Indicators of auditory-guided speech development in infants and toddlers who are deaf or hard of hearing.

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► David Ertmer has the following publications with PRO-ED, Inc.
  – The Source for Children with Cochlear Implants
  – Contrasts for Auditory and Speech Training
Part 1:
A New Era for Children who are Deaf or Hard of Hearing

• Multi-channel Cochlear Implants
• Newborn Hearing Screening
Multichannel Cochlear Implants

- Cochlear implants (CI): Surgically implanted electronic devices that bypass damaged hearing hair-cells to stimulate the auditory nerve directly
- Three main manufacturers in the US
  - Advanced Bionics
  - Cochlear Americas
  - MED-EL
- Approved for children of 1;0 or older
- Approximately 30,000 deaf or severely hard of hearing children have received CIs in US
- Bilateral CIs are becoming more common
Expected Threshold Range for CI Users
In sum, CIs provide ...

- **increased auditory access** to conversational-intensity speech and auditory feedback, thereby increasing opportunities to develop phonological abilities through **incidental learning**.

- access to a **wide range of spectral information** to support the development of a complete inventory of phonemes.

- **BUT speech intervention usually needed because** ...

- of a relatively **late start** in auditory-guided speech development

- **CI thresholds often not within normal hearing sensitivity limits.**

- speech is represented **electronically, not naturally**
Newborn Hearing Screening

- 2 -3 children per 1,000 are born deaf or hard of hearing
- 43 states have mandated Newborn Hearing Screening (NHS)
- Common interventions:
  - Hearing Aids
  - Cochlear Implants if HA trial indicates limited audition
  - Family-centered intervention

- Best spoken language results
  - identified <6 months of age (Yoshinaga-Itano, 1998)
  - Intervention started by 11 months of age (Moeller, 2000)

(Photograph of a newborn sleeping)
Part 2: The nature of prelinguistic vocal development
Prelinguistic Speech

Vocal Development:
A process by which infants and toddlers begin to produce phonetically diverse, structurally complex, and speech-like vocalizations prior to saying words on a regular basis.

Cross-linguistic similarities and later-emerging differences
1. Precanonical Vocalizations...

(Range of emergence 0 – 6 months in NH children)

- lack true vowels and true consonants in combination with a rapid transition between them (Oller, 2000)

Types
  - Quasi- and fully-resonant nuclei (Oller & Lynch, 1992)
  - Squeals
  - Vowels / vocants in isolation or in series (Kent & Bauer, 1985)
  - Consonants / closants in isolation or in series (Stark, 1980)
2. Basic Canonical Syllables

(Range of emergence 6 – 10 months in TD children)

• characterized by...
  – Normal phonation
  – Full vocalic resonance (vowel)
  – At least one consonant
  – Rapid CV transitions
    (Oller & Lynch, 1992)

• Types
  – CV syllables and disyllables (CVCV)
  – Reduplicated and nonreduplicated babbling
  – Whispered vocalizations
Percentage of CV and Babbled Utterances as an indicator of hearing status.


![Graph showing age of onset of canonical babbling in deaf and hearing infants](image-url)
3. Advanced Forms

(Range of emergence in NH children: 10 - 18 months)

• ... have canonical attributes but are phonetically and/or prosodically more complex than BCS (Nathani, Ertmer, & Stark, 2002)

• Types
  – Complex syllables (e.g. CCV or CVC)
  – Jargon
    • combinations of different consonants and vowels with changes in stress or intonation
  – Diphthongs
Emergence of Speech-Like Utterances (BCS + AF) after CI Activation (Ertmer, Jung, & Kloiber, 2013)

* $p<.05$, and ** $p<.005$

Pre | early | 3 months | 6 months | 9 months | 12 months | 15 months | 18 months | 21 months | 24 months
--- | --- | --- | --- | --- | --- | --- | --- | --- | ---

CI PC | CI SL | TD SL
Vocal Development Expectations for Children Without Secondary Disabilities
(Ertmer, Jung, Kloiber, 2013)

- **Precanonicals** - gradually decrease in quantity during the first two years of CI use

- **Basic Canonical Syllables** – increase to about 30 - 40% of child utterances by 1 year of CI use and remain stable.

- **Advanced Forms** – Increase to 25% by 1 year and 50% by 2 years of CI use.

- **Speech-like utterances (BCS + AF)** - account for at least 60% of utterances by 18 months.
Reasons why Expectations for Vocal Development Might Not Be Met

• 35 – 40% of children with hearing loss have additional disabilities
• Relatively high CI-aided thresholds may slow development
• Difficulty in perceiving speech features
• Limited access to specialized intervention
• Presence of a speech/phonological impairment
• Limited follow-up in wearing CIs and mapping
• others
Part 3
Assessing progress in vocal development
Speech Sampling at Prelinguistic Level

• Commonly used in research
• Sampling involves
  – Recording 20 – 30 minute parent-child interactions
  – Classifying utterances produced by child (1 – 2 hours)
  – Analyzing the proportions of utterances that are Precanonical, Basic Canonical Syllables, and Advanced Forms
• Likely to be impractical in most clinical settings
CASP: An alternative to speech sample analysis

- The **Conditioned Assessment of Speech Production (CASP)** (Ertmer & Jung, 2012; Ertmer & Stoel-Gammon, 2008;)

