

# DESCRIPTION OF SPEECH PRODUCED BY INFANTS WITH BRONCHOPULMONARY DYSPLASIA: METHODOLOGICAL ISSUES AND PRELIMINARY DATA

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## 1. INTRODUCTION

Up to seventy percent of infants born prematurely and of low birth weight develop significant medical complications (1). One relatively common and serious complication is BPD, a form of chronic lung disease that can have persistent effects on respiratory function through at least early childhood (6). Infants who have suffered BPD are at especially high risk for poor developmental outcomes, even in comparison with other groups of high-risk infants, and there is some evidence that the risk of language delay is higher for infants who develop BPD, relative to other complications (5). Recent research suggests phonetic development during the first year of life impacts on later language development and clinical observations suggest that infants with BPD have difficulty producing good quality canonical babble at the expected age. Therefore, the purpose of this pilot study is to: 1) obtain a comprehensive description of the vocalizations produced by full-term infants, preterm infants without BPD, and preterm infants with BPD; 2) determine the reliability of measures of babbling ability for each of these subject groups; 3) examine the relationship between maturity of babble and aspects of development that may impact on babbling ability (i.e., cognitive ability, hearing acuity, oral motor skills, and respiratory function).

## 2. METHOD

### 2.1 Subjects

The subjects are 13 children who were born prematurely and who have been diagnosed with BPD (BPD group), 8 children who were born prematurely but who have not experienced any major medical complication such as BPD or intraventricular hemorrhage (HP group), and 10 healthy children who were born at term (HT group). For the BPD, HP, and HT groups respectively, mean birthweights were 834, 1027 and 3408 grams; mean number of days on supplemental oxygen to 12 months of age were 149, 3, and 0; and mean Blishen scores were 41, 40 and 52.

### 2.2 Procedure

The children were assessed at 8 and 12 months adjusted age. At 8 months, cognitive function, muscle tone, and pulmonary function were assessed. At 12 months auditory function and feeding skills were assessed. At both ages, a sample of babble was audiorecorded from the infants. Twelve samples were re-recorded within one week of the original recording in order to assess test-retest reliability. Each sample contained 50 to 100 utterances. Details of analysis procedures have been previously described (4) and will be summarized briefly here. Each utterance is coded according to 5 discrete categories: canonical babble (CB), marginal babble (MB), fully resonant vowel (FRV), quasiresonant vowel (QRV), and other (rasperies, growls, squeals etc.). A count of the number of canonical syllables in the entire sample is obtained. Canonical syllables are characterized by the presence of at least one consonant combined with a vowel, normal phonation and resonance and mature timing char-

acteristics (2). The canonical syllable ratio (CSR) is calculated as the number of canonical syllables divided by the number of utterances (3). Efforts to replicate the more recent procedure of taking the ratio of CB syllables to the total number of syllables failed. We were unable to reliably identify the number of noncanonical syllables in a sample, although reliability for canonical syllable counts was good as described below. The ratio of MB syllables with abnormal phonation to the total number of utterances was also calculated as the abnormal phonation ratio (APR). Finally, the frequency of the second formant (F2) of vowels contained within canonical syllables was determined, and the standard deviation (SD) of F2 frequencies was calculated as an indicator of the size of the infant's vowel space.

## 3. RESULTS

### 3.1 Reliability

Inter-rater and intra-rater reliability was examined for coding of individual utterances in 12 samples (600 utterances in all). The percent agreement and kappa statistics are shown in Table 1. The Kappa statistics indicate good inter-rater reliability and very good intra-rater reliability, although percent agreement between raters is not as good as we would like. Inter-rater, intra-rater, and test-retest reliability was determined for CSRs, APRs and SD of the F2, using 12 additional samples. Mean differences, range of differences, and Pearson correlation coefficients for these pairs of scores are shown in Table 2. When this study is complete, we will determine intraclass correlations as a more appropriate measure of reliability than the Pearson *r*. In the meantime however, the information in Table 2 indicates excellent inter-rater and intra-rater reliability for CSRs and APRs. Test-retest CSRs and APRs indicate reasonably good temporal stability for these measures. The mean difference between the SD of the F2s is greater than desired but there is only one pair of samples yielding a large difference between raters. When this outlier is removed the mean difference between raters is reduced to 50 Hz, with the range 0 to 221 Hz and  $r = .92$ . Intra-rater and test-retest reliability is poor for the SD of the F2 frequencies.

