Children's Hospital Colorado

Infant Speech Perception Informing Clinical Practice

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Acknowledgments

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Lynne Werner, PhD	Melinda Anderson, PhD	
Robert Freedman, MD	Megan Hedman, AuD	
Christie Yoshinaga-Itano, PhD	Emily Nightengale, BA	

Learner outcomes

- Describe implementation of PMSTB in children under the age of two in children with hearing loss.
- Identify novel approaches to the analysis and interpretation of EEG for translational and clinical applications.
- Compare the relationship between evoked potentials and behavioral measures of infant speech discrimination.

Overview

Outcomes in children with hearing loss: What do we know?

Standardization of tools for assessing children with hearing loss

Can we improve early assessment, intervention, and outcomes in these children?

What have we learned so far?

Continuing research and future directions

How can we translate these findings to clinical applications?

Rationale for a Pediatric Minimum Speech Test Battery (PMSTB) for children with HL

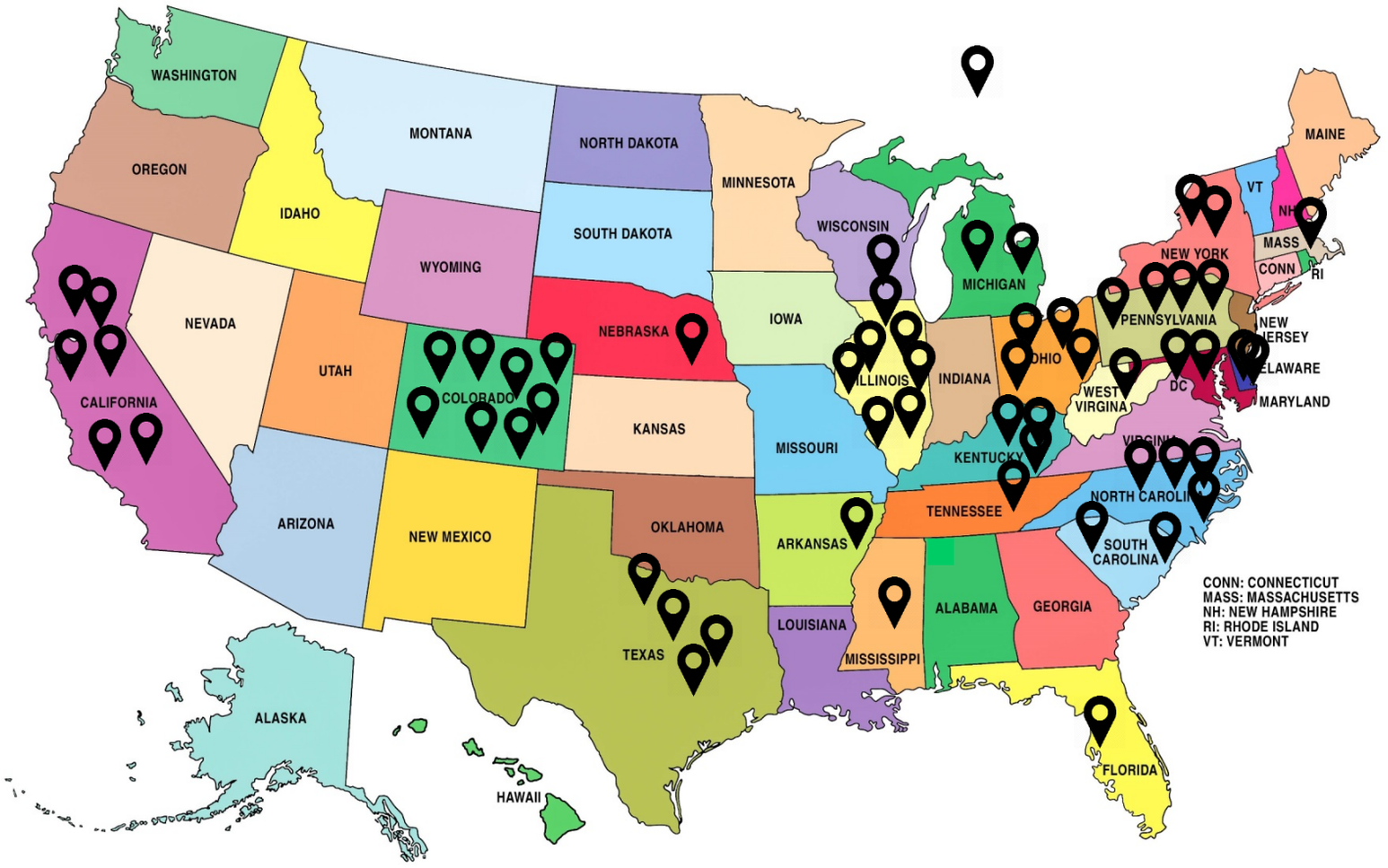
- No standardized protocol for speech perception
- Vast variability in clinical outcomes

Goals of PMSTB

- Setting guidelines and performance level across sites
- Setting realistic expectations for families
- Guiding clinical decision-making
- Supporting a database registry of children with hearing loss

Hierarchical protocol from phonemic speech discrimination through sentence comprehension in noise

