


Improving Diagnosis and Management of Children with Mild Hearing Loss

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Outcomes of Children with Hearing Loss

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Acknowledgements



Outcomes of Children with Hearing Loss

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My history



- Master's degree in Communication Disorders from University of Minnesota-Twin Cities
- PhD in Speech and Hearing Science from University of Iowa
- Associate professor in Department of CSD, University of Iowa



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Outcomes of Children with Hearing Loss Consortium




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What is OCHLCON?

- Started in 2008 by Mary Pat Moeller (Boys Town National Research Hospital) and Bruce Tomblin (University of Iowa)
- Goal: to examine the impact of newborn hearing screening, early intervention, and advances in hearing technology on developmental outcomes of children who are hard of hearing
- Continuous NIH funding for the past 14 years

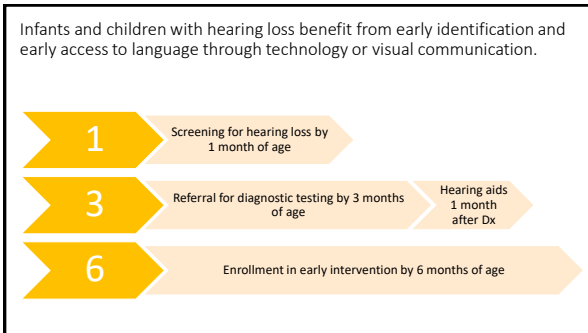




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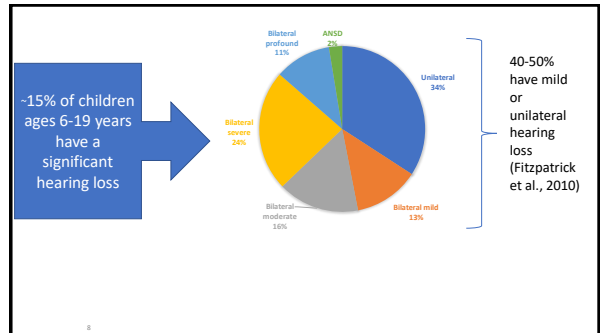
Topics to be discussed today:

- Special challenges for children with mild hearing loss
- Is mild bilateral hearing loss a developmental risk?
- Does amplification help children with mild bilateral hearing loss?
- How to implement an audibility-based criteria for children with mild hearing loss

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What are special challenges for children with mild hearing loss?

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Identification and diagnosis

- NHS not intended to identify < 35 dB
- Delays in confirmation
- Insert earphones calibrated to 2 cc coupler. Sound is louder in an infant ear canal than an adult ear canal.

Management

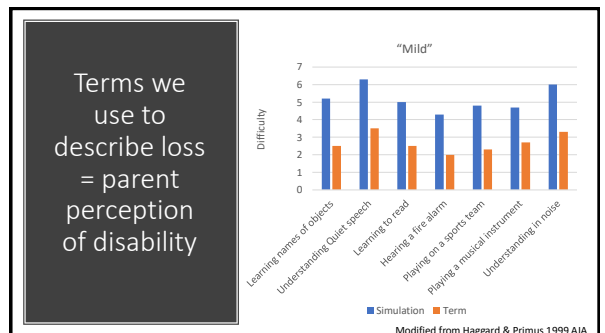
- Delays in hearing aid fitting
- Lack of consensus on optimal intervention strategies

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Why are children with mild HL receiving services later?

- Terms we use?
 - It's "just a mild hearing loss" (Fitzpatrick et al., 2017)

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 - It's "just a mild hearing loss" (Fitzpatrick et al., 2017)
- Uncertainty about benefit?

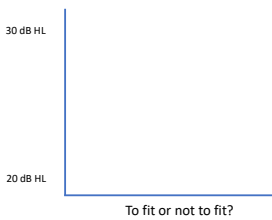
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Why are children with mild HL receiving services later?

- Terms we use?
 - It's "just a mild hearing loss" (Fitzpatrick et al., 2017)
- Uncertainty about benefit?
- Clinical equipoise?

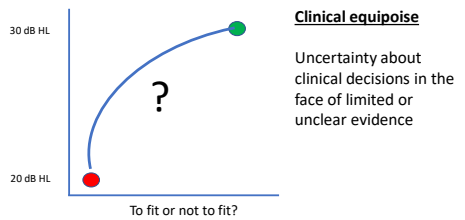
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Fit children with mild bilateral hearing loss?



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Fit children with mild bilateral hearing loss?



