

INTRASYLLABIC PATTERNS IN BABBLING AND EARLY SPEECH

Barbara L. Davis*, Peter F. MacNeilage** and Christine Matyear*

**Department of Communication Sciences and Disorders, The University of Texas at Austin,*

***Department of Psychology, The University of Texas at Austin*

ABSTRACT

Three patterns of intrasyllabic co-occurrence, reflecting putatively fundamental infant production constraints, have been found in phonetic analyses of babbling and first words. They are labial-central (LC), coronal-front (CF), and dorsal-back vowel (DB) intrasyllabic patterns. Evidence of these patterns was sought in three databases; targets for words attempted by eight English learning infants, lexical items on the CDI, a parent report instrument of words frequently produced by infants, and a dictionary count of English words. The predicted trends were present in the two infant databases, but not at significant levels. The lingual trends (CF and DB) were strongly present in the dictionary database and have been found in other languages as well. These findings suggest that the infant phonetic trends above are not based on imitation, as they are not strongly present in the targets. The lingual trends in the dictionary database may reflect extremely fundamental production propensities present in languages.

1. INTRODUCTION

Research has demonstrated systematic phonetic characteristics of speech-like utterances in babbling and first words [15,26,31]. While syllable level regularities have been previously explored [1,27,32]. However, one prominent aspect of intrasyllabic sequencing during this period has been noted in recent studies of 10 English learning infants: consonant-vowel co-occurrence patterns of labials with central vowels (“ba”), coronals with front vowels (“dae”) and velars with back vowels (“ku”) [4,5,6,17]. These intrasyllabic co-occurrence patterns have been characterized as an emergent property of rhythmic mandibular oscillation accompanied by phonation. They have been characterized by the “Frames then Content” metaphor [19]. The sound qualities resulting from this mandibular oscillation form the rhythmic “Frame”. The jaw close-open cycle with either tongue presetting (i.e. “dae” or “ku”) or neutral tongue position (“ba”) results in listener perception of speech-like sequencing in babbling [5] and forms a basis for phonetic production patterns in early words as well [4,17]. These early rhythmic intrasyllabic patterns form a part of the phonetic substrate available for gradual acquisition of a mature speech production system in normally developing infants. Across the course of development, as the infant masters independent control of movements of the tongue, lips, and velum within syllables, the segmental “content” elements begin to emerge.

Description of phonetically-based movement patterns provides a basis for understanding the systematic nature of infant behaviors during speech acquisition. However, full understanding of the speech acquisition process requires description of both patterns for word targets attempted by infant learners and characteristics of the ambient language. These types of

comparison permit characterization of the relationship of the phonetic production substrate available to the infant to the targets in the language, both within the infant’s lexical repertoire and within the ambient language in general. In short, the infant must master both sound and meaning and link internal phonetic production propensities to the sound system employed in the ambient language for communicating messages to others.

This production perspective is in direct contrast to the classic perceptual view espoused by Jakobson [13] in which the driving force of acquisition is found in unfolding of universally determined perceptual contrasts in the infant. It is also in conflict with the view represented in Chomskian underlying grammar [2] characterized by innately available abstract features mediated by language specific rules. Both characterizations assign a minor role to the motor propensities of infants, as the nature of development is seen as being based in universally available abstract features. Secondly, both of these views assign a minor role to vowels as well as to serial complexity at the level of CV sequences. More contemporary non-linear models [10] incorporate syllable level associations of C and V. However, these models also focus on abstract underlying representations and rules mediating behavior rather than the nature of the behavioral repertoire in the infant as a driving force in producing the eventual mature speech production system.

The phonetically driven predictions generated from our research program [4,5,6,7,16,17,18] produce a model of acquisition congruent with formulations produced by the perspective of embodied cognition [3,29]. In this formulation, abstract thought is not divorced from embodied actions in the world. Inherent in this view is the potential for behavior to drive development of cognitive representation in an interactive way rather than abstract cognition representation being the facet of essential interest in understanding the nature of acquisition and behavior. The behaviors of the infant are seen as feeding into the internal processing capabilities available to produce eventual instantiation of mature representations for speech production processes.

This study represents an initial attempt to understand the linking of early phonetic production propensities with the targets for those abilities. Intrasyllabic characteristics of word targets attempted by 8 English learning infants were compared to characteristics of English words from the Oxford English Dictionary [25]. In addition, an analysis of words from the MacArthur CDI [8] was completed to allow comparison with lexical types generally characteristic of infants learning English.

