Consonant Harmony: Its Scope and Function in Child Language

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ABSTRACT

Consonant harmony (CH) is widespread in child phonology but rare in the world's (adult) languages. This paper investigates CH in child phonology in six languages by analyzing data from thirteen children (ages 0;7-3;5). Every child shows some examples of CH, but the nature and extent differ greatly, in part because of differences in phonological structure between languages and in part because of differences in individual strategies and paths of development between children. Functions of CH in child phonology are: a) to provide a source of substitutions for sounds the child cannot pronounce (most often liquids and s) and b) to allow focus on new segments or extra syllables by reducing the overall complexity of the word. The evidence suggests CH is not a universal innate process which the child must overcome: it is rare in some children and when it is used, it often operates after the sounds involved can be pronounced satisfactorily. CH in children seems analogous to types of speech errors and patterns of alliteration in adults.

CONTENTS

1. Introduction

It has been suggested that "some form of consonant harmony appears to be universal [in child language]" (Smith 1973: 20), and indeed in the literature on child language examples abound of forms showing consonant assimilation in place or manner across vowels: see, for example, Lewis 1936, where over 100 examples of consonant harmony are cited from diary studies of three children, speaking ENGLISH, FRENCH, and GERMAN (pp. 297ff). Among recent detailed phonological studies of a single child, Menn 1971 and Smith 1973 both include rules of non-contiguous consonant assimilation that affect a large portion of the child's utterances. At the same time, it is common for theoretical interpretation of child language to attempt to relate children's rules to the rules of adult phonology, both synchronic and diachronic -- yet consonant harmony is conspicuous by its near absence from the adult languages of the world.

The present study was undertaken in an effort to establish whether or not consonant harmony is in fact universal in child phonology, how significant a rôle it can play for a given child, and what relation it bears to adult phonology. A second focus of the study is to investigate the degree to which the language being learned seems to affect the child's strategies, and the degree to which the differences one finds are ascribable to individual differences among children (cf. Macken 1976, Ferguson 1977).

2. Sources and Data

In order to make a meaningful evaluation of the relative importance of consonant harmony in a given child's speech, I required access to a complete set of data for the child for a given time period -- complete in the sense of all forms produced during regular visits (in the case of outside investigators reporting the data), or all forms recorded over the period in question (in the case of a diarist observer). To limit acceptable kinds of data to either of those cases would have been to eliminate several reports and thus severely cut down the already small number of children and languages covered. But to accept sample forms or illustrative examples would have been to preclude use of any quantitative analysis. Thus, the data described in Menn 1971 or those presented in Lewis 1936 could not be included because in their published form, they were fragmentary. Nor could I make any use of the more diffuse but unfortunately typical reference to various consonant harmony forms in a survey such as Kerek 1975, which fails to provide any indication of the child's age, size of total vocabulary, or other phonetic

or phonological characteristics of the data as a whole for any child.[1] On the other hand, whenever a complete, apparently reliable data source was brought to my attention, I made a point of including it.

The data sources used are characterized in Table 1. Six languages are represented, from five languages families or branches, three of which are INDO-EUROPEAN, and all but one of which are spoken in Europe. Though reports on child language acquisition in Africa, Australia, etc. do occur in the literature, I was unable to locate any with complete sets of data.[2]

Of the eight children growing up in America, all have been exposed to ENGLISH and all are to some extent bilingual. The degree of influence from the non-dominant language may be roughly judged from the percentage of words from that language out of the child's total active (and spontaneous) lexicon — the range here being, for ENGLISH as the second language, from 2% (for Linda) to 9% (for Virve, who was attending an American day care center). Hildegard, who was raised at home as a bilingual from the start, had 13% GERMAN words. The remaining children are all monolingual.[3]

Each language is represented by at least two child learners, with the exception of CZECH, which may, however, be grouped with SLOVENIAN as far as general phonological structure is concerned. ENGLISH and CHINESE were the target languages of three children each. The work of nine primary investigators is represented by these data.

As indicated on Table 1, all but two of the data sets are longitudinal. The exceptions are Chao's data on his granddaughter Canta, which he collected over a period of one month and which thus represent a single (relatively advanced) stage in her acquisition of MANDARIN, and Smith's data on his son Amahl, for whom only the data reported for stage 1, the outset of Smith's study, were used here.

[1] I was unable to gain access to any of the sources of HUNGARIAN data cited by Kerek.

[2] Apronti's article on DANGME phonology (1969), for example, provides only a few sample forms.

[3] Though for Amahl's mother (INDIAN-)ENGLISH was the fourth language, Amahl "was brought up monolingual" (Smith 1973: 8), and refused to use HINDI even after a six-week trip to India.

Name of subject	Source and year[b]	Type of study[c]	Period covered	Age of child	Sex	Word total	% foreign[d] words
CHINESE							
Canta	Chao 1951	diary, 1 stage	1 month	2;4	F	311	5%
Didi[a]	Clumeck	visits	19 months	1;2-2;9	M	109	5%
Lolo[a]	Clumeck	visits	14 months	2;3-3;5	M	336	5%
ENGLISH							
Amahl	Smith 1973	diary, 1 stage	1 day	2;2	M	225	0%
Hildegard	Leopold 1939	diary	2 years	(0;10)-2;0	F	322	13%
Jacob	Menn 1976a	visits	8 months	1;0-1;8	M	150	0%
ESTONIAN							
Linda	Vihman	visits	6 months	1;6-1;11	F	364	2%
Virve	Vihman	diary	2 years	(0;7)-1;10	F	372	9%
CZECH							
Jiři	Pačesova 1968	diary?	2 years	(0;10)-1;8	M	300	0%
SLOVENIAN							
Maja	Kolaric 1959	diary	2 years	(0;6)-2;0	F	138	0%
Tomaž	Kolaric 1959	diary	2 years	(0;11)-2;0	M	320	0%
SPANISH							
Jesus[a]	Macken	visits	10 months	1;9-2;3, 2;4-2;6	M	144	7%
Sofia[a]	Macken	visits	10 months	1;7-2;4	F	152	8%

Table 1. Data Sources and Subjects

(For notes see next page)

Of the longitudinal data sets, five are diary studies which begin with the first words and include early onomatopoeia, exclamations and the like (peep-peep, aha!, boom!), as well as variation in the shapes of words over time. The remaining studies are based on longitudinal naturalistic observation via regular visits over an extended period of time.

The data collections vary in size from 109 forms (collected in bi-weekly two- to four-hour visits over a period of 19 months from a singularly non-talkative child, Didi) to 372 forms. Smith's corpus, as mentioned above, was restricted to the earliest stage which, besides offering a sufficiently large number of forms to allow comparison with other children, was most uniform in that it appeared to represent the complete lexicon recorded for the child at the outset of the study, whereas later stages reflect selection by the author for the purpose of illustrating phonological development (see Smith 1973: 210). Pačesova's data were arbitrarily cut off at the 300-mark (and at the date represented by that mark, in the case of words whose form continued to evolve), to keep the size comparable to the other collections. The total number of words in each lexicon is indicated in Appendix 1.

(Notes for Table 1):

(a) Name invented for mnemonic purposes for this study. The SPANISH subjects appear as J and Si in Macken 1976. The nicknames Lolo and Didi are used in place of ENGLISH names to mark these children as CHINESE speakers.

(b) The year of publication is given here only for those data sets which have been published in full. Harold Clumeck is preparing his data on several CHINESE subjects for his forthcoming U.C. Berkeley dissertation. Marlys Macken's data were collected as part of the Stanford Child Phonology project: see Macken 1976. My own data on Linda were described in Vihman 1971; my data on my daughter Virve were published in part in Vihman 1976.

(c) All studies are longitudinal unless otherwise noted. "Visits" means naturalistic observation conducted by a non-relative visiting the child periodically, at home or elsewhere. Pačesova does not specify her relationship to the subject of her investigation, but the frequency of the forms recorded strongly suggests that this is a (mother's?) diary.

(d) The foreign words are ENGLISH and FRENCH for Canta, GERMAN for Hildegard, and ENGLISH for the rest.

Only forms used spontaneously, with known adult models, were accepted for analysis: in just one case, Didi's, words classified as "repetitions" were included, though "imitations" were excluded as usual. "Repetition" is defined as words which the child used immediately after an adult, but with the child apparently focussing not on the shape of the word, but on the content of the communication (e.g. adult: "It's raining:" child (also looking out window): "Raining").

3. Method of Analysis

The purpose of the analysis is to arrive at a fair evaluation, for each child, of the degree of difficulty which consonantal contrast seems to represent for him, and the degree to which consonant harmony is used as a way out of the difficulty. As we shall see below, the function of consonant harmony seems to differ from one child to the next, as does the difficulty of producing contrasting consonant sequences. Still, percentages arrived at by applying uniformly defined categories to the various data sets give us a direct base of comparison, before we begin to inquire into the function of a particular process within a given child's phonological system.

Categories are defined for analysis here in such a way as to maximize the weight of consonant harmony and also, once words showing harmony are separated out, to give the child maximum credit for consonantal contrast (by disregarding substitutions and reorderings, as well as variants showing deletion, if two contrasting consonants appear in at least one child variant). The point of so defining the categories is to sharpen the focus on the two phenomena of interest, consonant harmony and consonant contrast, and also to reap as large a harvest of consonant harmony forms as possible, to provide data for a study of the kinds of assimilation that occur. The absolute rôle of consonant loss cannot be estimated from the figures given here, but its relative importance for any one child in comparison with the other children in the study is probably fairly assessed.

Four basic categories are distinguished for the purposes of this analysis. All the spontaneous words produced by the child have been scored for these categories, which I define as follows (examples from Amahl, on left, and Virve, on right, unless otherwise noted):

A. Consonant harmony: scored for a word if any child variant shows agreement in place and/or manner of articulation between two non-contiguous consonants which differ in that respect in the adult model. Examples:[4]

Full harmony	tiger → ġaigə	/tu.Pa/	'into the room, to indoors' → pup:a
Partial harmony	driving → waibin	/su.Pi/	'soup (obj.)' → fup:i

B. Consonantal contrast: scored for a word if no variant shows harmony, as defined above, and if there is at least one child variant showing two contrasting non-contiguous consonants — which may be different consonants or in a different order than in the adult model. The adult model must also contain at least two contrasting consonants. Examples:

aeroplane → ɐ:bəʔe̤in	/parT/	'duck' → pat:
back → b̥ɛk	/plA.ster/	'bandage' → 'pæ|sel
carpet → ġa:bi:	/va.lnis/	'ready' → masi

C. Consonant deletion: scored only where all variants of a word show loss of one or more consonants (or whole syllables), such that the child version does not show consonantal contrast, though the adult model does. Examples:

ball → b̥ɔ:	/sUr/	'big' → su:
handle → ɛŋu	/va.Ni/	'into the bath' → an:i
	/üles/	'up' → üg̈s

D. No contrast: scored where the adult model contains no two non-contiguous true consonants contrasting in place or manner,

[4] The format used for examples here and throughout this paper is: adult word (in standard orthography or, for ESTONIAN, phonemic transcription) → child form (as found in the data source). The long or tense ESTONIAN segments are represented by upper-case letters in the phonemic transcription, while the accentual prosodic feature realized phonetically as further segmental or syllabic lengthening is indicated by a period following the syllabic nucleus, except in monosyllables, where the "extra length" is predictable (see Raun and Saareste 1965, Tauli 1973, E. Vihman 1974). Stress falls on the initial syllable in ESTONIAN, unless marked otherwise. In the phonetic transcription of children's forms, | indicates "temporal spacing (syllabic break accompanied by slight pause)," as in Vihman 1976; see Bush et al. 1973.

regardless of the shape of the child version. Examples:

elbow	/auh-auh/	'bow-wow'
eye	/auTo/	'car'
lorry	/o.tsa/	'(to an) end'
wee-wee	/kuKu/	'(don't) fall'

In addition to the four basic categories, a fifth was added for some children:

E. Pseudo-harmony: scored for a word when the child's regular consonant substitution rules result in a merger of the two consonants which contrast in the adult model, so that the child's form shows no contrast but nevertheless is not necessarily the product of a consonant assimilation rule. Examples:

flower → wæwə
(cf. feet → wi:t)

Hildegard: kitty → diti
(cf. kiek! 'peek-a-boo' → ti)

For the purpose of grouping words into these five categories, glides (yod, w) were taken to be consonants only when they occurred word-initially in the adult model. Medially, a glide in the adult model counted as a non-consonant. Where a child substituted a glide for an adult consonant in any position, the change was treated as a deletion, unless the glide was incorporated into a consonant harmony pattern (where it then counted as a consonant). Examples:

Amahl:

whistle → wibu	(A) (partial progressive labial harmony)
room → wum	(A) (partial regressive labial harmony)
watch → wɔt	(B) (glide... consonant = consonantal contrast)
new (→ nu:)	(D) (non-initial glide = non-consonant: no contrast in adult word)

Virve:

/jOkse/ 'run!' → jo.ksa	(B) (glide...consonant=consonantal contrast)
/ju.Tu/ 'a story (obj.)' → ut.u	(C) (loss of initial glide = deletion)
/maja/ 'house' (→ maja)	(D) (medial glide = non-consonant: no contrast in adult word)

Linda:

/jAna(-li.nt)/ 'ostrich' → ja.ja	(A) (full progressive harmony)
/ru.Tu/ 'fast' → jut.u	(C) (consonant changes to glide: deletion)

The glottal fricative [h] constituted a class in itself for scoring purposes. In the adult model it was viewed as a consonant in all

positions (thus, adult EST. /maha/ 'down' has consonantal contrast, whereas /maja/ 'house' does not); where a consonant was replaced by [h] in the child version, however, [h] was treated as equivalent to a glide, so that consonant-loss would be scored if the word had at most one other consonant. Example:

Canta: bwu.shy 'is not' — bu.hy ~ bu (C)

As indicated earlier, for purposes of categorization only contrast in place and/or manner was considered relevant; contrast in voicing or tenseness was disregarded -- as it tended to be disregarded by the children, who sometimes established their own sub-phonemic distribution rules for voicing (e.g. Amahl: cf. Smith 1973: 37; see also Leopold 1947, who notes that "the distinction between voiced and voiceless is ... one of those finer discriminations which were not yet well achieved by the child" p. 197). Thus, ENGLISH teddy, ESTONIAN /tæti/ 'aunt,' CZECH tady 'here' were all scored D. Furthermore, where an adult form showed consonantal contrast only by virtue of a consonant cluster which the child failed to reproduce (whether due to misperception, difficulty in production, or some other unknowable source of error), the form was treated as if it had no contrast in the adult model (D). Examples:

bump → b̥ʌp /täht/ 'star' → tat;
church → d̥ə:t
tent → d̥ɛt

On the other hand, where the adult cluster was preserved by the child in a word of the shape $C_1 \ldots C_1C_2$, $C_1 \ldots C_2C_1$, etc., B was scored. Examples:

Hildegard: kritze 'handbrush (family word)' → titsə
Jiři: kluk 'boy' → kluk
Linda: /kaks/ 'two' → kaks

Inflectional endings, often omitted by children at early stages of language acquisition, were disregarded in scoring consonantal contrast. Just one child, Virve, made active use of consonant harmony in acquiring inflections (see below, sec. 5.3.2). Derivation played a significant rôle only in the case of the hypocoristic markers in SLAVIC (see Sec. 4.1).

4. Results

In order to compare the importance of consonant harmony for different children, as well as to assess the degree of difficulty

presented by consonantal contrast within a word, I first converted the raw scores for the four (or five) categories for each child into percentages, based on the total lexicon analyzed for that child. I then rank-ordered the children separately for each category. Table 2 presents the figures thus arrived; the raw scores and percentages are given in Appendix 1.

Table 2. Key: A = Harmony, B = Contrast, C = Deletion, D = No contrast, E = Pseudo-harmony (see Sec. 3)

Category A		Category B		Category C		Category D	
Amahl	32%	Tomaž	74%	Jacob	36%	Didi	50%
Virve	25%	Maja	72%	Hildegard	30%	Lolo	38%
Jesus	21%	Jiři	69%	Amahl	14%	Canta	34%
Sofia	18%	Linda	57%	Jesus	14%	Jacob	29%
Jiři	11%	Lolo	54%	Virve	12%	Hildegard	28%
Jacob	9%	Sofia	54%	Didi	12%	Linda	27%
Linda	9%	Canta	52%	Maja	9%	Sofia	25%
Canta	5%	Jesus	43%	Canta	7%	Virve	24%
Hildegard	5%	Virve	38%	Lolo	7%	Jesus	21%
Didi	3%	Didi	36%	Linda	7%	Tomaž	18%
Tomaž	3%	Hildegard	35%	Tomaž	4%	Maja	17%
Maja	1%	Amahl	33%	Sofia	3%	Jiři	17%
Lolo	1%	Jacob	25%	Jiři	3%	Amahl	16%
Mean	11%		49%		11%		26%
Median	9%		52%		9%		25%

Category E	
Amahl	5%
Hildegard	3%
Canta	2%
Virve	1%

4.1 Language effects

Language effects are apparent in two sets of figures on Table 2. Note, first, the clustering of all three CHINESE-speaking children at the head of category D. This indicates that words lacking consonantal contrast in the adult model make up a larger part of the lexicon of each of the CHINESE-speaking children than of the lexicon of any of the other children. To verify that this preponderance of adult model words lacking contrasting consonant sequences reflected a peculiarity of the language these children were learning, I turned to the Stanford Phonology Archive coding for (MANDARIN) CHINESE, where I found the following definition of the syllable:

A syllable may begin with one or no consonant, followed by one or more glides, one vowel, and one or no ending (/yod, w, n, eng/).[5]

This definition may be compared with the following formulas encoded for ENGLISH:

(C)(C)(C) V (C)(C)(C)(C),[6]

for BULGARIAN (neither CZECH nor SLOVENIAN happen to be included in the Archive sample of 200 languages):

(C)(C)(C)(C) V (C)(C)(C),[7]

and for SPANISH:

(C)(C)(G) V (G)(C)(C).[8]

Though each of the CHINESE children had a large number of compound words in his lexicon, the monosyllabic word is also well-represented in each case.[9] From the syllable definition cited above it is clear that among monosyllabic words only those with final nasals present a possible consonantal contrast across the word.[10]

[5] For a description of the Archive, its language sample, contents and structure, see Vihman 1977. The primary source used for MANDARIN was Chao 1968.

[6] The Archive source was O'Connor 1973.

[7] Three consonant clusters are said to be very rare finally, while final two consonant clusters are only of the type liquid + consonant, in native words. The Archive source for the phonetic inventory was Klagstad 1958.

[8] G = glide; word-finally, only a singleton consonant may occur. The Archive source for the phonetic inventory was Navarro 1961.

[9] Compounds make up 41% of the CHINESE adult model words (i.e. excluding ENGLISH models) in Lolo's lexicon, for example.

[10] Harold Clumeck reports a tendency among the parents of his CHINESE subjects to omit final nasals, leaving heavily nasalized vowels. Indeed, out of 21 cases of consonant deletion in Lolo's vocabulary, 16 involved omission of a syllable-final nasal, where the omission may have had its source in the adult model. Since Lolo also had 37 monosyllabic words with final nasal intact, however (vs. 7 monosyllabic words with final nasal loss), we can come to no definite conclusion on this point.

Where languages other than CHINESE are being acquired, the percent of D words tends to correlate inversely with linguistic maturity, as evidenced by the results of analysis on earlier cross-sections of the data for three children – Jiři, Virve and Hildegard: see Table 3. At the point where the first fifty words had been acquired, D scores of 56%, 46% and 42% were registered, as compared to 17%, 24% and 28% for these same children at the end of their respective studies.[11]

Table 3. First Fifty Words

Categories:	A	B	C	D	E
Hildegard	10%	12%	30%	42%	6%
Jiři	--	36%	8%	56%	
Virve	16%	20%	18%	46%	

It should be noted that the CHINESE-speaking children happened to be, on average, older at the conclusion of their studies than the group of 13 children taken together (mean age of 2;10 vs. a group mean of 2;2 — or 2;0 for the ten non-Chinese children). It seems clear, then, that the phonological structure of adult MANDARIN must be responsible for the unusually large proportion of D words in the lexicon of all three Chinese children.

The second apparent language effect, though comparable to the first, is more difficult to interpret. I refer to the clustering of the three SLAVIC-language children at the head of category B, consonantal contrast. Here again, one might look to the phonological structure of the language being learned. Of the three SLAVIC languages coded in the Stanford Phonology Archive, for example, all have relatively large numbers of consonant phonemes (RUSSIAN, 32; POLISH, 34; BULGARIAN, 35), as compared with the other languages in our sample (ENGLISH, 26; MANDARIN, 24; SPANISH, 19; ESTONIAN, which is not coded in the Archive, is reported by Raun and Saareste 1965 as having 16 consonant phonemes). But Pačesova 1968 lists only 24 for CZECH, and even if SLOVENIAN were taken to include as large an inventory as those reported in

[11] These figures would seem to support the idea, repeatedly suggested recently by Ferguson and others (cf. Ferguson et al. 1973, Ferguson and Farwell 1975), that lexical selection on phonological grounds is one early strategy children use to keep the problems of word-production within manageable bounds. See also Kiparsky and Menn 1975, Macken 1976, Menn 1976a and Vihman 1976.

the Archive, we would be left with the question of the relevance of those figures. How would the presence in the language of a fairly large number of different consonants, or even of formidable consonant clusters (up to five members in the child's vocabulary, according to Pačesova, by the end of her study, when Jiři had acquired 500 words and was just short of being two years old), lead the child to develop early or unusually rapidly a facility for producing consonantal contrasts?

To come to a fair understanding of this phenomenon, I analyzed two further parameters for all the children. First, I counted the number of consonant sequence types (e.g. p-t vs. p-k) in each child's word productions to arrive at the type:token ratios presented in Table 4. Second, I checked word-length, or more precisely length of consonant-sequences (across vowels: consonant clusters count here, as elsewhere in this study, as a single consonant) by calculating for each child the percent of all consonant-sequence types represented by sequences of three or more consonants (see Table 5).

Table 4. Ratio of types to tokens among consonant sequences

	Ratio : 1 to	No. of types	No. of tokens (= B words)
Maja	1.14	87	99
Jiři	1.16	178	206
Didi	1.22	32	39
Jacob	1.23	31	38
Sofia	1.30	64	83
Tomaž	1.39	171	238
Lolo	1.44	126	182
Linda	1.60	131	209
Virve	1.65	79	130
Jesus	1.82	34	62
Amahl	2.35	31	73
Canta	2.57	63	162
Hildegard	3.03	37	112
Mean	1.68		
Median	1.44		

From Table 4 we can see that two of the SLAVIC-language children, Jiři and Maja, still head the list; that is, they have the most diverse array of consonant sequences proportionate to the total number of B words reported for them. Tomaž, however, with a type:token ratio of 1:1.39, ranks near the median point of 1:1.44 (though still well above the mean of 1:1.68). On Table 5 the ranking shifts further, with Maja falling to fifth place, while Tomaž falls third from the bottom. This reflects the fact that both SLOVENIAN children, but especially Tomaž, tended to drop syllables in their word-productions, even while faithfully retaining a high number of consonant sequences. It is worth remarking that Maja and Tomaž, the only pair of siblings in our sample of 13 children, were only one year apart in age; it is quite possible that Tomaž, who carried the strategy of truncating words farther than his older sister, adopted it from her, and in fact some of his words may have had one of Maja's versions rather than the adults' as their starting point. Since we do not know what Maja's phonology was like after age 2, when the bulk of Tomaž's words appeared, there is no way to check this point.

Table 5. Percent 3-(or more) consonant sequences relative to total number of B-word types (see Table 4)*

		Excluding diminutives from SLAVIC lexicons	
Canta	60%	Jiři	27%
Jiři	54%	Maja	2%
Virve	33%	Tomaž	1%
Sofia	25%	(other children as in column on left)	
Maja	23%		
Jesus	21%		
Linda	20%		
Amahl	19%		
Hildegard	16%		
Lolo	15%		
Tomaž	14%		
Didi	10%		
Jacob	3%		
Mean	24%	Mean	18%
Median	20%	Median	19%

*Compounds and reduplications of B-roots are included here.