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Situation of "clinical equipoise" regarding management for children with mild hearing loss

Current evidence base

- Children with mild HL are at risk for delays and difficulties in the academic setting
 - Bess et al., 1985; Blair et al., 1985; Davis et al., 1981; Dokovic et al., 2013; Yoshinaga-Itano et al., 2008; Lewis et al., 2015

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Effect of Minimal/Mild Hearing Loss on Children's Speech Understanding in a Simulated Classroom

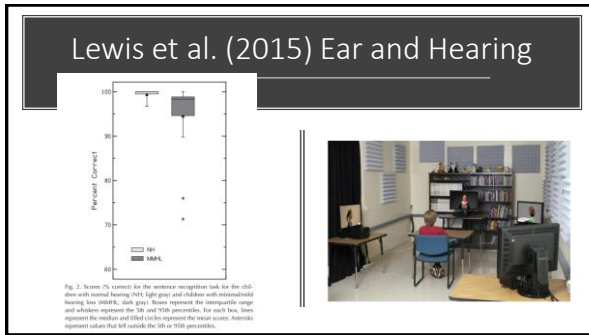
Dawna E. Lewis, Daniel L. Valente, and Jody L. Spalding



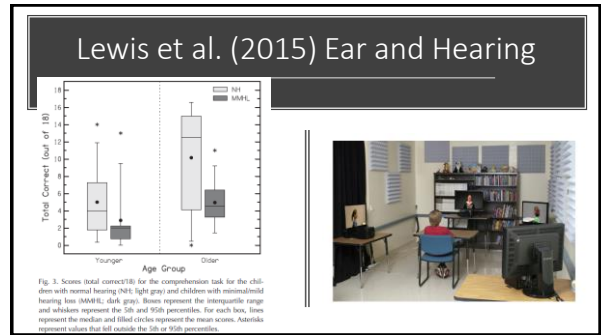
BKB sentences
 Story & comprehension questions
 +10 dB SNR
 0.6 s RT

Lewis et al., 2015

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Situation of “clinical equipoise” regarding management for children with mild hearing loss

Current evidence base

- Other studies show minimal impact of mild HL on outcomes, with ambiguity re. benefit from hearing aids and early identification and intervention
 - Porter et al., 2014; Wake et al., 2006; Carew et al., 2017

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Child care, health and development
Original Article

Mild/moderate non-sensorineural hearing loss: equivoque

Alternatively, mild hearing loss could represent ‘overdiagnosis’, defined as identification of a real condition for which treatment does not actually benefit an individual’s outcomes (Coon *et al.* 2014). This would imply that these children’s developmental deficits might not be attributable solely to their hearing acuity. If so, the decision to amplify mild losses early could represent not only overtreatment (i.e. treatment that cannot deliver benefit) but also active harm (costs, burden, stigmatization).

Carew et al 2017

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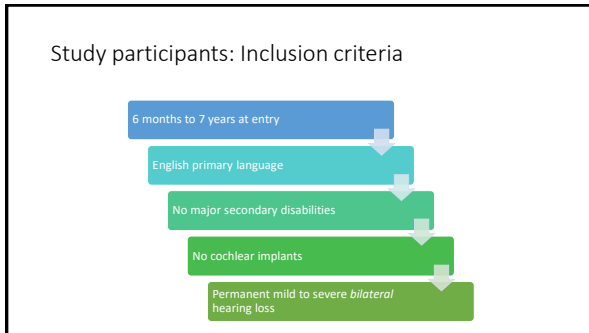
Limitations of past studies

- Mild often grouped with unilateral/minimal HL OR moderate to severe/profound
- Studies focus on the effects of age at service delivery (identification, hearing aid fitting, early intervention)
- Most studies do not describe influence of both aided audibility and amount of daily HA use on outcomes

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Is mild bilateral hearing loss a developmental risk?

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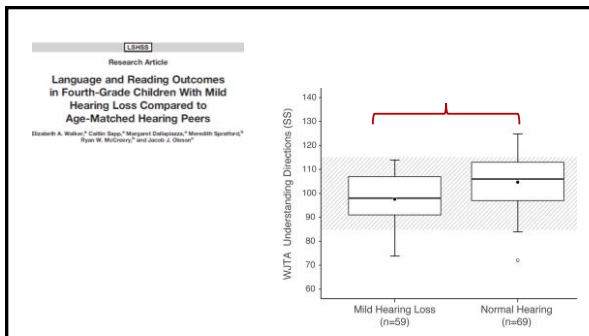


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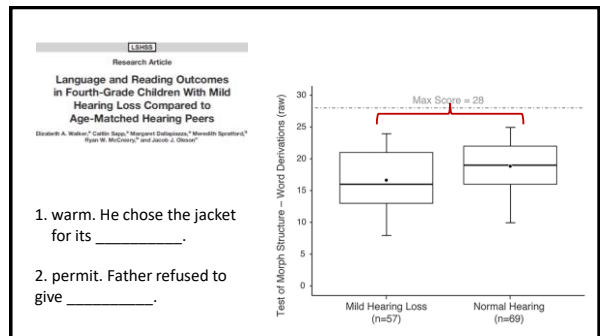
Study participants

	CHH	CNH	Both Groups
Number	317	117	
Gender	173 male; 144 female	54 male; 63 female	Matched on income & maternal education Higher than typical US sample
Hearing	M= 48.88 dB HL 7 without amplification 76% identified from NHS Age of ID = 7.32 mos	< 20 dB HL	

