CONSONANT (VOWEL) CONSONANT SEQUENCES IN EARLY WORDS

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ABSTRACT

Consonant repetition ("reduplication") predominates in #CVC sequences in babbling and early words, gradually giving way to consonant variation ("variegation") with a "Fronting" pattern whereby the first consonant has a more anterior place of articulation than the second. The various reduplicative patterns are primarily attributed to a "Frame" consisting of rhythmic mandibular oscillation. Evidence, including new evidence from a case study, suggests a labial-coronal-dorsal hierarchy of consonant production difficulty. Fronting may therefore result from a tendency to begin variegated sequences with an easier consonant and continue with a more difficult one. Easier initiation may be a self organizing response to the functional load involved in interfacing the lexicon with the motor system. The heavy favoring of one particular variegated sequence, the labial-coronal sequence, in both infants and languages, suggests that it may have been a first discrete step towards increasing serial output complexity in phylogeny just as it is in ontogeny.

1. INTRODUCTION

Serial output complexity is the most distinctive property of speech. In a typical utterance, a number of diverse consonants and vowels are strung together, and it is unusual for the same consonant or vowel to occur in two adjacent syllables. This paper is concerned with how infants develop this serial complexity. As the study of consonant acquisition has dominated the field of child phonology, this will be the focus of this paper, although we will conclude with some preliminary remarks on the role of vowels.

Because of Jakobson's conclusion that babbling was unrelated to speech [1], the study of consonants in child phonology formerly began with the first words (around 12 months). However it has now become clear that phonological development proceeds relatively continuously from babbling through first words [2]. We will consider the development of stops and nasals, which are by far the most frequently occurring consonants in babbling and early speech.

The dominant mode of consonant sequencing in babbling and early speech is one of syllable repetition or "reduplication" , in which both the consonant and the vowel are repeated (e.g. "baba"). This proclivity, in early speech, is labeled by the term "Consonant Harmony" [3], denoting a tendency to repeat consonants, particularly their place of articulation, when the target word requires consonant variation or "variegation" (e.g. "guck" for "duck"). The first systematic departure towards consonant variegation in early words is a tendency for the first of two consonants to have a more anterior place of articulation (e.g. "bunny"), a tendency described by Ingram as "Fronting" [4].

Two hypotheses regarding the relative frequencies with which stops and nasal consonants occur in babbling and early speech, in both reduplicative and variegated sequences, will be presented and evaluated here. They will be evaluated with the aid of a large database from the infant reported by Davis and MacNeilage [5], and preliminary data from a study of ten other infants at the "First 50 Word Stage [6]. The first hypothesis is that there is an anterior-to-posterior hierarchy of increasing consonant production difficulty. The second hypothesis is that easier consonants are favored in initiation of utterances with consonant variegation (See also [7]). The hypotheses are embedded in the "Frame/Content" theory of evolution of speech [8], according to which the first speech-like stage both phylogeny and ontogeny involves frames produced by rhythmic mandibular (mouth open-close) oscillation, with most "Content" - independently controlled consonants and vowels - added later.

2. LABIAL-CORONAL-DORSAL CONSONANT DIFFICULTY HIERARCHY.

The inference that labial consonants are easier to produce than lingual consonants is derived in part from 6 published studies by our research group (summarized in [9]) and other studies, which have produced evidence for three patterns of consonant-vowel (CV) co-occurrences in babbling and early speech. As most consonants are reduplicative in babbling and early speech CV co-occurrences imply VC co-occurrences. The three patterns are a.) Coronals with front vowels ("Fronted Frames"); b.) Dorsals with back vowels ("Backed Frames"); c.) Labials with central vowels ("Pure Frames"). The median ratios of observed to expected occurrence of these three patterns in a study of 6 babbling infants [10] were: coronal-front, 1.28, dorsal-back, 1.22, and labial-central 1.34. The corresponding ratios for 10 infants at the first 50 word stage (12-18months) were: 1.27, 1.17 and 1.23 [6]. The co-occurrence patterns of the lingual consonants (coronals and dorsals) seem attributable to a bio-mechanical constraint on tongue movement. The co-occurrence of labial consonants, which do not involve active tongue movement, with central vowels, suggests that the tongue may typically be in a rest position in the center of the mouth during vowel production. The pattern may therefore result from mandibular oscillation alone; hence the term Pure Frames. Labials may thus be easier to produce than lingual consonants in that lingual consonants involve a tongue movement in addition to the basic frame cycle seen in pure frames, a cycle which is characteristic of most early syllables. The evidence for pure frames is particularly revealing because it is counter to the expectation that a wider variety of vowels might be achieved when the surrounding consonants do not also require tongue movement.

