Language Environmental Analysis (LENA): Special Populations

Dinah Beams, MA
Program Coordinator
Colorado Home Intervention Program
Colorado School for the Deaf and the Blind
Items

• Number of Adult Words
• Conversational Turns
• Child Vocalizations
• Audio Environment
  ▫ Meaningful
  ▫ Distant*
  ▫ Overlap*
  ▫ Noise
  ▫ TV/Electronic
  ▫ Silence/Background
Speech Scores

• AVA Standard Score
  ▫ Complexity of child’s speech

• Vocal Productivity Standard Score *
  ▫ Duration of child’s utterances
Pilot: Spring 2016

• 5 children
  ▫ Boy, 10 months, moderate bilateral loss
  ▫ Boy, 29 months, mild-moderate loss, late identified, adopted from China
  ▫ Girl, 21 months, progressive severe loss
  ▫ Girl, 7 months, profound loss, CMV
  ▫ Girl, 7 months, severe conductive loss

• All children were aided and in early intervention with CHIP for less than 6 months at the start of the pilot.
Procedure

- Monthly recordings over a 4-5 month period
  - Interventionist delivered and picked up device
- Reports shared with family by the interventionist
CONFIDENTIAL

Name: Anna
ID: -
Age: 10 months as of 05/12/16

PCTL Legend
High: 75-99
High Avg: 50-74
Low Avg: 25-49
Low: 1-24

Daily Adult Words:
Star goal was: 26315 words

Hourly Adult Words on 05/12/2016

Daily Conversational Turns:
Star goal was: 422 turns

Hourly Conversational Turns on 05/12/2016

Child Vocalizations:

Hourly Vocalization Count on 05/12/2016

Total Stars earned through this report: 7

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06-02-2016, 10:00:03 AM
Recording Summary

Child Name: Anna
Report Date: Jun 02, 2016
Testing Date: May 12, 2016

Birthday:
Age at Testing: 10 months

On May 12, 2016, a LENA recording was completed with your child. The recording duration was around 16 hours. This report provides a summary of the results of the recording.

In 1995, Drs. Betty Hart and Todd Risley published a landmark study discovering that the number of words spoken by parents to their children was a powerful predictor of verbal intelligence and academic success. Although differences in the number of spoken words were predicted by socio-economic conditions, the impact of these conditions could be overcome by the amount of talk in the home. We are conducting this analysis to provide you with feedback on the "auditory diet" or the language environment of your child.

Building on the work of Hart and Risley, the LENA Research Foundation collected over 3000 recordings in the natural audio environments of children 2 months to 48 months of age. These recordings were then analyzed to determine normal counts of adult words, the counts of adult-child interactions (conversational turns), and the counts of child vocalizations.

Your recording was analyzed by this same LENA software. The software calculates Adult Word Count by estimating the number of audible words spoken by adults to and near your child. The software also estimates the number of Child Vocalizations made by your child as well as the number of Conversational Turns. Conversational turns (back and forth interactions between a child and adult) are computed by counting the number of times utterances spoken by the child or adult were responded to by another person. By comparing the report to your daily log, you can gain insights into the times when you are most verbally engaged with your child, and what kinds of activities occurred at that time.
Recording Summary

Child Name: Anna
Report Date: Jun 02, 2016
Birthday:
Testing Date: May 12, 2016
Age at Testing: 10 months

Adult Word Count: On the day of this recording, the software identified 31,471 adult words spoken to or near your child. This number of adult words is at the 99th percentile when comparing your recording to the LENA database norms. The time of the day when your child was exposed to the most words was between 05:00 PM - 06:00 PM.

Conversational Turns: On the day of this recording, the software identified 444 conversational turns. This number of conversational turns was at the 83rd percentile when comparing your recording to the LENA database norms. The time of the day when your child experienced the most turns was between 08:00 AM - 09:00 AM.

Child Vocalizations: On the day of this recording, the software identified 929 child vocalizations. This number of child vocalizations was at the 39th percentile when comparing your recording to the LENA database norms. The time of the day when your child vocalized the most was between 08:00 AM - 09:00 AM.

AVA: LENA also analyzes the full range of your child's vocalizations across the recording day to produce an AVA (Automatic Vocalization Assessment) score. The AVA score is a unique measure of the similarity of your child's patterns of vocalizing to those of a reference sample of typically developing children around the same age. AVA is reported as an age-standardized score to make it easier for you to track your child's development over time. For the most recent recording, your child's AVA score was 86, placing him or her at the 17th percentile.