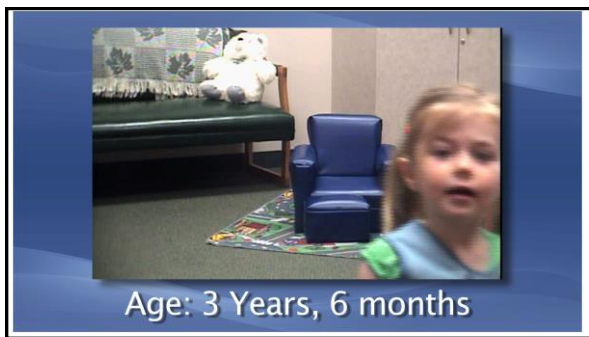
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Bound morphemes, especially in verbs, are less salient and less frequent in the input

- Typically sentence medial (He needs to find...)
- Often involve fricatives in English
- Complex phonetic contexts (It's, Greg's calling...)

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What other areas of language are difficult for children with mild hearing loss?



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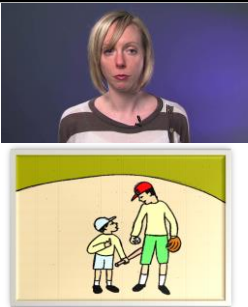


Higher-level social cognition:
Sarcasm

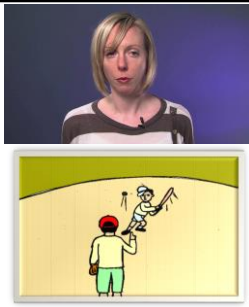
Method

- 9 Picture-Supported Stories
 - de Villiers & de Villiers
- Presented in standard audio-visual format
- Child answered questions requiring interpretation or reasoning

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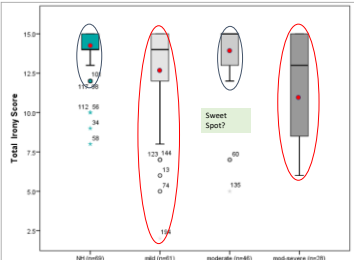


1. What did the big brother mean when he said that?
2. Did the brother think that the little boy was a bad hitter or a good hitter?
Bad _____ Good _____

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Results – Understanding Sarcasm and Irony at 8 years

Main effect of hearing category $p = .001$



Hearing Category	Median Score	Q1	Q3
NH (n=69)	~12.5	~11.5	~13.5
mild (n=61)	~10.5	~9.5	~11.5
moderate (n=48)	~8.5	~7.5	~9.5
mild-severe (n=28)	~7.5	~6.5	~8.5

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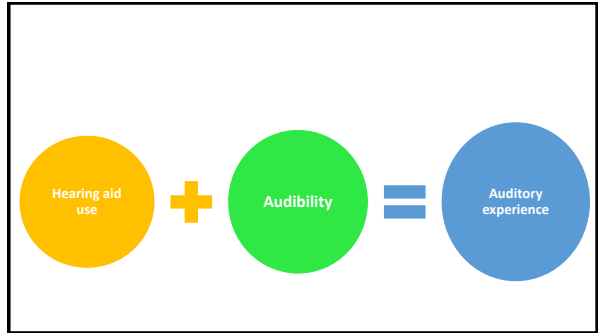
Take-home points!

- Children with mild hearing loss experience delays in diagnosis and clinical management.
- Children with mild hearing loss are at risk for deficits in language and psychosocial outcomes out to fourth grade (at least).
- Cumulative auditory experience may account for these deficits
....but we need to consider role of hearing aid use and audibility

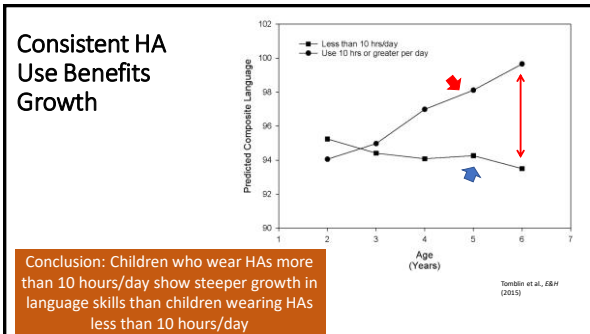
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Does amplification help children with mild bilateral hearing loss?

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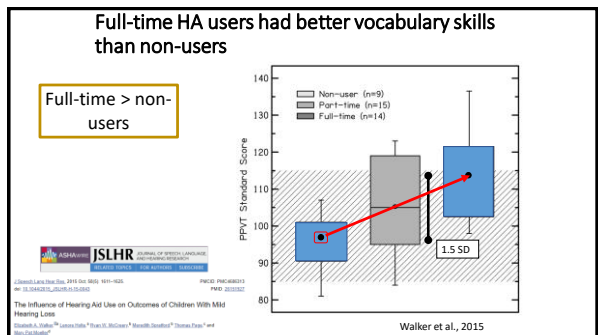
Are there differences in outcomes for children with mild hearing loss based on hearing aid use?

