TOO YOUNG TO TEST?
ASSESSING PHONOLOGY IN INFANTS AND TODDLERS

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Tools for assessing articulation and phonology

• Standardized, norm-referenced tests
  ➢ Goldman-Fristoe Test of Articulation (GFTA): 2;6
  ➢ Clinical Assessment of Articulation and Phonology (CAAP): 2;6
  ➢ Hodson Assessment of Phonological Patterns (HAPP): 2;0 (normative data from 3;0)
  ➢ Structured Photographic Articulation Test (SPAT): 3;0
But, what do you do for.....

- Infants and toddlers younger than 2;6
  John – (1;11) Recently evaluated by AzEIP but did not qualify for services. Expressive vocabulary of 15 words (also used additional 23 manual signs).

- Children (any age) with limited expressive vocabulary who are not able to name pictures or imitate a model
  Alex – (3;5) Expressive vocabulary of 132 words, but not able (or not willing) to name pictures or imitate clinician models.
If expressive language is so delayed (or child is so young), why would we even care about “speech”? And if we do, how do we assess it?
Outline

I. Relationship between babble, phonology, and language

II. Quick review of pre-linguistic vocal development

III. Independent analyses of pre-linguistic vocalizations and early speech

IV. Case studies

V. Future directions
What is babble?

“...purposeless egocentric soliloquy of the child”

“...biologically oriented period of tongue delirium...”

Roman Jakobson (1941)
Relationship between babble and language

“It appears that babble, ..., is one of the most reliable markers for early identification of speech and language disorders in children.”

Stoel-Gammon (1998)
But still...

- Articulation and phonology are still often considered “peripheral” and unrelated to language

- Children rarely (if ever) qualify for Early Intervention services based on limited “speech” production
Predictive value of babble in typically developing children

Correlations between:
(summarized in Stoel-Gammon, 1998)

1. age-of-onset of canonical babble and onset of meaningful speech
2. volubility at 3 months and vocabulary size at 27 months
3. number of CV syllables at 12 months and onset of first words
4. use of consonants at 12 months and articulation ability at 3 years
5. diversity of syllable and sound types at 6-14 months and performance on speech and language tests at 5 years
Predictive value of babble in children with *developmental delay*

Rate of vocalization and rate of vocalization with consonants were better predictors of expressive vocabulary a year later in children with developmental delay than either degree of developmental delay (Bayley MDI) or mental age (McCathren et al., 1999)
Predictive value of babble in children with *expressive language delay*

- Use of consonant babble at 28 months is the best predictor of vocabulary growth 5 months later in children with specific expressive language delay (even better than number of true words produced, history of ear infections, or behavior problems)  (Whitehurst et al., 1991)
Predictive value of babble in children with cochlear implants

- Mean Babbling Level at 6 to 9 months post-CI predicts overall language, receptive vocabulary, and articulation ability by 4 years of age. (Walker & Bass-Ringdahl, 2008)

**Relationship between babbling and language was stronger than relationship between babbling and articulation**
Pre-linguistic vocal development: a quick review

<table>
<thead>
<tr>
<th>Stage</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1 mo</td>
<td>vegetative</td>
</tr>
<tr>
<td>2</td>
<td>2-3 mo</td>
<td>cooing/gooing</td>
</tr>
<tr>
<td>3</td>
<td>4-6 mo</td>
<td>vocal play/expansion</td>
</tr>
<tr>
<td>4</td>
<td>6+ mo</td>
<td>canonical babble</td>
</tr>
<tr>
<td>5</td>
<td>10+ mo</td>
<td>jargon</td>
</tr>
</tbody>
</table>

Onset of first words: 12-13 months

End of babbling: 18-20 months
A babble medley
Characteristics of babble

- ‘Vowel babble’ is more common than consonant babble
- Most consonants are stops, nasals, and glides
- Most vowels are lax vowels
- Alveolar stop is most common
- Simple syllable structure (mostly V and CV)
The sounds of babble

