Steven Losorelli,[1] and Austin C. Swanson[1]

A Large-Scale Study of the Relationship Between Degree and Type of Hearing Loss and Recognition of Speech in Quiet and Noise

Michael L. Smith,[1,2] Matthew B. Winn,[2] and Matthew B. Fitzgerald[1]

Assessment Protocol

CAREFUL CASE HISTORY

AUTHENTIC SUBJECTIVE ASSESSMENT

STANDARD AUDIOMETRIC ASSESSMENT

SUPRATHRESHOLD AUDITORY PROCESSING ASSESSMENT

Suprathreshold Auditory Processing Assessment: WHY?

1. Pure-tone detection is easy
2. Word-recognition in quiet is easy
3. **Deficits emerge when the task challenges, or taxes the auditory system**

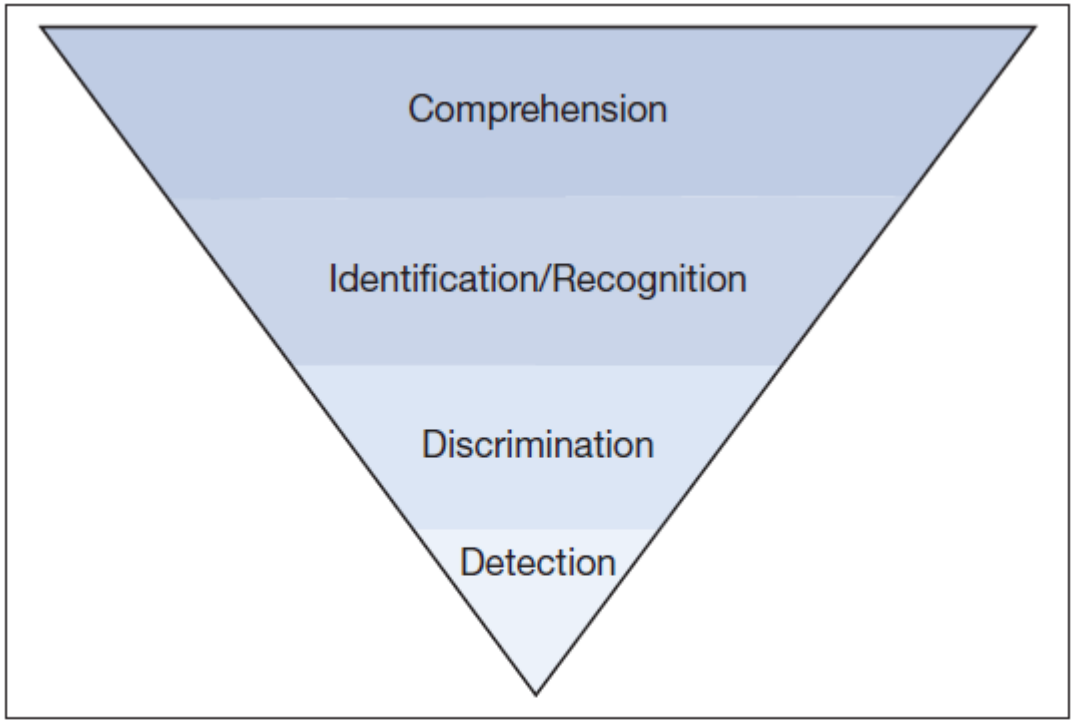
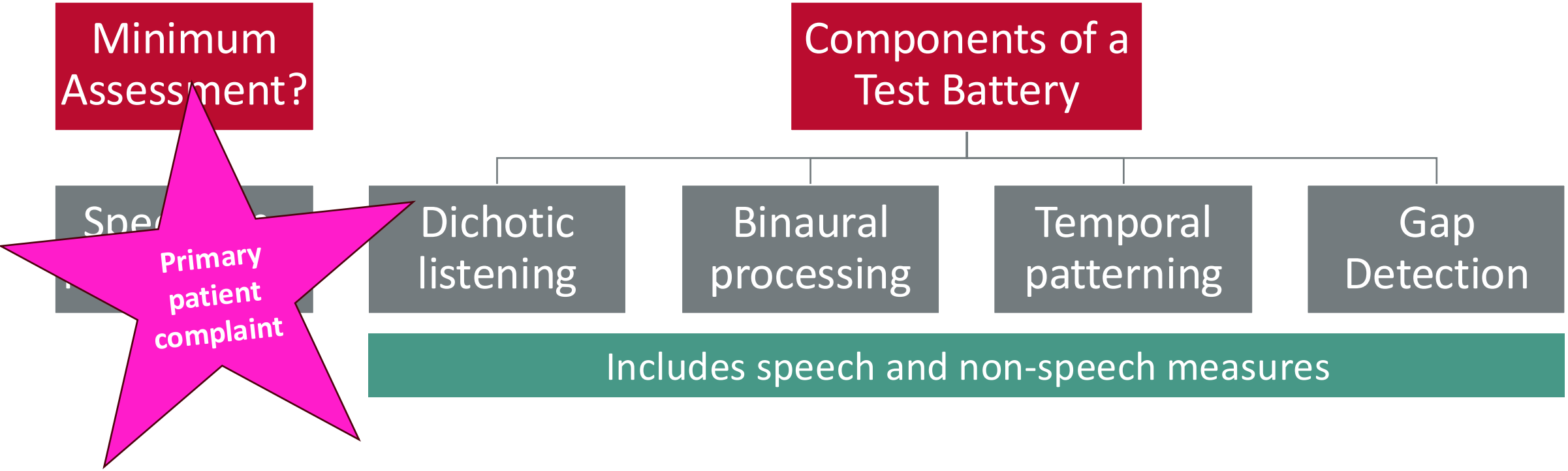


Figure 2. Schematic of Erber's hierarchy of auditory skills from easiest (bottom) to most difficult (top).

Roup, Whitelaw, & Baxter (2019)

Suprathreshold Auditory Processing Assessment



Speech Audiometry: Speech-in-Noise

What test should I use?

- Lot's of options!

- Two tests recommended by the NASEM "Measuring Meaningful Outcomes for Adult Hearing Health Interventions"
  - Quick Speech-in-Noise (QuickSIN) Test *(Killion et al., 2004)*
  - Words-in-Noise (WIN) Test *(Wilson et al., 2003)*

Free pdf download!

https://nap.nationalacademies.org/catalog/29104/measuring-meaningful-outcomes-for-adult-hearing-health-interventions

Excellent references!

