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An Analysis of the Frame-Content Theory in Babble of Nine-Month-Old Babies with Cleft Lip and Palate

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Abstract

The aim of this study was to examine the consonant-vowel co-occurrence patterns predicted by the Frame-Content theory in 16 nine-month-old babies with unrepaired cleft palate ($\pm$ cleft lip) and 16 age-matched non-cleft babies. Babble from these babies was phonetically transcribed and grouped according to the intrasyllabic predictions of the theory (labial-central, alveolar-front, and velar-back). Both groups demonstrated the three consonant-vowel co-occurrence patterns predicted by the Frame-Content theory. Other patterns not predicted by the Frame-Content theory emerged as strong patterns as well.

Introduction

Canonical babbling is considered an important foundation for early speech production. Babble provides the opportunity for babies to practice sounds and sound sequences, and it is through this practice that they develop the control and precision needed for easy execution of these skills in speech (Stoel-Gammon, 1998). Research has demonstrated that the consonants that occur most often during canonical babbling are also those that typically appear in a child's first words (Stoel-Gammon and Cooper, 1984; Vihman, 1992; Vihman, Macken, Miller, Simmons, and Miller, 1985). Further, a number of correlational studies have demonstrated positive associations between prelinguistic vocal development and later speech and language performance (Kagan, 1971; Menyuk et al., 1986; Stoel-Gammon, 1989; Vihman and Greenlee, 1987).

Although the appearance of canonical syllables at 7-8 months of age is an important milestone in prelinguistic development, syllables produced during this time are restricted by

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limitations in fine motor control. MacNeilage (1998) pointed out that the tongue moves in tandem with the jaw and rarely alters course to accommodate new articulations. Davis and MacNeilage (1990) proposed the Frame-Content (F-C) theory to explain the limitations seen in early articulatory movements. According to the theory, the *Frame* refers “to the regularity of mandibular oscillation resulting in listener perception of syllable-like and therefore speech-like output” and the *Content* refers to “segment-specific” elements (i.e., consonants and vowels) (David and MacNeilage, 1995, p. 2000). The authors suggested that the elements of babble are organized by specific production patterns. Specifically, they hypothesized that the vowel produced by a baby is dictated by the position of the consonant that precedes it. They predicted that these constraints would typically result in the following consonant- vowel co-occurrences: alveolar-front (e.g., /di/), labial-central (e.g., /bʌ/), and velar-back (e.g., /go/). In 1994, Davis and MacNeilage analyzed the babble of a single male infant and reported that “pure frames” (labial consonants with central vowels) and “fronted frames” (tongue-front consonants with front vowels) were common in reduplicated and variegated babble. The authors noted that the infant produced too few dorsal consonants for testing the presence of velar consonant – back vowel co-occurrence pattern. In a subsequent research project, Davis and MacNeilage (1995) found the three predicted co-occurrence patterns to be at significant levels in six English-learning infants. In 1998, MacNeilage compared the results from three studies analyzing the F-C theory by examining the structure of consonant-vowel sequences in 14 infants. Results suggested that “of 99 tests, 91 showed positive results, typically at statistically significant levels, 6 showed countertrends, and 2 showed an absence of trend” for the frame content theory (MacNeilage, 1998, p. 505).

Support for the F-C theory has been obtained in studies involving typically developing, English-speaking infants as well as infants from other language environments (MacNeilage, Davis, Kinney, & Matyear, 2000), including those who speak Swedish, Japanese, Quichua, Brazilian-Portuguese, Italian, Serbian, and Korean (with the exception of velar-back co-occurrence patterns in Italian and Serbian infants) (Davis & MacNeilage, 2002; Gildersleeve-Neumann and Davis, 1998; Teixeira and Davis, 2002). The three consonant-vowel co-occurrence patterns predicted by the F-C theory have also been observed in French, Turkish, and Dutch babies (Kern et al., in press). Tunisian babies exhibited coronal-front and labial-central co-occurrence patterns, but not dorsal-back co-occurrence, and Romanian babies only exhibited strong front-coronal co-occurrence patterns (Kern et al., in press).

Support for the F-C theory has also been reported in studies involving at-risk populations. McCaffrey et al. (1999) examined babble in a child with profound bilateral sensorineural hearing loss who received a cochlear implant (McCaffrey, et al., 1999). Data indicated that this baby did not show any significant tendencies for co-occurrence of labial consonants with central vowels or alveolar consonants with front vowels until after seven months post-implantation of a cochlear device. McCaffrey et al. (1999) explained that due to the small inventory of velar consonants in this subject the co-occurrence of velar consonants and back vowels was not examined.

In a more recent report, von Hapsburg and her colleagues (2008) examined CV co-occurrence patterns in 13 babies (9 with varying degrees of hearing impairment and 4 with normal hearing) ranging in age from 7-24 months. They found that while the majority of significant CV co-occurrences were those predicted by the F-C theory, there was no relationship between pure-tone average and CV co-occurrence patterns.