Vocal Productivity: LENA also provides a Vocal Productivity measure to estimate the length of child utterances within conversations. Estimates are based on automated detection of well-formed syllables (consonant-vowel pairs) produced by the child within a single conversational turn. The measure determines the median number of these syllables produced by your child per conversational turn on the day of the recording. This new measure is LENA's automated proxy for mean length of utterance (MLU), which is a well-established estimate used by professionals to gauge language development. Vocal Productivity is reported in a standard score, and you can see on the graph how the standard score varies for your child from recording day to recording day. Because Vocal Productivity is an utterance length measure versus an utterance complexity measure (i.e., AVA), the Vocal Productivity standard score may not necessarily match the AVA score. The Vocal Productivity measure is available for children 6 months and older. For the most recent recording, your child's Vocal Productivity standard score was 81, at the 10th percentile.
Daily Adult Words:
Star goal was: 16364 words

Daily Conversational Turns:
Star goal was: 398 turns

Child Vocalizations:

Hourly Adult Words on 03/23/2016

Hourly Conversational Turns on 03/23/2016

Hourly Vocalization Count on 03/23/2016

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Name: Naomi
ID: 
Age: 9 months as of 04/18/16

**Daily Adult Words:**
Star goal was: 19941 words

**Hourly Adult Words on 04/18/2016**

**Daily Conversational Turns:**
Star goal was: 540 turns

**Hourly Conversational Turns on 04/18/2016**

**Child Vocalizations:**

**Hourly Vocalization Count on 04/18/2016**
Daily Audio Environment

Hourly Audio Environment on 04/21/2016

AVA Standard Scores

Vocal Productivity Standard Scores

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What We Learned

• Ability to provide immediate feedback enhanced intervention
• Family buy-in was increased due to immediacy of feedback (Parents could remember what happened that day!)
• Parents very motivated by information
  ▫ Opportunity to provide parent education
  ▫ Opportunity to discuss specifics
Advantages

• Reduced logistical barriers for our program
  ▫ Provider buy-in increased with reduction of barriers
• Direct access for parents to reports
• Reminders assisted us in staying on schedule
• Ability to track progress over time was easier
  ▫ Results of multiple recordings on one page
• Immediate feedback key to changing behavior
Dinah Beams
dbeams@csdb.org
Language Environment Analysis (LENA) as a tool to enhance intervention

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Disclosure

- I am an unpaid member of the Scientific Advisory Board for the LENA Foundation
LENA CAN BE USED WITH CHILDREN WHOSE NATIVE LANGUAGE IS NOT ENGLISH

SPANISH – RELIABILITY STUDY
MANDARIN – STUDY IN PROCESS
RUSSIAN
FRENCH – RELIABILITY STUDY IN PROCESS
GERMAN – STUDY IN PROCESS
ARABIC – STUDY IN PROCESS
Range: Adult Word Count

Number of Adult Words Spoken/day

3rd Quartile
1st Quartile

Spanish D/HH
Typically Developing Spanish
Typically Developing English
English D/HH

Range:
LENA CAN BE USED TO EVALUATE CHILDREN IN GROUPS AND TO DEMONSTRATE WHAT IS HAPPENING IN A SPECIALIZED PRESCHOOL.

COMPARISONS OF SCHOOL OR THERAPY TO HOME.
## Results

### Comparisons of Conditions

<table>
<thead>
<tr>
<th></th>
<th>adult words per hour</th>
<th>conversational turns per hour</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>home</strong></td>
<td>M=913.60 SD=381.41</td>
<td>M=36.39 SD=14.87</td>
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<tr>
<td><strong>preschool</strong></td>
<td>M=4181.63 SD=345.20</td>
<td>M=90.04 SD=35.74</td>
</tr>
</tbody>
</table>
LENA to demonstrate what happens during therapy
The Adult Words report displays the number of words spoken to and in the vicinity of the child during the course of a recording.

Roll over data bars, data points, or legend icons for more detail.

Please see User Guide for additional information.

