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External Sources of Individual Differences? A Cross-Linguistic Analysis of the Phonetics of Mothers' Speech to 1-Year-Old Children

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Wide individual differences in early word production characterize children learning the same language, but the role of specific adult input in this interchild variability is unknown. Sampling the speech of American, French, and Swedish mothers (5 in each language group) to their 1-year-old children, this study analyzed the distribution of consonantal categories, word length, and final consonants in running speech, content words, initial consonant of content words, and target words (adult models of words attempted by the children) as well as the children's own early words (from age 9 months to about 18 months). Variability is greater in child words than adult speech, and individual mother–child dyads show no evidence of specific maternal influence on the phonetics of the child's speech.

To investigators concerned with the formative factors affecting a child's entry into speech production, the phonetic properties of the adult language to which different normally developing children are exposed are of interest for two main reasons. First, the balance among universal factors (biological or physiological constraints), ambient language effects (the influence of the specific adult language), and such individual (motor and cognitive) factors as vocal exploration and the construction of phonetic plans or production schemata remains controversial. Several studies have provided persuasive evidence of ambient language influence on prelinguistic vocalizations and early words. Such effects have been demonstrated for infant use of vowel space at 10 months (de Boysson-Bardies, Hallé, Sagart, & Durand, 1989), for syllabic organization at about 1 year (de Boysson-Bardies, 1993), and for consonantal place and manner, vocalization length, and final consonant production over the period of about 9 to 18 months (de Boysson-Bardies & Durand, 1991; de Boysson-Bardies & Vihman, 1991; de Boysson-Bardies et al., 1992). Early intonational effects have also been reported (over the period of 6–13 months: Whalen, Levitt, & Wang, 1991; by about 18 months: Engstrand, Williams, & Strömquist, 1991; Hallé, de Boysson-Bardies, & Vihman, 1991). On the other hand, investigators' attempts to evaluate ambient language influence on the vocalizations of infants exposed to different languages by asking listeners to determine which infants were exposed to the listener's native language have yielded mixed results (for reviews, see Locke, 1983; Vihman, 1991). A representative phonetic profile of input speech is needed to identify specific ambient language effects.

The second motive for attention to the phonetic characteristics of the input is the pervasive finding of wide individual differences in phonetic preferences or production patterns across children (Ferguson, 1986; Schwartz, 1988; Studdert-Kennedy, 1986). Individual differences have sometimes been taken to provide support for a cognitive (Vihman, Ferguson, & Elbert, 1986) or linguistic (Goad & Ingram, 1987) account of phonological development, as opposed to a biological model (Locke, 1983). However, as Locke (1988) pointed out in a reply to Goad and Ingram, "Many of the so-called 'individual differences' in children's behaviour are undoubtedly an expression of their biological differences" (p. 665; see also Kent & Bauer, 1985; Vihman, 1993b).

It has sometimes been suggested further that variability in the speech addressed to children may account, if only in part, for the observed variability in early vocal production (e.g., Locke & Pearson, 1992). At least one study directly addressed this question through a comparison of the early phonological development of a pair of identical twins alongside that of 10 unrelated children (Leonard, Newhoff, & Mesalam, 1980); no fewer differences were found between the twins than across the other children. To our knowledge, however, the extent of variability across mothers within a single speech community has not so far been investigated directly.

With regard to the first question, one may appropriately ask what would constitute the most adequate way to characterize the adult language itself, as background to the study of ambient language influence. In earlier studies arising out of the Cross-Linguistic Project on Infant Vocalizations, a sample of the target words attempted by the children was used (e.g., de Boysson-Bardies & Vihman, 1991). This sample of word types was constituted from the words produced either spontaneously or as imitations by any of the 5 children in the four language groups included in these studies (English, French, Japanese, and Swe-

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dish). For that sample, words attempted in any of the six sessions analyzed for each child, extending from 9 months of age to the point when the child had about a 50-word vocabulary (14–20 months), were considered as target words for that child; the total number of different word types attempted by one or more children for each of the four language groups ranged from 96 (Japanese) to 120 (see database for present study in Table 1, presented later).

