# Language underperformance in children who are D/HH: How to recognize it and what to do about it

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## Conflict of interest

- No conflicts of interest

- Personal Biases:
- Focus is on **language**, not modality
- It is about the brain
- The motivation for solid language foundation is to promote independent functioning now and later in life

## Learning Objectives

- To describe language underperformance in children who are D/HH
- To identify the impact of language underperformance in children who are D/HH on developmental domains
- To recognize the impact of high-tech augmentative and alternative communication intervention strategies on language learning in children who are D/HH

## Outline

- Background
- Research culmination
  - Labels are not predictive
  - Understanding language gaps
  - Impact on functional outcomes
- Clinical considerations from findings
- Motivation to change
- Technology assisted language intervention
- What to consider

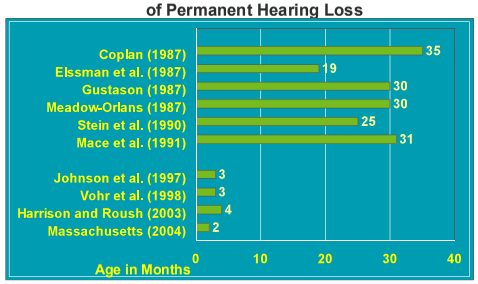
## Impact and Accomplishments

- 1-3/1000 infants born with significant hearing loss
  - Which impacts how language and communication is accessed

- Universal Newborn Hearing Screening (UNHS) has decreased the ages of identification and intervention
  - Earlier age of intervention supports language development
  - Many with average language levels

*CDC 2016 EHDI Summary; Sininger et al. JAAA. 2009. Uus K, Bamford J. Pediatr. 2006; Meinzen-Derr et al. Am Ann Deaf 2011. Moeller. Pediatr. 2000. Yoshinaga-Itano et al, Pediatr. 1998.; Yoshinaga-Itano, Pediatrics 2017*

## Hearing Screening has made a difference



## Rationale

- Improvements in technology have occurred over the years enhancing acoustic access and communication access for many children
  - Cochlear implants and implantable devices, advances in hearing aid technology, video relay, texting
- With these great accomplishments, and when children meet the benchmarks, many children have language levels in the low average range

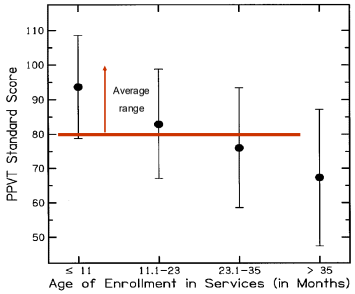
*CDC 2016 EHDI Summary; Sininger et al. JAAA. 2009. Uus K, Bamford J. Pediatr. 2006; Meinzen-Derr et al. Am Ann Deaf 2011. Moeller. Pediatr. 2000. Yoshinaga-Itano et al, Pediatr. 1998.; Yoshinaga-Itano, Pediatrics 2017*

## Vocabulary at Age Five by Age of Intervention

Significant Predictors:

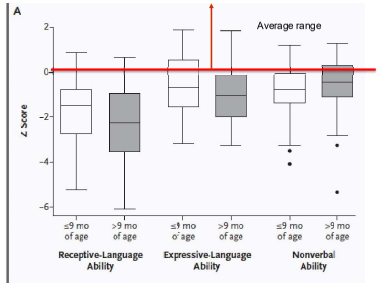
ID Age: 8%

Family Involvement: 37%




Moeller 2002

## Impact of the **Age of Identification** on Language Outcomes in Children who are Deaf/HH



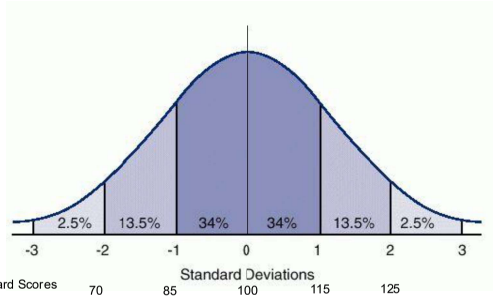

Kennedy et al 2006, n=104

## Language Gaps in D/HH

- Language continues to hover in "average" to low average range
- Is this average to low average good enough?
- Should language scores be used as a "target"?
  - This approach does not consider a child's cognitive capabilities
- My personal and scientific belief is that language levels should be commensurate to a child's cognitive abilities
  - Above average cognitive abilities should have above average language abilities