**Table 1.** Inter-rater and intra-rater reliability for coding of individual utterances as CB, MB, FRV, QRV, or OTHER.

	Inter-rater	Intra-rater
Percent agreement	78%	89%
Kappa statistic	0.70	0.85

**Table 2.** Inter-rater, intra-rater and test-retest reliability for sample level analyses.

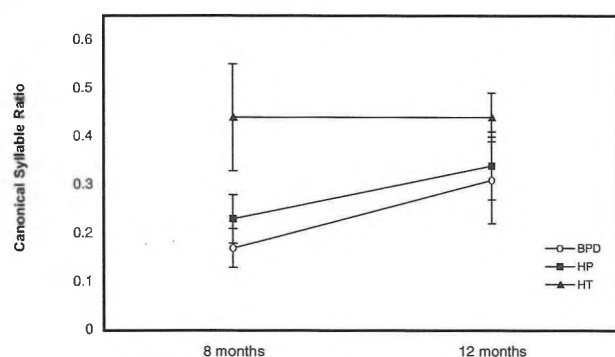
	Inter-rater	Intra-rater	Test-retest
<b>CSRs</b>			
M Difference	.05	.03	.10
Range	0 - .12	0 - .08	0 - .28
Pearson r	.97	.98	.71
<b>APRs</b>			
M Difference	.03	.03	.05
Range	0 - .10	0 - .06	0 - .12
Pearson r	.91	.95	.77
<b>SD of F2s</b>			
M Difference	87	108	230
Range	0 - 505	19 - 303	23 - 478
Pearson r	.69	.64	-.54

### 3.2 Phonetic Development

Figure 1 shows mean CSRs for the three groups at 8 and 12 months. There are significant differences as a function of group [ $F(2,28) = 5.10, p = .01$ ], but not age. Tukey pair-wise comparisons indicate that the HT group produces more canonical babble than the BPD group [ $t(20) = 3.17, p = .01$ ]. Differences between the BPD and HP groups and between the HT and HP groups are not statistically significant. There are no between group differences in the frequency of marginal babble produced with abnormal phonation. Mean APRs are .12, .13, and .18 at 8 months and .12, .10 and .09 at 12 months for the BPD, HP, and HT groups respectively. Between group differences for size of the vowel space were not observed either. The SD of F2 is 388 Hz, 564 Hz, and 420 Hz at 8 months and 451 Hz, 461 Hz, and 570 Hz at 12 months for the BPD, HP, and HT groups respectively.

### 3.3 Correlates of the Canonical Syllable Ratio

Table 3 shows for each group the mean and standard deviation for the following variables: feeding score, Bayley Mental Development Index, and number of episodes of otitis media. The feeding score is based on a videotape of the infant eating. Drooling, biting, chewing, and lip closure/movement were rated as normal (score 0), suspect (score 1) or abnormal (score 2).



**Figure 1.** Mean CSRs at 8 and 12 months for the BPD, HP, and HT groups (standard error bars shown).

**Table 3.** Mean (standard deviation) of feeding scores, Mental Development Index, and number of episodes of otitis media.

	BPD	HP	HT
Feeding	2.00 (1.50)	1.38 (1.19)	0.90 (0.99)
MDI	94.85 (5.15)	97.50 (9.35)	97.2 (5.05)
Otitis Media	0.92 (1.66)	0.13 (0.35)	0.70 (1.25)

There are no significant between-group differences or predictor relationships between any of these variables and babbling ability. There may be some threshold effects: infants who received more than 28 days of supplemental oxygen produced less canonical babble than infants who required less oxygen (M summed CSR = 0.48 vs. 0.75). Infants who experienced more than 3 episodes of otitis media produced less canonical babble than infants who experienced fewer episodes (M summed CSR = 0.45 vs. 0.65).

### 4. CONCLUSIONS

Inter-rater, intra-rater, and test-retest reliability for Canonical Syllable Ratios and Abnormal Syllable Ratios is good or excellent. Reliable determination of F2 frequencies is difficult. Infants born prematurely who have BPD produce less canonical babble than healthy infants born at term. CSRs may also be impacted by otitis media history but are not correlated with feeding and cognitive abilities. Correlational analyses are suspect due to restricted range and small sample size, however.

### 5. REFERENCES

- Landry, S.H., Fletcher, J.M., & Denson, S.E. (1993). Longitudinal outcome for low birth weight infants: Effects of intra-ventricular hemorrhage and bronchopulmonary dysplasia. *Journal of Clinical and Experimental Neuropsychology*, 15, 205-218.
- Oller, D.K. (1986). Metaphonology and infant vocalizations. In B. Lindblom & R. Zetterstrom (Eds.) *Precursors of early speech* (pp. 21-36). New York: Stockton Press, Inc.
- Oller, D.K. & Eilers, R.E. (1988). The role of audition in infant babbling. *Child Development*, 59, 441-449.
- Rvachew, S., Slawinski, E.B., Williams, M., & Green, C. (1999). The impact of early onset otitis media on babbling and early language development. *Journal of the Acoustic Society of America*, 105, 467-475.
- Sauve, R.S. & Singhal, N. (1985). Long-term morbidity of infants with bronchopulmonary dysplasia. *Pediatrics*, 76, 725-733.
- Vohr, B.R., Coll, C.G., Lobato, D., Yunis, K.A., O-Dea, C., & Oh, W. (1991). Neurodevelopmental and medical status of low-birth-weight survivors of bronchopulmonary dysplasia at 10 to 12 years of age. *Developmental Medicine and Child Neurology*, 33, 690-697.

### 6. ACKNOWLEDGEMENT

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