The advantage of using target words in studies of ambient language effects is that they necessarily reflect vocabulary that is salient to the child (as opposed to frequency counts based on adult conversation). Furthermore, they are easily obtained, once child words have been identified; no time-consuming transcription of maternal speech need be undertaken. However, a possible difficulty arises from the fact that this sample is not independent of the children themselves: Given the substantial literature on phonological constraints on children's selection of adult words to produce (Ferguson & Farwell, 1975; Leonard, Schwartz, Folger, & Wilcox, 1978; Schwartz, 1988; Schwartz & Leonard, 1982; Shibamoto & Olmsted, 1978; Stoel-Gammon & Cooper, 1984), the sample of attempted words must be assumed to reflect an intersection of adult language affordances and individual child preferences or phonetic proclivities. Because 1-year-olds' words are often quite remote from the adult language (deleting all but one consonant in a word, omitting final consonants, substituting dentals for velars and stops for fricatives, and so on), the child's choice of words to say (reflected by the target words) is not related in any straightforward way to the child's word forms as produced. Nevertheless, the relative contribution of child and adult factors to a phonetic profile of the adult language derived from an inventory of target words is unknown; most likely it differs across both individual children and various phonetic parameters. Combining the effects from 5 children learning the same language can be expected to cancel out much of the individual child factor, but the problem remains open.

The present study of mothers' speech to their 1-year-old children in three languages—English, French, and Swedish—is intended to provide further information relevant to both the question of the representativeness of the adult sample provided by the analysis of children's target words and the issue of individual differences and their possible source in input speech. Given the small sample sizes (5 subjects in each group), any findings must be viewed as indicative, not definitive. Nevertheless, the use of three independent groups may be seen as a kind of threefold replication of a single analysis or experiment; to the extent that the same results obtain across all three small samples, they may be seen as mutually validating.

The phonetic parameters to be investigated are those that have been reported for infant vocal production in earlier studies (de Boysson-Bardies et al., 1992; Vihman et al., 1986; Vihman, Macken, Miller, Simmons, & Miller, 1985): place and manner in consonants, vocalization or word length in syllables, and proportionate use of word- or vocalization-final consonants.

The four languages that were included in the Cross-Linguistic Project on Infant Vocalizations were chosen for a combination of theoretical and practical reasons. In particular, four distinct prosodic systems are represented by these languages (Cruttenden, 1986). Two are languages with relatively prominent accent—one with lexical contrast involving stress but not tone (English), the other including tonal contrast (Swedish)—and two are languages with relatively weak accent—one with a phrase-based stress accent (French), the other with a word-based pitch accent (Japanese). The languages differ structurally in a number of additional ways that affect their phonetic profile, such as incidence of consonant clusters or final consonants. Practically speaking, teams that were experienced both in phonetic analysis and in infant study were available in Paris and Stockholm as well as in the United States.[1]

The goals of this study should be distinguished from the focal issue motivating a better developed line of research regarding possible clarification effects in British and American adult speech to children (i.e., mothers' use of "extra-clear" pronunciation; see the review in Bernstein-Ratner, 1987). In the present study we are not concerned with clarification effects, nor with contrasting adult-directed and child-directed speech, but with the possible differential effect on the children of exposure to different samples of input speech within the same language community. We are further interested in the use the children make of the adult speech to which they attend. That is, this study is part of an ongoing research effort aimed at disentangling the relative contribution to the shaping of early words of (a) the child's own relatively stable articulatory routines and (b) auditorily salient word forms afforded by the linguistic input. It may be possible to settle one piece of this puzzle by comparing adult and child production both across linguistic communities and across different mother–child dyads within a single community.

This study addressed the following questions.

1. Representativeness of the sample: Does the sample of target words used in de Boysson-Bardies and Durand (1991), de Boysson-Bardies and Vihman (1991), and de Boysson-Bardies et al. (1992) constitute a representative sample of the adult language for the purpose of investigating ambient language effects? In particular, how similar is the phonetic profile derived from the target words to profiles taken directly from maternal speech?

2. Source of variability: How does the extent of variability across the five mothers within each group compare with the variability reflected in the children's word shapes? If the mothers show significantly less variation within a language group than the children, the hypothesis that differences in the input are an important source of within-group interchild variation will be weakened.