*Tomblin, 2015; Nittrouer 2014, 2016; Meinzen-Derr, 2014; Luckner 2005; Traxler, 2000*

## What does average even mean?




## Culmination of research

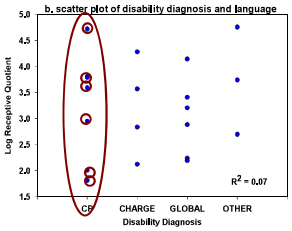
Children with Cochlear implants with "additional disabilities"

Clinical characteristics of children who are D/HH

Disparities in access to CI

| Early 2000's | 2005-2010 | 2010-2015 | Current |
|---|---|---|---|
| **CI and Disability Focus** | | | |

## Specific Disability Label Not Very Predictive




*Meinzen-Derr J, et al. 2010 Laryngoscope;*
*Meinzen-Derr J, et al. 2011 Res Dev Disabil*

## Culmination of research

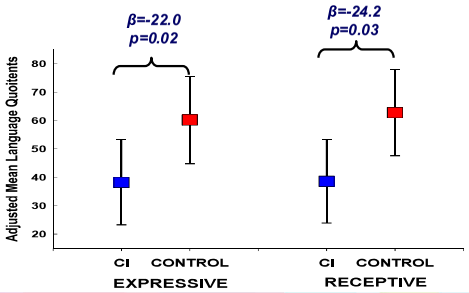
Multi-site observational study of children who are Deaf-blind with CI's

Understanding language in children who are D/HH Plus

Early 2000's | 2005-2010 | 2010-2015 | Current

**Disability Focus**
**Recognition of non-verbal IQ as necessary but not sufficient**

## Language Differences




## D/HH Plus Overall Findings

- **Nonverbal cognitive abilities** biggest predictor of language skill progress (*necessary but not sufficient*)
- In children who are DHH Plus, language skills **significantly lower** than age-cognitively matched peers
- **Language levels not commensurate with nonverbal cognitive abilities**

*Laryngoscope 2010 (120) 405-413; Research in Developmental Disabilities 2011 (32) 757-767*

## Culmination of research

Recognition of a cognitive-language gap in children who are D/HH plus as compared to DD matched controls

Cross-sectional study on language and cognitive abilities in children who are D/HH (DD and typically developing D/HH)