Jiři remains strikingly far ahead of the other children on the consonant sequence or contrast measures on Tables 4 and 5. One further factor needs to be considered, however. The word lists for all the Slavic children reflected a well-known characteristic of SLAVIC languages, namely, heavy use of diminutive or hypocoristic

affixes. If the relatively few long consonant sequences the Slovenian children produced are scanned for occurrence of these markers (-cV, -kV, or -ek vs. -Vk or -ka for CZECH); they are found to account for 90% of Maja's 3+ consonant words, and for 92% of Tomaž's. For Jiři the figure is a more modest 44%. If we subtract these diminutives from the long-consonant-sequence figures and recalculate our percentages, Tomaž and Maja now fall to the bottom of the list (with 1% and 2%, respectively), while Jiři now ranks third with the much smaller figure of 27%

It is at least conceivable that the constant exposure to diminutive markers whose addition frequently creates a consonantal contrast played a rôle in advancing the capacity of these children to handle consonant sequences. Of the adult models reported for Tomaž, 18% are marked for diminutives, while fully 25% are marked on those reported for Maja. It is often the case -- as the figures cited earlier suggest -- that Maja and Tomaž include the diminutive ending in their version of the word, while omitting one or more of the other syllables (cf. Tomaž drevešček 'small tree' → [véško] at age 1;10,0, balonček 'little balloon' → [lónčke] n.sg., at 1;10,3, golobček 'little dove' → [lópčka] at 2;0,7; Maja bombóncka 'candy' → [bóncka] at 1;7,20; both children metuljček 'small butterfly' → [túlčək] (Maja at 1;7,24, Tomaž at 1;10,17 and 1;11,8). In Jiři's case the adult form is only occasionally presented with a diminutive marker, though the child forms abound in them. By the age of 1;8, when he had made active use of 300 words, 122 or 41% of them included a hypocoristic.

Since Pačesova gives separate, dated entries for each word in chronological order, we can easily trace the appearance of these markers in the child's speech. By age 1;3, with 50 words, Jiři had used no hypocoristic markers in his own speech, though at least one of his words -- bebičko 'pain' (→ J. [bebe: - bibi:], etc.) -- apparently is not used without the marker in adult speech. By age 1;5, with 100 words, 34% of his forms show a diminutive marker, the earliest being bebičko, in the form [bibi:ško] (1;3,2). Of the first 50, 12 now have diminutive markers, with several appearing together at 1;5,0 and 1;5,1 (máma 'mummy' → [mamišta], bába 'granny' → [babišta - babiška]; kvítí 'flowers' → [kiťiški]; dítě 'child' → [ďiťišto - ďiťiško]; čaj 'tea' → [aji:ček]).[12]

[12] Compare the relative infrequency of diminutive or hypocoristic markers for the other children. In ESTONIAN there is a marker in -u preceded by palatalization of the last stem consonant (or cluster, if it is dental). This appears in five of Linda's words and five of Virve's, or 1% of each child's lexicon; the marker more commonly

All three Slavic children present a profile of rapid development where consonant sequences are concerned. We can only speculate as to whether repeated exposure to the affectionate forms in -c- and -k-, which the children soon begin producing themselves, facilitates progress in mastering the skills involved in the production of consonantal sequences. If those skills are purely articulatory, it is hard to see how the prevalence of a particular consonant or pair of consonants will help. If the stumbling block is as much mnemonic as articulatory, with consonant harmony playing the rôle of simplifying the mnemonic problem involved for some children, then the addition of a single morpheme, or a small number of phonologically related morphemes or morphemic variants, to a large portion of the vocabulary should be a facilitating factor for the child.

4.2 Quantitative analysis

To return now to the general results presented in Table 2, we can say that on average just over one-quarter of the child's lexicon is accounted for by category D (or 22%, if the Chinese children are excluded), while roughly half is accounted for by category B. Where the child does not use a consonant sequence though the adult model does, his version will fall in either category A or category C, which account for equal share of the children's production, on average. If over 5% use of either of these categories is taken to be significant, we can say that seven (or over half) of the children made use of consonant harmony -- which, however, was maximized by our method of analysis (see Sec. 3); on the other hand, ten (or well over half) of the children made significant use of consonant deletion -- which was minimized by our method of analysis.

(ftnt. 12 cont.)
used in adult speech, -Ke(ne) appears only in the words /væiKe/ 'small' and /pisiKene/ 'tiny' among Virve's adult models (Virve omits the marker in her version of the latter); Linda's lexicon lacks the marker entirely. Among the ENGLISH-speaking children the marker /-i/ (-ie, -y) makes an occasional appearance -- once for Amahl, three times for Jacob, five times for Hildegard, who also has one GERMAN proper name bearing the marker -chen, for a total of nearly 2% diminutives. Sofia has five words or 3% marked by the diminutive -ito/-ita, while Jesus has none. Only in CHINESE do we have significant use of a diminutive marker, -tzy in Chao's orthography, -zi in the Pinyin orthography used by Clumeck. The figures are Canta: 10%, Lolo: 7%, and Didi: 8%, but Didi disregards the marker in his own production of seven out of nine words, substituting reduplication, which is also used in adult presentation.

We saw earlier that the results were skewed for the Chinese children, because the structure of their language was such that a disproportionate share of their words fell into the D category. Since that category is the only one primarily based on the adult forms regardless of the shape of the child's version, it seems reasonable at this point to eliminate the words falling in that category for each child and re-evaluate the rôle played by the other categories, based on percent of the remaining words. The results of that tabulation are given in Table 6. As far as the rank-position of individual children is concerned, notice that, as compared with Table 2, all three Chinese children now rank higher in the B category, with Lolo, the oldest of the 13 children at the end if his study, now ranking, along with Maja, second only to Tomaž. In the C category Didi has now moved up from sixth to third position. As far as A, consonant harmony, is concerned, there is no change in rank, nor are there any changes for the non-Chinese children.

Table 6

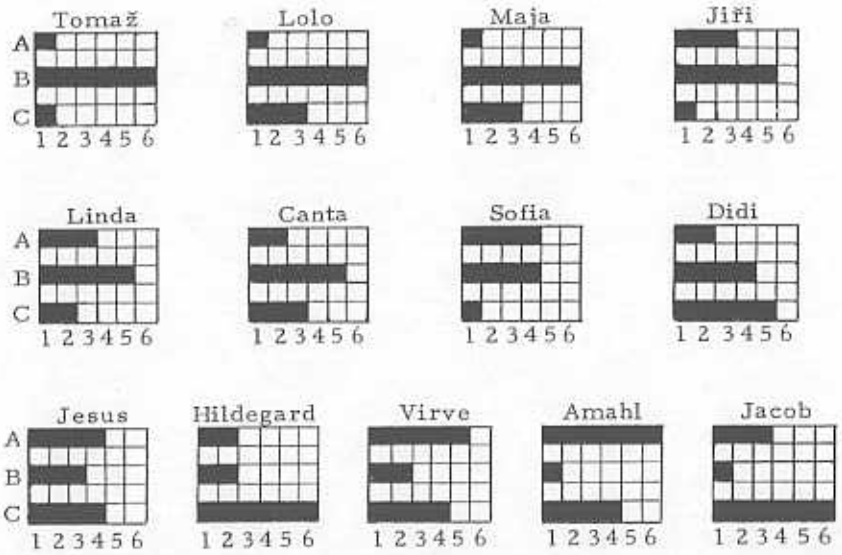
Category A		Category B		Category C		Category E	
Amahl	38%	Tomaž	91%	Jacob	50%	Amahl	6%
Virve	32%	Lolo	87%	Hildegard	41%	Hildegard	4%
Jesus	26%	Maja	87%	Didi	24%	Canta	2%
Sofia	23%	Jiři	83%	Amahl	17%	Virve	1%
Jiři	13%	Canta	79%	Jesus	17%		
Jacob	13%	Linda	78%	Virve	16%		
Linda	12%	Sofia	73%	Maja	11%		
Canta	7%	Didi	70%	Canta	11%		
Hildegard	7%	Jesus	56%	Lolo	11%		
Didi	6%	Virve	50%	Linda	10%		
Tomaž	3%	Hildegard	48%	Tomaž	5%		
Maja	2%	Amahl	39%	Sofia	4%		
Lolo	2%	Jacob	38%	Jiři	4%		
Mean	14%		68%		17%		
Median	12%		73%		11%		

As far as over-all percentages are concerned, the B category now accounts for well over half of the lexicon, on average (the median score is 73%, or nearly three-quarters consonant-sequence production). The rôle of A and C remains close, on average, though C now shows a larger average percentage. If we arbitrarily pick 10% as the limiting figure above which a category may be said to play a significant rôle in a child's production, we find that consonant

harmony is still significant for seven, consonant deletion for nine out of the 13 children. Aside from the individual ranking of the Chinese children, then, there is little change in the results after elimination of category D.

On Table 7, the A-B-C profiles for all the children are displayed, ordered by B rank. This set of graphs is based on the relative rank frequencies given on Table 6, but the differing ranges reflected by the actual percentage figures for the three categories (i.e. 53-point range for B vs. 46-point for C and 36-point for A) have been translated here into a single six-point scale.

Table 7. A-B-C scores ordered by rank



Looking at Table 7, we see that three children, the Slovenian siblings and the oldest Chinese child, Lolo, scored 6 for category B. Consonant harmony plays an insignificant rôle for all of them, while consonant deletion is moderately important for Lolo and Maja (recall, however, that Tomaž was inclined to truncate words; sophisticated in handling two-consonant sequences, he very rarely added a third within the period studied).

Three children scored 5 on category B. Of these, two made moderate use of consonant harmony, while only one made significant

use of consonant deletion. Among the three children scoring a medium 3 or 4 on B, two make relatively heavy use of consonant harmony, the other uses consonant deletion. And among the four children with low scores of 1 or 2 on B, two score 5 or 6 on consonant harmony, two score 6 on consonant loss. Among these four, only Hildegard, with a B score of 2, fails to make significant use of the alternate, less-favored strategy as well (in her case, consonant harmony).

In short, as suggested by the close mean scores for A and C, the children divide fairly evenly into those using harmony and those preferring to omit troublesome consonants, with a predictably heavier reliance on one or the other, or to some degree both, for those children who score low on B. In a later section we will consider the function of consonant harmony and the issue of which comes first: difficulty handling consonantal contrast, or a preference for a particular kind of phonological process.

5. Consonant Harmony in the Children's Speech

5.1 Typology

When all the consonant harmony forms for all the children are combined and categorized as to segments and gross articulatory features involved, full or partial assimilation, and regressive or progressive direction of assimilation, we arrive at the results given in Table 8. The categories "full" and "partial" are not unambiguous. Change of k to t in the (discontinuous) environment of t, for example, might be considered a change in place of articulation, while change of l to v in the environment of m (Linda, three instances) yields incomplete agreement in place as well as in manner. I count assimilations "full" where the surface result was two identical segments, "partial" where the two segments still differed in any feature, even voice. Thus the first case cited above, k to t, would be scored "full," while the l to v example counted as partial labial assimilation. Since, as noted in Sec. 3, many children had subphonemic distribution rules for voicing, I combined the voiced and voiceless pairs in tabulating the results. Those results are summarized more broadly in terms of percentages in Table 9, where the figures for Amahl and Virve, who together account for 47% of all the consonant harmony forms, are separated out from the rest. It is apparent that since those two children had quite different kinds of harmony, they fail to combine to skew the overall pattern in any particular direction.

Table 8. Assimilating segments and features in consonant harmony forms.*

I. Full assimilation

	Regressive	%	Progressive	%
p, b	16		14	
t, d, t', d	29		16	
k, g	27		18	
STOP	72	50%	48	66%
f, v	4			
s, ʃ, š, ž	8		4	
FRICATIVE	12	8%	4	5%
m	12		4	
n	26		8	
NASAL	38	27%	12	16%
l	9		2	
yod, w	5		7	
LIQUID, GLIDE	14	10%	9	12%
h	1			
cluster	6			
TOTAL	143		73	

II. Partial assimilation

	Regressive	%	Progressive	%
labial, labiodental	30		15	
dental, palatal	21		3	
velar	22		15	
PLACE	73	74%	33	75%
stop, affricate	15		10	
nasal	10		1	
MANNER	25	26%	11	25%
TOTAL	98		44	

*The total here is not equivalent to the total number of A words across all the children, because some words were counted as showing both directions of assimilation (e.g. Hildegard's grand(pa) → [ŋæŋæ]; Virve's /pu.Tru/'porridge (obj)'→[p͡tru p͡tru]), while in other cases both place and manner change were counted (e.g. l → d or p = stop and dental or labial harmony).