3. Individual dyads: A further clue to the source of variability across children may be obtained from the closeness of fit between phonetic profiles based on individual child words and on the input samples from their mothers. If individual dyads may successfully be characterized phonetically in contrast to other dyads within the same community, this will support the hypothesis of external input as a potential source of between-child variability, although the direction of influence will remain

[1] The Japanese data were collected at the Stanford Child Phonology Project in California, where infants who are being raised in essentially monolingual Japanese-speaking homes can be found. Japanese-speaking assistants were recruited to help with data collection and preliminary analysis (see de Boysson-Bardies et al., 1992). Unfortunately, it was not possible to include Japanese in the present study of mothers' speech because a linguistically trained Japanese speaker was not available to carry out the necessary analysis into content and function words (see *Mothers' Speech Categories* in the Method section).

Table 1
Age of Subjects and Mean and Total Target Words

Language	Lexical points: Age range in months 0	4	15	25	Total different target words (*M* per child)
English	9–10	11–13	13–14	14–16	120 (56.2)
French	10–11	11–13	13–17	14–20	114 (37.8)
Swedish	9–10	9–16	13–18	16–19	106 (70.4)

unknown. On the other hand, if it is difficult to identify a child's mother from the characteristics of that child's phonetic production, the hypothesis will fail to be supported.

Method

Subjects and Data Collection

Fifteen normally developing children were followed longitudinally from 9 months of age to the time when they had produced 25 words in a half-hour recording session (corresponding to a cumulative lexicon of 50 words or more; Vihman & Miller, 1988). The American children were recorded weekly in California, and the French and Swedish children were recorded every other week in Paris and Stockholm, respectively. All of the children were audio- and video-recorded in the home in unstructured play sessions with the mother; an electric condenser microphone was placed in an inside pocket of a soft vest worn by the infants. Mothers were aware of our interest in the children's language and communicative development and cooperated by making available situations for words they believed to be currently in the children's productive repertoire.

Sampling: Child Vocalizations

Analysis of the children's vocalizations was conducted for six sessions (four lexical points): one prelinguistic (*0-word*) session,[2] two sessions from the month in which 4 or more different spontaneous words were first identified (*4-word point*), two sessions from the month in which 15 spontaneous words were first used (*15-word point*), and a final session in which 25 or more words were used (*25-word point*; see Table 1). The American children were the 5 most lexically advanced subjects from an earlier study of 10 children, in which recordings terminated when the children reached 16 or 17 months of age (Vihman et al., 1985; Vihman et al., 1986).

Transcription and Reliability

Transcription of the six sessions was carried out at each site by native transcribers using the International Phonetic Alphabet supplemented by a few infant-specific diacritics. Reliability on the four parameters reached 89% for Swedish, 85% for English, and 80% for French (see Vihman et al., 1985, for details on transcription and the assessment of reliability). Cross-linguistic agreement, tested by retranscription of one 4-word and one 15-word sample for each of the French subjects by M.M.V. (829 vocalizations) and for five 4-word and three 15-word samples of the American subjects by C.D. (597 vocalizations), reached 86% (French) and 82% (English) for consonants and syllables.

Word Identification

Word identification followed the procedures developed by Vihman and McCune (in press) at all three sites. In brief, vocalizations were considered as word candidates if they showed a plausible formal resemblance to a situationally appropriate adult word. A number of additional criteria were weighed in deciding whether to include such word candidates in a child's lexical record. These criteria involved both formal (phonetic) and functional (or pragmatic–semantic) considerations, such as degree of segmental and prosodic match with the adult target, use in a clearly determinative context, identification by the mother, repeated use of a closely related vocalization in similar contexts, and absence of use of such a form in inappropriate contexts (see also de Boysson-Bardies & Vihman, 1991).

Sampling: Mothers' Speech

To obtain a direct sample of the phonetic characteristics of the input, we transcribed separately all of the mother's child-directed speech recorded in one half-hour session for each of the dyads, at close to 12 months for the American and Swedish subjects and 13 months for the French subjects. To form some idea of the relationship between the target words (based on the longitudinal sample for each child) and the 12-month maternal speech sample, we undertook a detailed comparison of target word types and content word types and tokens for the American dyads only. A mean of 29% of each child's target words was used by the child's mother in the single session sampled. As regards *tokens* of content words, for the categories that figured most prominently in the children's speech (nouns and personal–social terms), we again found a mean occurrence of 29% in the mothers' samples. We conclude that a single session of the mother's speech provides an adequate and relevant sampling of the words to which the children are attending.