Frequently occurring consonants:
  p, b, t, d, k, g, m, n, w, j, h, s

Frequently occurring vowels:
  i, e, ð, u, a, æ
Types of Analysis

**RELATIONAL**
Compares child’s production to adult target form:
- Percent consonants correct (PCC)
- Phonological process analysis
- Phonological Mean Length of Utterance (PMLU) (Ingram, 2002)
- Proportion whole-word proximity (PWP) (Ingram, 2002)

**INDEPENDENT**
Analyzes child’s productions without reference to target form:
- Phonetic inventory
- Mean Babbling Level (MBL)
- Syllable Structure Level (SSL)
- Word Complexity Measure (WCM)
The speech sample

- Use of these independent analyses requires a speech sample
- Is it possible to obtain an adequate speech sample in a typical clinical setting?
Phonetic Inventory

- Independent analysis of sounds the child produces
- Can include both consonants and vowels, or just consonants
- Typically include only sounds that are produced at least twice (but...)
- Can include all utterances produced (intelligible and unintelligible) or just intelligible attempts at words
Phonetic Inventory, con’t

- Initial consonants produced
- Final consonants produced
- Syllable shapes produced
- Vowels produced
Phonetic Inventory:  
What should we expect?

Data from Stoel-Gammon (1985)

**Initial consonant inventory:**

<table>
<thead>
<tr>
<th>Age</th>
<th># of cons.</th>
<th>Cons. in 50% of inventories</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mos.</td>
<td>3.4</td>
<td>/b, d, h/</td>
</tr>
<tr>
<td>18 mos.</td>
<td>6.3</td>
<td>/b, d, m, n, h, w/</td>
</tr>
<tr>
<td>21 mos.</td>
<td>6.7</td>
<td>/b, t, d, m, n, h/</td>
</tr>
<tr>
<td>24 mos.</td>
<td>9.5</td>
<td>/b, t, d, k, g, m, n, h, w, f,s/</td>
</tr>
</tbody>
</table>
Phonetic Inventory:
What should we expect? (con’t)

**Final consonant inventory:**

<table>
<thead>
<tr>
<th>Age</th>
<th># of cons.</th>
<th>Cons. in 50% of inventories</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mos.</td>
<td>.6</td>
<td>(none)</td>
</tr>
<tr>
<td>18 mos.</td>
<td>2.8</td>
<td>/t/</td>
</tr>
<tr>
<td>21 mos.</td>
<td>3.6</td>
<td>/t, n/</td>
</tr>
<tr>
<td>24 mos.</td>
<td>5.7</td>
<td>/p, t, k, n, r, s/</td>
</tr>
</tbody>
</table>
Phonetic Inventory:
What should we expect? (con’t)

Summary of expectations for a 2-year-old:

✓ Voiced and voiceless stops at 2 (and often 3) places of articulation
✓ Initial and final nasals at 2 places of articulation
✓ Some glides
✓ 1 or 2 fricatives (often /f/ and /s/)
✓ CV, CVC, CVCV, CVCVC
✓ Large vowel inventory (distinction between high and low and front and back)
Phonetic Inventory: Example

Alex
Male
Age 3;5
Expressive vocabulary of 132 words (MacArthur Bates Communicative Development Inventories – CDI)
PLS-4 Total Language Score of 50
Unable to administer formal articulation test

Language sample obtained during free play used for analysis
Phonetic Inventory: Alex

Initial consonants produced:
/b, d, g, m, n, h, w/ = 7 initial consonants

Final consonants produced:
/m/ = 1 final consonant “mom”