A number of studies conducted in the past decade have demonstrated that canonical babbling in babies with cleft palate (with or without cleft lip) differs from that of typically developing babies in both frequency and quality of productions. Compared to their noncleft

peers, babies with cleft palate are delayed in the onset of babble (Chapman et al., 2001) and some reports suggest that they babble less frequently (Scherer et al., 2008). The composition of their babble is also different, with fewer total consonants (Lohmander et al., 2004) and more vowel-only syllables than consonant-vowel productions (Scherer, Williams, Henley, Lambert, Lassiter, and Osborne, 2000). Their consonant inventory is typically smaller and characterized by consonants that require little intra-oral air pressure (e.g., nasals, glides, and liquids) (Chapman et al., 2001; O’Gara and Logemann, 1988; Olsen, 1965; Salas-Provence et al., 2003). When compared to noncleft babies, babies with cleft palate produce fewer oral stops, velars, and alveolars (Chapman, 1991; Chapman et al., 2001; Hutters, Bau, & Brøndsted, 2001; Lohmander et al., 2004; Lohmander, Olsson, & Flynn, in press; O’Gara & Logemann, 1988; Willadsen and Albrechtsen, 2005), as well as more nasals and glottals (Chapman et al., 2001; Hutters, Bau, & Brøndsted, 2001.; O’Gara and Logemann, 1988; Olsen, 1965; Willadsen and Albrechtsen, 2005). To date, vowel production has been largely ignored in this population.

Some authors have questioned whether the presence of a cleft might disrupt the development of the rhythmic motor patterns that underlie canonical babbling (Chapman et al., 2001). Although this question has not been directly examined, Philips and Kent (1984) provided preliminary acoustic evidence to suggest that while the phonetic components of babbling are compromised in babies with cleft palate, the rhythmic structure is maintained. Their findings would suggest that the frame dominance evident in the babble of non-cleft babies should be evident for babies with cleft palate as well.

The current study was performed to examine the impact of clefting on the organization of syllable co-occurrence patterns in babble. It is well documented that the presence of a palatal cleft influences the type of consonants that toddlers produce, but it is unclear whether atypical oral-pharyngeal structures will impact the CV co-occurrences observed in early vocal development. For example, alveolar consonants are infrequent in the speech of babies with cleft palate (Chapman et al., 2001; Lohmander, Olsson, and Flynn, in press; Olsen, 1965), yet the alveolar-front CV co-occurrence is one the three major patterns identified. Babies without cleft palate were included in this study to 1) permit age-matched comparisons with the cleft group and 2) facilitate comparison of the data with findings previously reported for typically developing babies in the literature. This was deemed necessary because while some reports have confirmed the findings of MacNeilage and Davis, others have reported discrepant findings. The purpose of this study was twofold: 1) to determine if the consonant-vowel co-occurrence patterns produced by babies with cleft palate differ from those produced by non-cleft babies and 2) to examine whether the consonant-vowel co-occurrence patterns predicted by the F-C theory were evident in the babble of nine month old babies with unrepaired unilateral cleft palate. It was hypothesized that 1) the consonant-vowel co-occurrence patterns of babies with cleft palate would differ from that of non-cleft babies and 2) the babies with unrepaired cleft palate would demonstrate the labial-central and velar-back CV patterns predicted by the F-C theory but would not demonstrate the alveolar-front CV pattern predicted by the theory.

Methods

2.1 Participants

Participants included 16 infants with unilateral cleft lip and palate and 16 typically developing infants. The babies ranged in age from 8 months, 15 days to 9 months, 26 days (mean age cleft group: 9 months, 5 days; mean age non-cleft group: 8 months, 27 days). The cleft lip and palate group included 7 females and 9 males, while 5 females and 11 males participated in the non-cleft group (see Table 1). Babies in the cleft group had received

surgical repair of their cleft lip but had not received palatal repair. All babies were from monolingual American-English speaking homes.

All babies scored within normal limits on the Bayley Scales of Infant Development (Bayley, 1993). None of the babies had been identified as having congenital anomalies, neurological impairments, or intellectual deficits. Hearing thresholds were not obtained at the time of recording because the babies were seen in their homes. Screening tympanometry was performed for 29 of the 32 babies (15 cleft and 14 noncleft) following the recording session. Six (37.5%) of the babies in the cleft group failed the screening compared to four (25%) babies in the noncleft group. Thirteen babies in the cleft group had received myringotomy and tubes. In contrast, none of the noncleft babies had received tubes. Information about ear infections was available for 30 babies (15 in each group). According to parental report, 11 (73.33) babies in the cleft group and eight (53.33) babies in the noncleft group had experienced at least one bout of otitis media by nine months of age. Five (33.33%) babies in the cleft group had experienced four or more episodes since birth. In contrast, only two (13.33%) of the noncleft babies had four or more episodes.

Seven of the sixteen babies with cleft palate wore palatal obturators from birth until one month prior to palatal surgery. The appliances obturated only the hard palate; the soft palate cleft was left unobtured. Previous research from our laboratory has demonstrated that the vocalizations of babies with cleft palate who wear palatal obturators do not differ significantly from vocalizations of babies who do not wear obturators in either place or manner of production (Hardin-Jones et al., 2002).

2.2 Procedures

All but one of the babies had been participants in a larger, longitudinal study of speech development (Chapman et al., 2001). For that study, sound recordings had been obtained for both groups of babies in the home while interacting with their primary caregiver. Audio-tape recordings were obtained using a Country-man wireless microphone (MEMWF05ETS), Telex receiver (RMR-70) and transmitter (WT60), and a Marantz portable cassette recorder (PMD 430). The number of vocalizations obtained for the babies in the cleft group ranged from 100 to 113 (mean= 104.38). A comparable number of vocalizations were obtained for the babies in the noncleft group (range= 84 to 128; mean= 104.13).