Table 9. Consonant harmony types

	Virve		Amahl		Others		All	
Full, regressive	39	43%	22	31%	85	46%	146	42%
Full, progressive	14	16%	8	11%	49	26%	71	20%
Partial, regressive	23	26%	34	48%	29	16%	86	25%
Partial, progressive	14	16%	7	10%	23	12%	44	13%
Full	53	59%	30	42%	134	72%	217	63%
Partial	37	41%	41	58%	52	28%	130	37%
Regressive	62	69%	56	79%	114	61%	232	67%
Progressive	28	31%	15	21%	72	39%	115	33%
Total	90		71		186		347	

To illustrate the typology used, I cite in Appendix 2 all those words which happen to show up in assimilated form in the vocabulary of more than one child in the study. The ENGLISH words are of course part of the "foreign vocabulary" for Canta, Jesus and Virve. In two cases I have compared the phonologically similar, but not identical, forms of a word in two different languages (cf. 'soup,' 'tiger'). In just one case I have drawn, for comparison, on a word that in fact appears in the harmony category for only one child (Jacob). Amahl renders doggie as [ġɔgi:] only at stage 2, not included in this study,[13] while Hildegard's [doti], superficially a harmonized form, in fact has to be scored Ė, since she tends to substitute dentals for syllable-initial velars in general (cf. cover → [da], icecream → [ati], kiss → [diš], etc.).

By presenting words assimilated to a harmony pattern by more than one child I hope to illustrate, in addition to the categories used in typing the forms, the kind of consonantal sequence that poses a problem or a challenge or temptation to the child, and, on the other hand, the variety of patterns that can be applied to a single form. The word thank you, for example, was assimilated by all four children who used it, with three different resultant patterns.

5.2 Function

Tables 8 and 9 are based entirely on the consonants used by the child in his own productions. If we look as well at the consonants

[13] At stage 1, Amahl uses [wowo], which I score D, assuming it derives from an adult wowwow. Smith unfortunately fails to specify the actual shape of the likely adult source for such nursery words, which tend to vary somewhat from family to family.

affected or replaced in the assimilation process, a pattern emerges for most of the children who made significant use of consonant harmony (that is, those who scored 5% or more on Table 2), which suggests the function of consonant harmony for the child in question.

In Linda's data, for example, the consonant affected is typically word-initial (25 out of 32 cases). If we compare the incidence of the various manner-of-articulation types among word-initial consonants in each category, we arrive at the following results (A + C = problem words, B + D = no problem for the child):[14]

	A	B	C	D	A+C	B+D
stop	7	127	5	23	21%	59%
s	5	11	1	7	11%	7%
v	-	18	-	1	-	7%
nasal	2	24	1	8	5%	13%
liquid	13	8	11	4	43%	5%
yod	5	10	1	3	11%	5%
h	-	8	5	2	9%	4%

It is obvious that liquids pose a problem for Linda (r was not produced at all during the period included in this study, while l is changed to yod in nine words -- C category -- and assimilated in nine). Similarly, s and yod tend to be assimilated, as shown by their disproportionate incidence in category A. It seems clear that Linda made use of consonant harmony, as well as consonant deletion, to solve particular segmental problems.[15]

Canta, who scores only 5% harmony on Table 2, uses the process almost exclusive to deal with l, which she does not produce at all.

[14] Of the initials on the seven A words in which a noninitial consonant was affected, five are k, one is p, one is yod.

[15] Linda's use of harmony is evaluated on the basis of a somewhat more thorough analysis of the same data in Vihman 1971: "Linda is operating with a tentative consonant assimilation rule which copies the post-vocalic consonant initially just in case the initial consonant is not a stop (oral or nasal). This 'rule' is optional at all stages, and loses force steadily as the various consonantal articulations are mastered. It thus constitutes, in effect, more of an operational principle or strategy for dealing with difficult initial consonants than a "productive rule" in the sense of adult grammars..." (p. 78).

Eight out of 14 cases of harmony affect l, assimilating it to n or to a stop (l becomes d), while l is lost in 14 out of 22 cases of consonant deletion. The remaining instances of l in the adult models are assimilated to an adjacent, morpheme final n in the child's corpus (five instances), deleted (four instances categorized as B because there remain two contrasting consonants in the word), or replaced by yod (six instances which fall into the B or D categories).[16]

The two SPANISH-speaking children, who rank third and fourth in use of harmony after Amahl and Virve, both made use of the process in dealing with long words (three syllables or longer). For Sofia, 15 out of 26 consonant harmony words (or 57%) are at least three-syllables long (some of these "words" are unanalyzed phrases, such as ¿què es ésto? 'what is this ' or simply article plus noun: la niña 'the girl'). Eleven of them (or 42%) have a three-consonant structure (where a cluster counts as a consonant but non-initial glides do not) in both adult and child form. Of the B words, in contrast, only 22 out of 83 (or 25%) are three-syllables long or longer, and 14 (or 17%) have the three-consonant structure. Among the long words or phrases, five show assimilation to a cluster:

Fernando 'proper name' → tsəndando
llorando 'crying' → ɲrdardno
telefono 'telephone' → ɸweɸwʌno
television 'television' → widsezo:n
vestido 'sweater' → batsidzo

In five others, a fricative or liquid is assimilated to a stop:

comiendo 'eating' → kabiendu
la radio 'the radio → dadazo
què es ésto 'what is this' → kiketo
tenedor 'fork' → ɛbədʌɹ
zapato 'shoe' → dəbata

Clearly Sofia is using (partial) harmony to help her deal with long sequences of syllables, and she appears to favor the maximally contrastive stop-vowel syllable structure.

Unlike Sofia, Jesus has only a slightly higher percentage of three-consonant, three-syllable words among his A words than among his B words, whether we are counting those reduced to two syllables in his version (9, or 29%, A words; 15, or 24%, B words), or those which he successfully reproduces with at least three syllables (6, or 19%, A words; 8, or 13%, B words). Setting the six long A words aside, however, on the assumption that these fall in the harmony category because Jesus, like Sofia, is using assimilation as an aid in handling the long string of syllables, we find that in the 25 remaining words, s is affected in eight and m or n in five. Yet the nasals were among Jesus' earliest segments, according to Macken 1976, though s had not yet been produced at the outset of her study. In fact, the rôle of harmony in Jesus' phonological system cannot be adequately described in terms of single segments or total wordlength, but is related to the complete consonantal structure of a word. At the beginning of Macken's study, "if two consonants co-occurred in a word, they had to agree in place and manner" (p. 42; compare Vihman 1976, where a similar condition is described as operating during the period in which Virve's first 50 words were acquired). Later, for "words which have a final nasal or a non-final fricative in the adult model, J's productions showed a gradual increase in complexity in terms of the number, type and order of syllables" (p. 47). "Fricatives in C_1VC_2V words, where either $C_1 \ldots$ or $\ldots C_2$ was a voiceless stop or nasal, underwent complete or partial assimilation" (p. 48). In general, Macken notes that for Jesus, "the greater the similarity between two consonants, the fewer the restrictions on their co-occurrence in any word" (p. 49).

Turning to Jiři, we find that k is the consonant affected in 30% of the harmonized forms (11 out of 33 A words). Pačesova (1968) notes that k at first tended to alternate with t, and that the majority of early occurrences of k were in interjections, where, according to several sources she mentions, difficult sounds tend to be mastered early. By the time 100 words had been acquired (at 15 months), however, k had become the most commonly occurring consonant in Jiři's productions, yet where it co-occurs with an alveolar, Jiři typically spreads either the alveolar or the velar articulation across the word:

kolečko 'wheel' (dimin.) → tolešto (age 1;5,1)
tužka 'pencil' → tušta - kuška (1;5,1)
taška 'bag' → tašta (1;6,13), kašku (1;7,15)

A principle which Lewis formulated (1936) and supported with data from three children appears to apply in this case: "Of the two sounds in the adult word, the one which comes later in the child's

[16]Because Chao deals only with the child's system, he fails to mention Canta's treatment of adult l in his description of her phonology.

history is assimilated to the one that comes earlier, even if he can pronounce both" (p. 183).

None of the instances of k being assimilated to another consonant occur earlier than 17 months. In fact, no consonant harmony forms at all appear among Jiři's first fifty words (see Table 3), though some of those words are produced in an assimilated form later. For example (the number on the left indicates position in the acquisition order; the harmonized variants are underlined):

35 balon 'ball' → baji ~ bali (1;2, 27), balo:n ~ balonek (1;5,1), babo:nek (1;7,19), baloŋki (1;8, 0)

47 na shledanou 'so long' → nosono (1;2, 30), naslono ~ naslenanou (1;5,1), nasledanou (1;7,13)

86 ježek 'hedgehog' → jǿ:zǿ: (1;4, 30), jeďek ~ žežeček ~ žežek ~ ješešek (1;5,1), žežeci (1;6,14), ježek, etc. (1;7, 0)

93 knoflik 'button' → noti:k, nofik (1;5, 0), oki:k ~ koki:kek (1; 5,1), kofi:k (1;6,12)

164 gramofon 'gramophone' → mofo:n ~ mofo:nek (1;6,12), kakofo:n (1;7,19), gamofo:n ~ gagafo:n (1;8, 20)

In all but the first of these examples we see harmony being used when a longer version of the word — a hypocoristic or a version supplying syllables omitted earlier — is first attempted. But no such function can be claimed for harmony in such cases as

90 žaba 'frog' → ba:ba ~ wa:ba (1;5, 0)

182 koupat 'to bathe' → po:pat ~ poupat (and poupala 'she bathed') (1;6, 20)

259 čap 'stork' → pap (1;7, 20)

270 sova 'owl' → fofa (1;7, 31)

Instead, we seem to see here the use of an optional rule of consonant harmony as a kind of sound-play; perhaps the rôle of assimilation in such cases is at least partially aesthetic, like the rôle of alliteration for adults in poetry or in formulaic phrases such as do or die, to have and to hold, kith and kin, might and main, etc.

5.3 Extensive use of consonant harmony

As we have noted earlier, two of the children made such extensive use of consonant assimilation that their A forms account for nearly half of the total harmony corpus. Each of these children was observed by a parent who largely took notes on the spot, rather than make tapes for subsequent transcription. On the other hand, the data collection methods used in the Stanford Child Phonology Project, from which the SPANISH data derive, were rigorous, with two transcribers working first independently, then together, to arrive at as faithful a record of the children's speech as current technology and experience will allow (cf. Macken 1976). The gap on Table 6 between the A figures for the two SPANISH-speaking subjects -- 23% and 26% -- and the figures for Virve (32%) and Amahl (38%) might be due in part to observer bias, since both Smith and I may have tended to write down all the phonologically "interesting" forms while disregarding some of the forms which were uninterestingly close to their adult models. At the same time, one assumes that there are also limitations inherent in an experimental situation such as that used in the SPANISH studies, with a restricted range of stimuli and observers not intimately familiar with the children. In any case the upper limits for the rôle of consonant harmony in a given child's lexicon would simply have to be revised downward slightly. Amahl and Virve are otherwise alike only in one respect -- namely, in a preference for regressive harmony that exceeds the norm for the other children (see Table 9).

5.3.1 Amahl

An exhaustive description of Amahl's phonology is to be found in Smith 1973. Two consonant harmony rules account for the majority of forms in our category A: Rule 19 (p. 20) assimilates alveolars and palato-alveolars to the point of articulation of a following consonant — optionally to a labial, obligatorily to a velar; Rule 17 (p.19) assimilates non-nasal alveolars and palato-alveolars to the point of articulation of a preceding velar and probably to a preceding labial as well. Regressive assimilation (Rule 19) affects 36 or 71 A words, while progressive assimilation (Rule 17) affects 11 words. Three forms are affected by optional harmony Rule 5 (p. 15), which changes continuants to nasals after a nasal plus vowel. Lastly, the rule affecting liquids and yod consists of three alternatives: realization of any of these segments as /l/ if no consonant other than another liquid or yod occurs in the adult word, or deletion intervocalically, or realization as /d/. Four words fall under the first alternative

above at stage 1. Since an l is present alongside r or yod in all of these words, they are viewed here as products of assimilation:

lorry → lɔli (progressive)
troddler → lɔlə (regressive)
trolly → lɔli (regressive)
yellow → lɛlo (regressive)

An additional 16 words with initial liquid or yod are viewed here as assimilating to a following /d/ (from adult t, d, s, z, š) or /n/ (partial regressive assimilation).[17] Since we find š → d in shoe, for example, and s → d in see (stage 2), forms such as shirt → [dət], side → [ḍait], etc. are categorized as E. But at stage 1 there are no examples of a single liquid or yod with no other consonant in the environment, so that the context-free substitutes can not be unambiguously determined (at stage 2 we already find alternation between /d/ and /r/ in Amahl's version of ray). It is possible that we are over-estimating the extent of consonant harmony in Amahl's lexicon by not placing the liquid and yod-initial words in E, which would lower the absolute A score from 71 to 55 words (32% to 22%) and raise the already high E score from 11 to 27 (5% to 11%), or more than three times Hildegard's next-highest E score of 3%.