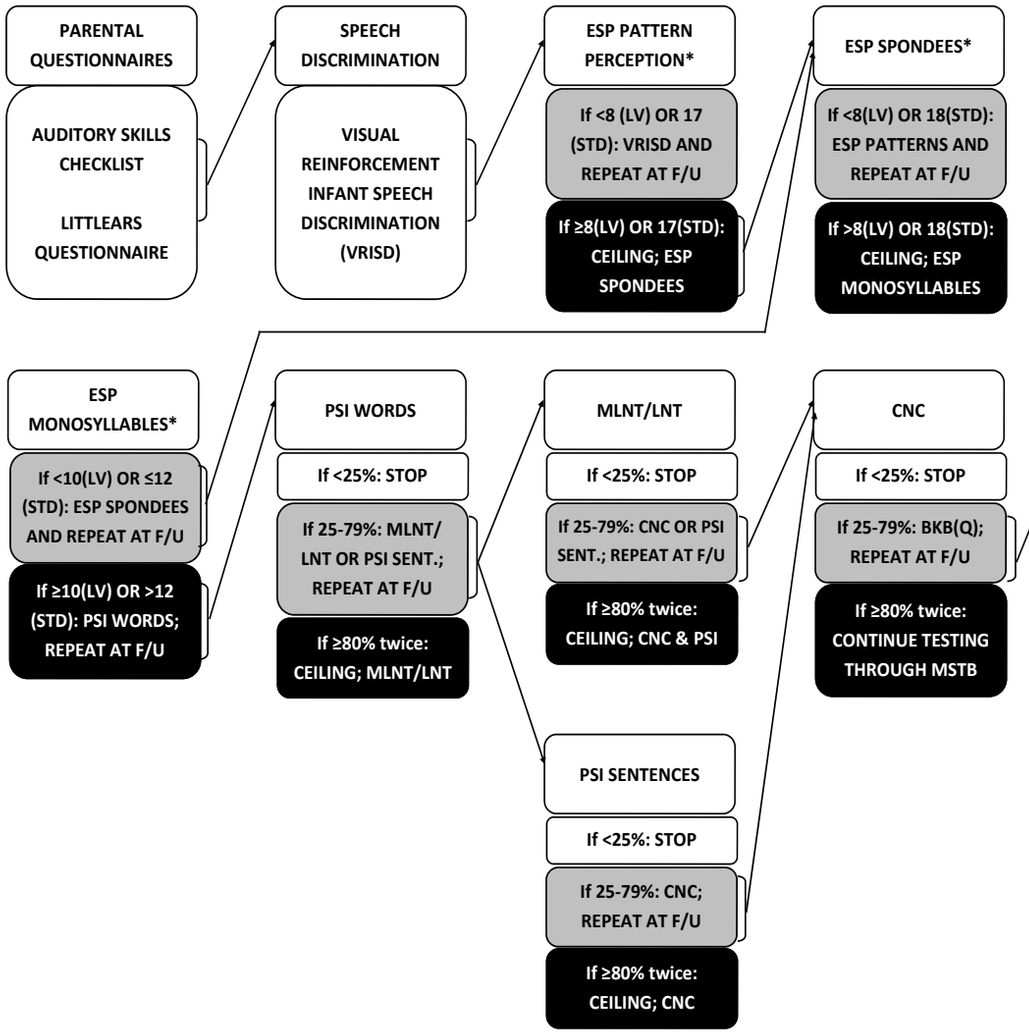
Pediatric Minimum Speech Test Battery (PMSTB) Working Group



First thing first

- All testing is done in the aided condition
- Assumes hearing aids/FM/DM have been optimized and verified

Pediatric Minimum Speech Test Battery (PMSTB)



RECOMMENDED TESTING PARAMETERS

1. **Stimulus presentation via recorded testing materials**
2. **Assessment of speech at conversational loudness (i.e., 60 dBA) in quiet**
3. **Assessment of soft speech (i.e., 50 dBA) in quiet**
4. **Assessment of speech in noise (i.e., four-talker babble) at a +5 dB signal-to -noise ratio with the signal at 65 dBA, unless otherwise specified in the manual**

GOAL FOR EACH SESSION: Obtain a measure of word recognition, sentence recognition in quiet, and sentence recognition in noise

MSTB = Minimum Speech Test Battery, which includes CNC, BKB-Sin, and AzBio tests.

*Clinicians should select the version of the ESP test (i.e., low-verbal or standard version) based on the child's language abilities.

Revised 10/2018

Listening configurations in which to test

	Conversational speech in quiet (60 dBA)	Low level in quiet (50 dBA)	Conversational speech in noise (65 dBA, +5 dB SNR)
Individual ear	✓	✓	✓
Bilateral or bimodal	✓	✓	✓
Device + FM/DM			✓