Analysis

Phonetic Parameters

The distribution of place and manner of articulation for true consonants (excluding glottals and glides), word length in syllables, and presence or absence of word-final true consonants was used to compare samples of mothers' speech, target words, and child words. Place categories (for stops, fricatives, affricates, and nasals only) were divided into (a) labials (including labiodentals), (b) dentals (including alveolars and palatals), and (c) velars (including uvulars, except French /r/, which was categorized as a liquid). Manner categories included (a) stops, (b) fricatives and affricates (grouped together because of the very small number of affricates in the children's repertoire), (c) nasals, and (d) liquids (including English glide [ɹ] and the French uvular fricative [ʁ] or trill [R]). Length in syllables included (a) monosyllables, (b) disyllables, and (c) polysyllables, or words of three or more syllables. Frequency of final consonants was calculated over the total number of words.

Mothers' Speech Categories

We included three measures of the potential phonetic sources of maternal speech effects on the child: (a) incidence of consonants in all child-directed *running speech,* or the totality of the speech stream as transcribed, including both content and function words; (b) *content words* alone, excluding the function words, which should be less salient to the child listener as they are usually unaccented and rarely produced in isolation; and (c) *initial consonant* of content words, because there is evidence that word-initial position has special salience for the child (de Boysson-Bardies & Vihman, 1991; Shibamoto & Olmsted, 1978).

Content Versus Function Words

Principles for identifying content words were established on the basis of the English samples and then were applied to the French and Swedish

[2] One Swedish child produced four words spontaneously in the very first session; there was thus no prelinguistic session for this child.

samples as well. Content words included all nouns, main verbs, adjectives, adverbs (including, for example, *not:* French, *comme tout* [very] and *pas* [not]; Swedish *nej* [not]), more or less conventional interjections (*hanh, oh,* [*wh*]*oops, yay;* French, *allez* [come on], *dis-donc* [hey], *hein* [hunh]; Swedish, *hej* [hi], *oj* [ouch]), and onomatopoeia (*bang, bump, moo;* French, *coin-coin* [quack-quack], *pouf* [poof]; Swedish, *vovov* [woof, doggie]) as well as simple formulaic routines (*happy birthday, peek-a-boo;* French, *à tes souhaits* [in response to a sneeze]; Swedish, *varsågod* [if you please; you're welcome]). Function words included articles, auxiliaries and catenatives, conjunctions, all forms of the copula, prepositions, quantifiers, question words, and all pro-forms except for the locatives *here* and *there* when used as true deictics (*put it in there*), but not as introducers or dummy forms (*there you go, here we are*). Sound effects, unconventional onomatopoeia (/rærææ/ for a lion sound), and imitations of baby vocalizations ("Where's the /kækæ/?," trying to determine the child's intent; French, /owa/ as an imitation of the child's production of *au revoir* [goodbye]) were treated as *noncontent* words. Recitations, including literal book reading, nursery rhymes, or songs were omitted entirely. Inflected forms were treated as content words (i.e., *daddy's, lookin';* French, *touche*[*s*], *toucher* [(to)-touch]; Swedish, *dansar* [to dance], *mammas* [mama's]), as were vowel-initial content words preceded by a clitic (French, *t'apprendre* [to teach you], *l'ours* [the bear], but not *la (brosse)* [the brush]; verb particles were treated as part of the verb in English and Swedish (*"hold" on, "wind" up;* Swedish, *"stoppa" in* [put in]), but the first verb in a grammaticized sequence was not counted as a content word (*come "help," go "see";* French, *tu vas "manger"* [you're going to eat] vs. *tu veux manger* [*you want to eat*], in which both verbs counted as content words).