Syllable shapes produced: CV and 1 CVC

Vowels produced: /e, o, ʌ, ai/
Phonetic Inventory: Alex (3;5), con’t

Age comparison:
• 7 initial consonants is average for a child between 21 and 24 months
• 1 final consonant is average for a child about 15 months old
• Inventory is lacking voiced/voiceless distinction and supraglottal fricatives
• Inventory is limited in terms of syllable and words shapes (almost all CV)
• Vowel inventory is limited (no high/low distinction)
Mean Babbling Level (MBL)
(Stoel-Gammon, 1987, 1989)

- Used to assess phonological diversity in babbling
- Used for children in the babbling or pre-meaningful stage of language development (expressive vocabulary < 10 words)
Mean Babbling Level: The speech sample

Ideally, should include 50 unique utterances

Guidelines for including vocalizations in the sample:

- Judged by the clinician and parent to be non-meaningful (i.e., babble and not a word)
- Contains, at a minimum, a voiced vowel or a voiced syllabic consonant
- Judged to be “speech-like” (produced with egressive airstream, not a cry, scream, cough, or vegetative sound)

(Morris, 2010; Stoel-Gammon, 1987)
## Mean Babbling Level: Coding the utterances

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Utterance contains voiced vowel, voiced syllabic consonant(s), or CV syllable(s) in which the consonant is a glottal stop (/ʔ/), a glide (/w,j/), or /h/. Examples: [a], [m], [wawa], [ɪhɪʔ]</td>
</tr>
<tr>
<td>2</td>
<td>Utterance consists of CV, VC, or CVC syllable(s) with a single consonant type (disregard voicing differences). Examples: [dIdIt],[ga], [baba]</td>
</tr>
<tr>
<td>3</td>
<td>Utterance consists of syllables with two or more consonant types (disregard voicing differences). Examples: [dʊgʌ], [ɔdæp]</td>
</tr>
</tbody>
</table>
Mean Babbling Level:
Calculating MBL

1. Assign value of 1, 2, or 3 to each utterance
2. Multiply 1 by the # of Level 1 utterances
   Multiply 2 by the # of Level 2 utterances
   Multiply 3 by the # of Level 3 utterances*
3. Divide the summed total by the number of utterances in the sample to determine MBL

*Or, just add up the scores for all utterances and divide by total number of utterances
# MBL Expectations
(Stoel-Gammon, 1989)

**TABLE 1.** Peer group (*N* = 32): mean babbling level and mean proportion of Level I, II and III utterances as a function of age.

<table>
<thead>
<tr>
<th>Age</th>
<th>9 mos.</th>
<th>12 mos.</th>
<th>15 mos.</th>
<th>18 mos.</th>
<th>21 mos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of subjects <em>a</em></td>
<td>32</td>
<td>32</td>
<td>24</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Number of utterances per sample</td>
<td>43–50 <em>b</em></td>
<td>41–50 <em>c</em></td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Mean Babbling Level (Standard Deviation)</td>
<td>1.33 (0.24)</td>
<td>1.50 (0.27)</td>
<td>1.58 (0.28)</td>
<td>1.65 (0.20)</td>
<td>—</td>
</tr>
<tr>
<td>Mean % Level I utterances</td>
<td>72</td>
<td>58</td>
<td>55</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Mean % Level II utterances</td>
<td>24</td>
<td>33</td>
<td>33</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Mean % Level III utterances</td>
<td>4</td>
<td>9</td>
<td>12</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