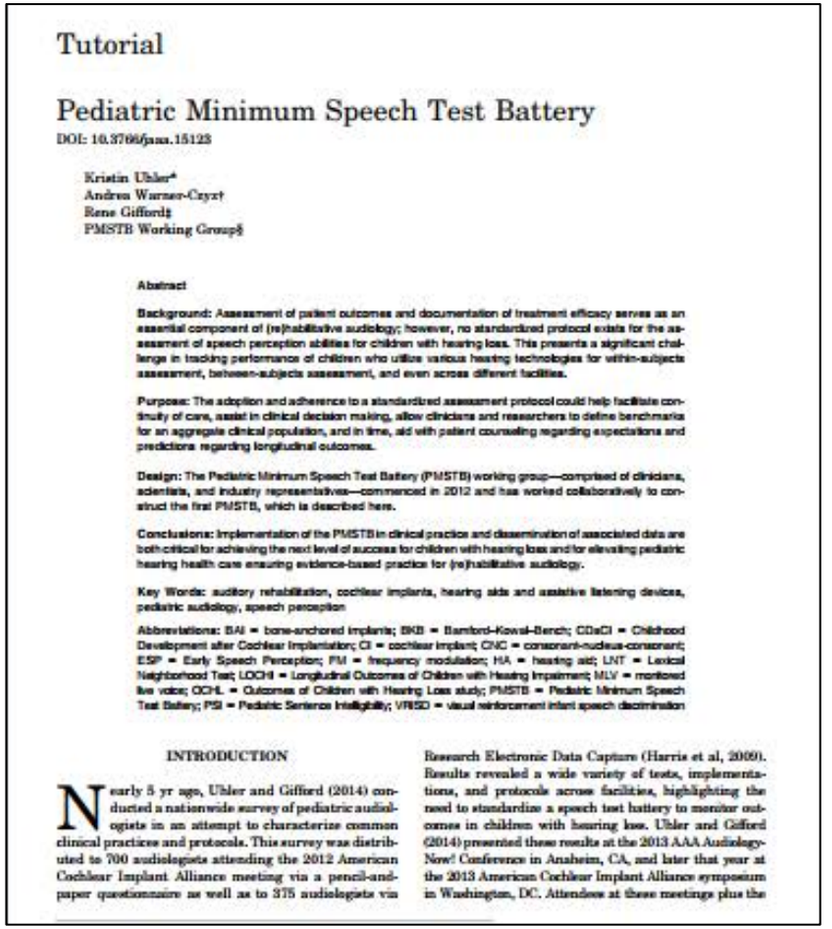
Age (months)	Receptive Language	Expressive Language	Appropriate Language Measures		Appropriate Speech Perception Tests
			Instrument	Score range	
6-12	Single words; short phrases	N/A	MBCDI: WG	Receptive: 21-74; Expressive: 0-3	1. Parent report
			Rossetti	Criterion-referenced	
			ROWPVT	SS: 85-115	2. VRISD
			EOWPVT	SS: 85-115	
			REEL-3	SS: 85-115	
12-18	Simple phrases and body parts	Single words	MBCDI: WG	Receptive: 74-260; Expressive: 3-94	1. SRT
			MBCDI: WS	52-86 words (expressive)	2. VRISD
			Rossetti	Criterion-referenced	
			PLS-5	SS: 85-115	
			REEL-3	SS: 85-115	
18-24	Follows 2-part instruction	Single words	MBCDI: WS	Expressive: 86-297	1. SRT
			Rossetti	Criterion-referenced	2. VRISD
			PLS-5	SS: 85-115	
			REEL-3	SS: 85-115	
24-36	Follows 2-part instruction	2-3 word combinations	MBCDI: WS	Expressive: 297-548	1. SRT
			Rossetti	Criterion-referenced	2. ESP (low verbal)
			PLS-5	SS: 85-115	
			REEL-3	SS: 85-115	
36-48	Follows 2-3-part instructions	3-word sentences	PLS-5	SS: 85-115	1. ESP (standard)
			OWLS-II	SS: 85-115	2. PSI words,
			CASL	SS: 85-115	3. MLNT
48-60	Follows simple instructions	3-5 word sentences	PLS-5	SS: 85-115	1. LNT
			OWLS-II	SS: 85-115	2. CNC
			CASL	SS: 85-115	
>60	Follows 3 commands	Mostly correct grammar	PLS-5	SS: 85-115	1. BKB (quiet)
			OWLS-II	SS: 85-115	2. BKB-SIN
			CASL	SS: 85-115	3. BabyBio

Recommended frequency of follow-up visits

	Device type	
Duration of device use	**Hearing aid**	**Cochlear implant**
0 to 1 year	**Every 3 months**	**Every 2-3 months**
1 to 2 years	**Every 3 months**	**Every 6 months**
2 to 3 years	**Every 3 months**	**Every 6 months**
3 to 5 years	**Every 6 months**	**Every 12 months**
> 5 years	**Every 12 months**	**Every 12 months**

Implementation

PMSTB manuscript and manual



Tutorial

Pediatric Minimum Speech Test Battery

DOI: 10.3766/jaaa.15123

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Abstract

Background: Assessment of patient outcomes and documentation of treatment efficacy serves as an essential component of (re)habilitative audiology; however, no standardized protocol exists for the assessment of speech perception abilities for children with hearing loss. This presents a significant challenge in tracking performance of children who utilize various hearing technologies for within-subjects assessment, between-subjects assessment, and even across different facilities.

Purpose: The adoption and adherence to a standardized assessment protocol could help facilitate continuity of care, assist in clinical decision making, allow clinicians and researchers to define benchmarks for an aggregate clinical population, and in time, aid with patient counseling regarding expectations and predictions regarding longitudinal outcomes.

Design: The Pediatric Minimum Speech Test Battery (PMSTB) working group—comprised of clinicians, scientists, and industry representatives—commenced in 2012 and has worked collaboratively to construct the first PMSTB, which is described here.

Conclusions: Implementation of the PMSTB in clinical practice and dissemination of associated data are both critical for achieving the next level of success for children with hearing loss and for elevating pediatric hearing health care ensuring evidence-based practice for (re)habilitative audiology.

Key Words: auditory rehabilitation, cochlear implants, hearing aids and assistive listening devices, pediatric audiology, speech perception

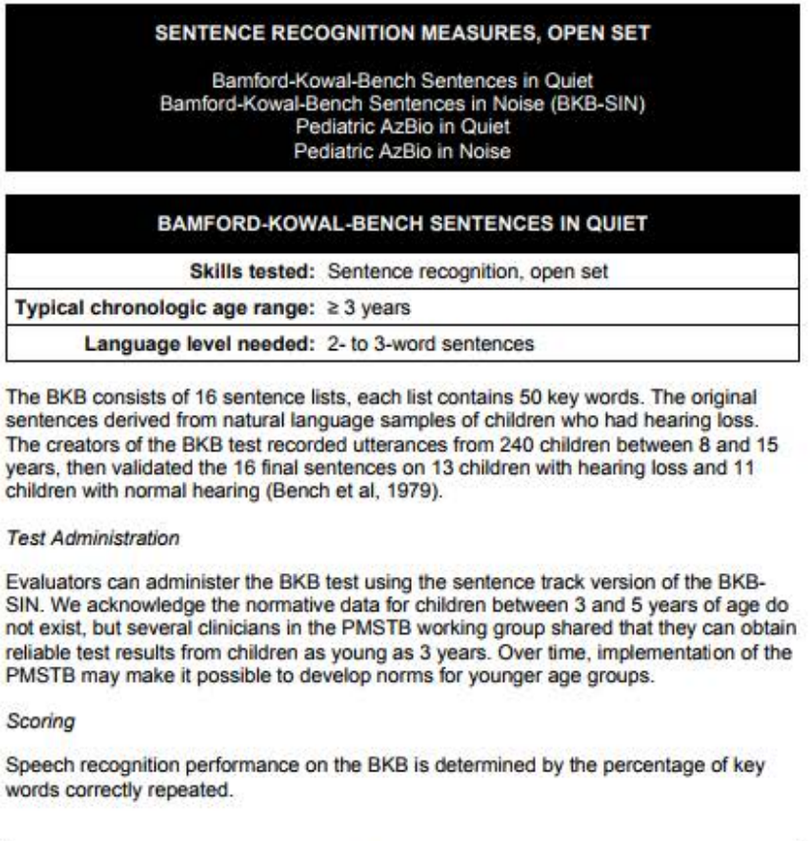
Abbreviations: BAI = bone-anchored implants; BKB = Bamford-Kowal-Bench; CDaCI = Childhood Development after Cochlear Implantation; CI = cochlear implant; CNC = consonant-nucleus-consonant; ESP = Early Speech Perception; FM = frequency modulation; HA = hearing aid; LNT = Lexical Neighborhood Test; LOCHI = Longitudinal Outcomes of Children with Hearing Impairment; MLV = monitored live voice; OCHL = Outcomes of Children with Hearing Loss study; PMSTB = Pediatric Minimum Speech Test Battery; PSI = Pediatric Sentence Intelligibility; VRSD = visual reinforcement infant speech discrimination