Speech Perception in Noise: The Basics

Rachel McArdle
Bay Pines VA Healthcare System
Bay Pines, FL
Department of Communication Sciences and Disorders, University of South Florida
Tampa, FL

Richard H. Wilson
James H. Quillen VA Medical Center
Mountain Home, TN
Departments of Surgery and Communicative Disorders, East Tennessee State University
Johnson City, TN

Speech-in-Noise Testing: An Introduction for Audiologists

Curtis J. Billings, Ph.D.,[1,2] Tessa M. Olsen, B.S.,[1] Lauren Charney, Au.D.,[2] Brandon M. Madsen, Au.D.,[2,3] and Corrie E. Holmes, Au.D.[1]

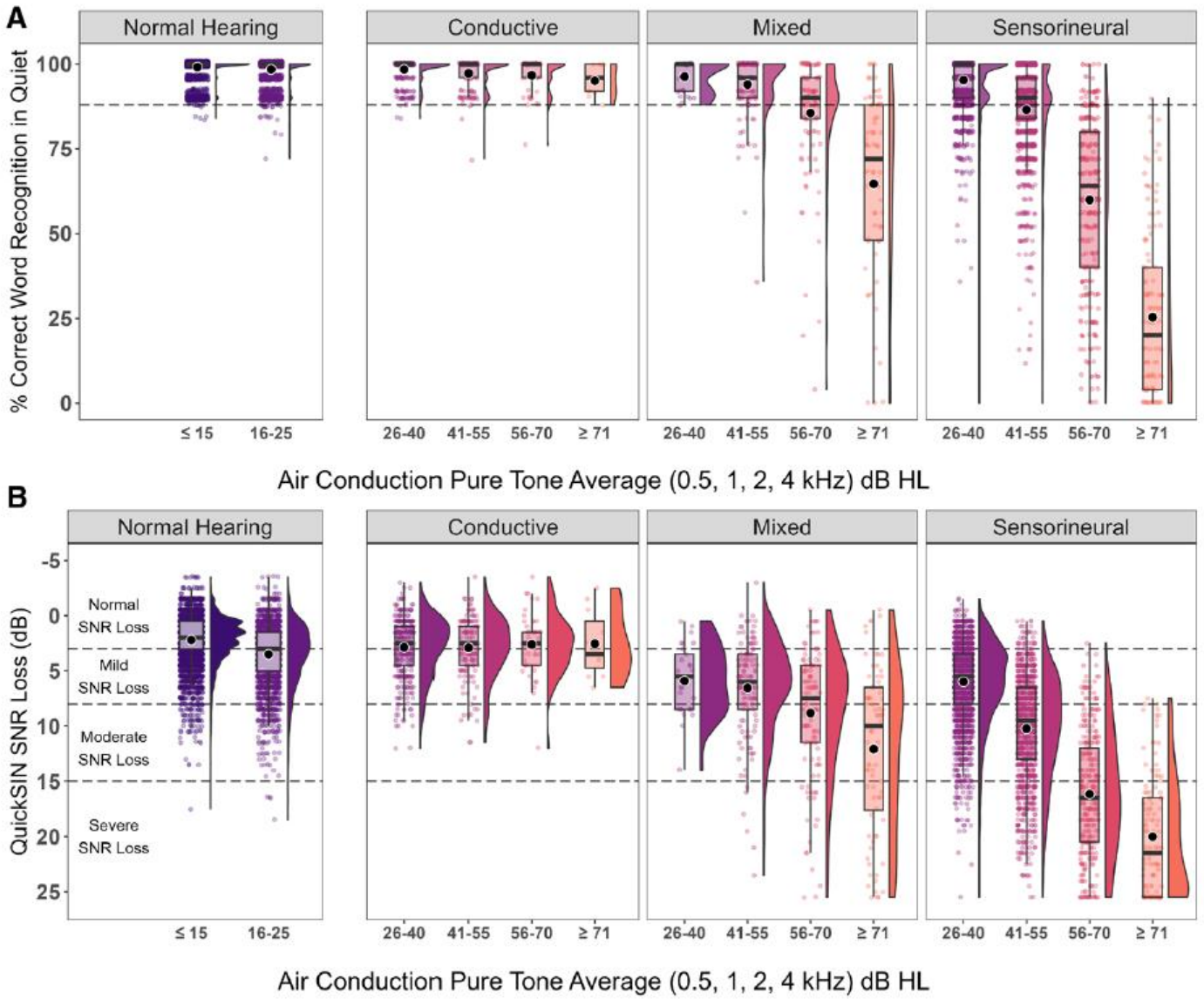
Open Acess Article: https://doi.org/10.1055/s-0043-1770155

Speech Recognition: Sensitivity of Quiet vs. Noise

A Large-Scale Study of the Relationship Between Degree and Type of Hearing Loss and Recognition of Speech in Quiet and Noise

Michael L. Smith,[1,2] Matthew B. Winn,[2] and Matthew B. Fitzgerald[1]