(a) The number of subjects decreases due to the onset of meaningful speech.
(b) Thirty-one subjects had babbling samples with 50 utterances; one subject had 43 utterances.
(c) Thirty subjects had babbling samples with 50 utterances; one subject had 41 utterances, another had 45 utterances.
Mean Babbling Level:
Example #1 (11 months)
<table>
<thead>
<tr>
<th>Utterance</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ΛV]</td>
<td>2</td>
</tr>
<tr>
<td>[Λb]</td>
<td>2</td>
</tr>
<tr>
<td>[bΛ]</td>
<td>2</td>
</tr>
<tr>
<td>[bΛ]</td>
<td>not unique</td>
</tr>
<tr>
<td>[ba]</td>
<td>2</td>
</tr>
<tr>
<td>[vΛv]</td>
<td>2</td>
</tr>
<tr>
<td>[wα]</td>
<td>1</td>
</tr>
<tr>
<td>[Δv]</td>
<td>not unique</td>
</tr>
<tr>
<td>Total =</td>
<td>11</td>
</tr>
<tr>
<td>MBL =</td>
<td>11/6 = 1.83</td>
</tr>
</tbody>
</table>
Mean Babbling Level:
Example #2 (23 months)
<table>
<thead>
<tr>
<th>Utterance</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>[bʌ?]</td>
<td>2</td>
</tr>
<tr>
<td>[u]</td>
<td>1</td>
</tr>
<tr>
<td>[mɬ]</td>
<td>1</td>
</tr>
<tr>
<td>[də]</td>
<td>2</td>
</tr>
<tr>
<td>[du]</td>
<td>2</td>
</tr>
<tr>
<td>[ba]</td>
<td>2</td>
</tr>
<tr>
<td>[ʌ]</td>
<td>1</td>
</tr>
<tr>
<td>[mɬ]</td>
<td>not unique</td>
</tr>
<tr>
<td>[nu]</td>
<td>2</td>
</tr>
</tbody>
</table>

Total = 13

MBL = \( \frac{13}{8} = 1.63 \)
Syllable Structure Level (SSL)
(Paul & Jennings, 1992)

- Used to assess phonological diversity in both meaningful and non-meaningful speech
- Used with children in the meaningful speech stage (＞10 words in expressive vocabulary, but ＜150 words), who may be producing both babble and real words
- Speech sample can include both intelligible and unintelligible utterances (ideally, 50 unique utterances)
- Levels (1-3) are defined in the same way as for Mean Babbling Level
SSL Expectations
(Morris, 2009)

<table>
<thead>
<tr>
<th>Age</th>
<th>20 months</th>
<th>24 months</th>
<th>28 months</th>
<th>36 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SSL</td>
<td>2.22</td>
<td>2.18</td>
<td>2.34</td>
<td>2.39</td>
</tr>
<tr>
<td>(standard deviation)</td>
<td>(.30)</td>
<td>(.21)</td>
<td>(.17)</td>
<td>(.10)</td>
</tr>
</tbody>
</table>
Syllable Structure Level:
Example #1 (21 months)
**Syllable Structure Level:**
Example #1 (21 months)

- Sample included 24 unique utterances

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>% of sample</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>3</td>
<td>13%</td>
<td>[ɛjæ]</td>
</tr>
<tr>
<td>Level 2</td>
<td>15</td>
<td>63%</td>
<td>[gak]</td>
</tr>
<tr>
<td>Level 3</td>
<td>6</td>
<td>24%</td>
<td>[mɛʊk]</td>
</tr>
</tbody>
</table>

SSL = 51/24 = 2.13
**Word Complexity Measure (WCM)**
(Stoel-Gammon, 2010)

- Similar to the *Index of Phonetic Complexity* (Jakielski, Maytasse, & Doyle, 2006)
- Used to assess phonetic complexity of words produced by young children
- Intended for children in the meaningful stage of language development who have a limited expressive vocabulary (may or may not be able to participate in a standardized articulation test)
- Can include both intelligible and unintelligible utterances
Word Complexity Measure: Coding the utterances

Each word in the sample is awarded “complexity” points based on 3 different phonological parameters: (1) word patterns, (2) syllable structures, (3) sound classes
Word Complexity Measure:  
Coding the utterances (con’t)

1. *Word patterns*  
   (a) Productions > 2 syllables = 1pt ("banana")  
   (b) Productions with stress NOT on the first syllable = 1 pt ("balloon")
Word Complexity Measure:
Coding the utterances (con’t)