INTRODUCTION

Nearly 5 yr ago, Uhler and Gifford (2014) conducted a nationwide survey of pediatric audiologists in an attempt to characterize common clinical practices and protocols. This survey was distributed to 700 audiologists attending the 2012 American Cochlear Implant Alliance meeting via a pencil-and-paper questionnaire as well as to 375 audiologists via Research Electronic Data Capture (Harris et al, 2009). Results revealed a wide variety of tests, implementations, and protocols across facilities, highlighting the need to standardize a speech test battery to monitor outcomes in children with hearing loss. Uhler and Gifford (2014) presented these results at the 2013 AAA Audiology Now! Conference in Anaheim, CA, and later that year at the 2013 American Cochlear Implant Alliance symposium in Washington, DC. Attendees at these meetings plus the

- Uhler, Warner-Czyz, Gifford, and the PMSTB Working Group (2017, March), *Journal of the American Academy of Audiology, 28(3),* 232-247
  - Rationale and resources for tests

PMSTB manuscript and manual



SENTENCE RECOGNITION MEASURES, OPEN SET

Bamford-Kowal-Bench Sentences in Quiet
Bamford-Kowal-Bench Sentences in Noise (BKB-SIN)
Pediatric AzBio in Quiet
Pediatric AzBio in Noise

BAMFORD-KOWAL-BENCH SENTENCES IN QUIET

Skills tested:	Sentence recognition, open set
Typical chronologic age range:	≥ 3 years
Language level needed:	2- to 3-word sentences

The BKB consists of 16 sentence lists, each list contains 50 key words. The original sentences derived from natural language samples of children who had hearing loss. The creators of the BKB test recorded utterances from 240 children between 8 and 15 years, then validated the 16 final sentences on 13 children with hearing loss and 11 children with normal hearing (Bench et al, 1979).

Test Administration

Evaluators can administer the BKB test using the sentence track version of the BKB-SIN. We acknowledge the normative data for children between 3 and 5 years of age do not exist, but several clinicians in the PMSTB working group shared that they can obtain reliable test results from children as young as 3 years. Over time, implementation of the PMSTB may make it possible to develop norms for younger age groups.

Scoring

Speech recognition performance on the BKB is determined by the percentage of key words correctly repeated.

- Uhler, Warner-Czyz, Gifford, and the PMSTB Working Group (2017, March), *Journal of the American Academy of Audiology, 28(3),* 232-247
  - Rationale and resources for tests
- Supplemental Appendix S1 (pages 17-62 of the downloaded manuscript)
  - Instructions
  - Administration
  - Scoring

Calibration

NOTE: The terms Speech-Shaped Noise, Speech Spectrum Noise, and Speech-Weighted Noise are all the same; they are interchangeable

<u>ESP, PSI, MLNT/LNT, CNC if you choose to complete testing in noise: Always use the Speech-Shaped Noise in the audiometer (not on an MP3 file) to calibrate for Speech-in-Noise Testing using External B (Only exception is if you chose to use the competing speech/sentences for PSI)</u>

Visual Reinforcement Infant Speech Discrimination (VRISD)

- You do not need to complete an input calibration. This is completed within the VRISD system itself.
- Change the audiometer presentation level (dB HL) to achieve the correct value in the sound field (dBA). ***Use "a, i, ba, da," from the Video VRA on repeat as stimuli to calibrate External A for 60, 70, 65 dBA. Remember: You want a/i and ba/da to be within +/-2 dB of each other as***

/a/ - /i/ Audiometer Level =	/a/ - /i/ Sound field Level (+/- 2 dB)
_____ dB HL	60 dBA
_____ dB HL	70 dBA
_____ dB HL	65 dBA

Tests

- Questionnaires
  - LittlEARS
  - Auditory Skills Checklist (ASC)
- Phonemic test
  - Visual Reinforcement Infant Speech Discrimination (VRISD)

LittlEARS

- **Skills tested**
  - Detection through comprehension; parent report
- **Typical chronologic age range**
  - Birth to 2 years
- **Language ability**
  - Pre-lexical to competent language

Auditory Skills Checklist (ASC)

- Skills tested
  - Detection through comprehension; parent report
- Typical chronologic age range
  - Birth to 18 years
- Language ability
  - Pre-lexical to competent language

Visual Reinforcement Infant Speech Discrimination (VRISD)

- Skills tested:
  - Discrimination; open-set
- Typical chronologic age range:
  - 6 to 24 months
- Language ability:
  - Pre-lexical to two-word phrases

What is VRISD?

- **Similar to VRA, VRISD is a conditioned head turn response.**
- **Rather than presence/absence of sound, VRISD assesses a response to a *change in sound* (e.g., /a/ vs. /i/ or /ba/ vs. /da/)**

What is VRISD?