- N=5593 adults
- 18-104 years of age

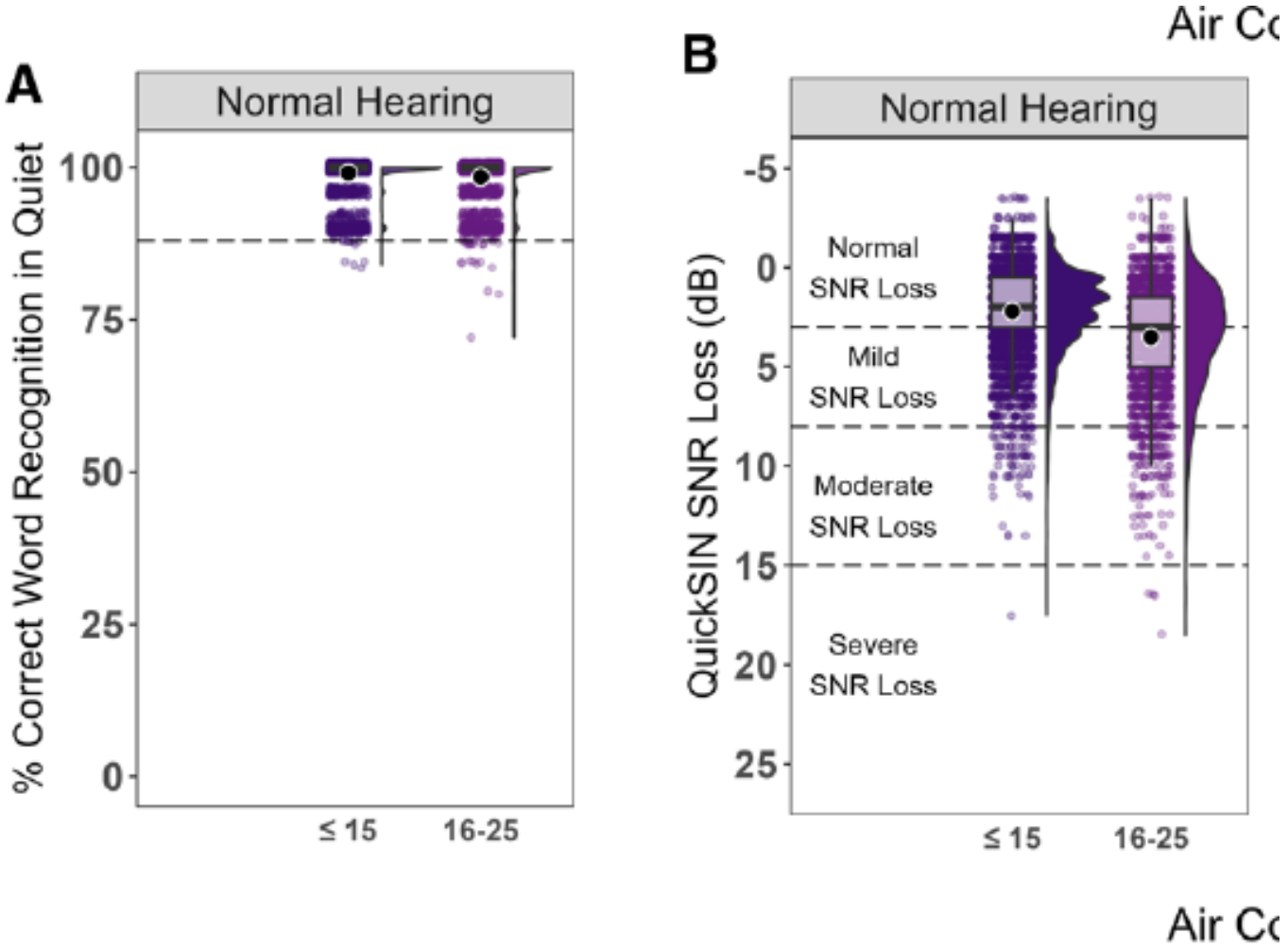


Speech Recognition: Sensitivity of Quiet vs. Noise

A Large-Scale Study of the Relationship Between Degree and Type of Hearing Loss and Recognition of Speech in Quiet and Noise

Michael L. Smith,[1,2] Matthew B. Winn,[2] and Matthew B. Fitzgerald[1]

- Normal hearing defined as PTA4 ≤25 dB HL



Smith et al. (2024)

What if you want to test more than speech-in-noise?

What are your options?

Assessment of Suprathreshold Auditory Processing

Examples of Behavioral & Electrophysiologic Measures of Auditory Processing

- Dichotic Listening (Competing Speech)
  - *Dichotic Digits*
  - *Staggered Spondaic Word (SSW) Test*
  - *Competing Sentences Test*
- Temporal Processing
  - *Duration Pattern Test*
  - *Random Gap Detection Test*
  - *Gaps-in-Noise Test (GIN)*
- Monaural Low-Redundancy
  - *Filtered speech*
  - *Time-compressed speech*
- Degraded Speech
  - *Speech-in-Noise tests*
    - *Words-in-Noise Test*
    - *Quick Speech-in-Noise Test*
    - *BKB-SIN*
    - *AZ-Bio*
  - *Speech in Reverberation*
- Binaural Interaction
  - *Masking Level Difference (MLD) test*
- **Electrophysiologic Tests**
  - *Auditory brainstem response*
  - *Middle latency response*
  - *Late auditory evoked potentials*
  - *Mismatch negativity*

Suprathreshold Auditory Processing
Test Batteries

Examples of Behavioral Test Batteries

- **SCAN-3:A Tests for Auditory Processing Disorders in Adolescents & Adults** *(Keith, 2009)*
  - *Auditory-Figure Ground @ 0 dB SNR (speech-in-noise)*
  - *Filtered Words*
  - *Competing Words*
  - *Competing Sentences*
- **MAPA 2: Multiple Auditory Processing Assessment** *(Katz & McCarthy, 2000)*
  - *Monaural: Selective attention, speech-in-noise for children*
  - *Binaural: Dichotic digits, competing sentences*
  - *Temporal: Tap test, pitch pattern test*
- **Buffalo Model** *(Katz, 2007)*
  - *Staggered Spondaic Words Test (SSW)*
  - *Phonemic Synthesis Test*
  - *Speech-in-Noise Test @ +5 dB SNR*
- **P.A.R.T.: Portable Automated Rapid Testing** *(Gallun et al., 2018)*
  - *Temporal sensitivity*
  - *Spectral sensitivity*
  - *Spectrotemporal sensitivity*
  - *Binaural sensitivity*
  - *Spatial release from masking*
  - *Informational masking*

Results from a Suprathreshold Auditory Processing Test Battery

Adults with FHD (n = 17)

- **16/17 (94%)** had abnormal performance on at least one test in the battery

Table 2. Number and Percent of Participants with HD with Performance below the Normal Range for Each Test in the Auditory Processing Battery

	Participants with Performance below the Normal Range	
Auditory Test	Number	Percentage
MLD	2	12%
SCAN-3:A	2	12%
DDT—free recall	7	41%
DDT—directed recall	9	53%
GIN	9	53%
R-SPIN high predictability		
12 dB SNR (<39.2%)	15	88%
8 dB SNR (<71.2%)	14	82%
4 dB SNR (<91.3%)	14	82%
0 dB SNR (<97.6%)	13	76%
R-SPIN low predictability		
12 dB SNR (<23.2%)	12	71%
8 dB SNR (<46.3%)	15	88%
4 dB SNR (<66.9%)	15	88%
0 dB SNR (<79.6%)	15	88%

Notes: The number of participants having HD with R-SPIN recognition performance below the lower cutoff of the 99.7% CI for the control group is included for each SNR: −12, −8, −4, and 0 dB. The lower cutoff percentage is included in parentheses for each SNR.

Speech-in-noise!

