LENA: Exploring novel approaches to language assessment and intervention

FCEI 2012
BAD ISCHL, AUSTRIA

Christine Yoshinaga-Itano, PhD
Dinah Beams
Jill Gilkerson, PhD
Robyn Cantle Moore, Ph.D.
Kristin Uhler, Ph.D.
Rosalinda Baca, Ph.D.
Mallene Wiggins, M.A.
Conflict of Interest Disclosure

- Dr. Jill Gilkerson is the Director of Research at the LENA Foundation
- Dr. Christine Yoshinaga-Itano has no financial relationship with the LENA Foundation
LENA: Language Environment Analysis

CHRISTINE YOSHINAGA-ITANO, PH.D.
PROFESSOR
UNIVERSITY OF COLORADO, BOULDER
DEPARTMENT OF SPEECH, LANGUAGE & HEARING SCIENCES
MARION DOWNS HEARING CENTER
EMAIL: CHRISTIE.YOSHI@COLORADO.EDU
Hart and Risley, 1995

- 42 families
- 7 to 36 months of age
- Amount of adult conversations is a powerful predictor of verbal intelligence and academic success
- Significant relationships between socio-economic status and amount of adult conversation were found.
This study found strong relationships between socio-economic status and words per hour in parent speech. Differences associated for maternal level of education, race/ethnic background and socio-economic status could be overcome by parent to child talk.
Parents of children who scored at the 90th percentile on standardized assessments of language talked significantly more to their children.

Most language training came from mothers with mothers accounting for 78% of the adult talk.
Infoture Research Findings:

Parents talk more to daughters than to sons
Parents talk more to first borns than to children who are born after
Most parent talk occurs in the late afternoon and evenings
Children of talkative parents are also talkative
Parents overestimate the amount of talk they have with their children
Strong relationships between early language input and development

- Intelligence (Campbell & Ramey, 1994; Campbell & Ramey, 1995; Garber, 1988), Gottfried (1984)
  - Vocabulary growth, and language development (Hall, et al., 1987; Huttenlocher, et al., 2002; McMurray, 2007),
  - Academic performance (Walker et al., 1994).
- Language development and interventions dealing with parental conversational strategies (Wells, 1985; Wells, 1986) have been accepted and are critical components of almost any early intervention program with children with disabilities who are at-risk for significant language delays.
The child’s Auditory Diet

ROBYN CANTLE MOORE, (RIDBC) UNIVERSITY OF NEWCASTLE, (2009) PROPOSES USING LENA TO INVESTIGATE THE “AUDITORY DIET”, EXPOSURE TO SPOKEN LANGUAGE IN THE DAILY ROUTINE OF CHILDREN WITH HEARING LOSS.
Data Collection and Processing

- Digital recorder children wear
- Records continuously for 16 hours
- Audio transferred to computer
- Speech recognition software processes file, automatically analyzing audio stream
LENA System Algorithm

- Feature Extraction
- Segmentation
- Segment ID
- Phone Decoder

- Key Child
- Adult Male
- Adult Female
- Other Child
- Overlap
- Noise
- TV/Media
Core Measures

Adult Word Count
Adult words spoken near child

Child Vocalizations
Frequency of child vocalizations

Conversational Turns
Adult child interactions

TV/electronic media
Amount of TV exposure
# LENA Norms: Totals per Day

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Adult Words</th>
<th>Child Vocs*</th>
<th>Turns*</th>
</tr>
</thead>
<tbody>
<tr>
<td>99&lt;sup&gt;th&lt;/sup&gt;</td>
<td>29,428</td>
<td>4,406</td>
<td>1,163</td>
</tr>
<tr>
<td>90&lt;sup&gt;th&lt;/sup&gt;</td>
<td>20,824</td>
<td>3,184</td>
<td>816</td>
</tr>
<tr>
<td>80&lt;sup&gt;th&lt;/sup&gt;</td>
<td>17,645</td>
<td>2,728</td>
<td>688</td>
</tr>
<tr>
<td>70&lt;sup&gt;th&lt;/sup&gt;</td>
<td>15,516</td>
<td>2,422</td>
<td>603</td>
</tr>
<tr>
<td>60&lt;sup&gt;th&lt;/sup&gt;</td>
<td>13,805</td>
<td>2,174</td>
<td>535</td>
</tr>
<tr>
<td>50&lt;sup&gt;th&lt;/sup&gt;</td>
<td>12,297</td>
<td>1,955</td>
<td>474</td>
</tr>
<tr>
<td>40&lt;sup&gt;th&lt;/sup&gt;</td>
<td>10,875</td>
<td>1,747</td>
<td>418</td>
</tr>
<tr>
<td>30&lt;sup&gt;th&lt;/sup&gt;</td>
<td>9,451</td>
<td>1,538</td>
<td>361</td>
</tr>
<tr>
<td>20&lt;sup&gt;th&lt;/sup&gt;</td>
<td>7,911</td>
<td>1,310</td>
<td>300</td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt;</td>
<td>6,003</td>
<td>1,024</td>
<td>225</td>
</tr>
</tbody>
</table>