- It has been around for over 4 decades, AKA the conditioned head turn procedure
- Contributed to:
  - our knowledge about early language acquisition, auditory development, and speech perception development in young children with normal hearing (e.g., Moore et al, 1975; Eilers et al, 1977; Nozza, 1987)
- It is similar to VRA, but rather than presence of absence of sound it assesses a response to a change in sound
  - Such as:
    - phonemes: /a/ vs. /i/ or /ba/ vs. /da/
    - Duration cues

VRISD Disclosure

- The working group fully acknowledges that most clinical settings do not use VRISD despite its availability for purchase and implementation
- However, guidelines for use and normative data available exist for this age group (Govaerts et al, 2006; Uhler et al, 2015)
- VRISD allows clinicians to assess speech discrimination in infants and toddlers in a manner that does not require linguistic knowledge
  - Benefits for device fitting in two primary ways.
    1. Knowledge of discrimination abilities, validation of amplification fitting for fine tuning is not possible until the child reaches at least 2 years of age, due to other standardly available tests
    2. VRISD assessment can validate that the amplification fitting provides access for phoneme discrimination of the native language. Continued research will enhance the utility and procedures for optimal clinical value

VRISD Summary

We can examine speech discrimination in infants with and without hearing loss who use HA and CI technology

95% of infants with and without hearing loss were able to at least of of the two contrasts at one of three levels (50, 60, and 70 dBA)

For /a-i/: 84% of infants with NH and 95% of infants with HL

For /ba-da/: 71% of infants with NH and 50% of infants with HL

No group differences for either contrast; however, for infants with HL, /a-i/ was easier to discriminate than /ba-da/ ($p=0.0004$)

Uhler et al (2018) Refining stimulus parameters in assessing VRISD in infants with and without HL, Presentation Level, JAAA, 29, 847-854

Speech Intelligibility Index and VRISD

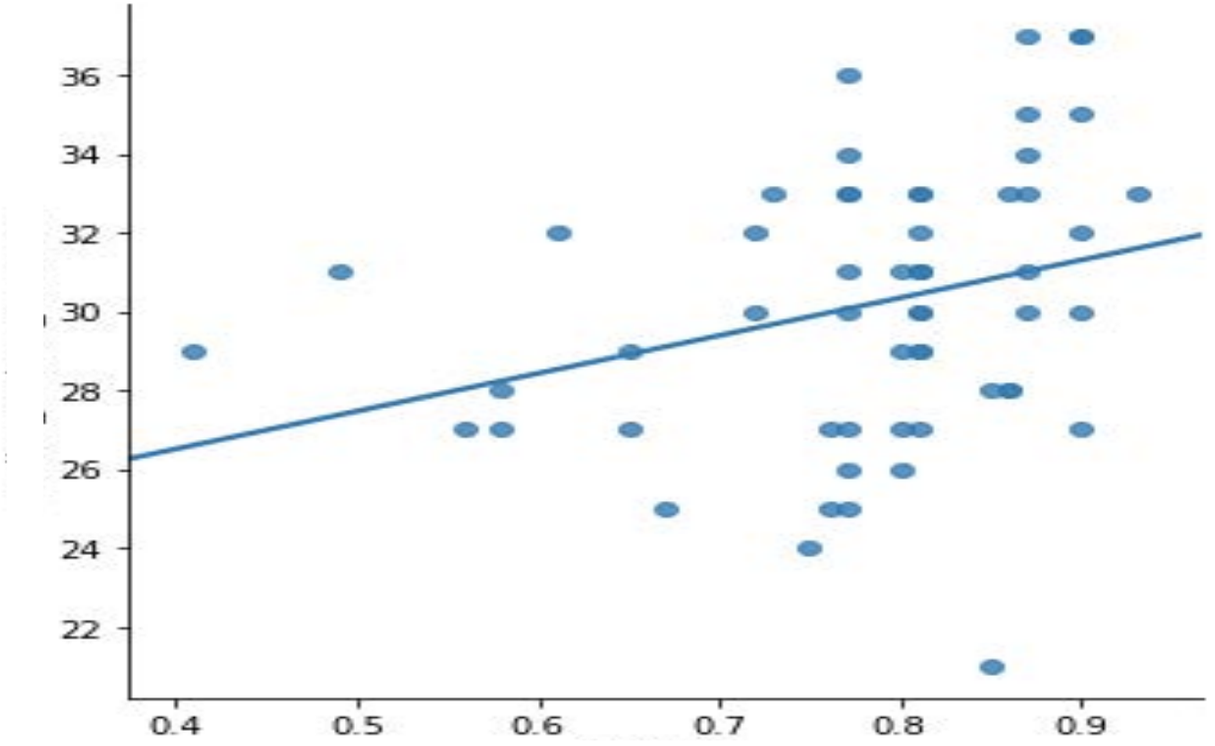
- There was a relationship between successful discrimination of /a-i/ versus unsuccessful discrimination of /a-i/ and aided SII (p=0.02).
  - Higher aided SII values were related to successful /a-i/ discrimination.
- There is also a relationship (p=0.03) between HFPTA and successful discrimination of /a-i/.
- However, the same relationship was not observed for successful discrimination of /ba-da/ and unsuccessful discrimination of /ba-da/ and aided SII (p=.20).
  - Higher aided SII values were not related to success on /ba-da/ discrimination.
- There was not a relationship (p=0.78) between successful discrimination of /ba-da/ and HFPTA.

To examine language at 30 months

- Mullen Scales of Early Learning (Mullen, 1995)
  - Normed on children up to age 5
  - Elicitation of developmental and communicative behaviors by the parent/or examiner
  - Examines 5 domains (Gross motor, visual reception, fine motor, receptive and expressive language)

Is VRISD related to receptive language?