Negative impact of language gaps on social functioning

Early 2000's | 2005-2010 | 2010-2015 | Current

**Expanded focus on impact of language gap in all children who are D/HH**

## Defined Language "Underperformance"

***Language abilities relative to cognitive abilities***

***Receptive Language standard score***
***Nonverbal IQ standard score***

**LANGUAGE = 85**

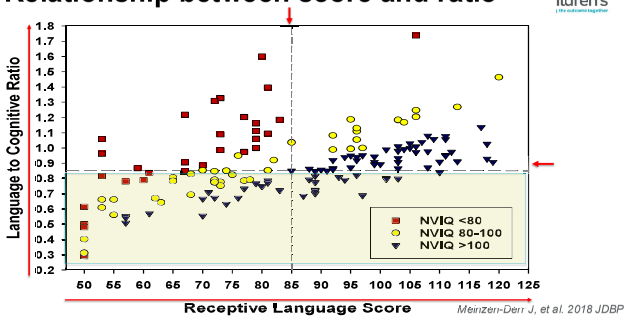
**IQ = 100**

**85/100 or 0.85**

***~45% have a language to cognitive ratio <0.85***

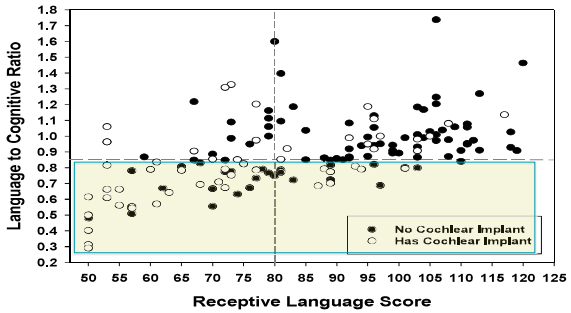
| Characteristics of participants | N=153 |
|---|---|
| Mean Age at study in mos | 47.3 (19) |
| Mean Age at HL identification in mos | 10 (12) |
| | Median 4 |
| Male | 57.8% |
| Caucasian | 80.7% |
| Premature birth | 19.2% |
| Mild to moderate hearing loss | 54% |
| Received a cochlear implant | 35.3% |
| Age at implant in mos | 26.3 (14) |
| Maternal education <HS/HS/GED | 18.5% |
| Some college | 24.5% |
| College graduate | 30.5% |
| Post college | 26.5% |
| Public health insurance only | 33.8% |
| Income at or below poverty level | 15.9% |

## Relationship between score and ratio

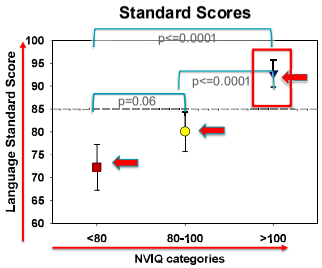



Meinzen-Derr J, et al. 2018 JDBP

## Relationship between score and ratio




## Understanding language levels differently

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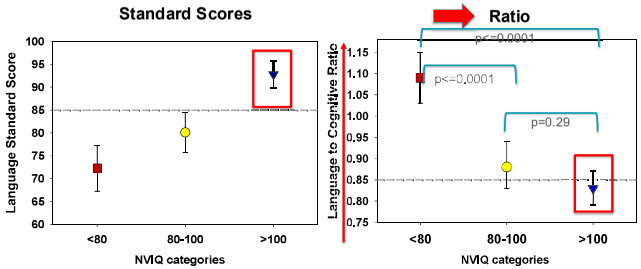
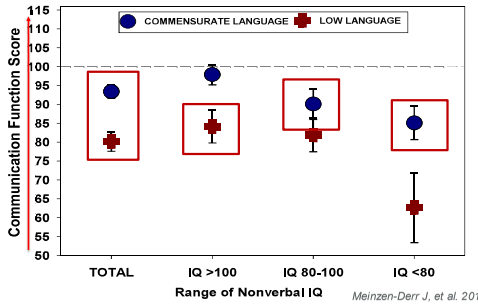
## Understanding language levels differently




Meinzen-Derr J, et al. 2018 JDBP

## Impact on functional outcomes




Meinzen-Derr J, et al. 2014 JDBP

- In this study, what were the independent factors associated with having a language underperformance?

## Factors associated with LU

| Factors | OR | 95% CI |
|---|---|---|
| **NVIQ categories** | | |
| >100 | **6.9** | 1.7, 27.5 |
| 80-100 | **8.2** | 1.9, 36.2 |
| <80 | | |
| **Use a CI** | | 5, 9.4 |
| **Aided thresho** | | 2,1.6 |
| **Socioeconomic index** | | |
| Lowest quartile | **6.5** | 2.1, 20.3 |
| Upper 3 quartiles | **Ref** | |
| **Nonwhite** | **3.2** | 1.02, 10.0 |
| **Age at study visit (each 1 mo)** | **1.02** | 0.99, 1.045 |
| *NS: age at ID, duration with device, time in therapy* | ***AUC*** | ***0.82*** |

**A child aided to 40 dB is nearly 3 times as likely as a child aided at 20 dB to have LU**

## Gap not identified through standard scores

- A high proportion of children who were deaf/hard-of-hearing had a LU
  - Children with higher NVIQ were at highest risk for LU
- Standard scores, however, did not always convey that a language "gap" exists
  - Potential missed opportunities for improvement

## What does this mean?

- When only looking at language standard scores, there are missing aspects of the full picture
  - Language standard scores alone do not necessarily help us understand a true under-performance
- By looking at how children are doing related to their cognitive abilities, we are able to identify true under-performance in children who are D/HH