Quantitative Measures

Representativeness of the sample. Our goal was to determine whether different sampling procedures produced significantly different phonetic profiles of the adult language. We used four categories to represent maternal speech and the adult language: running speech, content words, initial consonant of content words, and target words. For each of the four phonetic parameters (place and manner of articulation of consonants, word length in syllables, and words with final consonants), we used an analysis of variance (ANOVA) on proportions (Games, 1978) to compare the categories of maternal speech and the adult language. For example, we compared the frequency of labials, dentals, and velars (place of articulation parameter) for running speech versus content words. In his analysis, Games (1978) applied the arcsin transformation to the proportions before applying the ANOVA. Games pointed out that the error variance of the transformed data is known exactly and is not estimated. Consequently, the denominator of the resulting F has an infinite number of degrees of freedom.

Source of variability. Our goal was to determine whether the extent of variability across the mothers within a language group differed from the variability across the children. We examined this question for each measure within each language by first computing a chi-square test for the two-way (Subject × Phonetic Category) table of frequencies, in which the subjects were either the group of mothers or the group of children representing a given language.[3] This produced highly significant chi-squares in most cases. We then used the effect size (Cohen, 1969, p. 210 ff.) to compare the variability of the mothers' data to the variability of the children's data. According to Cohen (1969), the effect size, e, of a chi-square is computed by replacing the frequencies in the usual chi-square computation with the corresponding proportions. Although we know of no way to compare e's statistically, Cohen (1969, p. 218 ff.) stated that $e = 0.05$ is a "small effect size," $e = 0.10$ is a "medium effect size," and $e = 0.20$ is a "large effect size." For example, we measured how much the five English-speaking mothers differed in their frequency of use of mono-, di-, and polysyllabic content words by computing the chi-square on the resulting 3 × 5 frequency table, found a highly significant chi-square, and then computed e from the corresponding table of proportions.

Individual dyads. Is an individual child more similar in phonetic profile to his or her own mother than to other mothers within the same language group? Or equivalently, is the mother more similar to her own child than to the other children? We characterized each subject by the proportion of his or her observations in each of the various categories. We computed the (n-dimensional Euclidean) distance between 2 subjects by taking the square root of the sum of the squares of the differences between the subjects' corresponding proportions. The smaller the distance, the greater the similarity between 2 subjects. We denoted the distance between subject j and the mother of subject i by $D(i, j)$. For a given language, there were 5 children and thus a 5 × 5 matrix of distances $D(i, j)$: $D(1, 1)$, $D(1, 2)$, . . . , $D(5, 5)$. For this matrix, if the children most resemble their own mothers, the diagonal entries $D(j, j)$ should tend to be the smallest entry in both the jth row and the jth column.

Results

Representativeness of the Sample

Place and Manner of Articulation in Consonants

Table 2 shows the mean distribution of place of articulation categories in each of the languages for (a) three speech samples from each group of five mothers, (b) target words, and (c) child words. For English and French, the distribution of place categories was virtually identical in initial consonant of content words in the mothers' speech samples and the target words attempted by the children, whereas running speech showed the distribution least similar to the target words. In Swedish, however, the distribution of place categories in target words did not closely resemble any of the mothers' speech categories.

Table 3 shows the mean distribution of manner of articulation categories in each of the languages for the five data samples. Here again, for the category that dominated the children's words, stops, English and French showed closely similar distribution in initial consonant of content words in the mothers' speech and in target words, whereas Swedish did not.

We used an ANOVA to formally compare target words with each of the samples of mothers' speech (see Tables 2 and 3) as measures of the adult language. The three languages and seven categories (three of place and four of manner) yielded 21 ANOVAs for each of the three comparisons. Each was a 5 (mothers) × 2 (target vs. mothers' speech sample) ANOVA on proportions (Games, 1978). We were interested only in the main effect of the second factor, target versus mothers' speech sample. According to Games, the number of degrees of freedom is 1 for the numerator of this F and infinite for the denominator.

The ANOVAs demonstrated that in all three languages the target words differed significantly—for at least four of the seven phonetic categories—from running speech ($p < .01$) and content words ($p < .01$ or $.05$). However, significant differences between target words and initial consonant of content words were restricted to the three phonetic categories less used in child words (fricatives, nasals, and liquids) in English and French; in Swedish, target words differed from initial consonant of content words for all categories at $p < .01$.

Word Length in Syllables

In most cases the mean length in syllables for target words was very close to that for child word shapes, especially for the

[3] In these chi-square tests, we assume that the multiple observations from a single subject are independent (see, e.g., Hays, 1973, p. 735).