MSEL Receptive language

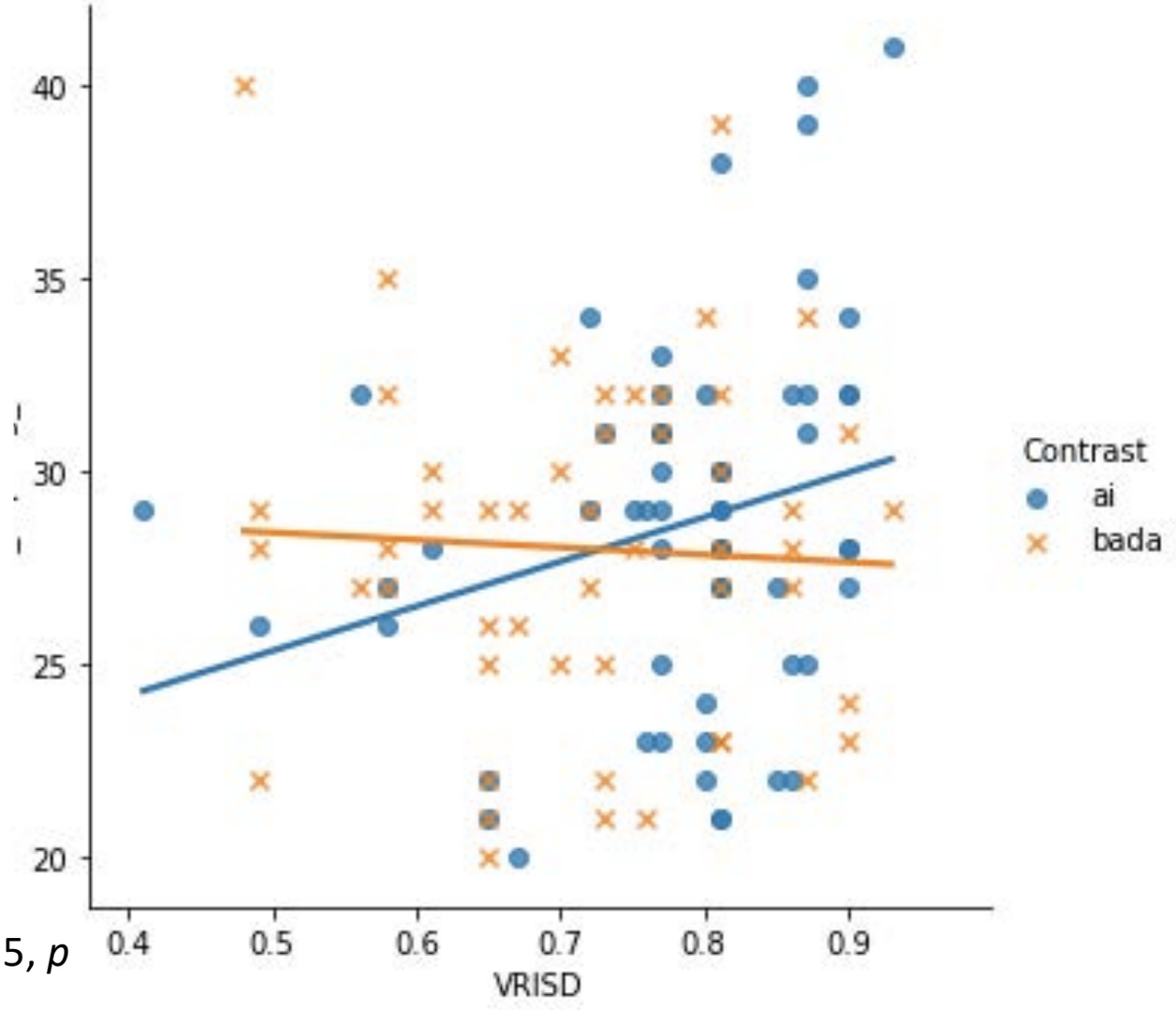


VRISD performance for /a-i/ (p(c) Max)

$B = 0.28$, $t(47) = 2.138$, $p < 0.038$

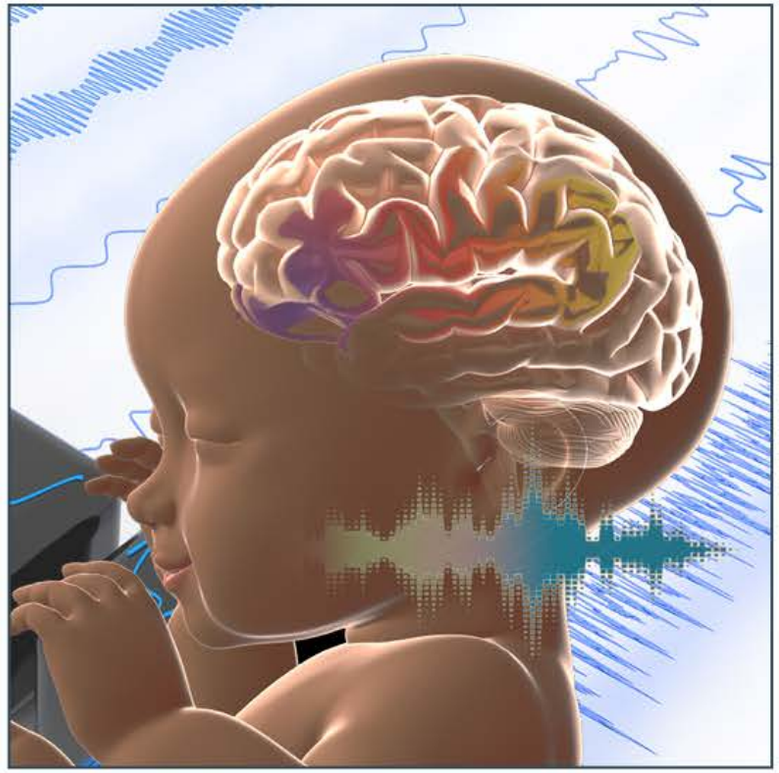
Is VRISD related to expressive language?

MSEL Expressive language



VCxVV B = -0.26, *t*(47) = -2.315, *p* < 0.025

Auditory Evoked Potentials



Can auditory evoked potentials inform us about later speech perception and language?