All babies in this study had entered the canonical babbling stage of vocal development, as verified through calculations of a canonical babbling ratio (CBR) for each participant. Oller and his colleagues (1994) defined the CBR as the number of canonical syllables produced in a sample divided by the total number of syllables present in the sample. A canonical syllable was defined as a syllable that includes a supraglottal consonant (i.e., any consonant other than /h/ or /ʔ/) and a fully resonant vowel. A CBR of 0.15 was considered evidence that a baby had entered the canonical babbling stage and was demonstrating adequate consistency of the canonical syllable type. All participants had a CBR of 0.15 or higher (See Table 1).

All canonical syllables were identified for each child and were transcribed independently by the first and second authors. Consonants were transcribed according to place of articulation: labial (p, b, m, w), alveolar (t, d, n, l, j, ɾ)², and velar (k, g, ŋ, ɣ) (Davis & MacNeilage, 1995). Vowels were transcribed according to place of production using the cardinal vowel diagram: front (i, ɪ, e, æ), central (ə, ɜ, ɐ, ʌ), and back (u, ʊ, o, ɔ, ɑ). Only syllables

²We recognize that /j/ and /ɾ/ are not produced with an alveolar place of articulation. They were categorized in this way to facilitate comparison of the data with previous reports. Both consonants have been categorized as an "alveolar", "tongue-front", or "coronal" consonant in Chen and Kent (2005), MacNeilage, Davis, and Matyear (1997), Davis and MacNeilage (1994) and von Hapsburg, Davis and MacNeilage (2008).

with a supraglottal consonant adjacent to a fully-resonant vowel were transcribed for this study.

Prior to transcription of the data for this study, the transcribers practiced transcribing vocalizations of eight babies to increase their interjudge reliability. The two transcribers sat on opposite ends of a six foot table during the transcription task. The samples were played using a Marantz portable cassette recorder (PMD 430) and an Audio Buddy Dual Microphone Preamplifier. Each transcriber wore a Bose Quiet Comfort Acoustic Noise Canceling Headphone. Only those consonants and vowels that were transcribed identically for place of production (consonants: labial, alveolar, and velar; vowels: front, central, back) were considered agreements during the practice transcription task. The two transcribers achieved 85% agreement for consonants and vowels independently, and 80% agreement for both consonant-vowel syllables.

The same instrumental set-up described above was used for the primary transcription task in this study. Each transcriber listened to the vocalization samples at the same time, but independently transcribed each of them. For purposes of data analysis, only those syllables with 100% agreement on *both* consonant placement (labial, coronal, and dorsal) and vowel placement (front, central and back) were considered in the data analysis. Samples that were judged to be too noisy were excluded, as were samples that the two transcribers did not transcribe identically for place of production. A total of 24 samples were discarded due to noise. Diphthongs were categorized according to the first vowel or onglide in the diphthong (e.g., $\alpha\bar{i}$ was transcribed as a back vowel, and $e\bar{i}$ as a front vowel).

2.3 Data Analysis

For the purposes of analysis, consonants and vowels were analyzed in pairs, with vowels linked to the preceding consonant³ because the F-C theory makes predictions about intrasyllabic combinations (Davis & MacNeilage, 1995, MacNeilage, Davis, Kinney, & Matyear, 2000, MacNeilage, Davis, & Matyear, 1997). Only those syllables with 100% agreement on *both* consonant and vowel placement (i.e., consonants- labial, alveolar, velar; vowels – front, central, back) were considered in the data analysis. The number of syllable tokens obtained for the babies ranged from 18 – 86 with an average of 55 in the cleft group and 56 in the noncleft group (see Table 1). These data were analyzed using the Statistical Package for the Social Sciences (SPSS) program. A Chi-square (χ^2) Goodness-of-Fit test was performed to compare the frequency of babble types in babies with cleft palate to the frequency observed in non-cleft babies.

An observed to expected ratio was also calculated to allow comparison with other studies that have examined the frame content theory. An expected ratio was determined by multiplying the total percentage of consonants by the total percentage of vowels for each category. For example, if 30% of all consonants in the corpus were alveolar consonants and 50% of all vowels in the corpus were front vowels, then the expected value for the alveolar-front co-occurrence pattern would be 0.3×0.5 , or 15%. The observed to expected ratio was calculated by dividing the observed frequency of syllables produced in each category by the expected ratio. Ideally, the expected value for each predicted co-occurrence pattern (alveolar-front, labial-central, and velar-back) is 1.0. As described by McCaffrey et al. (1999), an observed co-occurrence pattern greater than the expected value “indicates a preferential CV co-occurrence pattern, suggestive of a Frame Dominance effect” (p. 10). These observed to expected ratios were compared for the cleft and non-cleft groups,

³The consonant in a VCV was associated with the second vowel.

between each individual child, and to data from previous studies relating to the Frame Content theory.

RESULTS

3.1 Consonant and Vowel Preferences

The consonant and vowel inventories for each child are provided in Appendix A. Tables 2 and 3 summarize the percentage of babies producing each consonant and vowel type.