- Vocabulary
- Articulation
- Grammar
- Phonological processing
- Speech recognition in noise

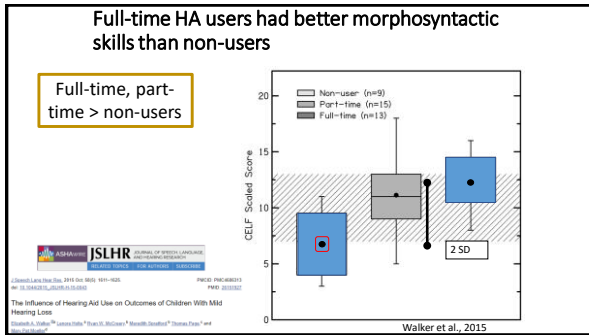
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HA use groups	n=	Average HA use (hrs)	Significant differences:
Full-time (>8.7 hrs)	14	10.99	• Better ear pure tone average (nonusers > part-time, full-time)
Part-time (2-8.3 hrs)	15	5.58	No significant differences between the three groups:
Nonusers (<2 hrs)	9	0.11	• maternal education levels
			• nonverbal IQ

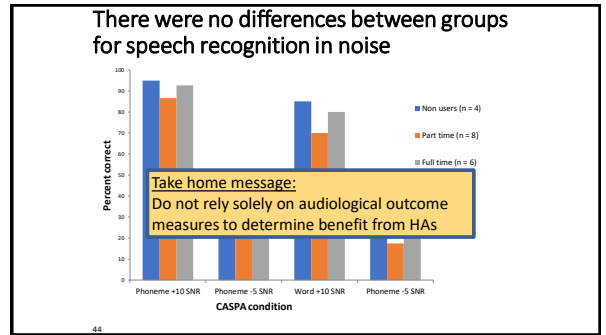
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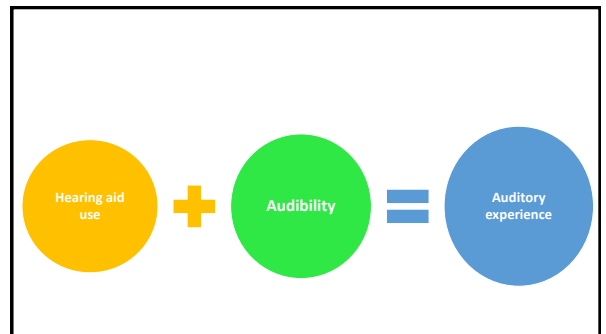


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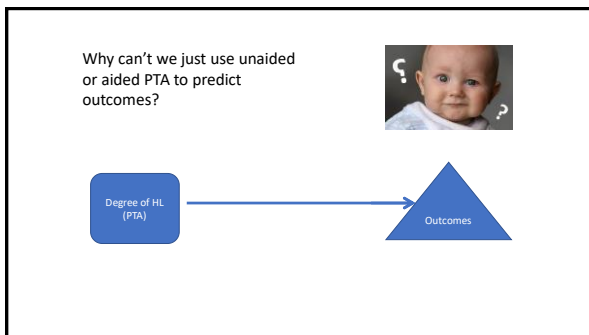
What are the implications?

Traditional word recognition tests may not be sensitive to individual differences for children with mild hearing loss

