A Need for Language Intervention in the NICU for Preterm Infants  
LENA Conference 2015

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Disclosure: I am a member of the LENA Foundation Scientific Advisory Board
Objectives are to describe:

- Known speech and language Outcomes or PT Infants
- LENA Intervention in the NICU
- Factors Contributing to Language Outcomes of PT Infants
Brain development during the 2nd & 3rd trimester involves a complex sequence of maturational events between 10-40w.

Production of neurons, migration, maturation, apoptosis, formation of inter-neuronal connections and pruning occur in rapid progression.

Volpe J, Neurology of the Newborn p 59,1995
Brain development in the NICU

Endogenous factors
Sensory input and experience

4-fold ↑ in cortical gray matter
Correlation between deep nuclear GM volumes and gestational age at Term

Inder et al showed the relationship between GA at birth and deep nuclear GM vol. at term. (Peds 2005)
How much does brain size matter for cognitive and Language development?

JJ Neil, 12-02
Relationship of Brain Volume and Cognitive Outcomes at 8 Years of Age.

- Cerebral volumes were linearly related to Full Scale IQ, Verbal IQ, Performance IQ & PPVT for preterm subjects
  - Peterson BS, Ment L et al, 2000
- This is worrisome, but does recovery of verbal and cognitive function continue after 8 y?
Random-effects sizes and heterogeneity statistics for A, simple language function (receptive vocabulary measured by PPVT) and B, complex language function (language measured by CELF).

This meta-analysis shows studies of PT infants have deficits in both simple and complex language skills between 3 & 12y after excluding children with scores > @SD↓.
Can Premies Catch up?
Raw Scores on PPVT from 3-12 y Indo cohort
Luu et al Pediatrics 2009
### Multivariate regression of Full Scale IQ @ 12y

<table>
<thead>
<tr>
<th>Variables in model</th>
<th>Regression coefficient (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth weight (100 g increment)</td>
<td>0.5 (-0.5, 1.6)</td>
</tr>
<tr>
<td>Small for gestational age</td>
<td>-0.4 (-4.3, 3.4)</td>
</tr>
<tr>
<td>Male sex</td>
<td>-0.7 (-4.0, 2.5)</td>
</tr>
<tr>
<td>Antenatal steroids</td>
<td>3.7 (0.3, 7.1)*</td>
</tr>
<tr>
<td>BPD</td>
<td>-2.4 (-6.1, 1.4)</td>
</tr>
<tr>
<td>Severe brain injury</td>
<td>-22.1 (-28.1, -16.2)*</td>
</tr>
<tr>
<td>Maternal age &lt; 20</td>
<td>-0.4 (-5.4, 4.6)</td>
</tr>
<tr>
<td>Maternal years of education</td>
<td>2.0 (1.3, 2.7)*</td>
</tr>
<tr>
<td>Single-parent household</td>
<td>-5.9 (-9.4, -2.3)*</td>
</tr>
<tr>
<td>Minority status</td>
<td>-8.4 (-12.2, -4.5)*</td>
</tr>
</tbody>
</table>

* *p-value < 0.05  

Luu et al Pediatrics 2009
Patterns of receptive language development from 8 to 16 years  

PT clusters ABCD

Who catches up?
Clustering A, B, C, and D
No difference in bwt, BPD, bilingual household
Maternal education A > B, C, D
D was all children with NSI
CP, seizure disorder, blind, HA, shunt
The Language Environment of a Term pregnancy

• In womb-
  – Mother’s voice
  – Low frequency, high intensity sounds
• FT infants prefer human voice to other acoustic stimuli
  Butterfield 1972

• 3 day old T infants prefer mothers’ voice to other female voices;
  De Casper et al 1980
What is the sensory environment of the Isolette (Uterus) in the NICU?
Why might there be a problem with the sensory input in the NICU? VLBW Infants are exposed to the atypical environment for weeks to months.

- Prolonged exposure to noise levels > 45 dB
- ↑ ambient light, often 24 h/day
- ↑ Stressful manipulation
- ↑ Painful procedures
- ↓ soothing tactile stimulation
- ↓ developmentally appropriate stimulation
- Multiple caregivers
What can PT preterm “brain” experience?