## How do you even know where a child should be?

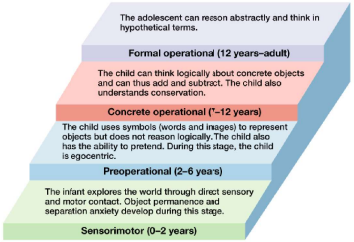
- This is like a growth curve, one point in time is not particularly predictive
- The pattern over time is most helpful

## Cognitive Development

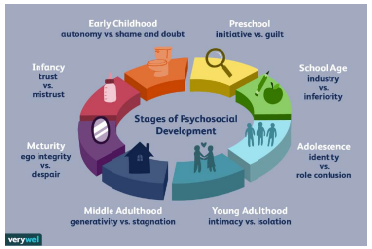
- Many theories, many with overlapping features
  - Neurologically driven (Gesell)
  - Cognitively driven (Piaget)
  - Socially driven (Erickson)

Among **children who are D/HH**, may need a different presentation/approach for language learning, but **should still follow typical cognitive trajectory**

## Piaget




## Erickson: Relational, purpose




## General windows for cognition

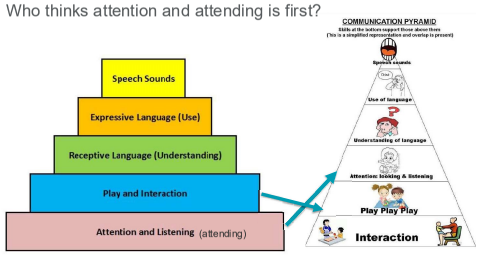
| Age | Interest/Skill |
|---|---|
| 4-6 months | Interested in faces/people over objects |
| 6-9 months | Mouthing, objects are becoming interesting |
| 9-12 months | Cause and effect, drop it pick it up game, waving, back and forth play (ball), getting reactions from others (biting, pulling off glasses) |
| 12-15 months | Exploration and movement, climbing, reaction of others |
| 15-18 months | Watch what others do and imitate, emerging but simple pretend play, tantrums (early emotional regulation) |
| 24 months | Expanded complex pretend play, independence, emerging first-then concepts (first eat your green beans, then you can have a cookie) |

## And what about language development?

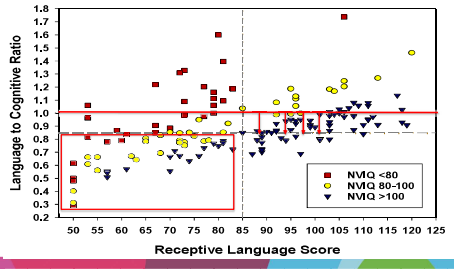
- Hierarchy of skill development
- Atypical language learning

## Frameworks for language learning

Who thinks interaction is first?
Who thinks attention and attending is first?




## Language Standard Scores by Language Ratios: Is there a Language Disorder here?



## Potential for Speech and Language Disorders in children who are D/HH

- Speech articulation disorders
- Apraxia of speech
- Dysarthria
- Language processing
- Language disorders (receptive and/or expressive)
- "Auditory processing"
- Autism Spectrum Disorder

Strategies for thinking about these possibilities:

Aidability: what would you expect to see?

Receptive vs Expressive: is this a gap?

Communication needs: Input vs Output, is it different?

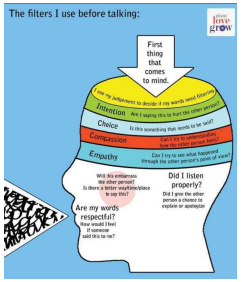
What and how is the child trying to communicate?

## Pre-Linguistic Communication Red Flags for Autism in Hearing Children

Barbaro, J. and Dissanayake, C. **Prospective Identification of Autism Spectrum Disorders in Infancy and Toddlerhood Using Developmental Surveillance: The Social Attention and Communication Study.** Journal of Developmental & Behavioral Pediatrics. 31(5):376-385, June 2010.

| Behavior | 8 months | 12 months | 18 months | 24 months |
|---|---|---|---|---|
| Eye Contact | X | X | X | |
| Turning to Name Call | X | X | | |
| Imitation | | | | X |
| Pointing | | X | X | X |
| Gestures-Waving | | X | X | X |
| Pretend Play | | | X | X |
| Showing Behaviors | | | | X |
| **Fail Criteria** | **Fail 2/2** | **Fail 3/4** | **Fail 3/4** | **Fail 3/5** |

## Higher level pragmatics




## Clinical Red Flags for LU

- How can we recognize these children earlier?
  - Tracking and measurement
- It takes a village (team approach)
- What do you do when you find a problem?