Additional evidence that labial consonants are easier to produce than lingual consonants is that their overall frequencies increase relative to lingual consonants in the first 50 word stage, perhaps as a response to the increased functional load involved in interfacing the mental lexicon to the motor system [11, 12]. For example, in extremely large databases on 4 infants [12] the mean ratio of labial to coronal stops, nasals and glides in pre-speech babbling was .71 while in first words the mean ratio was 1.83. The effect occurred in all three sound categories.

Steger and Werker [13] have observed a similar example of simplification of operation during the first word stage, at the perceptual level. They also attributed this result to the functional load involved in interfacing with the newly emergent lexicon. A third body of evidence for a labial ease hypothesis is the consistent observation of a strong preference for labial consonants in post-tracheostomy infants, who have been deprived of early production experience, though not deprived of ambient language input [14, 15, 16].

There is one apparent problem for the hypothesis that labials are easier than coronals. Why do coronal consonants tend to be favored over labials in babbling [12, 17]? We have argued that this effect may be due to the fact that coronal consonants in general are typically much more frequent in the ambient language than labials, and this language input imbalance is reflected to some extent in infant output [9].

One reason to suggest that dorsal consonants are more difficult for infants to produce than labials or coronals is that they tend to be a great deal less frequent than labials or coronals in babbling and early speech.

Further evidence that dorsals might be most difficult to produce comes from information regarding the amount of the required 'escape' from consonant harmony observed in early speech. Harder consonants might be expected to show less escape from consonant harmony (i.e. more reduplication). We have found evidence for this hypothesis in three databases by considering the ratio of observed instances of reduplication of stops and nasals in two-syllable sequences to the number which would be expected on the basis of the overall frequency of the particular consonant class in the corpus (See Table 1.). The first database was from the infant studied by Davis and MacNeilage from 14 to 20 months [5]. Data from first words (W) and babbling concurrent with first words (B) are reported separately in the table. The second database was from ten infants studied during the first 50word period [6]. The third database was derived from the appendix of a monograph by Smith [18] based on a case a study of an infant from 2;2 to 3; 9.

Table 1. Ratios of observed to expected reduplication in three databases.

Study	Labials	Coronals	Dorsals
[5] W	1.45	1.67	5.87
[5] B	1.35	1.23	8.5
[6]	1.5	2.05	5
[18]	1.43	192	2.19
Means	1.43	1.72	5.39

The mean ratios are as expected from the hypothesis of an ascending hierarchy of difficulty; labial< coronal< dorsal. There is only 1exception to this hierarchy in the 4 data sets: Labial reduplication is slightly higher than coronal reduplication in the babbling corpus (B). Ratios for dorsal reduplication are much higher than for the other two places of articulation except in the older infant ([18]).

3. CONSONANT EASE/DIFFICULTY AND THE ORIGIN OF SERIAL COMPLEXITY

If the L<C<D consonant difficulty hierarchy suggested here does exist, then the fronting phenomenon is a tendency to begin early words that have consonant variegation by producing an easier consonant and then following it with a more difficult one. Like the increase in labials in first words, this may be a response to the functional load involved in interfacing the lexicon with the motor system. Table 2. shows the relative frequencies of the 9 possible consonant-vowel consonant sequences in CVC words produced by the infant studied by Davis and MacNeilage [5].

Table 2. Relative frequencies of the 9 consonant sequences in one infant for speech (A) and concurrent babbling (B)

A. SPEECH

		C2			
		L	C	D	
C1	L	1450	755	276	2481
	C	256	1275	61	1592
	D	43	32	176	251
		1749	2062	513	4324

B. BABBLING.

		C2			
		L	C	D	
C1	L	166	235	40	441
	C	76	319	10	405
	D	2	9	17	28
		244	563	67	874

The ratios of observed to expected reduplications reported in Table 2 for this infant's speech and concurrent babbling were obtained from the cells on the diagonals in this table. Expected frequencies for the three cells on the diagonal in each data set were computed using the formula: row total multiplied by column total and then divided by the grand total. The overall patterns seen in Table 2 are very similar for speech and babbling. As expected from the general statement of the fronting principle, comparison of the row and column totals shows that the preference hierarchy in initial position is anterior-to-posterior while the opposite obtains for final position. For example, in speech, 59% of all labials, 44% of coronals and 24% of dorsals occur in initial position while 76% of all dorsals, 56% of coronals and 41% of labials occur in final position. In babbling the corresponding percentages are 64, 42 and 29% in initial position and 71, 58 and 36% in final position. The table shows that the most favored variegated patterns are those beginning with a labial consonant, and the one involving the two putative easier consonants but in the order coronal-labial. Of these variegated patterns, by far the most frequent is the labial-coronal pattern, accounting for more instances than the other 5 variegated patterns combined in