• Consciousness emerges with the establishment of the cortico-thalamic connections which relay sensations & motor signals to the cortex. (24-32 w)
  

• Begin to respond to auditory stimuli by 24 weeks; 16 weeks before their due date. Bernholz et al 1983

• Consistent auditory & visual responses by 28 weeks
The NICU Environment

- Can the NICU Language and Sound Environment be modified and incorporate the importance of parent talk?
Study: Preterm and LENA:  
Caskey et al. Pediatrics 2011

- This was a prospective study of infants ≤1250 g (2lb 8 oz) with recordings at 32w and 36 weeks gestation.
Objectives

• To determine the presence of AWCs, child vocalizations and CTs in the NICU.

• To test the association of AWC with CV and CT

• To test the associations of AWCs, CTs and CVs at 32w & 36w post-menstrual age (PMA) in the NICU with Bayley-III Cognitive and Language scores at 18m corrected age (CA)
Design

• 36 medically stable and non-intubated infants ≤ 1250 grams birth weight were enrolled

• 16 hour LENA recordings were made using the digital language processor inserted into a vest worn by the infant at 32w and 36w (PMA)

• Bayley-III was completed at 7 and 18 months CA
# Demographics of ELBW Infants

<table>
<thead>
<tr>
<th>Variable</th>
<th>N=36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males, n, (%)</td>
<td>15 (42)</td>
</tr>
<tr>
<td>Average Gestational Age (weeks)</td>
<td>27 ± 2</td>
</tr>
<tr>
<td>Average Birth weight (grams)</td>
<td>896 ± 195</td>
</tr>
<tr>
<td>Maternal age (years)</td>
<td>30.8 ± 7</td>
</tr>
<tr>
<td>Gravida 1 (%)</td>
<td>44</td>
</tr>
</tbody>
</table>

1 lb 15 ounces
% Language in Environment of Open Bay NICU

32 weeks:
- Language: 37.1%
- Electronic: 34.7%
- Noise: 26%
- Silence: 2.1%

36 weeks:
- Language: 37.4%
- Electronic: 37.7%
- Noise: 29.7%
- Silence: 5.3%
Total Adult Word Count at 32 and 36 weeks

- 32 weeks: 3306
- 36 weeks: 8556

% change 160%
P<0.0001
Total Child Vocalizations & CTs at 32 and 36 w

% Change 75%
P=0.0003

% Change 95%
P=0.0012
29w now 32 weeks, Giraffe bed, continuous feeds, no visits, room air
25w infant, at 36 weeks. Room air, crib, feeds all po, mom visited at noon, 4pm 8pm and 12am.
Hourly Adult Word Counts during a Parent Visit versus No Parent Visiting

Caskey M, Ped 2013

32 weeks
- Staff Present: 139
- Parent Present: 871
  Range: 14-7894

36 weeks
- Staff Present: 415
- Parent Present: 1427
  Range: 6-3742
Hourly Child Vocalizations during a Parent Visit versus No Parent Visiting
Caskey M, Ped 2013

Child Vocalizations
- Staff Present
- Parent Present

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Staff Present</th>
<th>Parent Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>36</td>
<td>11</td>
<td>16</td>
</tr>
</tbody>
</table>

P = 0.001
Hourly Conversational turns during a Parent Visit versus No Parent Visiting
Caskey M, Ped 2013

Conversation Turns

Staff Present
Parent Present

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Staff Present</th>
<th>Parent Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>36</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

P = 0.00
<table>
<thead>
<tr>
<th>Variable</th>
<th>Parent Visiting 91</th>
<th>No Parent Visiting 929</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean Hourly Adult Word Count</strong></td>
<td>1427*&lt;sup&gt;14-7894&lt;/sup&gt;</td>
<td>415&lt;sup&gt;0-5480&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Mean Hourly Conversational Turns</strong></td>
<td>7*&lt;sup&gt;0-43&lt;/sup&gt;</td>
<td>1&lt;sup&gt;0-59&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Mean Hourly Child Vocalization count</strong></td>
<td>16&lt;sup&gt;0-107&lt;/sup&gt;</td>
<td>11&lt;sup&gt;0-213&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* P<0.0001
The graphs depict the paired analyses of raw data. A regression line is shown, the coefficient is not presented since data are not normally distributed. Caskey M. Ped. 2014
Mean Bayley III Scores at 7 and 18 months