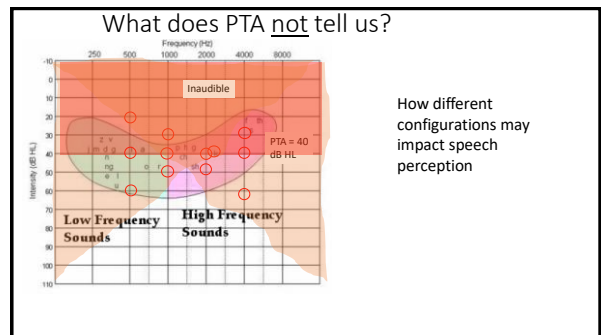
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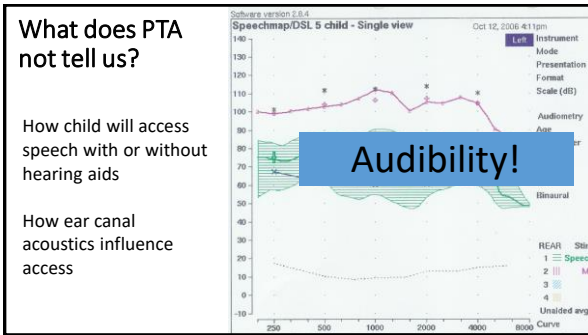
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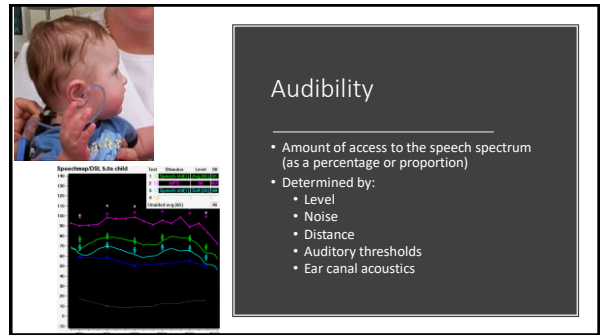
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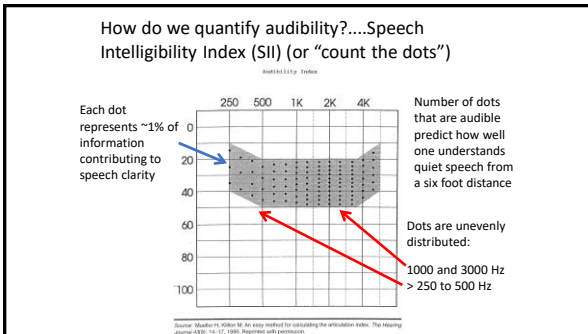
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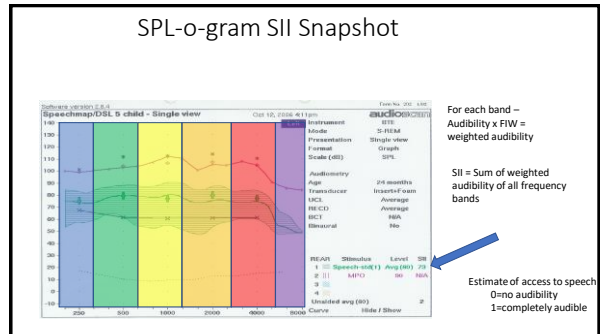
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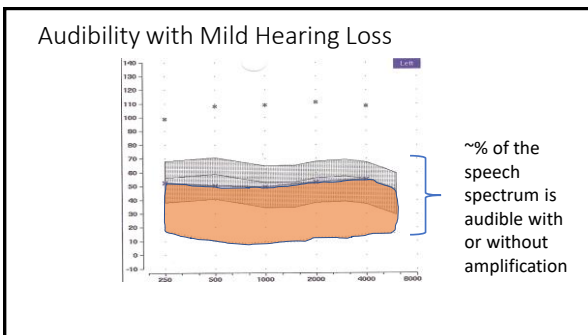
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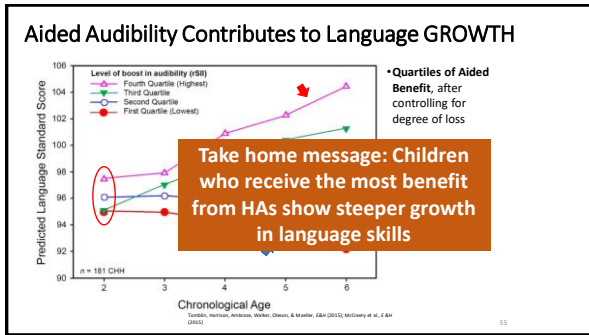


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Consistent audibility appears to be a key construct tied to positive outcomes among children whose families choose spoken language.

Across type and level of HL	Adequacy of amplification	Consistency of access
Tomblin et al., 2015 Walker et al., 2016 Walker et al., 2017 McCreery et al., 2020	Tomblin et al., 2015 McCreery et al., 2017 Walker et al., 2017 Stiles et al., 2012 Davidson et al., 2014	Tomblin et al., 2015 Walker et al., 2015 Walker et al., 2017 Walker et al., 2019 Tomblin et al., 2020 Walker et al., 2020 Park et al., 2019

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Hearing aid candidacy: is there a cut off for unaided SII?

Need evidence-based guidelines about how to use audibility objectively to determine when to recommend amplification.

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McCreery et al. (2020)

Examined 52 kids with mild bilateral hearing loss: either with no hearing aids, or low hearing aid use time (3-10 years old)

Which kids lagged peers with typical hearing, and which kids mirrored peers with typical hearing?

LSHSS LANGUAGE, SPEECH, AND HEARING SERVICES IN SCHOOLS

Audibility-based hearing aid fitting criteria for children with mild bilateral hearing loss

Journal	Language, Speech, and Hearing Services in Schools
Manuscript ID	LSHSS-0041-19-0023.R3
Manuscript Type	Research Article
Date Submitted by Author	10-Apr-2019
Complete List of Authors	McCreery, Ryan, Ross, Texas National Research Hospital, Research Institute, Elizabeth, University of Iowa, Communication Disorders and Hearing, Oregon, Oregon Children's Hospital, Audiology, Research, Marshall, Iowa National Research Hospital, Center for Childhood Hearing, Oregon, Pacific University of Oregon, Educational Leadership, Oregon, Ross, Texas National Research Hospital, Hearing Research
Keywords	Hearing, Amplification or hearing aids, Hearing loss, Children

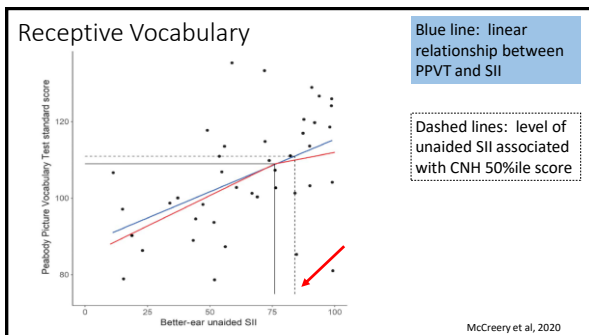
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What is the unaided SII cutoff point where hearing aid use no longer seems to influence language development?