Roup et al., (2018)

Results from a
Suprathreshold Auditory Processing Test Battery

Purpose

*To evaluate the impact of age on self-perceived **hearing difficulty** (HD) and **binaural** auditory processing in adults with and without a history of TBI.*

Participants

Group 1	Group 2	Group 3	Group 4
Young Control	Young TBI	Middle-Aged Control	Middle-Aged TBI
N = 38	N = 23	N = 16	N = 16
Age: 18-25 years	Age: 19-29 years	Age: 31-57 years	Age: 30-59 years

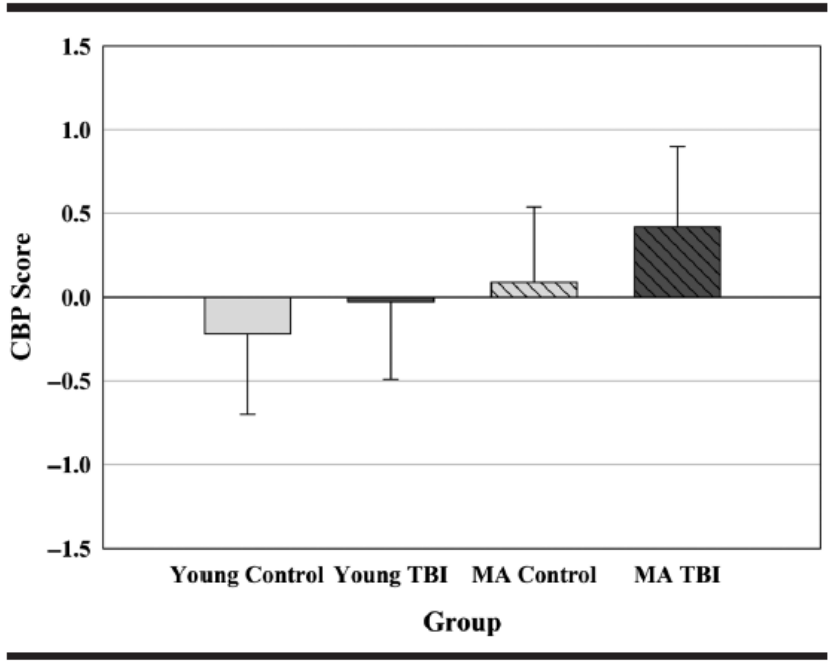
Results from a Suprathreshold Auditory Processing Test Battery

Composite Binaural Processing Score

Included 6 test results where a lower threshold or score indicated better performance:

1. MLD S_0N_0 threshold
2. MLD $S_\pi N_0$ threshold
3. LiSN-S Low-Cue SRT
4. LiSN-S High-Cue SRT
5. Dichotic free recall ear advantage
6. Dichotic directed recall ear advantage

Figure 3. Mean composite binaural processing (CBP) scores for all groups: young adult control, young adult TBI, MA control, and MA TBI. Error bars represent 1 *SD*. TBI = traumatic brain injury; MA = middle-age.



Assessment Protocol:

Putting the Pieces of "Mixed Methods" Together

CAREFUL CASE HISTORY

AUTHENTIC SUBJECTIVE ASSESSMENT

STANDARD AUDIOMETRIC ASSESSMENT

SUPRATHRESHOLD AUDITORY PROCESSING ASSESSMENT

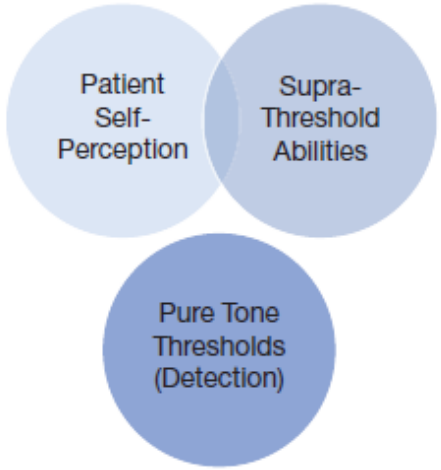
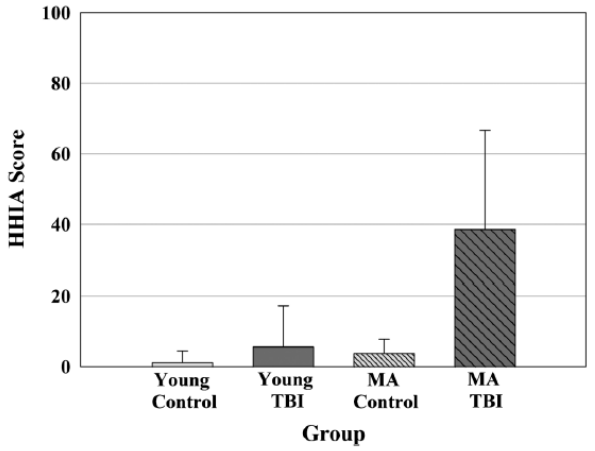


Figure 1. Mean Hearing Handicap Inventory for Adults (HHIA) scores for all groups: young adult control, young adult TBI, MA control, and MA TBI. Error bars represent 1 *SD*. TBI = traumatic brain injury; MA = middle-age.



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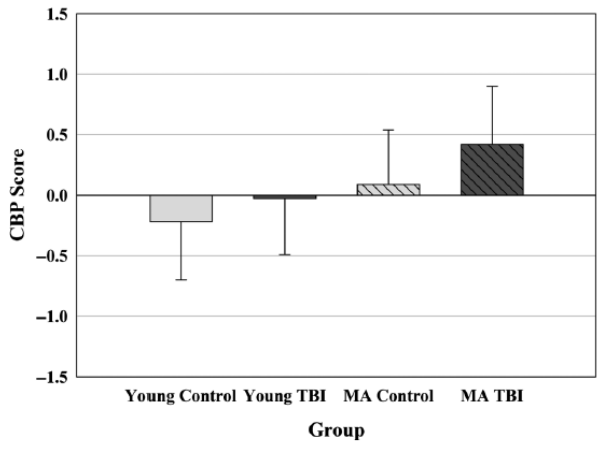


Roup, Whitelaw, & Baxter (2019); Roup et al. (2023)

Summary: Using a (Behavioral) Suprathreshold Test Battery to Assess FHD

Clinical Implication?

- Suprathreshold tests that challenge the auditory system are sensitive to functional hearing difficulties

Pros	Cons
• Validation of patient perception • Quantification of auditory processing deficits	• Added clinical time • Scoring and interpretation • Not all patients will score outside of normal limits

WAIT!

What if my patient presents with hearing complaints (or FHD), but has normal pure-tone thresholds AND normal auditory processing test results?

Consider the assessment of:

- Listening Effort
- Listening-Related Fatigue
- Cognitive Processing (in the auditory domain)

Subjective Listening Effort

NASA Task Load Index

iOS App option

Free download!

NASA Task Load Index

Mental Demand: How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?

Low ——————————— High

Temporal Demand: How much time pressure did you feel due to the rate or pace at which the task occurred? Was the pace slow and leisurely or rapid and frantic?

Low ——————————— High

Performance: How successful do you think you were in accomplishing the task? How satisfied were you with your performance in accomplishing the task?

Low ——————————— High

Effort: How hard did you have to work (mentally and physically) to accomplish your level of performance?