<table>
<thead>
<tr>
<th>Bayley III Scores</th>
<th>7 months</th>
<th>18 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>32</td>
<td>31</td>
</tr>
<tr>
<td>Cognitive Composite Score</td>
<td>94±8</td>
<td>91±10</td>
</tr>
<tr>
<td>Language Composite Score</td>
<td>78±9</td>
<td>85±15</td>
</tr>
<tr>
<td>Receptive Communication Scaled Score</td>
<td>6±2</td>
<td>7±3</td>
</tr>
<tr>
<td>Expressive Communication Scaled Score</td>
<td>7±2</td>
<td>8±3</td>
</tr>
</tbody>
</table>
Associations of CTs at 32 weeks and Bayley scores at 7 and 18 months

Conversational Turns per Hour at 32 Weeks and Bayley III Cognitive Composite at 7 M

\[ r = 0.36 \quad p = 0.04 \]

Conversational Turns per Hour at 32 Weeks and Bayley III Language Composite at 7 M

\[ r = 0.37 \quad p = 0.048 \]

Conversational Turns per Hour at 32 Weeks and Bayley III Language Composite at 18 M

\[ r = 0.60 \quad p = 0.0004 \]
Regression Analyses of LENA at 32 and 36 w with Bayley III scores at 18 m CA (after adjustment for bwt).

<table>
<thead>
<tr>
<th>LENA Measure/Bayley-III</th>
<th>b</th>
<th>P</th>
<th>Model $R^2$</th>
<th>LENA Partial $r^2$ Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 weeks, 100 AWC/hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receptive communication, 7 m</td>
<td>0.3</td>
<td>.0413</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>Language composite, 18 m</td>
<td>2.0</td>
<td>.0404</td>
<td>0.25</td>
<td>0.12</td>
</tr>
<tr>
<td>Expressive communication, 18 m</td>
<td>0.5</td>
<td>.0081</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>36 weeks, 100 AWC/hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive composite, 7 m</td>
<td>1.2</td>
<td>.0049</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Expressive communication, 18 m</td>
<td>0.3</td>
<td>.0701</td>
<td>0.24</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Regression Analyses At 18m  Caskey M. Ped. 2014

- **AWC/h @ 32w** accounted for 12% variance in language composite and 20% of variance in Expressive Communication at 18m

- Every ↑ in 100 **AWC/h@32 w** was assoc with a 2 pt ↑ in lang. comp. score. (p=.04) @ 18m and 0.5 pt ↑ in expressive communication score @ 18m (p=0.008).

- Every ↑ in 100 **AWC/h@36 w** was assoc with a 1.2pt ↑ in Cog Comp score @ 7m (p=.004) @ and a .3 pt ↑Exp Communication @ 18m (p=0.07)
Results Continued for CT

• For every increase in CT count per hour at the 32 week recording

  – the cognitive composite score increased on average by 1.7 points ($p = 0.005$) at 7 months

  – the language composite score increased by 5.3 points ($p=0.005$) at 18 months
Summary

• Daily AWC are highly variable among infants cared for in the NICU

• Preterm infants begin to make vocalizations 8 w prior to their projected due date and ↑ the number of vocalizations significantly over time.

• Language exposure increases over time, however accounts for only a small percent of the sounds to which an infant is exposed in the NICU

• Parent talk in the NICU has a strong positive effect on infant vocalizations and conversational turns
Summary

- PT Infants are at increased risk of language delays.
- PT infants exposure to ↑AWC & CTs in the NICU is associated with ↑ cognitive and language scores at 18 months corrected age.
- Parents should be encouraged to visit, talk, and sing to their infants in the NICU.
- Language Exposure in the NICU is a powerful predictor of language outcomes.
- An optimal home language environment is associated with continued recovery of language skills with ↑ age.
The Research Team

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THANK YOU
Women & Infants