Amahl has in common with Hildegard a high type-to-token score for consonant sequences (Table 4: Amahl 2.35 vs. Hildegard 3.03), a sign of a small segment inventory. In fact Smith counts just eight consonants for Amahl at stage 1 (p. 170), out of the 24 of adult ENGLISH (by Smith's reckoning). Hildegard, by comparison, had some 11 contrastive consonants by the end of Leopold's study, when she was two years old, or a little younger than Amahl at stage 1. It appears that where Hildegard made fairly massive use of consonant deletion to make up for her difficulty with certain segments (30% C words vs. 5% A words), Amahl preferred to use consonant harmony, though he did delete consonants as well (14% C score).

It is interesting to note that of all 13 children Amahl makes the least use of lexical selection to arrive at words with no contrasting consonant sequences (16% D words) -- insofar as category D reflects such selection. I pointed out earlier that, except for the special case of CHINESE, relative use of D appears to be an index of linguistic maturity. On those grounds Jacob and Hildegard score at the

[17] One A word, lawnmower (→ [mo:mə]), falls under none of Smith's rules and is cited as an exception (p. 35).

opposite end of the scale from Amahl, who is also quite a bit older than the other ENGLISH-speaking children, for whom data was gathered and analyzed here from the first words to age 1;8 and 2;0, respectively. Recalling that Jiři developed a minor consonant-harmony strategy at around age 1;5, when he already had over 50 words in his lexicon, we can only speculate as to the earlier, unrecorded stages of Amahl's development. Smith mentions in passing that 'sock' -- "which, by stage 1, was invariably [ġɔk]" (p. 29) -- was once pronounced [dɔk]; but he also guesses, on the basis of "a few 'remnant' forms," that the most general, regressive harmony rule (19) once applied to velars (in labial environment) as well as to alveolars and palato-alveolars.

5.3.2 Virve

Amahl's data reflect his lexicon at a single point in time. Virve's still larger array of assimilated forms represent a growing lexicon over a period of about seven months.[18] The kinds of assimilation we find recall Jesus' data, in the gradual relaxing of constraints on consonant combinations and on word-length, rather than Amahl's sweeping segment-substitution rules. The period of the first 50 words, ending at 1;4,12, is marked by two constraints of interest here: two syllables is the maximum word-length, and either place or manner is held constant across the consonants of a word, with a single exception (cf. piss, below). No liquids have yet been produced, while v occurs once finally but is not produced syllable-initially.[19] s was among the earliest consonants to be used, and it remained stable. The nasals m and n appeared after the first twenty words. k was acquired slowly, with substitution by t for over half of this early period. Consonant harmony applies, optionally, to stop-plus-nasal and stop-plus-s combinations during this period:

[18] Between the ages of 10 and 15 months, only 11 words were recorded. Except for one item, forms showing active use of consonant assimilation began to appear from 1;3,20 on, when about 30 words had been used spontaneously.

[19] The consonants occurring in native (adult) ESTONIAN words include three stops (p, t, k), two fricatives (v, s), two nasals (m, n), two liquids (l, r), the glide yod, h, and four palatalized dentals (t', s', n', l'). The stops are lax and partly voiced intervocalically and word-finally when short; the orthography marks them b, d, and g in such cases, but there is in fact no contrastive voicing.

/pIm/ 'milk' → mi:m - pim: (contrast /puM/ below)
/tantsi/ 'dance' → sa|si - ta|si

Where the initial consonant is k or v, assimilation to a following stop or s is obligatory (or v may be deleted).

Harmony	No Harmony
/kleiT/ 'dress' → tɛt·	/puM - pëM/ 'boom' → pim: - pi
/kIsu/ 'kitty' → (first) ti, (later) ši:š· - ši:s - ši·su - ti·t'u	/maNi/ 'proper name' → man·i
/veT/ 'water' → tɛt: - ɛt:	/parT/ 'duck' → pat· - pa:
/vO.ti/ '(to) bed' → po·t́·	/piS/ 'pee' → pi̥s
	/teist/ 'other' → tis
	this → tis

In this early period active consonant assimilation can be seen to come gradually into use, after several months of slow increase in word-production constrained by limits on possible consonant (and vowel) combinations (see Vihman 1976: 233ff). We know which consonants were difficult for Virve, based both on delay in attempting adult words which include them (e.g. only two include a liquid by 1;4,12) and on the child's use of simple substitution (t for k), deletion (cf. vett, above) or assimilation to handle them. Against this background, we note the use of the following processes over the period ending at 1;11:

1. Liquids and v are assimilated or deleted until 1;10. Medially, these segments assimilate to word-initial stop or nasal, where no other consonant follows:

/prAvo/ 'bravo' → papu (1;3)
/karu/ 'bear' → ka·u - kaɣu (1;5)
/kivi/ 'stone' → kiki - kip·i (1;4)
/ma.hla/ 'juice (obj.)' → mahma (1;5)
/priLit/ 'glasses' → pi·pi (1;5)

Where a stop or nasal follows, it is the preferred goal of assimilation:

/palun/ 'please' → panun (1;6)
/sUr auTo/ 'big car' → su·t·ot·o (1;6)

Where there is no stop or nasal in the immediate environment (i.e. across a single syllabic nucleus), medial liquid or v is deleted or becomes a glide:

/elevan'T'/ 'elephant' → en· (1;4)
/hiLe/ 'proper name' → i· (1;8)
/orav/ 'squirrel' → oa (1;4)
/sü.Le/ 'into (your) arms, lap' → suija - süija (1;6)
/vælyas/ 'outside' → aijas (1;7)
/vEl/ 'more' → we· (1;5)
/üles/ 'up' → üös (1;7)

Where yod follows a medial liquid, the liquid is deleted:

/palju/ 'much, many' → paju (1;6)
/(vIna-)ma.rja/ 'grape (obj.)' → maj·a (1;5)

and word-final liquids are deleted as well, even after an initial stop:

/koer/ 'dog' → koa (1;4)
/pëL/ 'apron, bib' → pe (1;5)
(contrast /paL'/ 'ball' → pap· (1;4), paj (1;8))

Word-final v is retained in Virve's version only as part of the cluster [hv] (which is perceptually very close to [f]): cf. /ahv/ 'monkey' → [ahv] (1;3) and /hirv/ 'deer' → [ihv] (1;4).

Initial l and v assimilate to a medial nasal or stop just in case the nasal or stop is part of a consonant cluster; otherwise l or v is deleted (unless the word has more than two syllables: see below). Where a tense stop follows the nasal, it serves as the goal of assimilation; where the stop is lax, the nasal serves.[20]

/læhme/ 'let's go' → mǽhme (1;10)
/lamP/ 'lamp' → pamp· (1;5)
/la.psi/ 'children' → pa|si - pat^{s}i (1;5)[21]

[20] The form /jænKu/ 'bunny' → [nae|nu] (1;5) fails to fit into this formulation, which is in any case based on very few examples. The same is apparently true of Amahl's tendency to delete the nasal before a voiceless stop in a cluster, but retain the nasal and delete the stop when the stop is voiced (Smith 1973: 166). For both children the lax or voiced stop seems generally to be less "noticeable" (in Priestly's terms), or lower on a strength hierarchy (in Macken's terms), than the tense or voiceless stop.

[21] I derive Virve's version of /la.psi/ 'children (obj.)' and /la.ntši/ 'lunch (obj.)' via the harmonized forms *[papsi] and *[nVnsi], which seem to fit better into her system than the alternate metathesized mediating forms *[palsi] and *[nVl(t)si]. Reduction of the resulting consonant cluster is to be expected in either case.

/linta/ 'proper name' → nin·a (1;4)
/la.ntši/ 'lunch (obj.)' → næ|si (1;10) (see footnote 21, above)
/van'Ka/ 'proper name' → pan'ka (1;10)

/læpi/ 'through' → æpi (1;8)
/lei.pa/ 'bread (obj.)' → ejpa (1;5)
/vA.Ta/ 'look!' → at:a (1;8)
/va.Ni/ 'into the bath' → an:i (1;4)
(But cf. /vana-ema/ 'grandmother' → manaema (1;9), /lume-mEs/ 'snowman' → mumeme:s (1;10))

There are just two instances of harmony to a glide (note that w does not occur in adult ESTONIAN):

/lëvi/ 'lion' → wijwi (1;6)
/væ.lja/ 'to outside' → jaija (1;4)

Initial r is always deleted.

2. Labials assimilate dentals if the labial follows, until 1;10. If the dental follows, the consonant sequence is replicated as is (see Table 10, A and B). There are five exceptions, as noted on the table: /trapÉts/ and /pati/, /plIats/, /putel/, and /muna/, all but /trapÉts/ cases of unexpected assimilation (in the "wrong" direction in the case of /muna/). One further special case is presented by the word /puTru/ 'porridge,' which Virve somehow managed to assimilate in both directions, combining the labiality of the initial consonant with the stop/trill medial unit to produce a segment I noted as ptr: [p͡trup͡tru] (1;5); by 1;6 the form was simply [put·u].

3. Labials assimilate velars until 1;8. Peek-a-boo is the sole exception (see Table 10, C and D).

4. Dentals assimilate velars until 1;9. Two early exceptions are /kOs/ and /ëi.kus/; at 1;9 Virve produced unassimilated forms for /kæes/ and /kæet/, inflected variants of the word /kæsi/ 'hand,' which is assimilated according to the rule, as is another inflected variant of the same word, /kæ.Te/ (see Table 10, E). It seems that here, as in the case of assimilation of liquids, syllable-initial consonants exert the strongest pull.

The sequence k - n shows the expected dominance of regressive over progressive assimilation at first, but at 1;8, when velars begin to assimilate labials (/prüki/) and dentals (in the sequence t - k), the direction of assimilation is reversed, and we find several instances of intervocalic and even word-final n → ŋ (which occurs only pre-consonantally in adult ESTONIAN).

Table 10. Virve's treatment of consonant combinations

	Harmony	No Harmony
A. Labial followed by dental		
p - t	/pati/ 'pillow' → papi - pai - pajpi (1;4) /plIats/ 'pencil' → pi·p·i (1;5) /putel/ 'bottle' → pupa (1;5)	/parT/ 'duck' → pat· (1;4) /pO.ti/ 'to the store' → po:ti (1;5) /pëter/ 'reindeer' → pëtel (1;10)
p - s		/poiS/ 'boy' → pos'· (1;5) /aPelsin/ 'orange' → apɔsi (1;5) /püksit/ 'pants' → pi|si (1;6)
p - n		/pirn/ 'pear' → pin· (1;5) it's a pin → səp·ín (1;5) /punane/ 'red' → punane (1;10)
m - t		/meT/ 'honey (obj.)' → mɛt· (1;5) /mesi/ 'honey' → mɛsi (1;5) /mO.si/ 'jam' → mo:si (1;5) /va.lmis/ 'ready' → masi (1;5) /mustat/'dirty (pl.) → mus·at (1;9)
m - n	/muna/ 'egg' → nuna (1;5)	/maNi/ 'proper name' → man·i (1;3) /maNa/ 'farina' → manta (1;10)
B. Dental followed by labial		
t - p	/tu.Pa/ 'into the room, to indoors' → pup:a (1;4) /tops/ 'cup' → pops (1;10) /tupa/ 'room' → pupa (1;10)	/traPÉts/ 'trapezoid' → tap·e·ts (1;7)
s - p	/su.Pi/ 'soup (obj.) → fup:i (1;7) /sEP/ 'soap' → fe:p (1;8)	/sApas/, /sApast/ 'boot' → sa:p, sa·p·at· (analogical) (1;10)
n - p	/napa/ 'navel' → papa (1;4)	
t - m	NO EXAMPLES	
s - m	/sEme/'seed'→ fe·me - se·me (1;7) /sÖ.ma/ 'to eat' → fö:ma (1;7)	/spinaT/ 'spinach' → se·mæt (1;10)

	Harmony	No Harmony
n-m	/nImO.ti-nImoti/ 'this way; that's the way!' → mi·mona (1;5) /minema/ 'to go' → mimema (1;10)	