Auditory Evoked Potentials

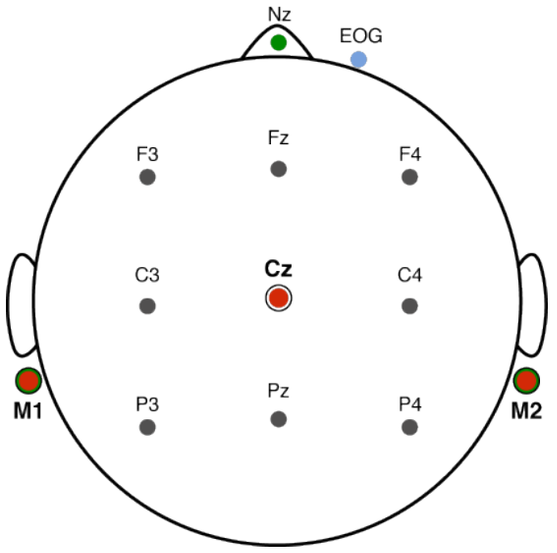
Non-invasive

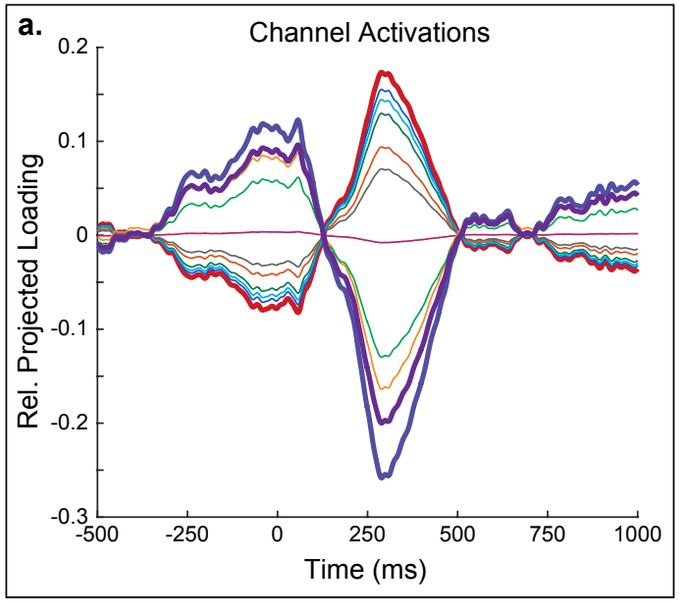
Up to 256 electrodes

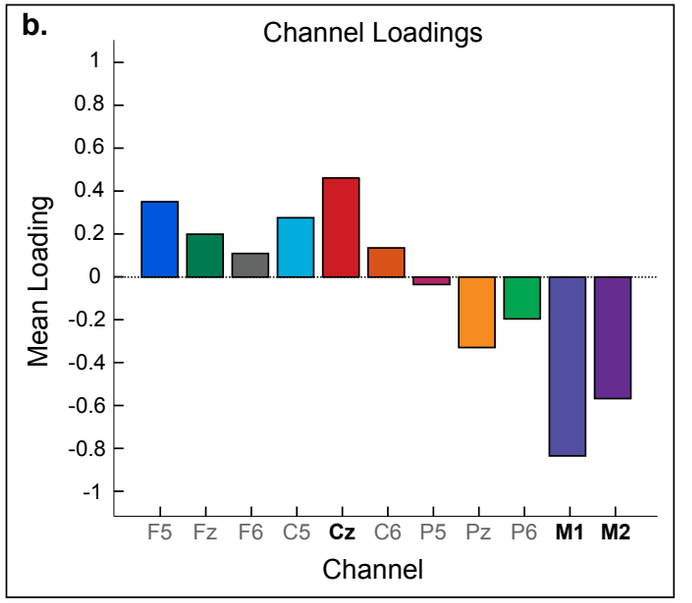
Safe for infants & children

Infant Speech discrimination

Is there an ideal electrode montage (i.e., minimal number of electrodes) for recording CAEP responses in infants?







Vertex referenced to linked mastoids: Cz – (M1+M2)

Significant findings to date

1) Infants CAN process speech information during sleep,

2) Infants DO process speech information during sleep,

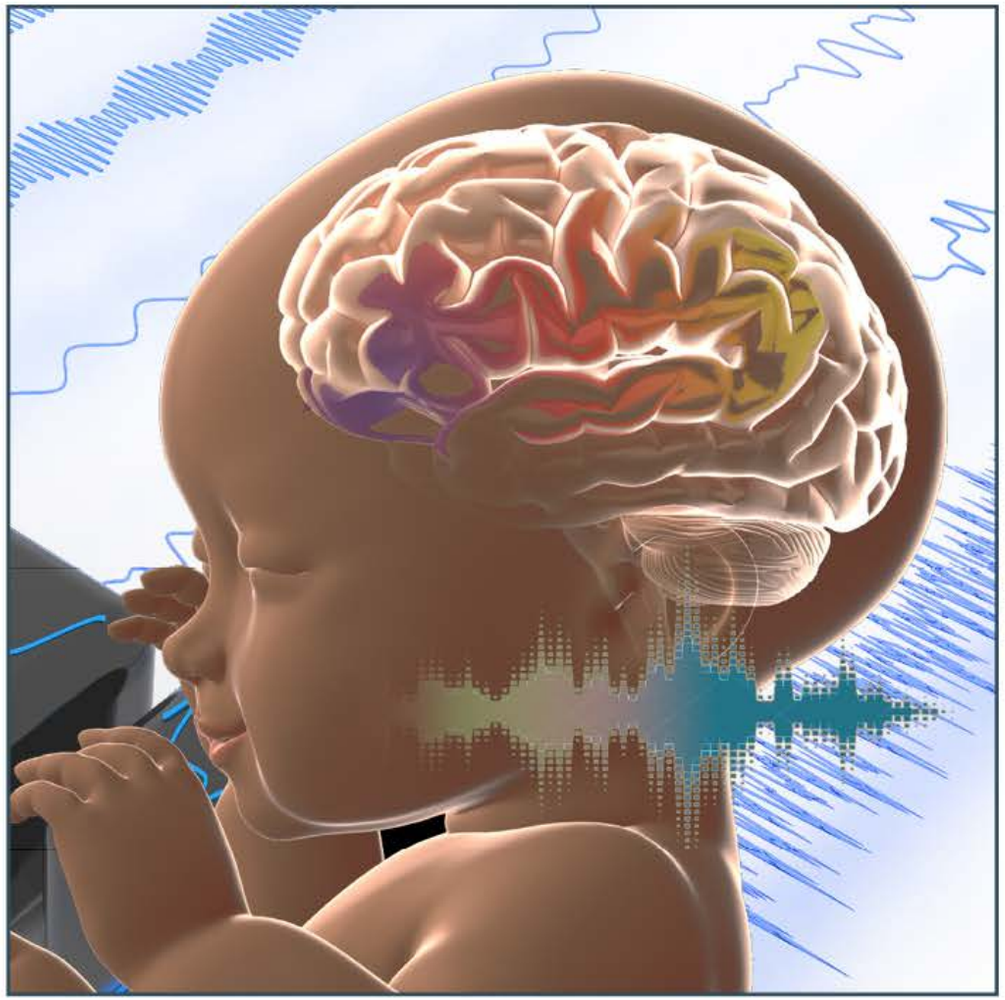
3) These processes include speech discrimination