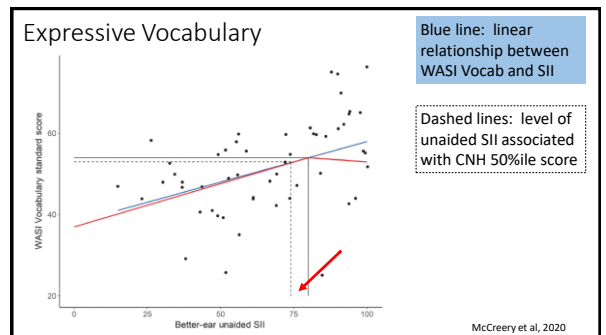
Used an analysis technique to identify an inflection point

- Compared two different criteria
- Level = 50% percentile for children with normal hearing
- Iterative piecewise regression
- Finds point or "knot" in unaided SII where relationship between SII and language changes

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Table 2. Final iterative piecewise regression models for each language outcome.

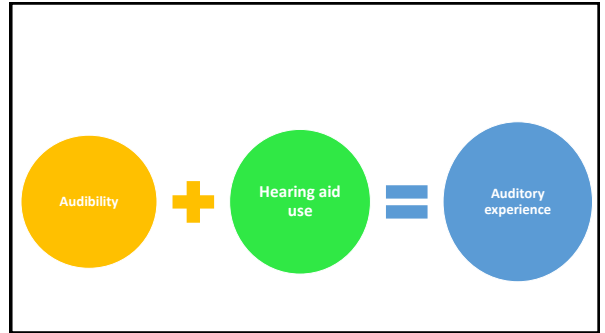
Language outcome	Knot	Akaike information criterion	MSE
PPVT-4	76	333.56	177.4
CASL Syntax Construction	72	345.6	156.8
WASI Vocabulary	80	322.8	152.6

Note. MSE = mean square error; PPVT-4 = Peabody Picture Vocabulary Test-Fourth Edition; CASL = Comprehensive Assessment of Spoken Language; WASI = Wechsler Abbreviated Scale of Intelligence.

Vocabulary- the cutoffs were SII values of 76%, and 80%

Grammar- the cutoff was an SII value of 76%

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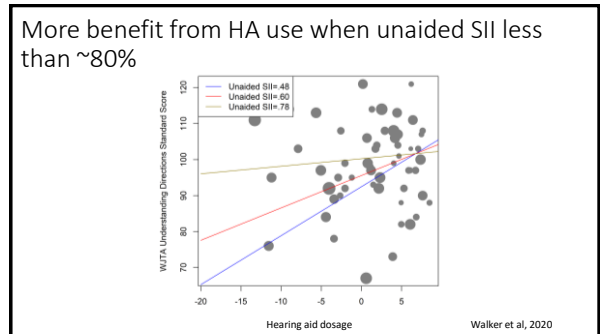
What if we combine SII with HA use?

$$\text{AidedHrs}^{\text{AidedSII}} - \text{UnaidedHrs}^{\text{UnaidedSII}} = \text{HA Dosage}$$

Hours	Aided SII	Hours	Unaided SII	HA dose
16	0.75	8	0.25	6.32
12	0.75	12	0.25	4.59
8	0.75	16	0.25	2.76
4	0.75	20	0.25	0.71

Walker et al, 2020

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What is the take-home message?

Children with mild hearing loss (**especially with unaided SII <.80**) are at risk for delays in language acquisition. Should be considered candidates for amplification.

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- | | |
|---|--|
| <p>PTA-based criterion</p> <ul style="list-style-type: none"> • Did not reflect effects of ear-canal acoustics • Not based on language outcomes data • Not easy to quantify impact of hearing on audibility | <p>New unaided SII criterion</p> <ul style="list-style-type: none"> • Reflects effects of ear-canal acoustics on thresholds • Based on language outcomes data • Quantifies impact of hearing on audibility |
|---|--|

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How to implement an audibility-based criteria for hearing aid candidacy?