speech (53%) and babbling (60%). The ratio of labial-coronal (LC) to coronal-labial (CL) sequences in speech is 2.95, and in babbling it is 3.09. In a review of 7 reports involving 22 infants in 5 different language communities [9] this pattern was observed in 21 infants, including 3 in which attempted words with the opposite sequence were produced with this pattern (e.g. "soup" -> "pooch"). In a study of consonant-vowel-consonant (CVC) and consonant-vowel-consonant-vowel (CVCV) words in 10 infants [18] 9 of the infants showed the trend towards more LC than CL sequences and the 10th infant showed no trend. The average ratio of LC to CL sequences was 2.55.

This preference is not only characteristic of infants, but it is also present in languages. Ratios of LC to CL sequences in the first and second consonants (with an intervening vowel) of words in ten languages were computed [19] The languages were English, Estonian, French, German, Hebrew, Japanese, Maori, Quichua, Spanish and Swahili. Eight languages showed a statistically significant excess of LC to CL sequences (beyond the .001 level in Chi square tests). The exceptions were Swahili, and Japanese, the latter of which showed the only countertrend. The average of LC to CL sequences was 2.23.

These results suggest that languages perpetuate a strong infant preference, and this may therefore be of fundamental significance. Infants are unlikely to be simply copying adults, as their preferences tend to be stronger than adult preferences (especially in the 3 infants who reverse adult CL sequences) even though they have as yet only learned a few words.

It has been suggested that the adoption of the LC sequence preference is a result of self organization, and may have been a first discrete step in increasing serial output complexity of speech beyond the level of consonant reduplication in the evolution of language. "Just as infants may more easily simulate serial complexity of a word by beginning with a mandibular (frame) cycle not including the tongue and then adding tongue action earlier hominids, under pressures for increases in the size of their linguistic message set, could perhaps more easily have produced a new sound pattern for a new word in this manner." [19]

4. THE ROLE OF VOWELS IN SERIAL ORGANIZATION

Up till now, the problem of producing variegated consonant sequences has been discussed as if it only involved consonants. However it is clear from the existence of the three different sets of consonant-vowel co-occurrence constraints that consonants and vowels are not independent of each other at the early stages of speech acquisition. In the study of 10 languages, it has been shown that all three CV co-occurrence patterns observed in infants tend also to be present in adult languages. They are especially in symmetrical consonantal place contexts (LVL, CVC and DVD) but to some extent also in asymmetrical contexts, suggesting that the identity of the first consonant is a more important influence on the vowel than the second consonant.

Table 3 shows that the infant studied by Davis and MacNeilage [5] also displays the three CV co-occurrence constraints in symmetrical contexts (LL,1.38; CC, 1,45; DD, 3.71).

Table 3. Observed to expected frequency ratios of front central and back vowels in the 9 consonant contexts.

Vowels

	F	C	B
LL	0.59	1.38	0.73
LC	0.96	1.28	0.31
LD	1.68	0.84	0.18
CL	0.98	0.86	1.43
CC	1.45	0.52	1.47
CD	1.25	0.92	0.82
DL	0.14	1.86	0.27
DC	0.38	1.35	1.27
DD	0.51	0.36	3.71

However vowel choice in asymmetrical contexts shows some differences from adult patterns. One choice not shared by languages is to favor front vowels in LVD sequences (1.68). However this is the result of the fact that the infant's name is "Becca"! Another preference specific to the infant and with no presently obvious causality is a preference for back vowels in CVL and CVC sequences. The analysis of these vowel effects in the 10 infant corpus [6] is presently in progress.

5. CONCLUSIONS

We have presented the hypothesis that various aspects of the production of labial, coronal and dorsal stops and nasals, first occurring in primarily in reduplicated forms and then showing a systematic transition into variegated forms, suggest an anterior to posterior hierarchy of increasing production difficulty. We have suggested that the main step towards increase in serial complexity - the favoring of a labial-coronal sequence - may be a self organizational response (initiate simply, then change) to a demand for increasing output complexity in infants. It may be a recapitulation of a key step in the phylogenetic progression towards serial complexity. A self-organizational origin for this output pattern in languages and/or infants would make it unnecessary for the pattern to be specified, a priori, as part of the phonological component of a genetically specified universal grammar [20]. This was apparently suggested by Ingram [4] in designating the fronting phenomenon as an instance of the "Markedness" principle in sound sequencing.

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