4) We can observe these processes with advanced EEG analyses.

5) 1-18 Hz bandpass filtering led to MMR in 100% of infants with NH (Uhler et al 2018)

Continuing research and future directions

Where do we go from here?



Summary

- Pilot data supports that MMR_{TF} can be used to successfully predict behavioral speech discrimination
- Higher frequency responses in the Theta band (~8.4 Hz) was associated with better VRISD performance
- Earlier response latencies (~160 ms) were associated with better VRISD performance

Tips and tricks from the trenches

- Patience
- Practice
- Calibrate into dBA and start completing clinically per the PMSTB
- Become comfortable with the “if this then that” of the flowsheet
  - Know the percentages for ceiling and when to move onto another test
- For the first time, start off with a test or multiple tests that you already feel comfortable with
- For the newer tests just pick one to start with
  - Learn it well, practice/roleplay with a co-worker then start completing clinically. Once you feel comfortable with that particular test, focus on another.

Tips and tricks from the trenches

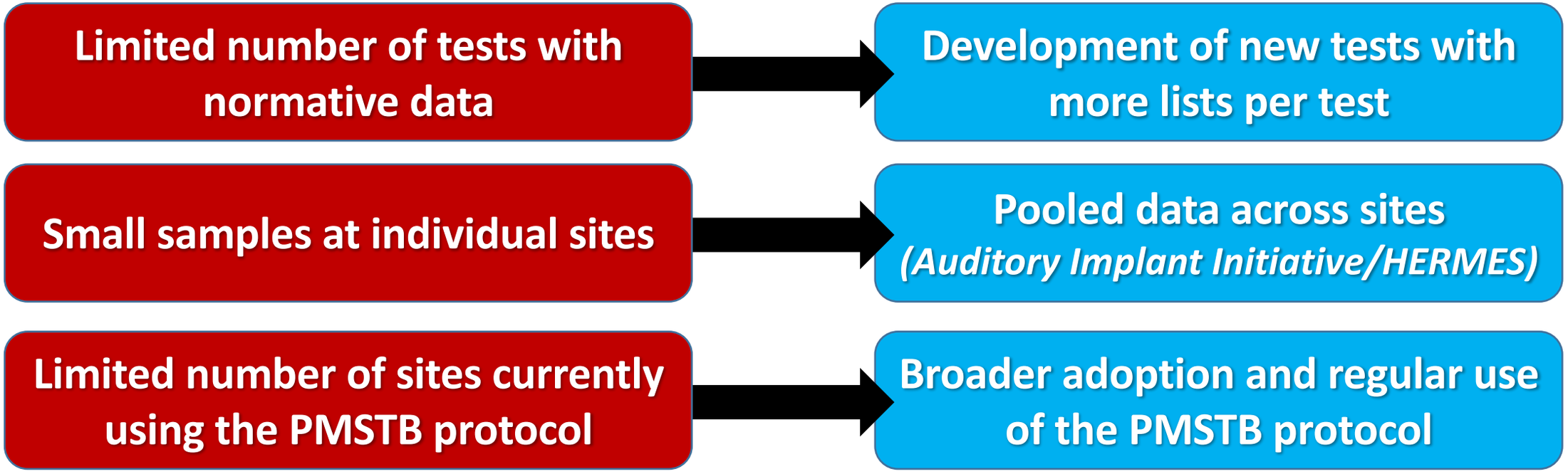
- Prepare and go in with a plan
  - If you have access-review the child's recent speech and language evaluation and/or ask the parents about their child's receptive language.
  - Use pg. 10 of the manual, which lists the child's age, receptive and expressive language, appropriate language measures related to the appropriate PMSTB tests
- Always plan ahead for what you think you might complete with a particular patient.
- Once you've thought of possible testing then think "what clinical question am I trying to answer today"?
  - You may have time to only complete one so make sure you have the most pertinent one addressed first
  - How do you prioritize?
    - New CI user, recently received a second implant

Availability

- Pick something and do it!
- If cost is a major limitation:
  - Questionnaires
  - Words and/or Sentences
- If cost is not a limitation
  - Begin full battery

Challenges and next steps

- The PMSTB provides a standardized protocol to assess speech perception in children with hearing loss
  - Speech discrimination in quiet to sentence recognition in noise



Challenges and next steps

- The PMSTB provides a standardized protocol to assess speech perception in children with hearing loss
  - Speech discrimination in quiet to sentence recognition in noise

- Adoption and adherence can facilitate
  - Clinical decision making
    - Transform pediatric (re)habilitation from the “expert opinion” model to a data-driven, evidence-based model
  - Benchmarking re: peers with typical hearing and hearing loss
  - Critical steps toward development of a national data repository

Thank You