*Values represent percentiles for 24 month-olds
What predicts language development of children who are D/HH (0-7 years)

- Unchangeable characteristics:
  - Cognitive status
  - Degree of Hearing Loss
  - Age of identification of HL
  - Maternal Level of Education

  - Maternal Level of Education is overlapping with the amount of language access provided by the parent
Validity

LENA AND MACARTHUR COMMUNICATIVE DEVELOPMENT INVENTORIES

LENA AND MINNESOTA CHILD DEVELOPMENT INVENTORY
Pilot study: Validity

Relationship between MacArthur Communicative Development Inventory and Conversational Turns: $r = .662, p < .05$

(children in pilot were ages 9 months to 18 months)
Pilot Study: Validity

Relationship between Minnesota Child Development Inventory and LENA

CDI with Child Vocalizations
\[ r = 0.72, p = 0.02 \]

CDI with Conversational Turns
\[ r = 0.69, p = 0.03 \]

CDI and AVA Standard Score
\[ r = 0.70, p = 0.02 \]
Reliability of scores

- Average of three recordings of 16 hours each day resulted in stability of scores for normal hearing dyads—i.e. avoiding the Hawthorne effect
- **Interactor/s would need to be similar, i.e. parents with multiple recordings versus day care or school**
  - Language levels can differ dramatically for the same child, in the same week in different language environments –
  - i.e. with parents or in daycare
3 recordings in one week

Recordings were reliable for Adult Word Count, Conversational Turns and Child Vocalizations.

Recording 1 and Recording 2 were reliable with Pearson Product Moment Correlations between .78 and .95 p<.05, p<.01

Reliability for recording 2 and 3 dropped to r=.70 predominantly because parents began conducting their own experiments with different environments.
Cross-linguistic studies
Languages

- English
- Spanish (Mexico, US) (data currently in press)
- Chinese (Shanghai)
- Arabic
- French
Comparison of D/HH in English-speaking homes and D/HH in Spanish-speaking homes
Range of Child Vocalizations:  
Spanish D/HH  
vs  
English D/HH

Spanish

Min: 410  
Mean: 1687  
Max: 3653

English

Min: 810  
Mean: 2065  
Max: 4686
Range of Conversational Turns:
Spanish D/HH

vs

English D/HH

Mean: 407
Mean: 644
Min: 155
Min: 223
Max: 646
Max: 1279
Range of Adult Word Count:
Spanish D/HH
vs
English D/HH

Spanish
Min: 4081
Mean: 13914
Max:

English
Min: 5292
Mean: 17605
Max:
Children who are deaf and hard of hearing

- Adult Word Count is higher than Children with typical development in English speaking homes
- ADULT WORD COUNT:
  - 17605 (D/HH)  12,297 (HEARING)
- CHILD VOCALIZATIONS:
  - 2065 (D/HH)  1955 (HEARING)
- CONVERSATIONAL TURNS:
  - 644 (D/HH)
  - 474 (HEARING)
<table>
<thead>
<tr>
<th>Language</th>
<th>Min:</th>
<th>Max:</th>
<th>Mean:</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spanish</strong></td>
<td>7%</td>
<td>25%</td>
<td>17%</td>
<td>5</td>
</tr>
<tr>
<td><strong>D/HH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>English</strong></td>
<td>5%</td>
<td>33%</td>
<td>20%</td>
<td>6</td>
</tr>
<tr>
<td><strong>D/HH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Distant Language: Spanish D/HH vs English D/HH (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Min:</th>
<th>Max:</th>
<th>Mean:</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spanish D/HH</strong></td>
<td>10%</td>
<td>51%</td>
<td>30%</td>
<td>13</td>
</tr>
<tr>
<td><strong>English D/HH</strong></td>
<td>10%</td>
<td>39%</td>
<td>21%</td>
<td>7</td>
</tr>
</tbody>
</table>
TV: Spanish D/HH vs English D/HH (in percent)