View Adult Word Normative table and Average Daily Pattern of Talk table here.
LEN A CAN BE USED TO CHARACTERIZE EXPERT VERSUS NOVICE TEACHERS

CAN BE EFFECTIVE IN INDIVIDUAL THERAPY
CAN BE USED IN CLASSROOM SITUATIONS
CAN DESCRIBE CONVERSATIONAL TURNTAKING
CAN DESCRIBE ADULT TO CHILD WORD FREQUENCY
LENA CAN BE USED TO DEMONSTRATE CHANGE OVER TIME

INCREASE IN AMOUNT OF PARENT WORDS
INCREASE IN CONVERSATIONAL TURN-TAKING
INCREASE IN SPEECH DEVELOPMENT - AVA
INCREASE IN CHILD VOCALIZATIONS
CHANGE IN HOME ENVIRONMENT:
  TIME IN SILENCE
  TIME IN NOISE
  TIME WITH TV
  TIME WITH MEANINGFUL LANGUAGE
Intervention Uses and Implications: Increased Adult Word Count

- LENA recording on a 13 month old with moderately-severe bilateral hearing loss
  - Adult Word Count: 6066, 3rd%ile
  - Conversational Turns: 185, 16th%ile

- LENA recording after 8 months of intervention
  - Adult Word Count: 21,048, 97th%ile
  - Conversational Turns: 1136, 98th%ile
LENÁ CAN BE USED FOR DIFFERENTIAL DIAGNOSIS

CAN THE DEAF/HH CHILD NOT HEAR THE SPEECH
NOT DISCRIMINATE
NOT COMPREHEND
NOT BE ABLE TO PRODUCE THE SPEECH MOTOR COORDINATION
IS THE FREQUENCY OF PARENT WORDS NOT SUFFICIENT
IS THE CONVERSATIONAL TURN-TAKING TOO LOW
ARE THE FREQUENCY OF THE VOCALIZATIONS TOO INFREQUENT
IS THE QUALITY OF THE SPEECH APPROXIMATING INTELLIGIBLE SPOKEN ENGLISH
LENA CAN BE USED TO CHARACTERIZE THE LANGUAGE LEARNING ENVIRONMENT

NOISE
TV
SILENCE
DISTANT LANGUAGE
MEANINGFUL LANGUAGE
Averages  N=3384
Language Environment Analysis
TYPICAL DEVELOPMENT

- Meaningful  19%
- Distant  40% (25%)
- TV/Media  10%
- Noise  3%
- Silence/Back  28% (43% including NOF, TOF)
<table>
<thead>
<tr>
<th>Percentile</th>
<th>Adult Words</th>
<th>Child Vocs*</th>
<th>Turns*</th>
</tr>
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<tr>
<td>99th</td>
<td>29,428</td>
<td>4,406</td>
<td>1,163</td>
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<td>90th</td>
<td>20,824</td>
<td>3,184</td>
<td>816</td>
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<td>80th</td>
<td>17,645</td>
<td>2,728</td>
<td>688</td>
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<tr>
<td>70th</td>
<td>15,516</td>
<td>2,422</td>
<td>603</td>
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<tr>
<td>60th</td>
<td>13,805</td>
<td>2,174</td>
<td>535</td>
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<tr>
<td>50th</td>
<td>12,297</td>
<td>1,955</td>
<td>474</td>
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<tr>
<td>40th</td>
<td>10,875</td>
<td>1,747</td>
<td>418</td>
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<tr>
<td>30th</td>
<td>9,451</td>
<td>1,538</td>
<td>361</td>
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<tr>
<td>20th</td>
<td>7,911</td>
<td>1,310</td>
<td>300</td>
</tr>
<tr>
<td>10th</td>
<td>6,003</td>
<td>1,024</td>
<td>225</td>
</tr>
</tbody>
</table>

*Values represent percentiles for 24 month-olds
LENA CAN BE USED TO HELP DIFFERENTIATE DISORDERS: HEARING LOSS, LANGUAGE DISORDERS, AUTISM AND TYPICAL DEVELOPMENT
Frequency of Consonant-like Sound

TD versus ASD:  
$t(90) = 7.95^{***}$

TD versus LD:  
$t(68) = 5.52^{***}$

LD versus ASD:  
$t(118) = 2.62^{**}$

Correlation with age:
- TD: 0.67***
- LD: 0.42**
- ASD: 0.32**
Probability of Sound Collision

ASD versus TD: t(132) = 3.66***
ASD versus LD: t(111) = 2.94**
TD versus LD: t(90) = 0.13

*p<0.05  
**p<0.01  
***p<0.001
**Child Vowel Volume (dB)**

**t-test** (Welch 2-sample 2-side)

ASD versus TD:  
\[ t(125) = 5.84^{***} \]

ASD versus LD:  
\[ t(117) = 4.78^{***} \]

TD versus LD:  
\[ t(97) = 0.45 \]

*p<0.05  
**p<0.01  
***p<0.001
Spectrum Entropy of Child Unvoiced Consonant t-test (Welch 2-sample 2-side)

ASD versus TD: 
\[ t(113) = 5.70^{**} \]

ASD versus LD: 
\[ t(118) = 4.41^{***} \]