## Culmination of research

**Implementation of a research advisory committee**

Longitudinal study on language and cognitive abilities in children who are D/HH

RCT of novel intervention to improve language in children who are D/HH with a language gap

Data linkage study of EHDI, EI, ODE data for children who are D/HH with focus on long-term outcomes (Broader Public Health Focus)

Early 2000's
**CI and Disability Focus**

2005-2010
**Disability Focus**
**Recognition of non-verbal IQ as necessary but not sufficient**

2010-2015
**Expanded Focus on Impact of Language gap in all children who are D/HH**

Current
**Typical D/HH and Disability Focus, Shift to Intervention**

## Overall motivation for something different

WHY
- Recognition of a language gap among children who are D/HH
  - language outcomes continue to hover in the average/low average range
- Belief that this gap does not have to persist
  - language levels should be commensurate with cognitive abilities

WHEN
- We should address this gap **early in novel therapeutic ways** when traditional approaches are not sufficient to allow children to meet their cognitive potential

HOW
- Wanted to apply augmentative and alternative communication (AAC) strategies as a **teaching tool** for language learning in children who are D/HH with language underperformance

*Tomblin, 2015; Nittrouer 2014, 2016; Meinzen-Derr, 2014,2018; Luckner 2005; Traxler, 2000*

## Why AAC strategies?

Spoken language relies on auditory input channel and vocal output channel
Input is temporally based (sequence in time) and dynamic (rapidly fading nature)

- Language development through augmented means
- Role of graphic symbols in language development
- Importance of visual learning

*Romski, 1997; Bedrosian, 1997;Stredler-Brown, 2010; Harris, 2010;Allen, 2014; Sevcik, 1991;Sutton 2008*

## Why AAC strategies?

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Input is temporally based (**sequence in time**) and dynamic (**rapidly fading nature**)

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- Role of graphic symbols in language development
- Importance of visual learning

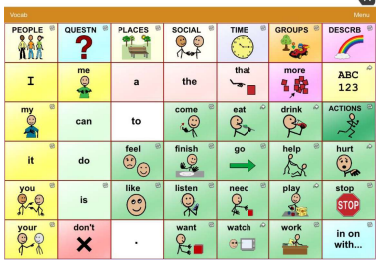
Provides a **stationary visual** (symbolic/iconic) representation of language

Leverages **multi-sensory input** (auditory and visual) to enhance development

## Technology-Assisted Language Intervention-TALI

- AAC strategies incorporated into speech-language therapy as a teaching tool for more complex verbal language skills
- Provides static visual representations for abstract linguistic concepts, offers grammatically appropriate options
- Can easily add appropriate morphological word endings
- Consistent model for verbalizations and feedback for self-monitoring
- Children were taught to use their own voice to speak the message after creating it
- Active family participation in using aided language stimulation to model more and encourage more complex language

## Sample Page-Set – TouchChat HD with Word Power




## Study Objectives

To determine if high-tech augmentative and alternative communication (AAC) supports within the context of speech-language therapy are effective **as a teaching tool** to enhance language development among children who are D/HH compared to treatment as usual

We conducted a randomized control trial to determine the efficacy of the intervention

*Enrollment is closed and follow up is ongoing*

## Randomized Control Trial

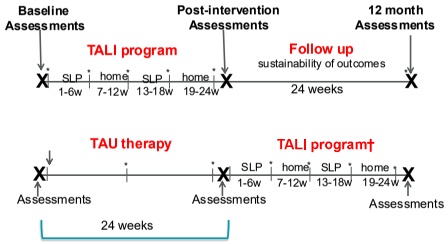
- Intervention (**TALI**)
  - High-tech AAC intervention strategies (TouchChat© on an iPad) within a series of speech-language therapy sessions
- Control (Treatment as usual – **TAU**)
  - Continue with standard care
  - Given option to cross-over into the technology intervention following the 24-week period
- Language goals and interventions based on child's specific language needs and family priorities