3.1.1 Cleft Group—A total of 881 tokens/syllables were analyzed in the cleft group. The most frequently produced consonant type for the babies in this group was labial consonants (53%) followed by alveolar consonants (42%). Very few velar consonants (5%) were produced by these babies (Table 2). The most frequently produced consonants were /m/ and /w/, occurring in 100% of the babies, followed by /l/ (81%) and /n/ (75%) (Table 3).

All of the babies in the cleft group produced front and central vowels and 15 produced a back vowel. As evident in Table 4, 50% or more of the babies produced /ε/ and /u/. All of the babies produced /æ/ and /ʌ/. Front vowels (43%) were favored over central (41%) and back (16%) vowels.

3.1.2 Non-Cleft Group—A total of 890 tokens/syllables were analyzed in the non-cleft group. Over half of the consonants produced in the non-cleft group were alveolar consonants (56%) followed by labial consonants (30%) (Table 3). Similar to the production frequencies of the cleft group, velar consonants (14%) were produced less frequently. The phonemes that were produced by the majority of the babies in the non-cleft group were /d/ (94%), /l/ (88%), /w/ (88%) and /j/ (81%). At least 50% or more of the babies also produced /b/ and /g/.

Vowel production for the non-cleft group was similar to that seen in the cleft group (Table 4). All babies produced a front and central vowel but only 11 produced a back vowel. Front vowels (54%) were favored over central (30%) and back (15%) vowels. All of the non-cleft babies produced /ε/ and /ʌ/. Fifty percent or more of the non-cleft babies produced /æ/ and /ɪ/.

3.2 Consonant-Vowel Co-Occurrence Patterns

Consonant-vowel co-occurrence patterns produced by the babies with cleft palate differed from those produced by the age-matched, non-cleft babies (see Table 2). A Chi-square (χ^2) Goodness-of-Fit test was performed to determine if the distribution of the observed frequencies of CV co-occurrence patterns produced by the babies with clefts differed from that of the expected frequencies of CV co-occurrence patterns produced by the babies in the noncleft group (see Table 2). Results from this analysis indicated that the frequencies of the CV co-occurrence patterns in the cleft group were statistically different from those of the non-cleft group ($\chi^2 = 366.69$; $p < .001$). Standardized residuals were examined to determine which cells produced the significant difference. All of the CV co-occurrences patterns were significant contributors to the chi-square relationship except the alveolar-central and velar-back patterns.

Table 5 shows the observed to expected ratios for each co-occurrence pattern for the cleft and non-cleft groups. In the cleft group, the labial-central and alveolar-front patterns were confirmed as preferred patterns with ratios above 1.0. Although the velar-back pattern also emerged as a strong co-occurrence pattern in this group, it should be noted that only 5 of the 16 babies with cleft palate actually produced velar consonants. An unpredicted pattern,

labial-back, was also confirmed. When co-occurrence patterns were examined for individual babies, only 25 of the 48 predicted patterns (3 patterns X 16 babies) emerged as preferred patterns. Of these 25 co-occurrence patterns, 13 were alveolar-front and 10 were labial-central. Eleven babies did not produce velar consonants and therefore did not produce velar-back syllables. Three babies did not show preference for any of the predicted CV patterns. Fourteen babies showed preferences for unexpected co-occurrence patterns. These patterns include alveolar-central, alveolar-back, labial-front, labial-back, and velar-central. Ten babies showed a preference for the labial-back co-occurrence pattern and seven babies showed a preference for the alveolar-central co-occurrence pattern.

In the non-cleft group, the three predicted patterns were confirmed as preferred patterns with ratios above 1.0. In addition, the unpredicted patterns of labial-back and velar-central also emerged as preferred patterns in the group data. When CV patterns were examined for individual babies, only 24 of the 48 predicted patterns were confirmed with ratios above 1.0. Of the remaining 24 co-occurrence patterns, three patterns were alveolar-front, nine were labial-central, and 12 were velar-back syllables. As was true for the cleft group, the majority of non-cleft babies (n=12) did not produce velar consonants. Three babies did not show preference for any of the predicted CV patterns. Fifteen babies showed preferences for co-occurrence patterns that were not predicted by the F-C theory including the alveolar-central, alveolar-back, labial front, labial-back, velar-front, and velar-central. Seven babies demonstrated the labial-back co-occurrence pattern.

The data were further examined to determine the contribution of /w/ to the labial-back co-occurrence pattern. Although commonly classified as a labial consonant, /w/ has two recognized places of articulation: labial and velar. The data revealed that CVs produced with a /w/ accounted for a large percentage of the labial-back preferences observed in the cleft (53%) and noncleft (54%) groups.

DISCUSSION

The purpose of the present study was to examine the presence of consonant-vowel co-occurrence patterns predicted by the Frame-Content theory (MacNeilage & Davis, 1990, 1993) in 9-month-old babies with unrepaired unilateral cleft palate. As a group, the babies with cleft palate produced the alveolar-front, labial-central, and velar-back co-occurrence patterns with a ratio of 1.0 or greater as predicted by the theory. It is pertinent to point out, however, that while all of the babies with clefts produced the alveolar-front and labial-central CV patterns, only 2 of these babies produced the velar back pattern. This latter finding was attributed to the low number of babies in this group who produced velar consonants (n=5). All three predicted patterns were evident for the non-cleft babies.