Table 2
Distribution of Consonantal Place Categories in Mothers' Speech, Target Words, and Child Words

Category/measure	English	French	Swedish
Labial			
Mothers' speech			
Running speech			
M	19.28	31.81	22.93
SD	3.4	6.7	2.3
Content words			
M	25.91	41.04	21.18
SD	6.5	4.6	1.8
Initial consonant			
M	33.98	52.99	27.5
SD	7.0	7.6	5.8
Target words			
M	35.50	52.19	33.77
SD	6.3	12.9	5.6
Child words			
M	47.99	58.10	27.94
SD	11.9	13.0	16.6
Dental			
Mothers' speech			
Running speech			
M	62.69	52.30	62.63
SD	1.9	5.7	4.0
Content words			
M	48.64	48.04	61.12
SD	5.1	8.1	3.1
Initial consonant			
M	45.59	36.87	58.49
SD	8.8	7.4	4.6
Target words			
M	42.64	35.37	39.21
SD	3.2	11.3	7.0
Child words			
M	35.03	31.20	47.67
SD	16.1	16.8	18.6
Velar			
Mothers' speech			
Running speech			
M	18.03	15.88	14.43
SD	1.9	5.2	1.8
Content words			
M	25.44	11.91	17.69
SD	4.0	4.2	2.4
Initial consonant			
M	20.44	11.52	13.99
SD	2.4	5.4	3.5
Target words			
M	21.86	11.65	26.96
SD	5.6	7.9	3.4
Child words			
M	16.97	10.64	24.38
SD	12.4	12.8	6.5

Note. Means are in percentages and are based on total true consonants (excluding liquids, glides, and glottals). Target words = word types attempted by the children; all other categories are based on word tokens.

Table 3
Distribution of Consonantal Manner Categories in Mothers' Speech, Target Words, and Child Words

Category/measure	English	French	Swedish
Stop			
Mothers' speech			
Running speech			
M	39.27	43.18	39.14
SD	4.4	2.5	1.5
Content words			
M	44.49	43.17	38.95
SD	7.1	5.6	1.8
Initial consonant			
M	54.85	48.91	46.67
SD	7.6	2.7	4.7
Target words			
M	55.12	48.00	57.84
SD	2.3	6.5	8.4
Child words			
M	75.45	61.51	77.86
SD	6.1	15.8	9.8
Fricative/affricate			
Mothers' speech			
Running speech			
M	28.33	23.38	26.13
SD	1.5	4.5	1.8
Content words			
M	18.91	18.08	23.09
SD	3.2	2.0	2.5
Initial consonant			
M	23.48	22.19	35.41
SD	5.1	6.4	4.5
Target words			
M	12.49	11.56	9.58
SD	2.5	7.6	3.3
Child words			
M	7.32	6.78	3.28
SD	3.9	7.5	2.9
Nasal			
Mothers' speech			
Running speech			
M	16.84	12.21	19.74
SD	5.2	4.7	1.3
Content words			
M	17.64	15.02	19.07
SD	5.3	6.2	2.0
Initial consonant			
M	11.05	15.84	9.50
SD	4.0	8.6	1.3
Target words			
M	15.16	21.35	17.48
SD	3.2	2.7	8.4
Child words			
M	13.48	21.45	14.2
SD	8.7	7.3	8.3
Liquid			
Mothers' speech			
Running speech			
M	15.56	21.22	14.99
SD	1.4	2.9	1.7
Content words			
M	18.95	23.84	18.88
SD	3.5	6.3	2.1
Initial consonant			
M	10.62	13.06	8.39
SD	4.6	6.5	1.7
Target words			
M	17.24	19.09	14.98
SD	2.3	3.9	3.9
Child words			
M	3.69	10.21	4.59
SD	3.2	9.2	4.1

Note. Means are in percentages and are based on total true consonants (excluding glides and glottals). Target words = word types attempted by the children; all other categories are based on word tokens.

categories that dominated the children's productions, one- and two-syllable words (Table 4). Mean use of monosyllabic content words (mothers' speech) was higher than the target word mean in all three languages (and conversely for disyllables). For monosyllables, 2 (content words vs. target words) × 5 (mothers)