C. Labial followed by velar

p-k	book → pʊp· (1;4) /prüki/ 'trash' → küki (1;8)	peek(-a-boo) → pík·(pù) (1;4) /pE.Kon/ 'bacon' → pe:kɔn (1;8) /paK/ 'package' → pak: (1;9) /piK/ 'tall' → pik: (1;8)
m-k	/makama/ 'to sleep' → ma:ma (1;4) /makap/ 'is sleeping' → mamak (1;7)	/miks/ 'why' → miks (1;9) Micky Mouse → mík·imàus (1;10)

D. Velar followed by labial

k-p	/kærpes/ 'fly' → pæs (1;6) /ka.mPsun/ 'sweater' → pa|su (1;5)	
k-m	/kaM/ 'comb' → pam: (1;5) /krE.mi/ 'cream (obj.)' → pe·mi - pi·mi (1;6)	/kolm/ 'three' → kom: (1;8) come → kam: (1;8) /komPu/ 'candy' → komp·u (1;10)

E. Velar followed by dental

k-t	/kleiT/ 'dress' → tɛt· (1;4) /kArT/ 'card' → ta:t (1;5) /ka.rTul/ 'potato' → ta|tu (1;5) /ka.tki/ 'broken' → ta|ti (1;4) /koT'/ 'bag' → tot: (1;5) /kütTe/ 'heating' → tüt·e (1;7) /kä.Te/ 'into the hand' → tæt:e (1;9)	/kæet/ 'hands' → kæet (1;9)
k-ts	/klotsit/ 'blocks' → to|si (1;5)	(/kaks/ 'two' → kats (1;8)) /kut'sʼuT/ 'puppy (obj.)' → kut'sʼut· (1;9)
k-s	/kIsu/ 'kitty' → ši:š - ši:su - ti·tʉ (1;3); ti:su (1;6) /kA.sa/ '(take) along' → ta:sa (1;5)	/kOs/ 'together' → ko:s (1;7) /ëi.kus/ 'right' → ëikus (1;8) /kuS/ 'where' → kus· (1;10)

	Harmony	No Harmony
k-s	/takasi/ '(go, take) back' → tasisi (1;5) /kaesi/ 'hand' → taesi (1;9)	/karÁ.ži/ 'to the garage' → ká:si (1;10) /kaees/ 'in the hand' → kaees (1;9
k-st	/kristi/ 'proper name' → tsitsi (1;4); ti|si (1;9); kis·i (1;10) (cf. /kut'sʼu/ 'puppy' → tsutsu imitation, 1;4)	
k-n	/kilP-koN/ 'turtle' → ti|ton: (1;5) /kiNas/ 'glove' → tin·as (1;5) /aKen/ 'window' → atɛn (1;5); akɛŋ (1;10) /kana/ 'chicken' → kaŋa (1;8) /kena/ 'nice' → keŋa (1;8) /kaNap/ 'carries' → kaŋ.ak (1;9) /koN/ 'frog' → koŋ: (1;10)	/ki.Ni/ 'closed' → kin·i (1;4) kleenex → kí·neks (1;10)

F. Dental followed by velar

t-k	/heat-ae.ka/ 'goodbye' → tata (1;5) /tütruK/ 'girl' → kiuk (1;8) /teKi a.La/ 'to under the blanket' → kek·i al:a (1;9) /(kaks) tü.Ki/ '(two) pieces' → (kaks) kük:i (1;9) /teki/ 'did (it)' → keki (1;10) thankyou → kæŋku (1;10)	/tIK/ 'pond' → ti:k·(1;4) /tiku/ 'snail' → tiku (1;5)
dž-g	jingle bells → tintupeu (1;10)	
s-k	/soKit/ 'socks' → so|si (1;5); sokit (1;7)	/šoKolAt/ 'chocolate' → sɔk: (1;10)
n-k	/nuKut/ 'dools' → nu|nu (1;5); nuk·u (1;10)	

Before 1;8 the sequence dental-velar results in assimilation to the dental or, in two instances, in exceptional absence of harmony (/tIK/, /tiku/). After 1;8 regressive assimilation obtains in all cases of dental/velar stop combination, with the single exception of jingle-bells, where we find [tintupeu] instead of the expected *[kiŋkupeu].

Of the constraints obtaining in the early period, then, the manner harmony requirement is applied only optionally already by 1;4, while place harmony is still actively maintained for certain combinations at 1;10. The word length constraint is relaxed in several stages. Among the first fifty words, only two have an adult model longer than two syllables -- /kìKeriKÍ/ and /paPakoi/ (see Table 11 for the complete long word data). Those adult words which were typically presented in reduplicated form, such as /aLo-aLo/ 'hello-hello (on the telephone),' bye-bye, or various animal sounds such as /auh-auh/ 'bow-wow,' /kòKoKoKó/ 'cut-cut-cut-cut (of hens),' were invariably reproduced without the reduplication: [ao], [paj], [au], [kɔ](see Vihman 1976). At 1;4 Virve attempted five longer adult words, reducing all to one or two syllables. At 1;5 the first trisyllabic child forms appeared. Of the adult models with three consonants as well as three syllables (counting clusters as single consonants), Virve may have perceived, and in any case produced, those with initial h or r, which she generally deleted, as having only two (/heat-ae.ka/, /repane/), and the same was true of /aPelsin/ with its final nasal in unstressed syllable. It's a pin was an ephemeral form, apparently a delayed imitation (used just once, but in context) of an utterance remembered from the diaper-changing routine at the day care center. The remaining forms, /panÁ.ni/, /takasi/, /teist ri.nta/, and /nImoti/, pose different kinds of problems.

Table 11. Virve's long words

1;2 /kìKeriKÍ/ 'cock-a-doudle-doo' → tìtí:
1;3 /paPakoi/ 'parrot' → (pa)wawey: (1;4) pa
1;4 /panÁ.ni/ 'banana (obj.)' → pa·ni ~ ma·ni
/kael-kirjaK/ 'giraffe (lit. spotty-neck)' → kak·i
/elevan'T'/ 'elephant' → en·
/makama/ '(to go) to sleep' → ma:ma
peek-a-boo → pík(pu)
1;5 /aPelsin/ 'orange (fruit)' → aṕ·əsi (1;3 imitation: apwə)
/panÁ.ni/ 'banana (obj.)' → pá·nini
/eiTáha/ 'don't want' → ejtáha
/heat-ae.ka/ 'goodbye' → tata
/i.stuta/ '(to want) to sit' → it:uta
it's a pin → səp·ín
/nI mO.ti ~ nImoti/ 'this way, that's the way' → mi·mona
/repane/ 'fox' → epa (cf. /hopu(ne)/ → ɔpu (1;3))
/takasi/ '(to go, take) back' → tasisi
/teist ri.nta/ '(to want to nurse) the other breast' → teisín·a
1;6 /leNuKiT/ 'airplane (obj.)' → nanunu
/mAsiKas/ 'strawberry' → ma·sini

1;6 /porkantiT/ 'carrot (obj.)' → pɔnini
/rAmaTuT/ 'book (obj.)' → ma·nunu (cf. /rAmaT/ 'book' → a· (1;5); also /rAmaTuT/ → ma·nut· (1;9), /rAmaTu peal/ 'on the book' → ma·nu peaj (1;9))
/rosinat/ 'raisins' → o·sini
/virsiKuT/ 'peach (obj.)' (?) → is·uya (/sʊi.a/ may have been intended)
1;7 /makus-toiT/ 'dessert (lit. sweet food)' → masusu
/mesilane/ 'bee' → mesini
/piKali/ 'full length, lying down' → pik·ak·aj
/viKerKAr/ 'rainbow' → vik·ak·ay
1;8 /mín̄e áera/ 'go away' → miáe·
/pitšama/ 'pajama' → pisama
1;9 all fall down → ɔ·fɔ·dáwn
/nU.tli su.Pi/ 'noodle soup (obj.)' → nu·dit sup:i
/pitu-kinkat/ 'party shoes' → pitutkiŋka
/tun't' (ae.ka)/ 'an hour('s time)' → tunti (kaeka)
Viviane → mimian
/jOnista/ 'draw' → nonini
/mëistaTus/ 'puzzle' → misusu
/mëistaTuse/ 'puzzle (total obj.)' → misuse
1;10 /ei óle/ 'is not' → ej óle
/karÂ.ši/ 'to the garage' → ká:si
/hæit pʊhi/ 'happy holidays' → haeit pʊhi
/intjÂ.nlane/ 'Indian' → éante
jingle bells → tintupeu
happy (birthday to you) → hæ̀p·i (tów̌s:ei tʊ̀u)
Mickey Mouse → mík·i màus
patty-cake → páelik·èyk
/punane/ 'red' → punane
/šoKolAt/ 'chocolate' → sɔk:
/unustas/ 'forgot' → unus
/Utiseit/ 'news' → u·tisi
/viTamín̄it/ 'vitamins' → mitan - mit·
/ʊ̀le ɛ́la/ 'over the shoulder' → ʊ̀lɛ́la

In /teist ri.nta/ we have place agreement across the consonants in the adult form; Virve's version maintains all three syllables and three consonants. In /nImoti/ the nasal dominance in the adult model is extended in the child version, so that the long word is further complicated by a place contrast, but not a manner contrast (note that m - n was the earliest place contrast Virve used, in /ma-Ni/, at 1;3, and compare /vana-ema/ 'grandmother' → mánaèma (1;9)). For /panÂ.ni/ and /takasi/, with their combination of place and manner contrasts, including the difficult dental/velar combination, Virve invented an idiosyncratic strategy reminiscent of the

bisyllabic word strategy described in Priestly 1977.[22] It involves maintaining the syllable count and overall syllabic structure of the adult word, while abandoning any attempt at segmental fidelity for all but one of the unstressed syllables.

In the following month we have five more instances of the trisyllabic strategy (and no other new long words, except possibly /virsiKuT/). It is clear that nasals are (perceptually?) dominant here (see Table 11). The form [ma·sini] (← /mAsiKas/) is anomalous; for a while it seemed that [-ni] was acquiring morpheme status as a marker of desirable foods, but no new items were added to the list. At 1;7 four new words, one the quadrisyllabic /mesilane/ (not a harmony form), were produced; at 1;9 two more words reflecting the trisyllabic strategy, /jOnista/ and /mëistaTus/, completed the list, while as of 1;8 Virve produces more and more long words (several of them compounds) which fail to be adapted to the pattern: cf., for example, /pĺtšama/ and, at 1;10, /intjÂ.nlane/, /punane/, /Utiseit/.[23]

In reviewing the steps in Virve's progress from one- or two-syllable to longer words, I am inclined to doubt that she was in any sense "aware" that she was attacking a long — or problematic, challenging — word at 1;2 when she produced /kĺKerikĺ/ (as [titĺ], but with a level/high-falling intonation taken from the adults' stereotyped imitation of a cock's cry). By 1;4, on the other hand, she may well have perceived as long the few long words she attempted,

[22] Amahl's strategy for dealing with unstressed initial syllables (Smith 1973:171ff) falls in the same category, though Amahl drew on ENGLISH derivational morphology rather than on the phonological context for a dummy syllabic shape.

[23] The number of multisyllabic ENGLISH compounds or bits of songs or games that Virve began using at this time, without shortening or applying any kind of harmony to them, is surprising. It could be argued that these set phrases, none of which can have had any "meaning" for Virve beyond the fact that they were frequently recited at the day care center (to which she had returned after a three-month absence, a few weeks earlier), were not filtered through her usual phonological system, but were repeated as closely as possible from some kind of aural store. The same kind of interest in, or talent for, mimicking wholly unintelligible foreign phrases was apparent much later when, for example, she could repeat at dinner a CANTONESE phrase, down to the tonal contour, that she had heard that day at lunch (she was nearly four at the time).

but she seems to have encoded as noise the syllable adjacent to a liquid or velar when the word has more than two syllables, yielding bisyllabic forms in the case of /kael-KirjaK/ and /makama/, a monosyllable in the case of /elevan'T'/ (cf. also /karÂ.si/ at 1;10).[24]

By 1;5 we can see that the constraint on word-length has been relaxed sufficiently to allow some trisyllabic forms to be produced, presumably also reflecting improvements in perception and encoding of underlying forms. Where the segments themselves present difficulties, independent of the length difficulty, the processing space seems to be insufficient to allow full recording of all three syllables. Instead, a rough sketch is made to serve, with an accurate syllable count and some indication of vowel content. The form [pa·nini] (← /panÂ.ni/) may be based on Virve's own earlier output form [pa·ni], with the addition of a reduplicated syllable as a kind of patchy repair job to come closer to the trisyllabic adult model; in that case, the choice of reduplicated vowel in [tasisi] (← /takasi/) may have been influenced by [pa·nini]. But it is equally likely that the contrast a -i was encoded in both cases as the most striking aspect of the total vocalic contour of either word.