We hypothesized that babies with cleft palate would demonstrate the labial-central and velar-back CV patterns predicted by the F-C theory but would not demonstrate the alveolar-front CV pattern. The findings of this study did not support this research hypothesis. This prediction was made based on the fact that babies with unrepaired cleft palate produce fewer stops (Chapman et al., 2001) and alveolar consonants (O'Gara & Logemann, 1988) than typically developing babies. While it is true that these babies may not produce the variety of alveolar consonants seen in typically developing babies, 75% of the babies with clefts produced /n/ and 81% produced /l/. None of the babies with cleft palate in this study produced a /d/ or /t/. In contrast, 94% of the noncleft babies produced a /d/, 31% produced a /t/, 44% produced a /n/, and 88% produced a /l/. These findings suggest that an unrepaired cleft palate will affect manner of production as opposed to place of production. Babies in this group produced nasal alveolar consonants as opposed to stop alveolar consonants.

Because place of articulation was preserved, the alveolar-front pattern of co-occurrence predicted by the F-C theory was evident.

4.1 Unpredicted CV Co-Occurrence Patterns

It is interesting to note that syllable co-occurrence patterns not predicted by the F-C theory emerged as strong patterns in the populations examined. The labial-back pattern emerged as a preferred pattern, occurring in 81% of the cleft and 56% of the non-cleft babies. This pattern has also been observed in populations from several language communities (Chen & Kent, 2005; Davis & MacNeilage 1995; MacNeilage, Davis, Kinney, & Matyear, 2000; and Kern et al., in press). Davis and MacNeilage (1995) discussed this pattern and suggested that “there may be a secondary tendency for the tongue to move back but not forward in labial environments” (p. 1207). This seems particularly likely when the labial consonant is /w/. Because /w/ is an approximate that has both a labial and velar place of articulation, there could be a tendency for the tongue to adopt a more posterior (velar) placement for production of vowels paired with this consonant. In the present study, CVs containing /w/ accounted for a large proportion of the productions that were included in the labial-back category for babies in both groups.

A velar-central co-occurrence pattern was also noted in the non-cleft group. This pattern was also observed in studies of English-speaking babies by Davis & MacNeilage (1995) and Davis, MacNeilage, and Matyear (2002), and in Romanian-speaking babies by Kern et al. (in press). Kern et al. (in press) reported unexpected patterns appearing in French, Romanian, and Dutch-speaking babies and suggested that the ambient language of the babies in their study may influence vocal development in babble. Although Chen and Kent (2005) observed the velar-central pattern prior to one year in infants learning Mandarin, they noted that the velar-back emerged after one year and became the predominant pattern.

Based on the results from this study, the observed to expected ratio of labial-back syllables was higher than that of labial-central syllables suggesting that the labial-back co-occurrence pattern was the preferred co-occurrence pattern for this group of babies. These findings were similar to those reported earlier by Chen and Kent (2005) for their Mandarin-learning infants. They observed that the labial-back pattern became more prominent than the labial-central pattern and speculated that the default CV pattern involving labials may be subject to early developmental changes prior to one year of age. It is pertinent to note, however, that when the number of syllables produced with a labial consonant was examined for babies in the current study, the majority of syllables produced were with a labial-front pattern. This finding would suggest that the tongue has a tendency to move forward with the production of a labial consonant similar to the tongue movement noted in the production of an alveolar consonant.

While the F-C theory has been determined to be a valid predictor of syllable structure in a variety of different populations, now including babies with cleft palate, the model itself may be too simplistic to account for all preferred patterns of syllable structure. Other strong co-occurrence patterns (e.g., labial-back, labial-front) are evident across studies and suggest more variability than predicted by the model.

4.2 Different Frequency Distribution Patterns

The Chi-square (χ^2) Goodness-of-Fit test indicated that the distribution of observed frequencies in the cleft group differed from that of the observed frequencies in the non-cleft group. These differences might be explained through analyzing the phonetic inventories of the babies in both groups. The phonetic inventory of the non-cleft group contained a greater variety of consonant productions compared to the cleft group.

The lack of velar-back co-occurrence patterns in the cleft group may be attributed to the fact that these babies generally produce fewer velar consonants than typically developing babies (Chapman et al., 2001; O’Gara & Logemann, 1988). However, research by Davis and MacNeilage (1994) found a lack of velar productions in their study of a typically developing male infant. In addition, McCaffrey et al. (1999) also reported a lack of velars in the babble of an infant with bilateral sensorineural hearing loss.