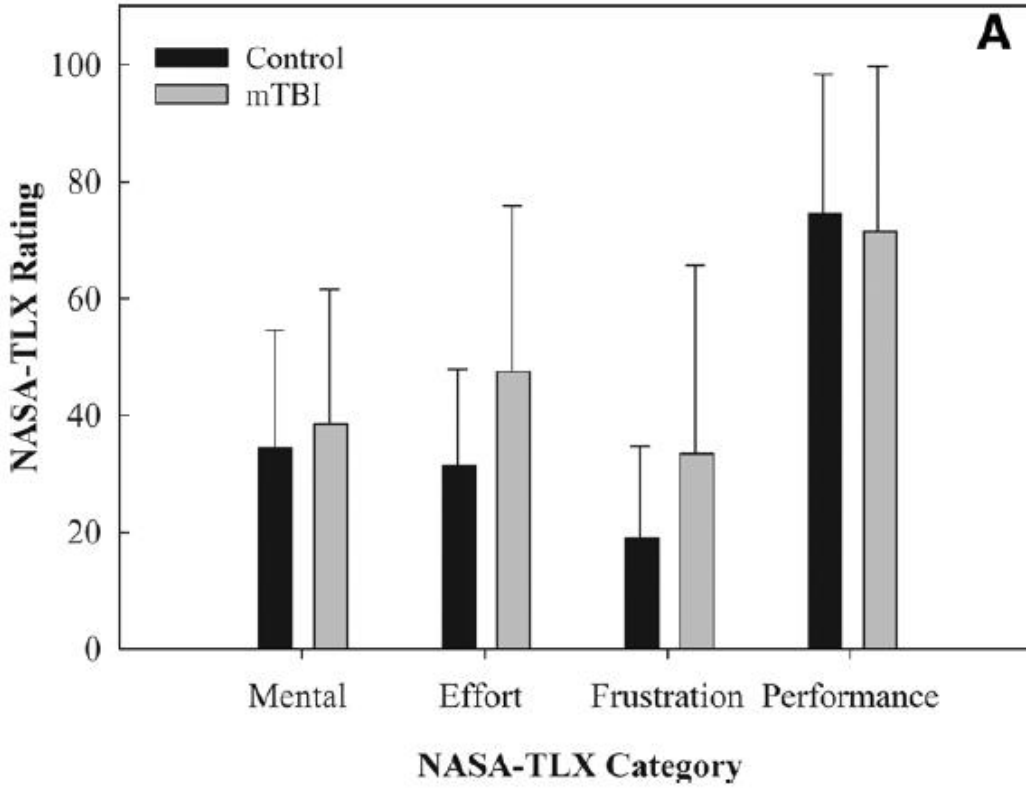
Low ——————————— High

Frustration: How discouraged, stressed, irritated, and annoyed versus gratified, relaxed, content, and complacent did you feel during the task?

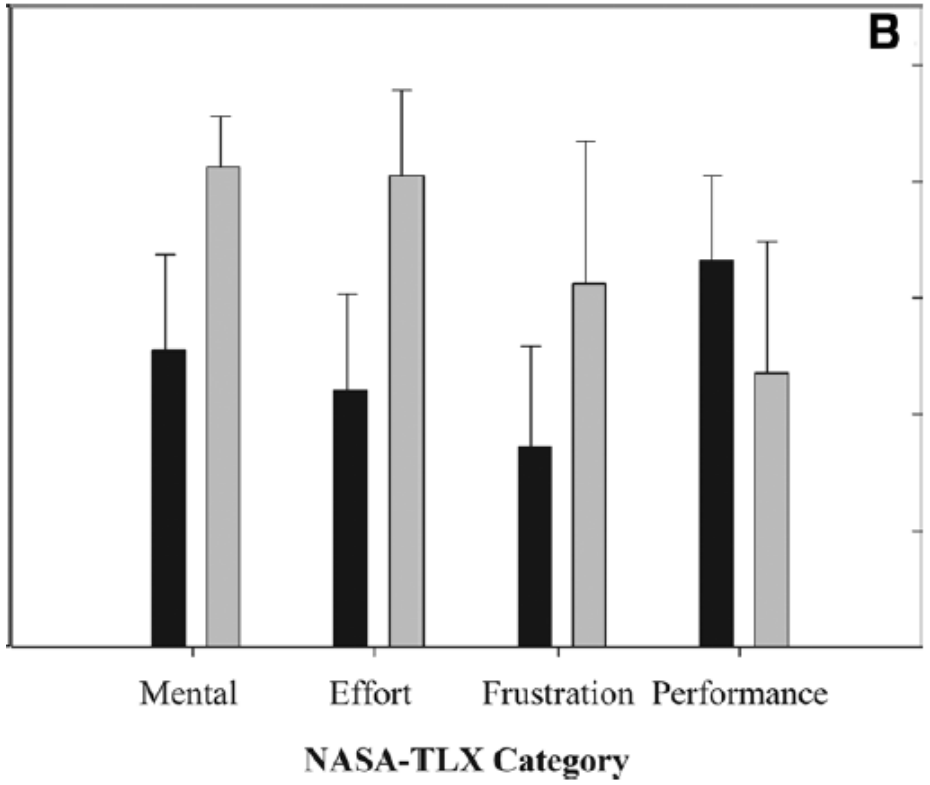
Low ——————————— High

Example of Listening Effort & FHD

Baseline Ratings



Post-Assessment Final Ratings

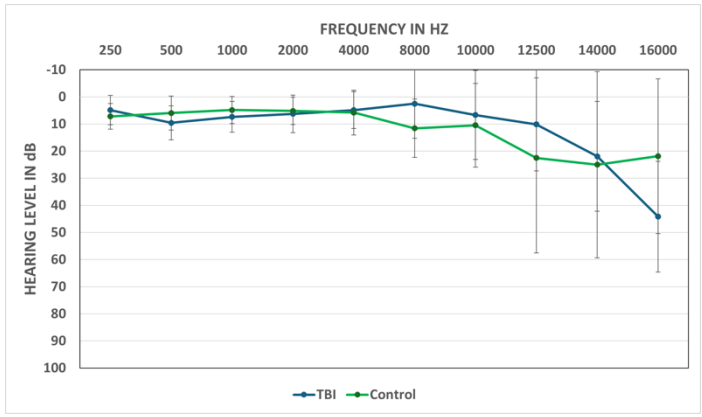


Lander et al. (2024)

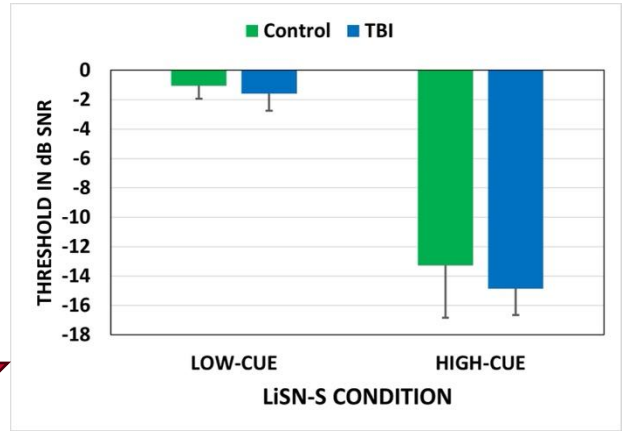
Normal pure-tone thresholds, normal speech-in-noise results. . .