TD versus LD: 
\[ t(96) = 0.91 \]

*p<0.05  
**p<0.01  
***p<0.001
Result of C-MLU: Trajectories & Correlation with Chronological Age

Correlation with chronological-age:

HH: 0.51 ***
TD: 0.63 ***
LD: 0.32 *
ASD: 0.32 *

*: p < 0.05
**: p < 0.01
**: p < 0.001
LENA HAS THE POTENTIAL FOR SCREENING FOR SPEECH DISORDERS OF CHILDREN WHO ARE DEAF OR HARD OF HEARING

AVA- AUTOMATIC VOCALIZATION ANALYSIS
APRAXIA
DYSARTHRIA
AUDITORY NEUROPATHY SPEECH
LATE IDENTIFIED: DEAF SPEECH CHARACTERISTICS

AUTISM SCREEN

AVA SHOULD BE USED IN CONJUNCTION WITH PROFESSIONAL JUDGEMENT AND OTHER ASSESSMENT TOOLS

RAISING THE RED FLAG FOR SPEECH DISORDER
## Study Samples

<table>
<thead>
<tr>
<th>Child Groups</th>
<th>Number of Children (N)</th>
<th>Number of Recordings</th>
<th>Child Segments (number in million)</th>
<th>Phoneme-like Units (number in million)</th>
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</thead>
<tbody>
<tr>
<td>Typical Development (TD)</td>
<td>106</td>
<td>802</td>
<td>2.15 M</td>
<td>8.42 M</td>
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<tr>
<td>Language Delay but not ASD (LD)</td>
<td>49</td>
<td>333</td>
<td>0.75 M</td>
<td>2.65 M</td>
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<tr>
<td>Autism (ASD)</td>
<td>71</td>
<td>228</td>
<td>0.53 M</td>
<td>1.82 M</td>
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<tr>
<td>Hard of Hearing (HH)</td>
<td>42</td>
<td>423</td>
<td>1.33 M</td>
<td>9.33 M</td>
</tr>
</tbody>
</table>

### Color Notation:

- **Green:** Typical Development (TD)
- **Blue:** Language Delay not Related to Autism (LD)
- **Red:** Autism (ASD)
- **Purple:** Hard of Hearing (HH)
AVA: A Composite Objective Measure of Child Phonetic Development

Correlation with chronological-age:

HH: 0.01
TD: -0.02
LD: 0.23 *
ASD: 0.10

*: p < 0.05
**: p < 0.01
***: p < 0.001
AVA: Summary

- Composite Objective Measure for Child Phonetic Development
  - Based on phone and bi-phone frequency information, a composite score to best match human assessed score (average of PLS-4 and REEL)
  - Significant strong correlation with Human assessments
  - HH group is similar to TD group
  - LD, ASD groups are significantly lower in AVA score
Email address: Christie.Yoshi@colorado.edu
LENA in Intervention

FCEI 2016

Kimberly Coulter
Manager of Training and Professional Development
LENA Research Foundation
17 June 2016
LENA in a Nutshell

• Technology to measure talk in early childhood
  – the global “gold standard” for this purpose
• Provides actionable real-time data to help…
  – Parents & caregivers
  – Teachers & childcare workers
  – Family workers
  – Clinicians
  – AVTs/Teachers of the deaf
  – Researchers
“Talk Pedometer,” But Much More
The LENA System™

• Recording
  – Compact digital unit records full day of parent/baby talk & environmental sounds

• Processing
  – Software translates recordings into data
  – Audio can be deleted or retained
  – Installs on multiple desktops or laptops for flexibility

• Online data management
  – Account verification, data storage, reporting, program administration tools, parent communication & more
  – 24/7 secure access from any device
What’s New?

• System improvements
  – More flexible, efficient recording processing
  – Online management of data & programs
  – Automated text reminders
  – Support for multiple approaches to closing opportunity gaps

• Basic model refinements
  – Process improvements to minimize failed recordings
  – Streamlined child report for at-a-glance summary feedback
New Recording Processor

• Loads on any number of desktops or laptops
• Connects online for user authentication, data storage, reporting, etc.
• Flexible options for processing recordings:
  – Immediate (real time)
  – Deferred (collected in field, processed later)
  – Transmitted to other computer for processing
  – Cloud processing
Online Functions

- Enrollment & authentication
- Recorder management
- Recording processing & transfer
- Reporting
- Scheduling
- Text communications

Confidential

May 5, 2016 - 60
How did LENA get started?
Terry Paul reads *Meaningful Differences*