4.3 Vowel Production in Babies with Cleft Palate

Although the consonant inventories differed markedly between the two groups, vowel inventories for the non-cleft group were similar to those seen in the cleft group. One notable difference between the groups was evident. High, front vowels (e.g., /i/ and/or /ɪ/) were produced by all but two of the non-cleft babies, but were evident in only seven of the babies with unrepaired clefts. Previous investigations of vowel production during the first year of life in non-cleft infants have revealed infrequent production of high, front vowels and a preference for low, unrounded vowels (Buhr, 1980; Donegan, 2002; Kent and Bauer, 1985). However, there is evidence that while high, front vowels occur infrequently, they are present in the phonetic inventories of most typically developing infants (Buhr, 1980; Kent and Bauer, 1985). The lack of high, front vowels in the phonetic inventories of our cleft group is a finding that has been previously reported in babies with cleft palate. Willadsen and Allbrechtsen (2005) compared characteristics of babbling for 12 month old babies with and without cleft palate and observed differences in vowel inventories between the groups. The cleft group demonstrated fewer high front and back vowels and more “other” front vowels. The authors cautioned that this finding may be more of a “listener phenomenon and may not indicate an avoidance of high front vocoids by the cleft children” (p. 199). They noted that, according to the results of Krakow et al (1988), nasalization results in “a lowering of high vowels in perception”. This is an interesting hypothesis but one that has yet to be investigated in this population. Although one would expect a high degree of hypernasality to characterize the early vocalizations of babies with unrepaired cleft palate, we have been more impressed by the lack of nasalization evident in their vocalizations prior to palatal surgery. We originally suspected that the lack of high front vowels in this population reflected a general tendency of babies with clefts to avoid the general alveolar place of production. Comparison of the frequency of alveolar consonants produced by babies in each group, however, yielded small differences that did little to explain the vowel findings.

4.4 Limitations of the Current Study

A relative weakness of the current study was its reliance on a small sample of CV tokens, with a total of 1,771 tokens transcribed across 32 babies (mean = 55 CV tokens per child). By comparison, Davis and MacNeilage (1995) transcribed over 1,100 tokens for each of the six babies in their study for a total of 6,659 tokens. Clearly, our decision to use only those CV tokens that were transcribed identically for both consonant and vowel placement significantly reduced the number of potential tokens available for study. We used the more stringent requirement for transcription because of concerns about transcription reliability with vowels. Reliability coefficients for vowel transcription in babies have historically been low. Davis and MacNeilage (1995) reported that they achieved an average of 44.8% reliability on vowels with a range of 0% for /u/ to around 60% for /æ/, underscoring the difficulty in vowel transcription. In the absence of acoustic analysis, we believe our stringent approach lent more face validity to the data.

Although we examined only those CV tokens transcribed identically by both examiners, several patterns of disagreement were evident for the discarded tokens. When consonant disagreements occurred, they typically occurred between /w/ and /l/, /w/ and /j/, and /m/ and /n/. Interestingly, when vowel disagreements occurred, they typically occurred across

the place spectrum between /æ/, /ʌ/, and /ɑ/. Vowels are typically considered difficult to transcribe because they 1) are less distinct than consonants, 2) vary across dialects, 3) lack a well established categorization system, and 4) are commonly ignored by speech-language pathologists who often pay more attention to the transcription of consonants (Pollock & Berni, 2001). The difficulty that speech-language pathologists demonstrate when transcribing vowels suggests that additional training in the transcription of vowels may be beneficial. An increased awareness of the problems that may be encountered during vowel transcription may increase inter-judge reliability. However, inter-judge reliability may be especially difficult to increase when transcribing productions of young toddlers since they are in the process of acquiring and learning to produce vowels. During acquisition, many non-language specific vowels are produced that are challenging to transcribe for adults with a vowel perception system tuned to the individual vowel qualities of their native language.

4.5 Implications of the Study

The findings of this study, in combination with those of previous reports provide basic support for the F-C theory. The three CV co-occurrence patterns predicted by the F-C model were observed in our cleft and noncleft groups. Similar to previous investigations, however, we also found that other co-occurrence patterns were preferred as well. Many of the studies that have analyzed the F-C theory (including those that have analyzed the theory in babies from different language communities and with different clinical diagnoses) have revealed similar patterns of co-occurrence that were not originally predicted by the F-C theory. Data from the current study and others (e.g., Chen & Kent, 2005; Davis & MacNeilage, 1995; Hapsburg et al., 2008; Kern et al., in press) indicate that the labial-back pattern is a preferred pattern for some babies. Other co-occurrence patterns that appear to be preferred by some study participants across studies include the alveolar-back (Davis & MacNeilage, 1995, Davis, MacNeilage, & Matyear, 2002; Teixeira & Davis, 2002), labial-front (Teixeira & Davis, 2002) velar-front (Davis & MacNeilage, 1995; Kern et al., in press), and velar-central (Chen and Davis, 2005; Davis & MacNeilage, 1995). MacNeilage, Davis, Kinney, and Matyear (2000) acknowledged the discrepant findings reported by others and argued that these studies may have classified vowels differently, used a smaller number of vocalizations, and calculated expected frequencies differently. They maintained that other investigators would confirm their findings if their studies were replicated for these three methodological issues. Differences in methodology could account for some of the differences reported across studies. However, the similarities in findings across studies suggest that while the original F-C model may provide a good framework for conceptualizing the organization of babble, it may be too simplistic to adequately capture the preferences of individual babies. The three predicted frames may account for the highest percentage of CV co-occurrences across most studies, but individual differences may lead some babies to search for other patterns of CVs as well. As Chen and Kent (2005) pointed out, “universal co-occurrence patterns may prevail at a very early stage (0;7 – 1;0) but only for a short period....no single universal pattern seems to persist and to apply in most language environments in the world” (p. 532).