2. METHOD

Intrasyllabic consonant-vowel co-occurrence characteristics were analyzed after being entered into a computer database. Consonant-vowel (CV), consonant-vowel-consonant (CVC) and

consonant-vowel-consonant-vowel (CVCV) utterance shapes were analyzed as they accounted for approximately 95% of the utterance types in the infant target data analyzed for this study. Intrasyllabic CV co-occurrences were analyzed by counting every instance of a C followed by a V, regardless of whether they were part of clusters or diphthongs. The contiguous portion of the CV syllable was analyzed for intrasyllabic associations. For this analysis, consonants were grouped into labial, coronal and dorsal places of articulation; vowels into front, central and back categories. Chi square analysis was used to compare the observed frequencies with the expected frequencies of occurrence within each cell. Expected frequencies were derived from the overall frequency of that vowel in the corpus (i.e. if 40% of the vowels in the corpus were front vowels, then 40% of the vowels in each consonant environment were *expected* to be front vowels).

Three types of data were selected for comparison: 1.) targets for early lexical types produced in approximately the period of the "First Fifty Words" [9] by eight normally developing infants in an English speaking environment (*Texas* data), 2.) targets for early word types on the MacArthur CDI [8], a normed parent report instrument used to note earliest lexical types produced by English speaking infants in the period of early word development (*CDI* data), and 3.) English lexical types based on analysis of 33,654 utterances (250,0059 segments) from the Oxford English Dictionary [26] (*SOED* data). The goal of these analyses was to compare specific characteristics of lexical targets for a group of normally developing infants (*Texas* data) with general characteristics of targets for infants learning English (*CDI* data). Both types of infant data were then compared to English target language characteristics (*SOED* data).

3. RESULTS

Total lexical types analyzed for the three data bases were: 1.) *Texas* data: 632 lexical types, 2.) *CDI* data: 715 lexical types, 3.) *SOED* data: 33,654 lexical types.

Raw frequencies for data analyzed are listed in Table 1 below.

Comparison of these frequencies reveals that the infant databases are highly comparable in the balance of segments and in lexical types. The *Texas* infant targets

Table 1. Segment and lexical type frequencies for *Texas*, *CDI*, and *SOED* databases.

	Segments		Lexical Types		
	C	V	Mono	Di	Poly
<i>Texas</i>	1475	980	423	180	29
<i>CDI</i>	1830	1167	439	230	46
<i>SOED</i>	143393	106658	3928	11263	18454

contained 61% consonants and 39% vowels; the *CDI* lexical types analysis revealed a 60/40% relationship. Segment frequencies for the *SOED* data revealed a 57/43% relationship of consonants to vowels with consonant frequencies higher than frequencies in the two infant databases. The higher frequency of consonants was related to greater presence of consonants in clusters in ambient language database. Both the infant databases contain targets which include less complex consonant sequences than those in their ambient language.

Analysis of lexical types revealed more general serial complexity in the adult database, consistent with results for

consonant and vowel frequencies. The *Texas* infants produced 67% monosyllables, 28% disyllables, and 5% polysyllables. The *CDI* analysis showed 61%, 32% and 6% respectively. In the *SOED* data, monosyllables accounted for 12%, disyllables for 33%, and polysyllables 55% of all lexical types analyzed

Table 2 displays results of the intrasyllabic consonant vowel co-occurrence analysis for the *Texas*, the *CDI* and the *SOED* databases. Ratios of observed to expected values for coronal, labial and dorsal consonant place in co-occurrence with front central and back vowels are listed. The figures in bold on the diagonal are the predicted ratios of interest related to the hypothesis evaluated here. Predicted CV intrasyllabic associations are LC, CF and DB related to articulatory compatibility between open and close portions of the rhythmic mandibular cycle.

Table 2. Ratio of observed to expected occurrences of coronal, labial and velar consonants with front, central and back vowels.

	Vowels	Consonants		
		C	L	D
<i>Texas</i>	F	1.09	0.97	0.93
	C	0.96	1.09	0.91
	B	0.85	1.09	1.38
<i>CDI</i>	F	0.97	0.33	0.98
	C	0.99	1.02	1.02
	B	1.09	0.85	1.01
<i>SOED</i>	F	1.05	0.99	0.59
	C	0.96	0.98	1.37
	B	0.91	1.1	1.48

The results for the two infant databases show ratios above chance, except for the coronal- front (CF) association in the *CDI* database. However, although the trends are in the predicted direction for the eight of the nine potential CV associations of interest, none achieved statistical significance. Non-predicted trends for intrasyllabic associations were found for labial-back (LB) vowels in the *Texas* data, coronal-back vowels (CB) and dorsal-central (DC) vowels in the *CDI* data. None of these were significantly associated, although the ratios were above chance. No other counter trends were noted the infant databases.

Inspection of the *SOED* results reveals that the two lingual intrasyllabic associations (CF and DB) showed ratios above chance. Both associations were found to be significant in this large database of words from the ambient language. The non-lingual LC association produced a ratio below chance and was not significantly associated in this data.