The underlying forms for these words and those used in the following three months might be stated as in Ingram 1974: /takasi/ → [taSsi], /porkantiT/ → [poSni] (where S = syllable), together with a rule: Reproduce S as identical to the unstressed syllable of the underlying form: [taSsi] → [tasisi], [poSni] → [ponini].

The difficulties which led Virve to treat one of the unstressed syllables in this cavalier fashion are similar to those Macken describes for Jesus ("the simultaneous realization of complex syllable and consonant structures exceeded J's production abilities" p.56). But it remains a moot question whether the source of the difficulty lay in production, perception, or, as I am inclined to believe, encoding.

Some of Virve's consonant harmony forms persisted for a long time after the period covered by this study, while new forms continued to appear even as her inventory of segments and syllable shapes grew. The word /va.lmis/ 'ready,' for example, which she used at 1;5 in the shape [mais], followed by [mas'] at 1;6 and

[24] Compare Linda's pattern of syllable loss: "In all cases in which the second vowel is lost, that vowel is either preceded or followed by /r/, the most difficult of consonants for Linda" (Vihman 1971: 71).

[masi] at 1;10, later developed the shape [malmis], which continued to be used well into Virve's fourth year, when initial v was otherwise well established.

Virve used one additional kind of consonant harmony as of 1;7, when she began to include the final consonants which serve as inflectional markers. At 1;7 two nominative plural forms /-t/ show harmony: /jænKut/ 'bunnies' → [jǽŋk·uk], /markit/ 'stamps' → [mǽŋkik]. Only one such form appeared later (/soKit/ 'socks' → [sok·ik] at 1;9), but the marker for third person singular present tense, /-p/, at first alternated between all three stops:

1;7 /tÖ.Tap/ 'works' → tö·tat·
/istup/ 'sits' → it·ut·
/kaNap/ 'carries' → kaŋ·ak
/makap/ 'sleeps' → mamak, makak·
/prOvip/ 'tries' → po·pip

By 1;9 the marker was [t] for Virve unless the preceding consonant was [k]:

1;9 /ai.Tap/ 'helps' → ajt·at
/aNap/ 'gives' → an·at
/hü.Pap/ 'jumps' → hüp·at
/kæip/ 'goes' → kæjk
/lǿep/ 'reads' → joet
/næep/ 'sees' → næet
/pánep/ 'puts' → pánet
/sÖp/ 'eats' → sö:t
/tEp/ 'does, makes' → te:t

At 1;10, when Virve produced her first third-person plural form, she extended the harmony still further: /tÖ.Tavat/ 'they're working' → [tö·t·at·at]. By this time she was tending to mark the singular with [t] even after [k]: cf. /kuKup/ falls' → [kuk·ut] (1;10). Forms in [p] finally began to appear at 1;11, regardless of medial consonant -- e.g. /læhep/ 'goes,' /makap/ 'sleeps,' /mænkip/ 'plays.' It should be mentioned that the second person marker is /-t/, so that Virve may have interpreted the adult alternation between /-t/ and /-p/ as phonological rather than semantic. She never produced a nasal for the third-person, however, though the first person marker /-n/ must also have presented a puzzle to her at this time.

6. Consonant Harmony in Adult Speech

We have seen that consonant harmony may serve different purposes for different children. Most narrowly, it can provide a source

of substitutes for a sound the child cannot produce (l for Canta, r, l, and s for Linda, liquids for Virve, s for Amahl). In other cases it may lower the number of uncontrolled variables, allowing the child to focus on a new segment or an extra syllable (Jesus, Sofia, Virve). As Lewis suggested, it is a sound acquired later that will be assimilated to a sound acquired earlier in most of those cases where the sound affected is well-established in the child's system, as in the assimilation of k to t by both Jiři and Virve, but the reverse also occurs, as when Jiři and Virve produce forms showing assimilation of t to k.[25] Further, the assimilation of a single consonant to a cluster (cf. Sofia, Virve) suggest that Priestly's notion of the "most noticeable" sound may well describe the target for some instances of consonant harmony. Clearly no simple notion of "ease of articulation" will greatly advance our understanding of the phenomenon.

Consonant harmony has been cited as one of a small number of innate tendencies representing "universal characteristics of language," "which the child has to escape from in order to learn his language" (Smith 1973: 206). There are in the present study two kinds of evidence that seem to run counter to this way of thinking. First, though consonant harmony is widespread among children and is of considerable importance for some of them, it is not in fact universal, unless the occasional occurrence of a harmonized form, in the speech of children with less than 5% harmony in their lexicon, can be taken as a sign of the child's struggle to escape from a "universal template" (Smith, ibid).

Secondly, consonant harmony is not necessarily applied to the earliest forms a child produces, as was most obvious in Jiři's case, described earlier. The two words exhibiting dental-velar contrast in Virve's lexicon also seem to have been produced before her rule of regressive assimilation in case of dental/velar stop combinations had quite jelled. The velar stop was already being assimilated to following dentals (though k did occur outside that context), but no solution had yet been found for the opposite order. The sequence t - k was generally avoided; /tIK/ and /tiku/ were

25 Both Linda and Virve assimilated yod to l as soon as they had begun to produce l. Thus, for Linda, /ja.lka/ 'onto the foot' → [jal:ka] at 1;7, but [lal·ka] a month later (and still at 1;10); for Virve, see footnote 29. These are further "exceptions that prove the rule" for Lewis' principle. Lewis himself provides several exceptions, but finds that the rule holds in 77% of the cases of harmony that he recorded.

produced without assimilation, and /heat ae.ka/ 'goodbye,' lit. '(have) a good time' was produced with dental assimilation. When, at 1;8, Virve began to generalize her rule of regressive harmony to cover the case of t - k, several new words were produced. The same point is made in Kiparsky and Menn 1975: "In the Daniel Menn corpus, for example, the first twenty-nine words ... showed no consonant harmony, and then consonant harmony quite suddenly appeared, as the cornerstone of the child's system of phonological rules."

The appearance of a particular kind of rule after the production of forms which fail to conform to the rule, and which may be closer to the adult model — as in the case of /tIK/ and /tiku/ or, for Jesus, tasa, which changed over time from [tata] to [tasa] to [sasa]: Macken 1976: 54; see also the example from Linda in footnote 25, and a further example, taken from a GERMAN-speaking child recorded at the end of the last century, in Ferguson 1977: 29 — is also evidence against Stampe's hypothesis, that the rules a child uses represent the natural unfolding of innate processes, automatically applied from the onset of speech until the child has gained sufficient experience with the language spoken to him to know which ones to "limit or suppress" (Stampe 1969: 1973). As Lise Menn has pointed out (1974), "it is not the case that ... the child initially has few phonemic contrasts because so many natural processes are operating. ...On the contrary, the evidence indicates that he speaks very little at the beginning -- and hence displays few contrasts — because he does not hit on an orderly way of discarding enough information for him to be able to handle the words" (p. 8). Consonant harmony is a natural successor strategy to lexical selection, or avoidance of words with difficult segments or segment combinations. Once a child's vocabulary and commitment to verbal communication reach a certain point, restriction of his active vocabulary to certain phonological shapes is no longer a statisfactory strategy, and recourse will now have to be had to substitution, deletion, or assimilation. Like Menn, I believe the evidence shows that the phonological processes a child uses are not "latent and ready to spring into action" from the start, but have to be invented (Menn 1974; see also Ferguson 1977: 30).

Basic to Smith's and Stampe's theories is the analogy between phonological processes used by children and those found in adult language. Though consonant harmony was found here not to be a universal of child phonology, it did in fact play a significant rôle in the phonological system of several of the children. Yet no such rule is found in the adult languages these children are learning to speak -- CZECH, ENGLISH, ESTONIAN, SPANISH -- nor in most

of the adult languages of the world, where consonant harmony figures only very exceptionally.

In the present as yet incomplete inventory of rules stored in the Stanford Phonology Archive, three out of 88 languages (or 3%) include a rule that may be roughly characterized as a consonant harmony rule.[26] One rule of MOROCCAN ARABIC involves assimilation of an alveolar fricative to the palato-alveolar position when a palato-alveolar fricative occurs later in the word (Abdel-Massih 1973); two variable rules of NAVAHO involve the same classes of segments, in both progressive and regressive assimilation at a distance, with likelihood of the assimilation taking place, decreasing as the distance between the two consonants involved increases (Sapir and Hoijer 1967). Finally, an automatic morphophonemic rule of ALAWA partially assimilates a retroflex consonant to a palato-alveolar (the retroflex becomes alveolar) under certain conditions (Sharpe 1972).

It is interesting to note that of four adult rules of consonant harmony (out of 850 rules coded in the Archive — or 0.5%) three involve fricatives -- which account for only 8% of the cases of full regressive assimilation in the present study, 5% of the cases of full progressive assimilation. The low incidence of full assimilation to fricatives among these children is easily understood: for many of the children, fricatives are difficult segments which are typically deleted or replaced by another segment. That a disproportionate number of instances of consonant harmony in adult language should involve fricatives assimilating to one another in place of articulation might be viewed as also stemming from the fact

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26 A rule governing the occurrence of pharyngealized consonants in MOROCCAN ARABIC is sometimes characterized as consonant harmony, since it serves the same classificatory function for stems that is associated with rules of vowel harmony. But the vowels intervening between the pharyngealized consonants are also paryngealized in this case (cf. Abdel-Massih 1973:5), so that I would rather view this as a prosody — like that affecting the occurrence of oral and nasal stops (and vowels) in GUARANÍ (Gregores and Suarez 1967) -- than as consonant harmony in the sense I have been using it here. The spread of retroflexion in SANSKRIT, which changes an apical nasal to a retroflex, has also been termed a prosody (Allen 1953: 66). Whether the vowels intervening between the consonants involved were also "r-colored" is not known; this may be another example of true adult consonant harmony (i.e. assimilation at a distance).

that fricatives are difficult segments. Their articulation requires delicate articulatory adjustments, and the manner of articulation difficulty is perhaps compounded when two adjacent points of articulation are to be distinguished in a single syntagmatic unit. It may be that s - š (and other combinations of the alveolar and palato-alveolar fricatives) represent, for adults, the same kind of difficulty that p - t, t - k, etc. apparently present for children.

The friction created in producing spirants can be considered a "mark," which renders a sound more complex and thus less favored (Greenberg 1966: 14; 1969: 476); within the marked series, of course, one expects to find less distinctions ("the number of phonemes with the marked feature is always less than or equal to the number with the unmarked feature but not greater," Greenberg 1966: 59), but this in itself will not explain why the subclass of sibilants, of all sets of neighboring sounds within a marked class, should stand out as the one subject to rules of non-contiguous consonant assimilation in adult language.

It has been observed that "in ENGLISH, voiceless fricatives tend to interact in tongue slips more frequently than plosives and other consonant-categories" (Laver 1973: 137). Laver hypothesized that "the more complex and delicate the adjustments for a particular class of sounds, the greater the likelihood of members of that class being mutually involved in tongue slips. One might expect that fricatives need more precise muscular control than plosives..." (ibid.).

Some of the other regularities which have been found to characterize phonological slips of the tongue are reminiscent of our data on consonant harmony in children. For example, in an analysis of "phonemic speech errors in spontaneous DUTCH," Nooteboom (1973: 147) found that anticipation accounts for about 75% of the errors, perseveration for 20%, and transposition for only 5%. This may be compared with the incidence of regressive (or anticipatory) vs. progressive (or perseverative) harmony in our data (see Table 9), in which the former was clearly dominant, though not by as wide a margin as in Nooteboom's speech error data. I have not calculated the incidence of metathesis (or transposition) of consonants in the children's speech, but it certainly is no greater than 5% of any child's lexicon.

In his article on spoonerisms, or transpositions, Mackay (1973: 174ff) investigated the phonetic similarity of the consonants which interact in the corpus he analyzed (Meringer's GERMAN corpus, published at the end of the last century, which included 124 "involuntary spoonerisms"). Mackay finds that the consonants interchanged

have the same value for "openness" (both stops, both fricatives, or both sonorants) in 65% of the cases (vs. 36% chance similarity, based on the frequency of these types in natural speech), and they had the same value for nasality in 93% of the cases, vs. 65% chance. Place of articulation, on the other hand, tended to differ, with labials and velars showing a tendency to interact in particular. The analysis showed only 10% same place of articulation, vs. 26% chance. In our consonant harmony data we are not, of course, looking at spoonerisms or exchange of consonants, but we can consider both the consonants involved in the assimilation, the affected consonant and that which replaces it, to see how commonly manner vs. place of articulation is held constant. Table 12 gives the results of that analysis. It seems reasonable, first, to eliminate the cases involving liquids from the children's data, if we wish to compare the data on assimilation in children with speech errors in adults, since liquids are acquired late by most children and the inclusion of assimilatory substitutes for liquids biases the data in the direction of manner of articulation change.