Despite the addition of other preferred CV patterns reported across studies, it is clear that the original CV co-occurrence patterns reported by Davis and MacNeilage are evident for most babies during babbling. Speech-language pathologists who work with populations that demonstrate early delays in consonant development should allow these preferential patterns to guide the selection of consonant-vowel combinations used to stimulate consonant and lexical development. McCaffrey and associates (1999) recommended that early intervention “target syllables and words that allow for practice of Pure, Front, and Back Frames” and then later “guide the child through an escape from the motor constraints of Frame Dominance, providing practice with CV combinations requiring movements of the jaw and

articulators” (p. 25). For the baby with an unrepaired cleft palate, it is important to realize that while the cleft may affect the consonant sounds a baby chooses to produce and may distort some that are produced, the cleft itself does not prevent a baby from achieving any particular articulatory posture in the oral cavity. That is, a palatal cleft does not result in oral motor deficits that prevent a baby from producing specific consonants or vowels. Early intervention for these babies should focus on three goals: increasing consonant inventory, increasing expressive vocabulary, and increasing awareness of oral airflow. During the prelinguistic period and prior to palatal repair, Hardin-Jones and her colleagues (2006) recommended that simple babbling games be used to stimulate those consonants that are least affected by the cleft (e.g., nasals, glides). Considering the preferred CV patterns demonstrated by the babies in this study, appropriate targets for stimulation might include [mʌ], [wʌ], [næ], and [jɛ]. Although stimulation of stops would not be a first goal for many toddlers with unrepaired clefts, Hardin-Jones and her colleagues noted that stimulation of these consonants could be incorporated into stimulation activities if the toddler already had one or more stops in their inventory.

Continuing Education Questions

1. The Frame-Content theory predicts that limitations seen in early articulatory movements will typically result in the following consonant- vowel co-occurrences:
 - a. alveolar-front
 - b. labial-central
 - c. velar-back
 - d. a and b
 - e. **a, b, and c**
2. Compared to their noncleft peers, babies with cleft palate
 - a. may babble less frequently
 - b. produce fewer total consonants
 - c. demonstrate a smaller consonant inventory
 - d. **all of the above**
 - e. none of the above
3. When compared to noncleft babies, babies with cleft palate produce
 - a. more oral stops
 - b. fewer alveolars
 - c. more nasals and glottal
 - d. **b & c**
 - e. all of the above
4. The vowel inventories of babies with cleft palate contain
 - a. the same vowels seen in infants without clefts
 - b. **fewer high, front vowels**
 - c. more low vowels
 - d. a & b

- e. none of the above
5. In the current study, the following consonant-vowel co-occurrence patterns were evident in the babble of babies with cleft palate:
- a. alveolar-front
 - b. labial-central
 - c. velar-back
 - d. all of the above
 - e. none of the above

Appendix A

Individual Child Information

Group	Age	Sex	Canonical Syllable Ratio	# of Tokens	Consonant Inventory	Vowel Inventory
Cleft						
1	9m 1d	M	0.22	38	m, w, n, j, h	æ, ε, ʌ, u, ɑ
2	9m 20d	M	0.43	86	m, w, n, l	æ, ɪ, ε, ʌ, ɑ
3	8m 23d	M	0.39	58	m, w, n, l, g, r	æ, ɪ, ε, ʌ, ɑ
4	9m 0d	F	0.35	62	m, w, n	æ, ε, ʌ, ɑ̃
5	8m 30d	F	0.27	18	m, w, n, l	æ, ε, ɪ, ʌ, u
6	9m 26d	M	0.51	43	m, w, n, l, g	æ, ε, ʌ, u, o, ɑ̃
7	8m 21d	F	0.37	53	m, w, l, h	æ, ε, ʌ
8	9m 22d	F	0.57	68	m, w, n, l, h	æ, ε, ʌ, u
9	8m 25d	M	0.16	57	b, m, w, l, j, k, h	æ, ε, ʌ, u, o, ɑ, ɑ̃
10	8m 27d	M	0.25	54	m, w, l, h	æ, ʌ, ʊ
11	9m 13d	M	0.46	75	p, m, w, n, l, h	æ, ε, ʌ, u, o
12	9m 13d	M	0.24	53	m, w, n, l, h	æ, ɪ, ʌ, u
13	9m 0d	F	0.15	36	m, w, n, j	æ, ε, ɪ, ɪ, ʌ, u, ʊ
14	8m 26d	M	0.44	78	m, w, n, l, g, h	æ, ʌ, u, ʊ, ɑ
15	8m 28d	F	0.20	38	m, w, l, j, h	æ, ɪ, ε, ʌ, u, ẽ
16	9m 4d	F	0.49	69	m, w, n, l, g, ʏ, h, r	æ, ɪ, ε, ʌ, u, ʊ, o, ɑ
Mean			0.34	55	5.06	5.13

Non-Cleft Group	Age	Sex	Canonical Syllable Ratio	# of Tokens	Consonant Inventory	Vowel Inventory
17	9m 6d	M	0.29	51	p, b, m, w, d, l, j, k, g, h, r	æ, ε, ɪ, ɪ, ʌ, u, ɑ, ẽ
18	8m 19d	F	0.44	62	w, d, n, l, j, h	æ, ε, ɪ, ʌ, ʊ, ẽ
19	9m 0d	M	0.64	86	b, w, d, l, j, g, h	æ, ε, ɪ, ʌ, ɑ
20	8m 28d	M	0.42	53	w, d, n, l, j, g, ɳ	æ, ε, ɪ, ɪ, ʌ, u, o
21	8m 15d	M	0.50	60	b, m, w, d, l, j, h	æ, ε, ɪ, ʌ
22	8m 22d	M	0.50	55	b, w, l, j, g	æ, ε, ɪ, ʌ, u, o
23	9m 12d	M	0.52	42	b, w, d, n, l, g, h	ε, ɪ, ɪ, ʌ, u
24	9m 3d	F	0.33	45	b, m, w, d, n, l, j, g, ʏ, h	æ, ε, ɪ, ɪ, ʌ, ʊ