*Meinzen-Derr et al, 2017;2019*

## Inclusion Criteria

- Children ages 3-10 years with bilateral permanent hearing loss
- Non-verbal IQ of ≥ 60
- Language "underperformance"
- *Screening visit occurred and eligibility decision made PRIOR to randomization*

## Study timeline




*Language samples obtained

†TAU participants may opt to participate in TALI upon study completion

## Primary endpoints (language sample outcomes)

- ~20 minute language samples (100 complete utterances)
- Mean length of utterances in morphemes (MLU) - *syntax*
  - Average number of morphemes per utterance
- Mean turn length (MTL) – *discourse*
  - Length of child's conversational turn that may include more than one sentence/utterance
- Number of different words spoken - *semantics*

## Additional outcome data

- **Standardized assessments**
  - Clinical Evaluation of Language Fundamentals -5 or CELF-P & Pragmatics Profile
  - Peabody Picture Vocabulary Test
- **Duration and frequency of use (continuous monitoring)**
  - TouchChat's software for monitoring

## Other Outcomes and Measures

- **Neuro-behavioral**
  - Leiter International Performance Scale-3rd edition
  - Behavior Rating Inventory of Executive Function (BRIEF-3)
- **Functional**
  - Vineland Adaptive Behavior Scales
  - Child Behavior Checklist
- **Detailed demographics questionnaire**
- **Health record review**

## Characteristics of eligible vs. ineligible

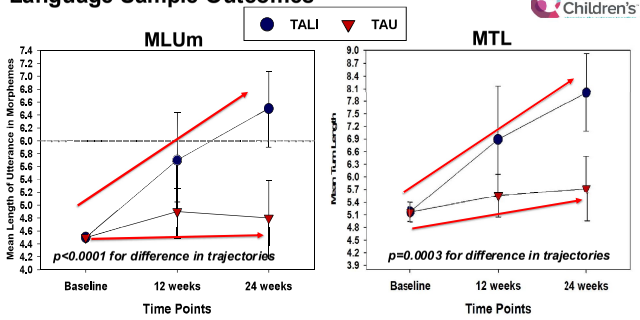
| CHARACTERISTIC | Eligible N=40 | Ineligible N=19 |
|---|---|---|
| Mean Age in years | 6.2 (2.5) | 9.0 (2.4) |
| 3-5 years of age | 62.5% | 17% |
| Median Age identification of hearing loss [IQR] | 21 [2-48] | 52 [21-84] |
| Gender – Female | 50% | 61% |
| Race - nonwhite | 30% | 11% |
| Health Insurance - Private | 41% | 41% |
| Mom college graduate | 47.5% | 50% |
| Household income <$20k | 27.5% | 6% |
| Use cochlear implants | 30% | 13% |
| Nonverbal IQ | 97.8 (17) | 93.8 (18) |

## Participant Characteristics

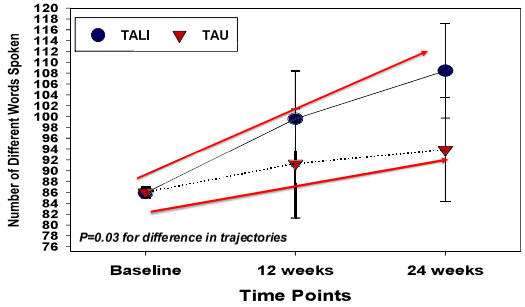
| CHARACTERISTIC | TALI N=20 | TAU N=20 |
|---|---|---|
| Mean Age in years | 6.3 (2.6) | 6.5 (2.5) |
| 3-5 years of age | 65% | 60% |
| Median age ident of hearing loss | 36.5 [iqr 2-55] | 17 [iqr 2-37] |
| Among 3-5 yr olds | 4.5 [4.2-47.1] | 3 [1-17] |
| Gender – Female | 45% | 55% |
| Race – Non-White | 25% | 35% |
| Health Insurance – Private only | 37% | 45% |
| Mom college graduate | 40% | 55% |
| Household income <$20k | 35% | 20% |
| Use cochlear implants | 30% | 30% |
| Median aided thresholds* | 20 [iqr 15-26] | 15 [iqr 12.5-20] |
| Nonverbal IQ | 96.2 (19.7) | 97.7 (17.6) |