<table>
<thead>
<tr>
<th></th>
<th>Min:</th>
<th>Max:</th>
<th>Mean:</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spanish D/HH</td>
<td>2%</td>
<td>33%</td>
<td>14%</td>
<td>10</td>
</tr>
<tr>
<td>English D/HH</td>
<td>2%</td>
<td>28%</td>
<td>8%</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Min:</td>
<td>Max:</td>
<td>Mean:</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>---------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Spanish D/HH</strong></td>
<td>1%</td>
<td>20%</td>
<td>4%</td>
<td>6</td>
</tr>
<tr>
<td><strong>English D/HH</strong></td>
<td>1%</td>
<td>11%</td>
<td>3%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Min:</td>
<td>Max:</td>
<td>Mean:</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>---------------------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>--------------------</td>
</tr>
<tr>
<td><strong>Spanish D/HH</strong></td>
<td>13%</td>
<td>59%</td>
<td>34%</td>
<td>14</td>
</tr>
<tr>
<td><strong>English D/HH</strong></td>
<td>20%</td>
<td>66%</td>
<td>47%</td>
<td>10</td>
</tr>
</tbody>
</table>
Averages N=3384
Language Environment Analysis

- Meaningful 19%
- Distant 40% (25%)
- TV/Media 10%
- Noise 3%
- Silence/Back 28% (43% including NOF, TOF)
• Everything but Noise correlates pretty strongly:
  o Child age,
  o Meaningful,
  o Distant, and
  o TV go up,

• Silence goes down with increasing age.
The biggest category change over time is in Distant, which increases by 2 hours per 12 hour day from 2 to 48 months;

Meaningful and TV increase over that span by roughly 30 minutes each.

Silence correspondingly drops by about 3 hours.
• the main driver of the Distant category is Overlap-Near [OLN] –

• that’s what increases by 2 hours over the age span.
AVA Percentile Rank

- Average 45%
- Minimum: 7%
- Maximum: 98%
AVA Standard Score

- Average: 98.6
- Range: 73.5 to 131.86
School-aged children have used LENA to record the amount of language that is accessible to them – not through their CI or HA but just at the level of the recorder. The noise levels in classrooms were so high and the volume of the teacher’s voice to the child was very low prompting the purchase of an FM for a school-aged child in a charter school.
LENA: Demonstrating the need for FM assistive technology- infant/toddlers

- One of our families lives in the mountains and spends a great deal of time with the toddler in a backpack hiking. She placed the LENA recorder on the child for a day when hiking and on a day when she was home with the child. While hiking almost none of her conversation reached the child at a level greater than 35 dB HL and there was very little conversational turn-taking.
The school district approved the purchase of a personal FM device for this toddler.

A study in the UK, University of Manchester has demonstrated using LENA that school-aged children have great conversational turns and greater child vocalizations when using FM systems.
LENA: An auditory-spoken language summer preschool
Preschool participants

- 8 children who were deaf or hard of hearing
- 2 of the children with CIs were at or above age level when compared with their hearing peers and are fully integrated now in first grade.
- 6 of the children were not advancing in their spoken language development at an optimal level
LENA demonstrated the type of interaction that occurred in the preschool. In a 3 hour session, the children were exposed to more than 12,000 adult words, at the 50\textsuperscript{th} %ile, and the child vocalizations and conversational turns were on average at the 50\textsuperscript{th} %ile or above when just using the language from those 3 hours.
Wiggins, Gabbard, Thompson, Goberis, Yoshinaga-Itano, 2011

Adult Words

<table>
<thead>
<tr>
<th>Participants</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preschool Adult Words Per Hour</td>
<td>4000</td>
<td>5000</td>
<td>4000</td>
<td>4000</td>
<td>5000</td>
<td>4000</td>
<td>5000</td>
<td>4000</td>
</tr>
<tr>
<td>Home Adult Words Per Hour</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
</tbody>
</table>
Wiggins et al., 2011

Conversational Turns

Number of Turns

Participants

Preschool Conversational Turns Per Hour
Home Conversational Turns Per Hour
LENA: Characterizing the spoken language interaction