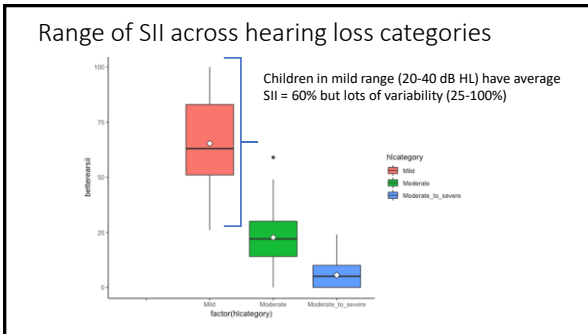
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How to implement audibility criteria

1. Enter audiogram into Verifit at diagnostic visit
2. Observe unaided SII value for average speech

The screenshot shows an audiogram plot on the left and a summary table on the right. The table includes fields for 'Speech-IGSRT', 'SII', 'BTE + HA.4', 'Audibility', 'Average', 'ACC', and 'NCT'. The 'SII' field is highlighted in red and shows a value of 60. The 'Average' field is also highlighted in red and shows a value of 60.

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What if you don't have a Verifit?

The screenshot shows the KIPA Pediatric Audiology website. On the left is the KIPA logo and the website URL 'Kipagroup.org/charts'. On the right is a chart showing 'Hearing Threshold' and 'Speech-IGSRT' for a child. Below the chart is a Verifit interface showing 'Average Speech SII at 60 dB SPL' and 'Average Speech SII at 50 dB SPL' for both Right (R) and Left (L) ears, both showing 89% (81-95)%.

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Case study

- 5 year old child ("Charlotte") with recently diagnosed hearing loss
- NHS results – suspected pass (parents reported technical problems with equipment)
- Parents have concerns because speech and language isn't as good as older brother's (Speech and language results at 5 years of age (6 months HA experience)
 - 3 on CELF Word Structure (expressive syntax; mean is 10 and SD is 1.5)
 - 86 on GFTA
 - 86 on PPVT
 - 100% on PBK-50

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Charlotte: Candidate for amplification?

- What do you think her unaided SII is?

Left ear 4F PTA = 22.5 dB HL
 Right ear 4F PTA = 31.25 dB HL
 Unaided SII, left ear = ?
 Unaided SII, right ear = ?

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Case study #1 (Charlotte)

	CELF Word Structure (mean = 10)	GFTA (mean = 100)	PPVT (mean = 100)
5 years of age (just fit with HAs)	3	86	86
7 years of age (2.5 years with HAs)	12	103	121

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Case study #2: "Kate" (6 years old)

	250	500	1000	2000	4000	6000	8000
Left	35	30	25	15	20	15	10

Left ear 3F PTA	Left ear 4F PTA	Left ear unaided SII
23 dB HL	23 dB HL	?

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"Kate"

	250	500	1000	2000	4000	6000	8000
Left	35	30	25	15	20	15	10

Left ear 3F PTA	Left ear 4F PTA
23 dB HL	23 dB HL

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Would you recommend hearing aids?

	250	500	1000	2000	4000	6000	8000
Left	35	30	25	15	20	15	10

A. Yes
 B. No
 C. Need more information

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"Kate"

	250	500	1000	2000	4000	6000	8000
Left	35	30	25	15	20	15	10

Left ear 3F PTA	Left ear 4F PTA	Left ear unaided SII
23 dB HL	23 dB HL	?

What do you think her unaided SII is?

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"Charlotte" (PTA = 23, unaided SII = 72%, aided SII = 94%)

"Kate" (PTA = 23, unaided SII = 94%, aided SII = 97%)

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Two issues going on here...

1. Same child: different year, different RECD measures...different dB SPL

Age	Ear	250	500	1000	2000	4000	6000
6	Left audio	35	30	25	15	20	15
6	RECD (ave)	3	5	9	8	13	13
6	dB SPL	53	41	35	29	35	
7	Left audio	25	30	30	15	25	5
7	RECD (meas)	3	1	3	5	5	5
7	dB SPL	37	37	34	26	32	-1

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1. Same child: different year, different RECD measures...different dB SPL

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Need to take ear canal acoustics into account!

Measured RECD may not equal average RECD

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Two issues going on here...

2.

Age	Left ear 3F PTA	Left ear 4F PTA	Left ear unaided SII	Left ear aided SII (65 dB input)
7 year	25 dB HL	25 dB HL	100	95

The SII in the Verifit includes a level distortion factor that negatively impacts audibility when the input is above 73 dB HL in a specific frequency band.

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Two issues going on here...

2.

Age	Left ear 3F PTA	Left ear 4F PTA	Left ear unaided SII	Left ear aided SII (65 dB input)	Left ear aided SII (50 dB input)
7 year	25 dB HL	25 dB HL	100	95	99

The SII in the Verifit includes a level distortion factor that negatively impacts audibility when the input is above 73 dB HL in a specific frequency band (in this case, 1000 and 1500 Hz).

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Case study #3: "Louis"

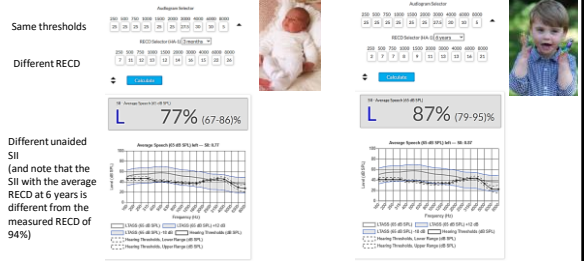


	250	500	1000	2000	4000	6000	8000
Left	25	25	25	25	30	10	5
Right	20	20	20	20	40	15	5

Left ear 3F PTA	Left ear 4F PTA	Left ear unaided SII	Right ear 3F PTA	Right ear 4F PTA	Right ear unaided SII
25 dB HL	26 dB HL	?	20 dB HL	25 dB HL	?