Non-Cleft Group	Age	Sex	Canonical Syllable Ratio	# of Tokens	Consonant Inventory	Vowel Inventory
25	8m 29d	F	0.59	53	b, m, w, d, l, j, g	æ, ε, I, Λ, u
26	8m 22d	F	0.68	66	p, b, w, t, d, g	æ, ε, Λ
27	9m 4d	M	0.26	59	b, m, w, t, d, n, l, j, g, h	æ, ε, i, I, Λ, eī
28	9m 0d	M	0.62	60	w, d, n, l, j, h	æ, ε, I, Λ, u
29	8m 27d	M	0.47	49	b, m, d, l, j, ð, h	æ, ε, I, Λ
30	8m 20d	M	0.24	49	b, m, w, t, d, n, l, g, h	æ, ε, Λ, u, o, α
31	9m 5d	M	0.32	38	w, t, d, l, j, g, h	æ, ε, I, Λ
32	8m 29d	F	0.51	67	t, d, j, k, g, h	æ, ε, i, I, Λ, α
Mean			0.46	56	7.38	5.37

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Research Highlights

- The babies with and without cleft palate produced the alveolar-front, labial-central, and velar-back co-occurrence patterns as predicted by the Frame-Content theory.
- Numerous syllable co-occurrence patterns not predicted by the F-C theory emerged as strong patterns in both populations
- Vowel inventories for the non-cleft group were similar to those seen in the cleft group.

Learning Outcomes

The reader will be able to:

- Describe consonant-vowel co-occurrence patterns produced by babies with and without cleft palate.
- Describe vowel inventories of babies with cleft palate.
- Identify possible therapy targets for babies with cleft palate.

Table 1

Description of participants.

	Mean Age	Sex	Mean Canonical Syllable Ratio	Mean Number of Tokens Collected
Cleft Group	9 months 5 days	7 Females 9 Males	0.34	55
Non-cleft Group	8 months 27 days	5 Females 11 Males	0.46	56

Table 2

Number (and percentage) of consonant-vowel tokens produced by each group.

Cleft Group				
	Alveolar	Labial	Velar	Total
Front	189 (21)	192 (22)	2 (0.2)	383 (43)
Central	146 (17)	199 (22)	14 (2)	359 (41)
Back	31 (4)	80 (9)	28 (3)	139 (16)
Total	366 (42)	471 (53)	44 (5)	881 (100)
Non-Cleft Group				
	Alveolar	Labial	Velar	Total
Front	315 (35)	123 (14)	47 (5)	485 (54)
Central	141 (16)	80 (9)	48 (5)	269 (30)
Back	46 (5)	60 (7)	30 (3)	136 (15)
Total	502 (56)	263 (30)	125 (13)	890 (100)

Table 3

Number (and percentage) of babies producing specific consonants in each group.⁴

Consonants	Cleft Group	Non-Cleft Group
Labial		
p	1 (06)	2 (13)
b	1 (06)	11 (69)
m	16 (100)	7 (44)
w	16 (100)	14 (88)
Alveolar		
t	0 (0)	5 (31)
d	0 (0)	15 (94)
n	12 (75)	7 (44)
l	13 (81)	14 (88)
j	4 (25)	13 (81)
ð	0 (0)	1 (06)
Velar		
k	1 (06)	2 (13)
g	4 (25)	12 (75)
ŋ	1 (06)	1 (06)

⁴The consonants /h/, /r/ and /ŋ/ occurred in the phonetic inventory of some participants but were not included here because 1) /h/ is not a supraglottal consonant which is required for canonical syllables, 2) /ŋ/ only occurred as a syllable final consonant, and 3) place of articulation of /r/ was not easily classified using the abbreviated classification system used in this study.

Table 4

Number (and percentage) of babies producing specific vowels in each category.

Vowels	Cleft Group	Non-Cleft Group
Front		
i	2 (13)	6 (38)
I	6 (38)	14 (88)
e	0 (0)	0 (0)
ɛ	13 (81)	16 (100)
æ	16 (100)	15 (94)
eɪ	1 (06)	3 (19)
Central		
ʌ	16 (100)	16 (100)
Back		
u	11 (69)	7 (44)
ʊ	4 (25)	3 (19)
o	4 (25)	2 (13)
ɑ	6 (38)	4 (25)
ɑɪ	1 (06)	0 (0)
ɑʊ	1 (06)	0 (0)
oʊ	1 (06)	0 (0)

Table 5

Observed to Expected Ratios for each co-occurrence pattern.

Cleft Group			
	Alveolar	Labial	Velar
Front	1.19	0.94	0.10
Central	0.98	1.04	0.78
Back	0.54	1.08	4.03
Non-Cleft Group			
	Alveolar	Labial	Velar
Front	1.15	0.86	0.69
Central	0.93	1.01	1.27
Back	0.60	1.49	1.57