IN PRESCHOOL
IN DAYCARE
AT HOME
IN SCHOOL
WHILE HIKING
AT FAMILY GATHERINGS
LENA: In daycare

- In some daycare situations even when in-service training is provided do not have much language interaction.
- A child was recorded at home with parents and in the daycare in the same week.
- The child’s vocalizations and turn-taking were in the “red flag” area for daycare but at age level at home during the same week.
Much of the language in this daycare was distant language—language not directed to the child and not loud enough—above 35 dB HL.
Considerations for use with Deaf/Hard of Hearing infants/Children

- **Automatic Calculations**
- **Percentile Ranking and Standard Scores**
  - Adult Word Count – How many words are directed to the child and how loud are they?
  - Child Vocalizations – how does the amount of adult words impact the amount of child vocalizations – with recordings can also look at quality of adult language
  - Conversational Turns - can assure that an adult dominance doesn’t happen – quantity with sufficient turn-taking
  - AVA (Automatic Vocalization Analysis) Developmental Age- diversity of the phonology of the child’s utterance
  - % time in Silence, Noise, Distant Language, Meaningful Language
  - Developmental Snapshot – should be used only in conjunction with other assessments
How Language was defined by Infoture for Developmental Snapshot

- Preschool Language Scale – expressive language in early years is highly loaded with symbolic gesture - children with hearing loss typically have no deficits in their development of symbolic gesture and this provide spuriously high language scores in the early years
- REEL-3 (highly auditory loaded) would yield a significantly lower language score for children using visual communication
- Child Development Inventory formerly Minnesota
- Developmental Snapshot scores should be used in conjunction with other language measures
Norms for typically developing children

The computer counts as meaningful sounds that are 35 dB HL or greater. With children who have hearing loss with appropriate amplification, we typically use 50 dB HL as meaningful volume.

It is possible that LENA may overestimate the number of words that are auditorially accessible for a child with hearing loss.
With the research software, it is possible to determine the dB HL levels of each utterance and to determine the percentage of vocalizations that are less than a 50 dB HL loudness level. dB in the research software is reported in SPL and must be converted.
Ability to determine dB SPL levels

- The research software can provide information about the dB SPL levels of each adult word counted in the recordings.
- For children wearing amplification technology, intensity levels determined to be “meaningful” for hearing children may not be “meaningful” for children with hearing loss because they are too soft. This could reduce the percentile rank and standard score.
- dB SPL levels provide information about whether or not adult language is loud enough for the child, i.e. in day care facilities.
LENA Calculations

- LENA norms are not intended to be able to look at the validity of a single half hour or hour segment.
- Reliability of the percentile ranking is based upon 10+ hours of recording.
- However, across any 16 hour day, it is possible to identify trends in the data such as periods of the day with the highest quantities of any of the calculations.
What do we know about children with hearing loss

- Language development for many children with hearing loss may be multi-modality
- Focus exclusively on spoken language - vocal/verbal language development as an index of language skills can significantly underestimate the language skills of the child if the child also uses a visual communication system or communicates exclusively through a visual communication system
Research possibilities with LENA

- Provides an easy and quick indicator of the amount of adult language that is accessible to the child – some adaptation for children with hearing loss may need to occur if dB levels of adult input are too quiet.
- Provides an important piece of information about the language environment of the child when not in therapy.
Research potential with LENA

- Provides a vehicle that can compare the impact of different language environments upon the child’s expressive spoken language.
- The amount of child vocalization is directly related to the language environment in which the child lives.
- Therefore, the same child could demonstrate significantly different language dependent upon the conversational partners in the environment or the style of interaction used by the conversational partner.
Research possibilities

- LENA analysis could provide parents with sufficient feedback that they will increase the amount of meaningful adult conversation with their child.
- LENA data indicates that parents increased their average use of meaningful conversation using LENA recordings and analyses.
Implementation of new interventions

- LENA may be used as an assessment to compare a new intervention strategy with traditional strategies by examining the change in the child’s vocalizations, conversational turns, and diversity of their vocalizations.
- LENA is particularly useful when comparing short-term interventions (i.e. 6 weeks), durations not long enough to show change in standardized clinical assessments.
- LENA could also demonstrate the difference between a child’s functioning within the intervention session and in a normal conversational interaction that is not therapeutic.
Research on CAPD/CALD/ANSD

- LENA can be used to investigate the language environment and its relationship for children with auditory neuropathy spectrum disorder, children with auditory processing disorders and children with auditory language disorders.
- LENA is being used to study the language development of children with autism and other speech/language disorders, such as specific language impairment.