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Same HL - 3 months vs. 6 years



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Conclusions:
Implications for counseling

- Diagnostic Audiologist can:
 - Use unaided SII to assess audibility
 - Discuss audibility and why it is important for language (explain auditory access in percentage instead of descriptive terms)
 - Discuss how even small disruptions in audibility can affect communication

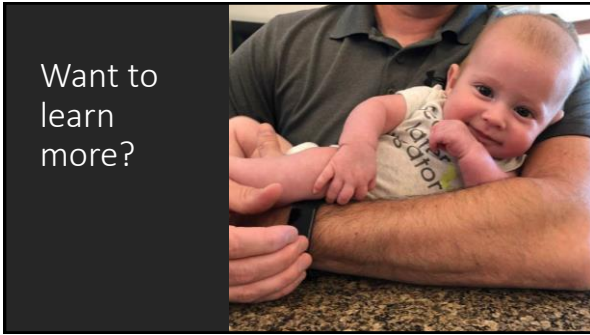
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Conclusions:
Implications for intervention for children with mild hearing loss

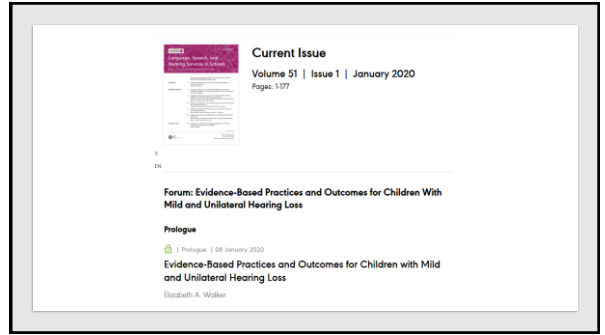
Children with mild hearing loss (specifically with unaided SII >80%) don't show increased benefit from hearing aids.

Children with mild hearing loss (specifically with unaided SII <80%) are at risk for delays in language acquisition without hearing aids.

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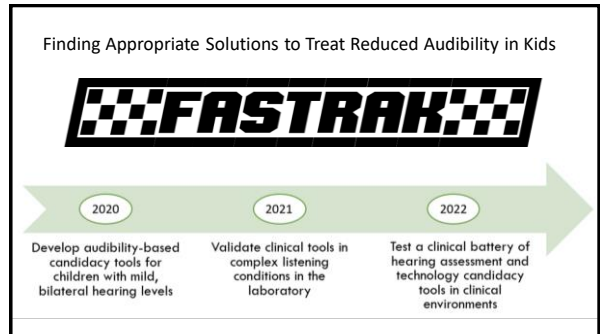
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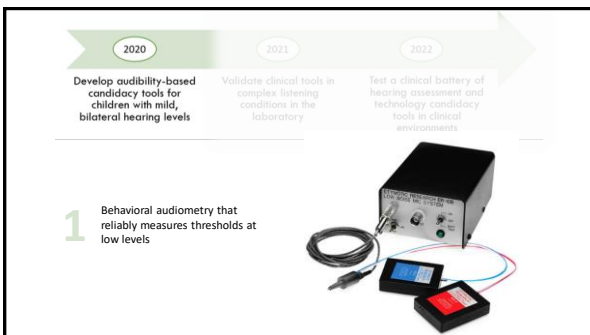
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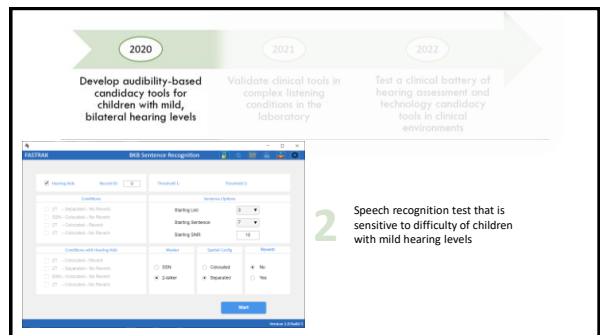
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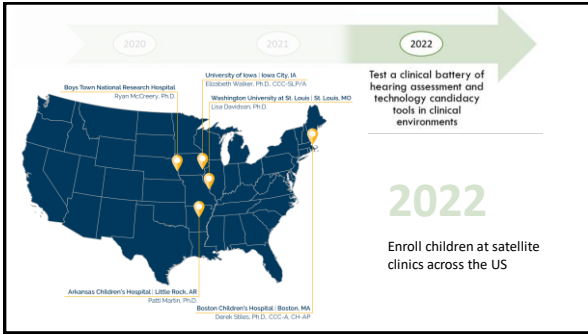
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