*TALI = technology-assisted language intervention*
*TAU = treatment as usual*

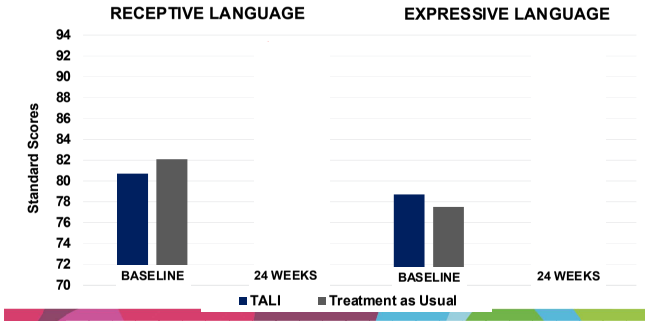
## Language Sample Outcomes



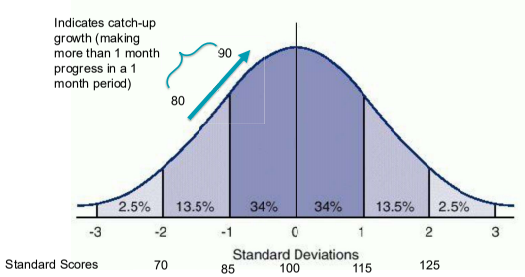

## Language Sample Outcomes-NDW




## Average assessment standard scores pre to post




## What does change across standard scores mean?




## Individual Impact Pilot study: Standardized Testing

PLS on 7/10/15

| | Raw Score | Standard Score | Percentile Rank | Age Equivalent |
|---|---|---|---|---|
| Auditory Comprehension | 42 | 73 | 4 | 3 years 7 months |
| Expressive Communication | 35 | 64 | 1 | 2 years 10 months |
| Total Language | 77 | 67 | 1 | 3 years 3 months |

PLS on 1/19/16

| | Raw Score | Standard Score | Percentile Rank | Age Equivalent |
|---|---|---|---|---|
| Auditory Comprehension | 56 | 93 | 32 | 5 years, 3 months |
| Expressive Communication | 54 | 91 | 27 | 5 years, 0 months |
| Total Language | 110 | 91 | 27 | 5 years, 2 months |

## Factors impacting effect size of outcomes

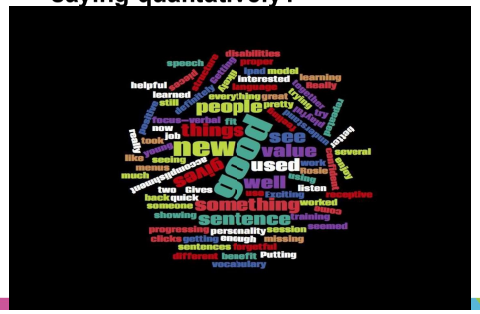
- Based on individual data review, no child lost skills in TALI
  - All children gained skills
- Age and IQ will impact expected growth of language

- What **did not** confound the relationship
  - Age of Identification
  - Degree of Hearing loss
  - Maternal education level
  - Private insurance vs Public insurance status

## Why we think it is so effective

- Visual component and message construction make auditory message more permanent and accessible
- Consistent verbal models are paired with visual supports
- Highlights low-emphasis language features that are commonly missed
- Children develop skills at an appropriate time developmentally, instead of playing catch up
- Independent means to initiate and self-monitor communication (buy-in, control over environment, social engagement, etc...)