4. CONCLUSIONS

This study moves beyond phonetic characterization of behavioral propensities to analysis of the relationship of the behavioral repertoire to the targets attempted. The phonetic predictions tested are: labial consonants with central vowels (LC), coronals with front vowels (CF) and dorsals with back vowels (DB). These predictions are related to a production hypothesis suggesting that the rhythmic close-open alternations of the mandible results in intrasyllabic consonant-vowel co-occurrences. These co-occurrences reflect articulatory compatibility and lack of movement autonomy in component

articulators in contiguous intrasyllabic sequences. The “segments” which characterize early speech production may not be segments in the sense implied for adult generative capabilities, but may instead be non-autonomous sub-components of the close open mandibular cycle. The predicted co-occurrences were significantly related in analysis of phonetic CV associations in babbling [5, 6] and early speech [4,17] in normally developing infants learning English. They have also been explored in acoustic analyses which generally suggest the primacy of the mandibular cycle [21] and the early predominance of height over front back changes in articulator movements [11,24].

How does the infant master the flexible use of available speech capacities necessary to communicate messages intentionally with those around him? Implied by posing the question in this way is a view of the infant as utilizing phonetic raw materials to actively construct messages as evidenced in the target forms attempted in the early lexicon. The infant is constructing a representational system during development using available behaviors rather than an innately available abstract system driving unfolding of the types of behavior observed [2]. Both phonetic and target-based characterization of infant production patterns are necessary to test this alternative hypothesis. In the more general sense, the infant is a learner of the ambient language and brings these same phonetic propensities to the task of mastery of the ambient language characteristics as well. Input language characteristics as well as output capacities of infants must be explored to fully explore this type of characterization of infant speech development.

The two infant databases represent alternative perspectives on the immediate task facing the infant-what messages to attempt using the phonetic resources available. The analysis of these 8 infants gives a specific focus within a small group of infants to this question. In addition, these infants are a part of a larger study where the targets analyzed here can be compared to phonetic propensities that have already been explored. The CDI analysis allows consideration of the general patterns in target words commonly attempted by infants learning English. Because the CDI is a normative instrument, general patterns can be compared to specific patterns in the group of 8 infants. Stoel-Gammon [28] has explored characteristics of consonant and vowel types and syllable structures on the CDI. She found confirmation of many phonetic characteristics of early speech output. This analysis explores intrasyllabic organization.

Results on the two infant databases show remarkable similarity in the trends found. The predicted trends are strong, though not significant in both data sets. No predominant counter-trends are present. Although the predicted trends are present, they are not so strongly apparent as in the data analyzed previously for phonetic behaviors [5]. The issue of selection and avoidance in infant learners has been raised in the speech acquisition literature [23]. This type of result, where the phonetic CV co-occurrences are not so strongly present in the targets attempted, would tend to weaken the argument that the Texas infants are selecting targets that match their phonetic propensities. The significant CV co-occurrences present in their phonetic output are present, but not at significant levels in the targets they attempt. The CDI analysis allows a more general statement regarding this issue. If the phonetic propensities are fundamental, they are also not present in the general types of lexical targets attempted by infants learning English. Neither of

these data types lend credence to selection as a characteristic of these learners on this index of serial organization. The three properties observed in phonetic patterning reflect basic properties of the speech production apparatus, not imitated patterns from the targets attempted.

One counter trend was noted in this data. The dorsal-central vowel association has been noted by our group in other analyses [4,5,17]. This counter-trend has been attributed to a potential palatalization, or more front production of consonants perceived as dorsal. The phenomenon of fronting [12] has been noted as characteristic of speech production in early words. The dorsal-central vowel association would be compatible with a hypothesis that some closures which are perceived and transcribed as dorsal, are produced with a more palatal articulatory closure, resulting in the open phase in a perception of central vowel articulation. An acoustic analysis of dorsal-vowel intrasyllabic associations is in progress in our lab [22] to examine the nature of these associations found in transcribed data.

Analysis of the SOED data revealed the significant associations for the two lingual contexts (CF and DB) but not the labial-central vowel context (LC). In the two lingual contexts, the tongue is engaged during the closure phase in the place of articulation for the vowel occurring during the open phase. In the labial-central vowel context the tongue is not engaged during the closure portion of the mandibular cycle. These same results were found in analyses of language data from Janson [14] and Maddieson and Precoda [20]. The compatibility of these three large language databases may illustrate an extremely fundamental property of serial movement in speech production. When the tongue is not engaged in the closure portion (LC), adult speakers master increase in complexity, so that the LC co-occurrence constraints are not found in languages. In contrast, in the lingually engaged contexts (CF and DB), languages retain the constraints found in infant learners.

Results of this study illustrate important issues related to the understanding acquisition of mature speech production skills. Analysis of intrasyllabic aspects of production provide important information on the development of serial complexity. Both analysis of phonetic behaviors and relational analysis related to infant and language targets are needed to develop a model of early acquisition based on the primacy of the behavioral repertoire in building a mature speech production system.

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