2. Syllable structures
   (a) Productions with word-final consonant = 1 pt (‘cat’)
   (b) Productions with a consonant cluster = 1 pt for each cluster (‘spoon’)

3. **Sound classes**
   
   (a) Productions with a velar consonant = 1 pt for each velar ("dog")
   
   (b) Productions with a liquid, a syllabic liquid, or a rhotic vowel = 1 pt for each ("leaf", "chair", "bottle")
   
   (c) Productions with a fricative or affricate receive = 1 pt for each ("cheese", "shoe")
   
   (d) Productions with a voiced fricative or affricate = 1 pt each ("van", "jump")
Word Complexity Measure: Scoring Examples

(1) [beɪbi] (target: baby)
(2) [məmi] (target: mommy)
(3) [məm] (target: mom)
(4) [maʊs] (target: mouse)
(5) [ɡwin] (target: green)
(6) [ˈweɪdibʌɡ] (target: ladybug)
(7) [dəˈwɛf] (target: giraffe)
Word Complexity Measure: Scoring Examples

(1) [beɪbi] (target: baby)

WCM = 0 points
Word Complexity Measure: Scoring Examples

(2) \[\text{[mami]}\] (target: \textit{mommy})

\[\text{WCM} = 0 \text{ points}\]

(3) \[\text{[mam]}\] (target: \textit{mom})

\[\text{WCM} = 1 \text{ point (final consonant)}\]
Word Complexity Measure: Scoring Examples

(4) \([\text{maus}]\) (target: mouse)

WCM = 2 points (final consonant, fricative)
Word Complexity Measure: Scoring Examples

(5) [gwin] (target: green)

WCM = 3 points

(final consonant, velar, cluster)
Word Complexity Measure: Scoring Examples

(6) ['weɪdɪbʌɡ] (target: ladybug)

WCM = 3 points
(more than 2 syllables, final consonant, velar)
**Word Complexity Measure:**

Scoring Examples

(7)  $[\text{də}^{\text{1}}\text{wæf}]$  (target: *giraffe*)

\[ \text{WCM} = 3 \text{ points} \]

(stress on 2$^{\text{nd}}$ syllable, final consonant, fricative)
Word Complexity Measure: Calculating WCM

- Total all complexity points for the sample and divide by the number of words in the sample.

1. [beɪbi] (target: baby) 0
2. [mæmi] (target: mommy) 0
3. [mæm] (target: mom) 1
4. [mɔːs] (target: mouse) 2
5. [ɡwɪn] (target: green) 3
6. [ˈweɪdɪbʌɡ] (target: ladybug) 3
7. [dəˈwɛf] (target: giraffe) 3

\[
\frac{12}{7} = 1.71
\]
Word Complexity Measure:
Example (19 months)
### Word Complexity Measure:

**19 month sample**

<table>
<thead>
<tr>
<th>Transcription</th>
<th>Target</th>
<th>WCM points</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ʃɪʃ]</td>
<td><em>fish</em></td>
<td>3</td>
</tr>
<tr>
<td>[ba]</td>
<td><em>ball</em></td>
<td>0</td>
</tr>
<tr>
<td>[mu]</td>
<td><em>moo (cow)</em></td>
<td>0</td>
</tr>
<tr>
<td>[das]</td>
<td><em>that’s</em></td>
<td>2</td>
</tr>
<tr>
<td>[ameɪ]</td>
<td>?</td>
<td>0</td>
</tr>
<tr>
<td>[nouguo]</td>
<td>?</td>
<td>1</td>
</tr>
<tr>
<td>[dɪs]</td>
<td><em>this</em></td>
<td>2</td>
</tr>
<tr>
<td>[bæ]</td>
<td>?</td>
<td>0</td>
</tr>
<tr>
<td>[bɪki]</td>
<td><em>piggy</em></td>
<td>1</td>
</tr>
<tr>
<td>[gak]</td>
<td><em>duck</em></td>
<td>3</td>
</tr>
<tr>
<td>[mukuk]</td>
<td><em>quack quack</em></td>
<td>3</td>
</tr>
</tbody>
</table>

