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

• Disclosure: My focus is on language.
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
• Motivation to change
• Technology assisted language intervention
• What to consider
Background

• 1-3/1000 infants born with significant hearing loss
  – Can affect language and communication

• 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

• Motivation for solid language foundation is to promote independent functioning now and later in life

Background

• Despite positive impact of ("hearing-focused") technology, language levels continue to hover in average to low average range for many
  – Expect 50% have scores >100; and ~15% scores >115

• Language scores are used as a “target”
  – Do not account for an individual’s capability
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 CI and Disability Focus

2005-2010

2010-2015

Current
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

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

2010-2015

Current
Specific Disability Label Not Very Predictive

b. scatter plot of disability diagnosis and language

Disability Diagnosis
- CP
- CHARGE
- GLOBAL
- OTHER

Log Receptive Quotient

$R^2 = 0.07$

Meinzen-Derr J, et al. 2010 Laryngoscope;
Language Differences

Adjusted Mean Language Quotients

- **Expressive**
  - CI: β = -22.0, p = 0.02
  - Control:

- **Receptive**
  - CI: β = -24.2, p = 0.03
  - Control:
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

<table>
<thead>
<tr>
<th>Receptive Language standard score</th>
<th>Nonverbal IQ standard score</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANGUAGE = 85</td>
<td>IQ = 100</td>
</tr>
</tbody>
</table>

85/100 or 0.85

~45% have a language to cognitive ratio <0.85
Relationship between score and ratio

Meinzen-Derr J, et al. 2018 JDBP
Relationship between score and ratio
Understanding language levels differently

Standard Scores

\[ p = 0.06 \]

\[ p \leq 0.0001 \]

Meinzen-Derr J, et al. 2018 JDBP
Understanding language levels differently

Standard Scores

Ratio

\[ p \leq 0.0001 \]

\[ p \leq 0.0001 \]

\[ p = 0.29 \]

Meinzen-Derr J, et al. 2018 JDBP
Impact on functional outcomes

Communication Function Score

TOTAL
IQ >100
IQ 80-100
IQ <80

Range of Nonverbal IQ

Meinzen-Derr J, et al. 2014 JDBP
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

- 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

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

- 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

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?

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
- Provides a stationary visual (symbolic/iconic) representation of language
- Leverages multi-sensory input (auditory and visual) to enhance development
Techology-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

<table>
<thead>
<tr>
<th>Vocab</th>
<th>Menu</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEOPLE <img src="image" alt="people" /></td>
<td>QUESTN <img src="image" alt="question mark" /></td>
</tr>
<tr>
<td>I <img src="image" alt="I" /></td>
<td>me <img src="image" alt="me" /></td>
</tr>
<tr>
<td>my <img src="image" alt="my" /></td>
<td>can <img src="image" alt="can" /></td>
</tr>
<tr>
<td>it <img src="image" alt="it" /></td>
<td>do <img src="image" alt="do" /></td>
</tr>
<tr>
<td>you <img src="image" alt="you" /></td>
<td>is <img src="image" alt="is" /></td>
</tr>
<tr>
<td>your <img src="image" alt="your" /></td>
<td>don’t <img src="image" alt="don’t" /></td>
</tr>
</tbody>
</table>
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

Baseline Assessments
- TALI program
  - SLP 1-6w
  - home 7-12w
  - SLP 13-18w
  - home 19-24w

Post-intervention Assessments
- Follow up
  - sustainability of outcomes

12 month Assessments
- 24 weeks

TAU therapy
- Assessments
  - 24 weeks

TALI program†
- Assessments

*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

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>Eligible N=40</th>
<th>Ineligible N=19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age in years</td>
<td>6.2 (2.5)</td>
<td>9.0 (2.4)</td>
</tr>
<tr>
<td>3-5 years of age</td>
<td>62.5%</td>
<td>17%</td>
</tr>
<tr>
<td>Gender – Female</td>
<td>50%</td>
<td>61%</td>
</tr>
<tr>
<td>Race - nonwhite</td>
<td>30%</td>
<td>11%</td>
</tr>
<tr>
<td>Health Insurance - Private</td>
<td>41%</td>
<td>41%</td>
</tr>
<tr>
<td>Mom college graduate</td>
<td>47.5%</td>
<td>50%</td>
</tr>
<tr>
<td>Household income &lt;$20k</td>
<td>27.5%</td>
<td>6%</td>
</tr>
<tr>
<td>Use cochlear implants</td>
<td>30%</td>
<td>13%</td>
</tr>
<tr>
<td>Nonverbal IQ</td>
<td>97.8 (17)</td>
<td>93.8 (18)</td>
</tr>
</tbody>
</table>
## Participant Characteristics

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

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

MLUm

\[ p<0.0001 \text{ for difference in trajectories} \]

MTL

\[ p=0.0003 \text{ for difference in trajectories} \]
Language Sample Outcomes-NDW

\( P=0.03 \) for difference in trajectories
Average assessment standard scores pre to post

RECEPTIVE LANGUAGE

E X P R E S S I V E LANGUAGE

Standard Scores

BASELINE

24 WEEKS

TALI

Treatment as Usual
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...)
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)
  – Often 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
Thank You!

Thank you to participating families and Deaf/Hard-of-Hearing Research Advisory Board

Also big thanks to:
Susan Wiley – Developmental Pediatrician
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

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• EXTRA SLIDES
Stratified randomization

40 Enrolled

Ages 3-4

NVIQ <100

NVIQ ≥100

Ages 5-10

NVIQ <100

NVIQ ≥100
Results of Crossing Over to TALI

<table>
<thead>
<tr>
<th>Child</th>
<th>Change in MLU pre to post</th>
<th>TAU</th>
<th>TALI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child 1</td>
<td>1.41-2.98</td>
<td>-</td>
<td>1.47-1.41</td>
</tr>
<tr>
<td>Child 2</td>
<td>7.03-10.29</td>
<td>7.25-7.03</td>
<td></td>
</tr>
<tr>
<td>Child 3</td>
<td>5.38-7.09</td>
<td>5.82-5.38</td>
<td></td>
</tr>
<tr>
<td>Child 4</td>
<td>3.81-5.40</td>
<td>2.49-3.81</td>
<td></td>
</tr>
<tr>
<td>Child 5</td>
<td>9.3-13.4</td>
<td>10.66-9.3</td>
<td></td>
</tr>
</tbody>
</table>
Cross-over data
Individual Impact Pilot study: Standardized Testing, quality of life

We enrolled a child in our pilot study with mild sensorineural hearing loss who had long-standing apraxia and global developmental delays (mild intellectual disability) due to progressive neurologic cerebellar atrophy.

She had initially been enrolled in a signing program which had a program for hearing children with apraxia with minimal improvements in speech.

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.