TBI Group vs.

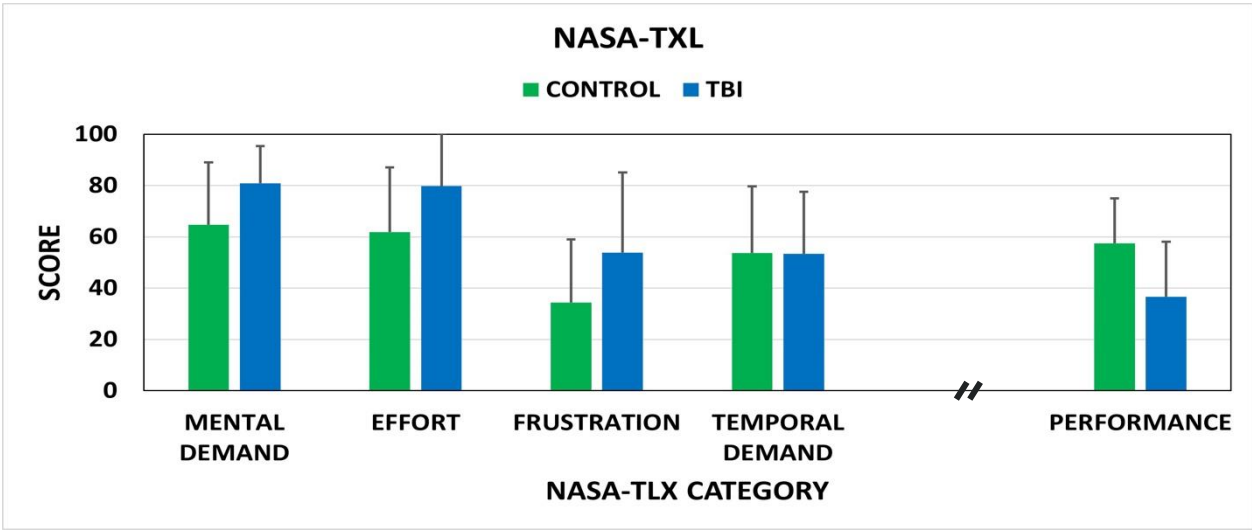
Control Group



Better SIN performance



Post-SIN Listening Effort



Subjective Listening-Related Fatigue

Vanderbilt Fatigue Scale for Adults (VFS-A)

Hornsby et al. (2021)

Brief 10-item version

Hornsby et al. (2023)

Free download!

Vanderbilt Fatigue Scale-Adult version- 40 items (VFS-A-40)

Sometimes communicating with others, or just listening, can be physically, mentally, or emotionally tiring. This questionnaire will help us understand how you feel, and respond, in different listening and communication settings.

The following items ask how OFTEN you experience or react in a certain way, in a given situation. For example, responding " Almost Always/Always" indicates that in the situation described (e.g., in noisy situations) you always or almost always experience a particular reaction (e.g., you feel tired or avoid a situation). On the other hand, responding "Never/Almost Never" indicates that in the situation described you never, or almost never, have such a reaction.

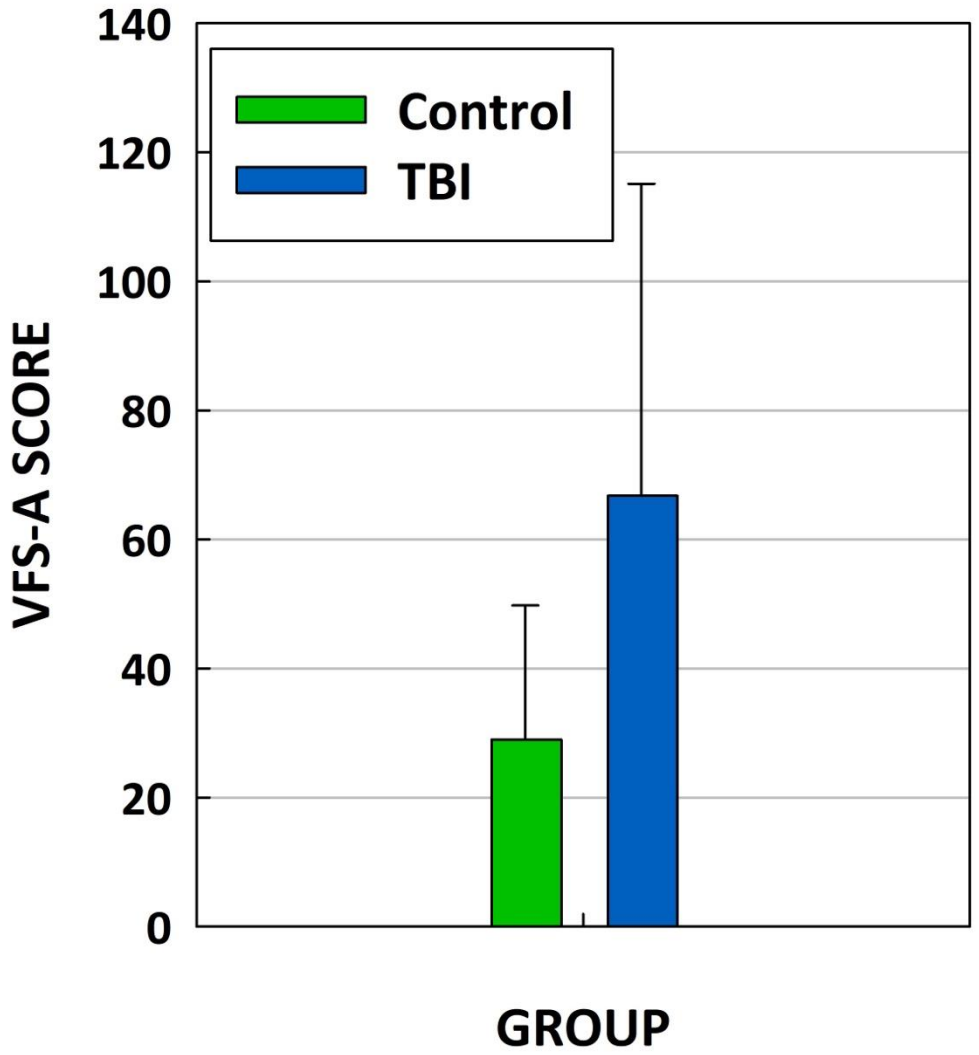
For each item, select the SINGLE response which best describes your day-to-day experiences over a typical WEEK.