  - Easy-to-administer
    - imitation during a “game-like” activity
  - Vocal stimuli from 3 developmental levels of the *Stark Assessment of Early Vocal Development-Revised (SAEVD-R; Nathani et al, 2007)*
    - Precanonical (PC)
    - Basic Canonical Syllables (BCS)
    - Advanced Forms (AF)

- Ages 18 – 48 months in children who have hearing loss

- Has been used with English, Spanish, and Korean
CASP Administration

- Parents and clinician provide models of 10 utterances
  - Isolated vowels (PC) (/ʌ/, /i i/, /æ æ æ/)  
  - CV syllables (BCS) ([ba], [ma], [wa], [sa], [ka])  
  - CVC, C + diphthong syllables (AF) [naI], [tʌk]
- Child’s imitative attempts are reinforced with Classical Stacker toy
- Graduated scoring scale  
  - 0 = no attempt, not a close match  
  - 1 = partially acceptable match  
  - 2 = fully acceptable match
### CASP Graduated Scoring Scale

<table>
<thead>
<tr>
<th>Models Transcribed Responses</th>
<th>0 Points</th>
<th>1 Point</th>
<th>2 Points</th>
<th>Score</th>
</tr>
</thead>
</table>
| **3. Three low-front vowels: /æ/ /æ/ /æ/** | 1. No response  
2. Response is not a vowel  
3. Syllables with vowels that do not match target (e.g., [bu]) | 1. Single /æ/ or /ε/  
2. Two matching vowels (e.g., /ææ/, /εε/)  
3. Three vowels, only one /æ/ or /ε/  
4. Two or three non-matching vowels (i.e., none are /æ/ or /ε/)  
5. CV syllables containing target vowel (e.g., [bæbæbæ]) | 1. Three low or mid front vowels (i.e., /æ/ or /ε/) | |
| **7. CV syllable with a velar stop: [kɑ]** | 1. No response  
2. Vowel in isolation  
3. Consonant in isolation | 1. CV syllable in which only the C or the V match the model (e.g., [ki] or [tɑ])  
2. Two or more matching CVs (i.e., [gɑgɑ, gɑ] or [kʌkʌ])  
3. CVC syllable with matching C or V | 1. A single CV with /k/ or /ɡ/ and /ɑ/ or /ʌ/ (i.e., [kɑ], [ɡɑ] or [kʌ], [ɡʌ]) | |
| **10. CVC: [tʌk]** | 1. No response  
2. Vowel in isolation  
3. Isolated consonant (e.g. [s])  
4. VC or CV syllable | 1. CVC syllable with non-matching Cs and V (e.g., [pip])  
2. CVC syllable with one or two segmental errors (e.g., [top]) | 1. CVC syllable with initial /t/ or /d/ and final /k/ or /ɡ/ combined with /ɑ/ or /ʌ/ (e.g., [tɑk], [dʌg], [tɑk], [dɑg]) | |
Research questions

• Do CASP scores have concurrent validity with speech sample measures?

• How closely are CASP scores associated with the percentage of speech-like utterances contained in speech samples?
Research Methods

• 19 children with CIs
  – (2 with additional disabilities)

• Mean implant age = 21.5 months

• CASP and 20-minute speech samples collected after 6, 12, 18, 24 months of CI use

• 50 child-utterances analyzed from speech samples
Correlation Variables

• Percent of speech-like utterances (BCS and AF) in sample samples

and

• Percent of CASP points earned at the same intervals
Relationship between speech-like utterances and CASP scores across 2 years of CI use. (Ertmer & Jung, 2012)
Mean Percent of Speech-like Utterances and CASP scores at each interval (Ertmer & Jung, 2012)
Conclusions regarding assessment

• The CASP ...
  – has **high concurrent validity** with speech sample measures in English-speaking children
  – is **time-efficient** tool for assessing progress in vocal development after CI of HA fitting
  – may identify children with **secondary disabilities** as well as those with speech delays
    – Scores of two children with second disabilities were found to be >1.5 standard deviations below the mean CASP scores at 18 months and 24 months.
  – Adaptations of the AF level are needed for languages that differ from English in the use of closed syllables and diphthongs (e.g., Japanese, French, Finnish, and Italian)

• Further study needed to develop norms based on amount of hearing experience
Part 4: Intervention at the prelinguistic level
Intervention: Short Periods of Prelinguistic Input (SPPI) (Ertmer et al, 2002; Ertmer, 2005; Ertmer & Iyer, 2010)

- **Goal** – to provide focused stimulation for developmentally appropriate vocalizations and to increase consonant and vowel diversity

- **Models**: vocalizations from the child’s current and next level of vocal development
  - PC – variety of vowels
  - BCS – assorted CV, CVCV, and babbled syllables
  - AF – CVC, diphthongs, jargon

  - Models are associated with toys and presented during play

- **Models presented** every 5 seconds for 1 minute, 5 times per day by parents
  - Models then pause

- **See**
  - [vocaldevelopment.com](http://vocaldevelopment.com) for more information and video examples
  - [http://www.youtube.com/watch?v=37JxkDNJ0Aw](http://www.youtube.com/watch?v=37JxkDNJ0Aw)