Timeline

- 1995
- 2000
- 2005
- 2010
- 2015
Timeline

Terry Paul reads
*Meaningful Differences*

1995

2000

2005

2010

2015

Sunshine Cottage
SCHOOL FOR DEAF CHILDREN

CHIP
COLORADO HOME INTERVENTION PROGRAM

For Families who have Children who are Deaf or Hard of Hearing

PROJECT ASPIRE
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>1995</td>
<td>Terry Paul reads <em>Meaningful Differences</em></td>
</tr>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
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<tr>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>2015</td>
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</table>
CONFIDENTIAL

Name: Makayla Stargazer
ID: Child_09
Age: 22 months as of 01/20/16

PCTL Legend:
High: 75-99
High Avg: 50-74
Low Avg: 25-49
Low: 1-24

Daily Adult Words:
Star goal was: 12131 words

Daily Conversational Turns:
Star goal was: 271 turns

Child Vocalizations:

Hourly Adult Words on 10/07/2015

Hourly Conversational Turns on 10/07/2015

Hourly Vocalization Count on 10/07/2015

Words
Turns
Child Vocalizations
Daily Adult Words:
Star goal was: 12131 words

# adult words spoken near child for the day

Daily Conversational Turns:
Star goal was: 271 turns

# back-and-forth turns between adults and child for the day

Child Vocalizations:

# speech-related utterances from child for the day
Parents earn stars for meeting or exceeding goals.

Hourly counts of adult words for highlighted day.

Hourly counts of turns for highlighted day.

Hourly counts of child vocalizations for highlighted day.
CONFIDENTIAL

Name: Makayla Stargazer
ID: Child_09
Age: 22 months as of 01/20/16

Daily Adult Words:
Star goal was: 13290 words

Hourly Adult Words on 12/09/2015

Daily Conversational Turns:
Star goal was: 308 turns

Hourly Conversational Turns on 12/09/2015

Child Vocalizations:

Hourly Vocalization Count on 12/09/2015
Complexity of child's speech

Duration of child's utterances

Meaningful: 21%  Overlap: 3%  Distant: 7%  TV/Electronic: 8%
Noise: 2%  Silence/Background: 60%

Nurturing minds, changing lives
LENA in Non-English Languages
Where is LENA?
LENA Language Validations

Validation Published:
• Spanish – Weisleder and Fernald, 2013
• French – Canault et al., 2015
• Chinese, Shanghai Dialect – Gilkerson et al., 2015

Validation In Progress:
• Korean
• Arabic, Saudi Arabian Dialect
LENA in Intervention
Supporting Multiple Approaches

• LENA HV
  – Home-visitation parenting programs (e.g., EHS)

• LENA SP
  – Speech/language pathologists & others serving hearing-impaired and language-delayed children

• LENA Start
  – Complete group program for disadvantaged parents; includes LENA’s Smarter Happier Baby™ curriculum

• LENA Classroom – emerging
  – Childcares & preschools – encourage & measure talk for professional development of teachers & workers
• Group model designed to increase parental investment in babies 0-3
  – LENA System with parenting curriculum
  – Increase quantity + quality of parent-child interactions

• Intent: lay a foundation, a start
Integrated Assessment

• Fidelity of Treatment
  – Participation: attendance, recording frequency, etc.

• Effectiveness Measures
  – **Parent**: Change in Words, **Turns**, TV, Reading

  – **Child**:
    • Child vocalizations: quantity of child speech sounds
    • Snapshot: global measure of language development
    • AVA: automatic vocalization assessment
    • Vocal Productivity: duration of child’s utterances
Significant Increases for those whom LENA Start Intends to Reach

Low Talk Group
Changes in Adult Words & Conversational Turns

+47 change in PCTL
+26 change in PCTL

Percentile

99
75
50
25
1

1st Recording
Avg of Last 3 Recordings

Adult Words
Conversational Turns

n=46
LENA Start and Providence Showing Promising Results

Adult Words

Conversational Turns

Low Talk Group

Data through end of January 2016
LENA Developmental Snapshot

• 52 questions
• Validated to 36 months
• English or Spanish
• Measures child expressive and receptive language development
• Completed by parents ~1/month


J. Gilkerson et al., "Language Assessment in a Snap: Monitoring Progress up to 36 Months" - in submission
Gains in Snapshot Language Scores: 2015 LENA Start Participants

~9 point standard gain
Statistically significant change
Summary

• LENA being used much more as Terry originally intended: in parent-directed initiatives to prevent the opportunity gap

• LENA Online improves logistics and situation awareness

• Different versions support a range of models
Thank you!