Item Code	Item	Never/ Almost Never	Rarely	Sometimes	Often	Almost Always/ Always
1. C3_1	It takes A LOT of mental effort to understand what people are saying.	0	1	2	3	4
2. C2_1	I become mentally tired when it is hard to listen.	0	1	2	3	4
3. C2_2	It takes a lot of energy to listen and understand.	0	1	2	3	4
4. P3_1	I feel worn out from everyday listening.	0	1	2	3	4
5. P3_2	I need a nap after a long period of listening.	0	1	2	3	4
6. S3_1	Feeling tired from listening causes strain on my relationships.	0	1	2	3	4
7. C3_2	I get so tired from trying to hear that I stop engaging.	0	1	2	3	4
8. S3_2	I leave noisy situations early to avoid getting too tired.	0	1	2	3	4
9. S3_3	I avoid listening situations that make me tired.	0	1	2	3	4
10. E2_1	I get frustrated when I have to put a lot of energy into listening.	0	1	2	3	4
11. S3_4	I get so exhausted from listening that I cannot do the things I enjoy.	0	1	2	3	4
12. E2_2	How often do you feel emotionally tired due to trouble hearing and understanding?	0	1	2	3	4
13. C3_3	I get so tired from listening that I start to miss details in a conversation.	0	1	2	3	4
14. C3_4	Trying to listen to conversations in the car makes me tired.	0	1	2	3	4

“Normal hearing”, but listening-related fatigue

TBI Group

- 83% scored >20 = *greater than normal levels of fatigue*



Role of Cognitive Processing: Working Memory

Working Memory and Extended High-Frequency Hearing in Adults: Diagnostic Predictors of Speech-in-Noise Perception

Ingrid Yeend,[1,2,3] Elizabeth Francis Beach,[2,3] and Mridula Sharma[1,3]

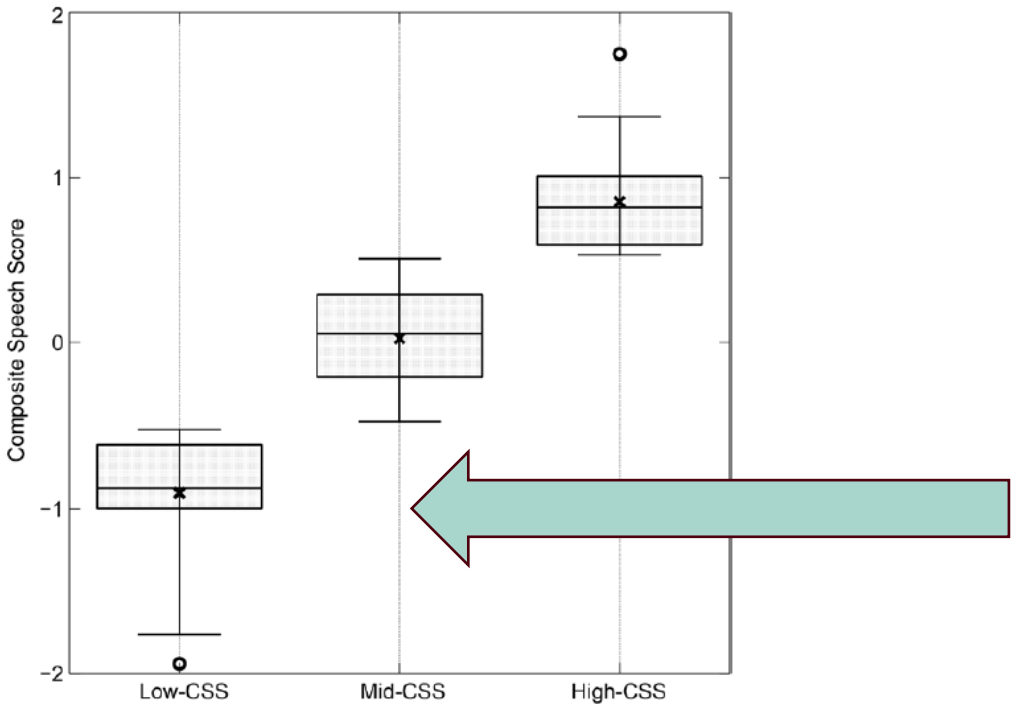


Fig. 1. The distribution of composite speech-in-noise scores for participants with the highest composite speech-in-noise scores (high CSS group; n = 30), those with the lowest scores (low CSS group; n = 30), and the remaining participants (mid CSS; n = 62).

Predictors of "Low-speech-in-noise"?

- Extended High-Frequency thresholds
- **Working memory performance!**

Outline

- ✓ Introduction to FHD
- ✓ Redefining “Normal” Hearing
- ✓ Assessment of FHD
- Case Examples

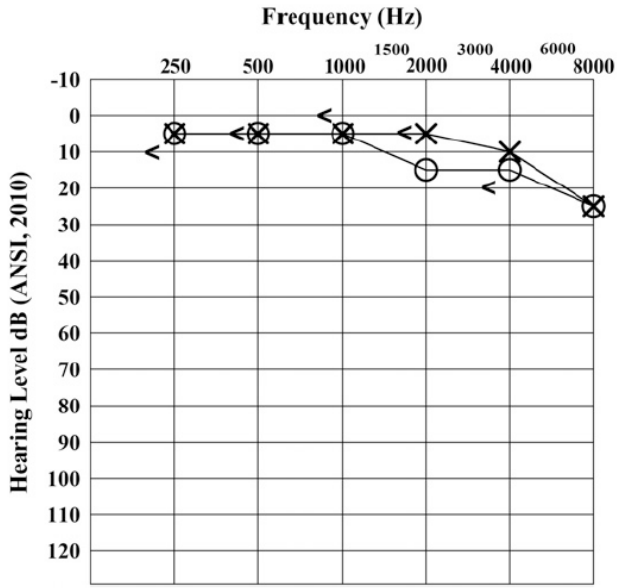
Case Example 1: SM FHD due to TBI (58-year-old woman)

Test results align!