Table 12. Relative proportion of types of consonant change involved in assimilation

1. Place of articulation change, manner held constant

		Eliminating liquids
Amahl	28%	36%
Virve	46%	59%
Other children	31%	40%
All children	35%	45%

2. Manner of articulation change, place held constant

Amahl	30%	27%
Virve	21%	17%
Other children	28%	19%
All children	27%	20%

3. Both place and manner change

Amahl	42%	36%
Virve	33%	24%
Other children	40%	41%
All children	39%	35%

Focussing on the results after the cases involving liquids have been set aside, then, we see that the two consonants share manner of articulation, but differ in place, in 45% of the cases; place of articulation is shared, but not manner, in 20% of the cases; and both change -- i.e. the two consonants involved are not notably similar -- in 35% of the cases.[27]

Other characteristics of adult slips of the tongue cannot be compared with consonant harmony in children because of the more primitive shapes on which the latter are based. For example, the consonants that interfere with one another in slips of the tongue overwhelmingly tend to share syllable position (98% of the cases in Mackay's data (vs. 30% chance: p. 177), 100% in Nooteboom's (p.149); see also Boomer and Laver's results in the same volume, p. 126). But consonant clusters tend to be reduced to a single consonant in children's speech, so that syllable-final consonants are relatively rare, and when clusters do occur, it is not syllable-position but articulatory type that appears to determine the kind of assimilation that will take place, if any (with liquids and lax or voiced stops disfavored: see footnote 20 above). Virve's tendency to assimilate (word- or syllable-initial) k to t before syllable-initial but not syllable- (and word-) final t or s does provide one parallel, however (see Sec. 5.3.2 above). Similarly, the tonic syllable tends to be involved in adult slips, as do open-class words in general, which typically dominate their "tone-groups" (see Boomer and Laver p. 126; Nooteboom p. 150). But only the open class words are normally used by children, at least in the earliest stages of language acquisition, and unstressed syllables are often omitted as well. These are, of course, further indications or consequences of the psychological or perceptual salience of stressed words and syllables.

One crucial difference in kind between slips of the tongue and the products of consonant harmony rules in children is their relative durability. Adults, aware of the gap between their production and the word-shape they intended, frequently correct themselves, and in any case would not be expected to produce the same slip twice, even in subsequent uses of the exact same word or phrase in which the slip appeared. The children, on the other hand, often use a consonant harmony form for some months. It is obvious

[27] Liquids are affected in roughly one quarter of the cases in each of our data-categories -- Amahl, Virve, and the other children taken together (23%, 29%, and 22%, respectively).

from this fact alone that the children's use of consonant harmony processes is not due to undetected errors in the "neuro-linguistic program-planning" of an utterance (to use Laver's terminology: 1973:134), still less to a slip in the course of "myodynamic execution of the utterance" (ibid.); rather, these processes make up a part of the child's phonological organization -- part of his system, in short.[28] Once the child has gained mastery over the difficult segments, segment sequences, and syllable-strings which the assimilated forms were created to avoid, these forms gradually disappear, as the child revises his entire system in the light of his new competence. The revision is not automatic nor instantly achieved, however; "new" and "old" forms typically co-exist for a time (see the discussion of "the lexical parameter in sound change" in Ferguson and Farwell 1975: 429ff).[29]

A second parallel between consonant harmony in children and in adult speech was mentioned in passing earlier, in connection with Jiři's use of harmony apparently for the mere pleasure of producing the forms in question. While it would be difficult or impossible to prove an aesthetic function for harmony in children, cases such as Jiři's or Virve's, in which the use of harmony long outlived other signs of phonetic immaturity or incompetence, seem to me to suggest such a function, at least secondarily. For adults, alliteration is very common in oral poetry, it is sometimes used in written

[28] It should be noted that slips of the tongue do occur in the speech of children as well: see the example in Vihman 1971: 84, footnote 7, where the child's efforts at self-correction provide clear evidence of a monitoring function at work.

[29] For example, at 1;9,13 Virve still had not begun producing l: /liL (oN) peal/ 'there's a flower on it' → [jij peaj]. By 1;10,2 she was using l in several new words: /koala/ 'Koala bear,' /üle ëla/ 'over the shoulder' (→ [ülëla]), /ei ole/ 'is not,' and in some old ones: /seLeka/ 'with this,' /kala/ 'fish,' but not in others: /laps/ 'child' still → [aps - japs]. At 1;10,3 she produced the new harmonized form /lume-meM/ 'snowman' → [mumemem:], though the day before she had produced an initial (assimilated) l in /jæ.Le/ 'again' → [læl:e], and on the following day she was able to use an initial and medial l in /li.Li/ 'flowers (obj.),' as well as to imitate the name /hiLe/ accurately, which she had been pronouncing [i:]. The verb 'to push' showed alternation (also at 1;10,4) between initial glide: /lü.Kap/ 'pushes' → [jük:ak] and l: /lüKaTa/ 'to push' → [lük'at'a].

verse, and it is a noticeable factor in formulaic expressions in many languages (cf. the ENGLISH examples given earlier, and such ESTONIAN expressions as võhivõõras 'total stranger,' in which võhi-, like kith in kith and kin, is an archaism used in no other such construction). In verse, "the most common type of alliteration is that of initial sounds, especially of consonants or consonant groups ... it is more prominent in the poetry of languages with stress accent (especially where the accent regularly falls on the first syllable, as in FINNISH, ESTHONIAN and CZECH) and in verse which is meant to be spoken rather than sung or chanted..." (Goldsmith 1965).

Goldsmith also notes that "in languages with tone systems or quantitative structures [alliteration] is either completely absent (as in CHINESE poetry, which is based on syllable count and tone patterns), or used rarely and only for very special emphasis (as in SANSKRIT ... and in JAPANESE...)" (ibid.). One cannot help but be struck by the fact that two of the CHINESE children in our sample made virtually no use of consonant harmony, while the third, Canta, made very narrow and limited use of it. A larger sample of children speaking a broader range of phonologically dissimilar languages would have to be studied before we could decide whether or not relative use of consonant harmony is in fact to some degree dependent on the language a child is learning.

Goldsmith speculates that "alliteration was partly a mnemonic aid to primitive oral recitation...," and adds, "the fondness for alliterative formulas is still noticeable in a language like ENGLISH, which uses them easily and habitually in and out of poetry" (ibid.). In a detailed statistical study of Structural Alliteration in Finnish, Leino found that "alliteration increases (or lack of alliteration diminishes) the average active life of a saying" (1970: 319). The psychological basis for our "fondness for alliterative formulas," as well as for rhymes and assonance, has not, to my knowledge, been explored. Goldsmith's suggestion that alliteration serves as a mnemonic aid, supported by Leino's independent results, which point in the same direction, seems intuitively satisfying, however. Setting this notion beside Menn's hypothesis that consonant harmony serves to increase "the redundancy of the articulatory instructions necessary to produce the child's forms" (1974: 3; cf. also Menn 1976b), we may expand on Menn's argument and suggest that the redundancy of consonant harmony forms also in some sense simplifies the child's mnemonic problems in recording and storing a rapidly growing lexicon.

APPENDIX I

Raw scores and percentages for five categories*

	Total no. of words analyzed	A	B	C	D	E
CHINESE						
Canta	310	5% (14)	52% (162)	7% (22)	34% (107)	2% (5)
Didi	109	3% (3)	36% (39)	12% (13)	50% (54)	
Lolo	334	1% (4)	54% (182)	7% (22)	38% (126)	
ENGLISH						
Amahl	225	32% (71)	33% (74)	14% (32)	16% (37)	5% (11)
Hildegard	322	5% (16)	35% (112)	30% (96)	28% (89)	3% (9)
Jacob	150	9% (14)	25% (38)	36% (54)	29% (44)	
ESTONIAN						
Linda	364	9% (32)	57% (209)	7% (26)	27% (97)	1% (3)
Virve	372	25% (92)	38% (143)	12% (46)	24% (88)	
CZECH						
Jiři	300	11% (33)	69% (206)	3% (9)	17% (52)	
SLOVENIAN						
Maja	138	1% (2)	72% (99)	9% (13)	17% (24)	
Tomaž	320	3% (9)	74% (238)	4% (14)	18% (59)	
SPANISH						
Jesus	144	21% (31)	43% (62)	14% (20)	21% (31)	
Sofia	152	18% (26)	54% (83)	3% (5)	25% (38)	

*Figures in parentheses indicate the number of words analyzed as belonging to that category. All fractions of percentage points are rounded off to nearest whole number.

APPENDIX II

Examples of consonant harmony forms
(drawn from coincidental lexical overlap between children)

Key: children's names: A = Amahl, C = Canta, H = Hildegard, J = Jesus, Ja = Jacob, L = Linda, M = Maja, T = Tomaž, V = Virve; classification: F = full, P = partial; r = regressive, p = progressive

Language	Adult forms	Harmony forms		Classification
ENGLISH	book	Ja	bʌp	P, p (labial)
		V	pʋp.	P, p (labial)
	doggie	Ja	ʌdʌdi	F, p (d)
		(H	doti: scored E)	
		(A	ġɔgi: stage 2)	
	grandpa	H	ŋæŋæ	P, r (nasal); P, p (velar)
	guampa	C	pampa	F, r (p)
	spoon	Ja	pom	P, p (labial)
		J	pom	P, p (labial)
	thank you	Ja	gɛgu	F, r (g)
		A	ġɛgu	F, r (g)
		H	dada	F, p (d)
		V	kæŋk·u	F, r (k)
	tiger	A	ġaigə (see SPANISH)	F, r (g)
ESTONIAN	/kiNas/ 'mitten'	V	tin·as	P, r (dental)
	/kintat/ 'mittens'	L	kiŋkat	F, p (k)
	/kleiT/ 'dress'	V	tɛt·	F, r (t)
		L	kik·	F, p (k)
	/lamP/ 'lamp'	V	pamp·	F, r (p)
		L	mamp·	F, r (m)
	/lint/ 'bird'	V	nint	F, r (n)
		L	nint	F, r (n)
	/napa/ 'navel'	V	papa	F, r (p)
		L	mapa	P, r (labial)
	/soKit/ 'socks'	V	sɔ|si·	F, p (s)
		L	kuk: i	F, r (k)
	/su.Pi/ 'soup (obj.)'	V	fup: i (see SPANISH)	P, r (labial)
SLOVENIAN	bicikel 'bicycle'	M	bibi	F, p (b)
		T	bibi	F, p (b)
SPANISH	casa 'house'	J	kaka	F, p (k)
	casas 'houses'	S	kakəs	F, p (k)
	gato 'cat'	J	tata	F, r (t)
		S	kaka	F, p (k)
	jugo 'juice'	J	puwu	P, r (labial)
		S	ɸuwo	P, r (labial)
	sopa 'soup	J	pwopa (see ESTON.)	F, r (p)

Language	Adult forms	Harmony forms		Classification
SPANISH (cont.)	tenedor 'fork'	J	tədáðə	F, r (d)
		S	əbədáɹ	P, r (stop)
	tigre 'tiger'	J	kíɣə (see ENGLISH)	P, r (velar)

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Universals of Tone

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ABSTRACT

Three areas of phonological universals of tone are considered: inventories of tone, tone rules, and interaction of tone with non-tonal features. It is proposed that five is the maximum number of phonemic tone levels that may contrast, and these five levels represent a phonetic scale. Languages with less than five levels use a smaller portion of the scale, with their marked tones generally drawn from the upper part. Contour tones do not occur unless at least one level tone also occurs in the system, and bidirectional contours only occur if simple contours also occur. These constraints on contours are related to parallel constraints on sequences of level tones. Tonal assimilation and related processes of displacement and contraction are discussed, and some asymmetries in their operation are explained by the usually marked status of high tones. The unusually frequent occurrence of rules of tonal polarity is pointed out. The final section comments on phonetic and phonological relationships of tones with adjacent consonants and with features of vowels.

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