**TOTAL = 15/11 = 1.36**
Are these measures reliable?

- Morris (2009) assessed the test-retest reliability of phonetic inventory, *Syllable Structure Level*, and *Index of Phonetic Complexity* (very similar to WCM) for 10 typically developing toddlers (18-22 months).
- *Syllable Structure Level* and *Index of Phonetic Complexity* had high test-retest reliability.
- Test-retest reliability of phonetic inventory (initial consonants, final consonants, and word shapes) was not as good.
- The most stable measure was the *Syllable Structure Level*.
Case study #1:
John

John – (1;11) Recently evaluated by AzEIP, but did not qualify for services. Expressive vocabulary of 15 words (also used additional 23 manual signs)

• PLS-4 Expressive Communication score = 81
  (Auditory Comprehension = 111; Total Language = 96)
• Gesture, play, and social communications skills are strong
• MBL = 1.63
• Phonetic inventory: 7 initial consonants /b, t, d, g, m, h, ŋ/; 3 final consonants /b, m, ʃ/; V, CV, CVCV, CVC syllable shapes, but, majority (70%) of utterances were isolated vowels, which is more typical of a much younger child (~ 9 months)
Case study #1: John (con’t)

Diagnostic questions:

*How do his “speech” abilities compare to his “language” abilities? What is the rate limiting factor?*

- MBL of 1.63 is about average for a 21 month old
- Expressive vocabulary is about average for a 14-15 month old (if you include his signs, it is average for a 16-17 month old) (based on CDI norms)
- Initial and final consonant inventory is typical of a 21 month old, but word and syllable shapes are limited
Case study #1: John (con’t)

Interpretation and recommendations:

- Speech and language skills seem to be commensurate.

“It is recommended that John receive speech and language therapy to improve expressive language skills. Treatment should focus on increasing expressive vocabulary and the production of word combinations; it is anticipated that speech production skills will improve as vocabulary increases.”
Case study #2: Emma

Emma 2;10. Receiving AzEIP services for language and feeding; eval conducted for pre-school transition. Reported expressive vocabulary of 35 words (CDI)

- PLS-4 Expressive Communication = 56
- Gesture, play, and social communication skills are strong
- Vocalizations limited to squeals, vowel babble (Level 1), and one CV syllable (/no/)
- MBL = 1.04
- Parents report that she rarely babbles and does not use consonant sounds
Case study #2: Emma (con’t)

Diagnostic questions:

*How do speech abilities compare to language abilities? What is the rate limiting factor?*

- 35 words is about average for a 15-16 month old
- 15-16 month old should have MBL of about 1.5
- 15-16 month old should have at least 3-4 initial consonants in the phonetic inventory, and final consonants should be emerging (only 1 initial consonant was observed /n/, and no final consonants)
Case study #2: Emma (con’t)

Interpretation and recommendations:

- Both speech and language are delayed, but speech appears to be more delayed than language and may be the rate limiting factor.

“Speech and language goals should focus on increasing productive vocabulary and increasing her phonemic repertoire, including a variety of consonants, vowels and different syllable shapes.”
Clinical Applications: One last point

A 17-month-old child who has never produced anything beyond a Level 1 babble (vowels or syllabic consonants), but has good gesture and social communication abilities would get a standard score of 101 on PLS-4 *Expressive Communication*. At 23 months, that same child would receive a standard score of 79 (age equivalent of 1;3).
Future directions:

- Develop valid and reliable normative information based on a large number of diverse children for *Mean Babbling Level*, *Syllable Structure Level*, and *Word Complexity Measure*
- Explore use of these measures as methods for documenting progress in therapy
- Look at relationship between independent measures of phonetic/phonological ability and vocabulary size
Thank you.