Subjective Hearing Complaints

- Difficulty hearing in a restaurant
- Difficulty hearing in groups
- Inability to attend church & family events
- Considerable emotional distress
- HHIA Score = 96/100
  - Hearing Handicap Inventory for Adults

Audiogram



Word Recognition in Quiet at 50 dB HL

Right Ear	Left Ear
92%	100%

Roup, Ross, & Whitelaw (2020).

Case Example 1: SM - FHD due to TBI
Assessment Summary

Poor Speech-in-Noise

1. QuickSIN = **6.5 dB SNR Loss**
2. R-SPIN @ 0 dB SNR
   - HP = 100%
   - **LP = 64% (abnormally poor)**

Left-Ear Dichotic Deficit

3-Pair digits free recall

- Right = 83% (WNL)
- **Left = 46% (abnormally low)**

Poor Temporal Processing

Gaps-in-Noise

- Right = 6 msec (WNL)
- **Left = 8 msec (abnormally long)**

Case Example 2: YAF with idiopathic FHD (34-year-old woman)

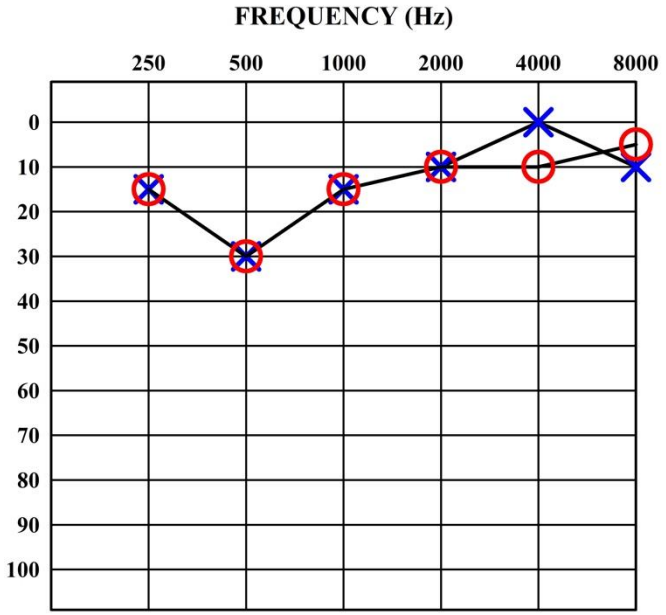
Case History

- Trouble hearing in background noise
- Present since her early 20's
- Situations of difficulty: teaching and parties
- HHIA score = 34/100

Evaluation

- Otoscopy unremarkable
- Tympanometry WNL
- Acoustic reflexes absent
- AC = BC (no air-bone gap)

Audiogram



Roup, Ross, & Whitelaw (2020).

Case Example 2: YAFAssessment Summary

Self-Perception

Mild hearing handicap re: HHIA

Abnormally high self-perceived listening difficulties in noise re: AAPS

Speech-in-Noise

Borderline performance on the SCAN auditory-figure ground (SIN)

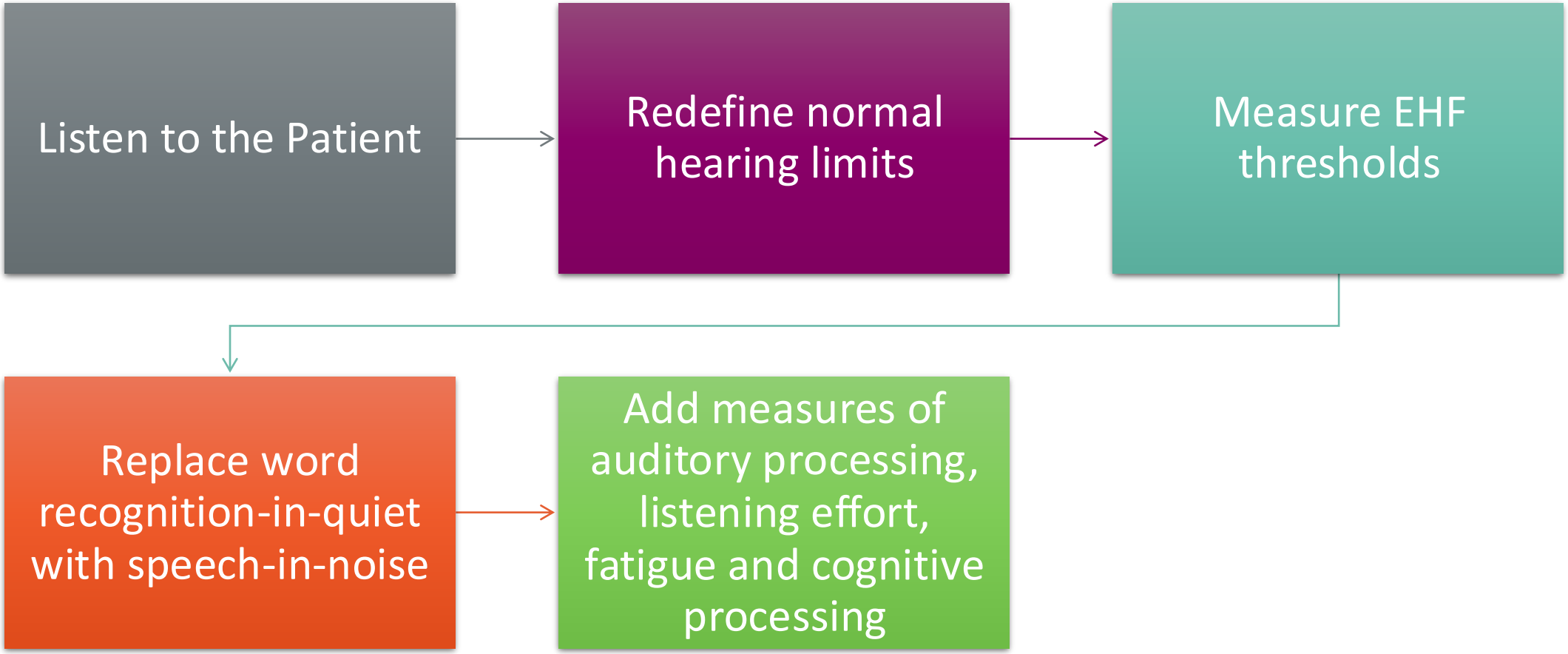
Temporal Processing

Abnormally poor GIN performance

Binaural Processing

Abnormally low MLD S_0N_0 threshold

Circling Back:
How do we detect what the audiogram misses?



Conclusions

- FHD are more common than we think
- FHD can have negative health-related quality of life consequences
- Subtle threshold elevation matters
- Extended high-frequency hearing matters
- Tests that challenge the auditory system matter

Questions?

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Thank you!

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