## Focus Group Feedback: what are families saying qualitatively?




## Focus Group Feedback

**Positive themes**

- Easy to use
- Enjoyment and excitement when using
- Enhanced attention and perseverance
- Improved language and expanded vocabulary
- Increased communication with more partners
- Overall successful in general
- Potential of TALI to help all kids

## Focus Group Feedback

**Challenges**

- Therapy location inconvenient
- Prioritizing therapies
- Level of carryover at school varied
- Need for caregiver support
- Implementation may be complicated due to classroom transitions
- Many may be unfamiliar with the technology
- Technology updates needed to meet the child's advancing communicative needs

## Discussion of TALI Results

**Benefits:**

- Able to target more complex language
- Visual support promotes learning
- Socially acceptable technology
- Individualized intervention to meet child's needs
- Active caregiver engagement during sessions to become effective models for communication

**Limitations:**

- Small sample size
- Carryover across environments
- Measuring language outcomes
- Financial

## Individual Impact Pilot study: Quality of Life

- We enrolled a child in an early pilot study (10 children) with mild sensorineural hearing loss who had long-standing apraxia and global developmental delays (mild intellectual disability) due to progressive neurologic condition
- She had initially been enrolled in a signing program which had a program for hearing children with apraxia, but made minimal improvements in speech due to the severity of her apraxia
- She transitioned to her public school and had various clinicians and educators encourage augmentative communication, none of which were effective and her mother felt that people were asking her what she thought we should do
- Following trial: school story, most recent medical visit

## Next Steps and Challenges

- Reproduce in a larger multi-site trial (current pathway)
- Understand the roles of adherence, dose response, and family engagement
- Use in natural settings/other settings (e.g., schools)
  - Tested feasibility in preschool setting
- Understand who would benefit most from treatment
- Evaluate optimal treatment cycles
- Sustainability of results (currently assessing)
- Effects on early literacy skills

## What to consider *within EI* to prepare children who may benefit from this therapeutic approach

- **Nonverbally connect:** stay physically matched on child's level, show interest
- **Focus:** use actions and words consistently to facilitate new learning (visuals if possible)
- **Imitate and turn-take**: build in time for a response or imitation during interactions
- **Build:** add to what has already been said or done (action/sound/word)

## What to consider, cont.

- **Model** and **honor** all types of communication
- Use **pictures/visual supports** of motivating objects, model pointing to picture or giving it to someone to communicate new messages
- Encourage and differentially **reinforce verbal attempts**
- **Read books together**, look at pictures and encourage talking about them
- Model language as a **shared learning experience** while using visuals

## Final thoughts

- Recognize when language development does not match a child's ability (understanding potential)
  - Don't be satisfied with low-average to average language levels
- Even subtle "deficits" (perhaps unobvious altogether) can significantly impact functional outcomes
  - Occurs across the range of IQ and hearing levels
  - Does not have to be "sub-normal" to have an effect
- Novel therapeutic techniques that incorporate AAC strategies can provide children with additional tools in the toolbox
  - We should provide them with all of the tools possible to maximize chance for success

## "Caveats"

- Please, do not just go out and buy touch-chat and an i-pad
  - This is a tool to be used in therapy, targeting specific goals, family training involved and expanding approach with gains
- If you are an SLP working with children who are D/HH, keep an open mind regarding strategies that can be effective
- If you are SLP with AAC expertise, provide guidance in this population of children
- If you are a parent, don't be satisfied with the status quo

## Most importantly thank you to:

- Children and families who we see clinically who have driven our questions, to the families and children who have participated in our studies, and to the power of advice and knowledge within our Deaf/Hard-of-Hearing Research Advisory Board

**Research Advisory Committee**

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- Carrie Spangler, Educational audiologist, adult who is D/HH

## Thank You!

**Also big thanks to:**

Jareen Meinzen-Derr– Quantitative Epidemiologist
Rosie Sheldon – SLP (interventionist)
Laura Smith -research coordinator
Sandi Grether - SLP
Cory Pfefferman – research coordinator
Jeni Anderson – SLP (interventionist)
Ilka Riddle – Co-I/dissemination
Lindsay Mays – psychologist
Mekibib Altaye – biostatistician

*Funded by: HRSA R40MC21513; MOD 12-FY14-178, 6-FY17-480; NIH CTSA 1UL1TR001425-01; NIDILRR 90IF0122*