Table 4
Phonotactic Structure: Distribution of Word Length in Syllables in Mothers' Speech, Target Words, and Child Words

Category	English	French	Swedish
Monosyllables			
Content words			
M	69.24	56.3	43.77
SD	7.7	7.4	8.7
Target words			
M	59.12	27.7	43.54
SD	5.8	7.8	7.7
Child words			
M	53.76	33.7	33.21
SD	12.1	8.5	10.1
Disyllables			
Content words			
M	22.94	38.6	46.06
SD	3.3	7.0	3.7
Target words			
M	35.10	68.0	52.46
SD	6.8	4.2	6.9
Child words			
M	37.52	54.3	50.12
SD	11.0	4.3	6.6
Polysyllables			
Content words			
M	8.16	5.0	10.16
SD	4.8	3.0	5.6
Target words			
M	5.98	4.3	4.00
SD	1.7	6.3	3.6
Child words			
M	8.66	11.96	16.67
SD	2.0	10.8	9.3

Note. Means are in percentages over total words. Target words = word types attempted by the children; all other categories are based on word tokens.

ANOVAs showed a significant difference between these two categories for English, $F(1, \infty) = 7.17$, $p < .01$, and for French, $F(1, \infty) = 12.94$, $p < .01$, but not for Swedish, $F(1, \infty) = 0.24$. In French, in particular, the difference was dramatic.

Word Class Differences in Length

To understand why the children should attempt relatively fewer monosyllables than were represented in the mothers' content words, despite their natural inclination to produce short vocalizations (as suggested by a cross-linguistic mean of nearly 50% monosyllables in babbling: de Boysson-Bardies et al., 1992), we broke down the mothers' content words by functional category (Table 5). We see that monosyllables constituted the dominant category for every word class in English, whereas in French and Swedish the pattern was more complex. In Swedish, the nouns were primarily disyllabic, verbs and adjectives were fairly evenly divided between mono- and disyllables, and the remaining two categories were primarily monosyllabic. In French, the nouns alone were heavily disyllabic.

Because nouns dominate early word production in all of these languages (de Boysson-Bardies & Vihman, 1994), it is not surprising that target words should most closely resemble the word length distribution of nouns in the mothers' speech rather than that of content words as a whole. And indeed, the proportion of target word disyllables in French (68%) closely matched the proportion of disyllabic nouns in the mothers' speech (67%). A similar pattern was found in the comparison of figures for English (59% monosyllabic target words vs. 52% monosyllabic nouns) and Swedish (52% disyllabic target words and 53% disyllabic nouns; see Tables 4 and 5).

Table 5
Distribution of Length of Content Word Tokens by Word Class

Word class	Word length in syllables: Monosyllable	Disyllable	Polysyllable	Total
English				
Nouns	52	30	18	716 (35)
Verbs	86	14	1	621 (30)
Adjectives	53	35	12	142 (7)
Adverbs	74	24	2	235 (11)
Other	75	20	6	361 (17)
French				
Nouns	23	67	11	487 (24)
Verbs	63	34	3	542 (27)
Adjectives	63	29	8	124 (6)
Adverbs	69	27	4	236 (12)
Other	73	24	2	602 (30)
Swedish				
Nouns	18	53	29	726 (35)
Verbs	41	58	1	658 (32)
Adjectives	42	48	10	102 (5)
Adverbs	64	30	6	283 (14)
Other	80	18	3	277 (14)

Note. Values in parentheses represent percentage of all content words in mothers' speech.

Final Consonants

Table 6 shows the distribution of final consonants in three samples: mothers' speech, target words, and child words. Here target words were clearly representative of all three adult languages. For each language, a 2 (content vs. target words) × 5 (mothers) ANOVA showed no significant differences in final-consonant distribution.

Summary of Sampling Differences

Quantitative analysis of the various data samples suggests that the target word sample is sometimes indistinguishable from

Table 6
Phonotactic Structure: Distribution of Final Consonants in Mothers' Speech, Target Words, and Child Words

Category	English	French	Swedish
Content words			
M	66.52	25.4	50.58
SD	8.4	4.4	3.3
Target words			
M	61.28	25.6	46.03
SD	13.3	6.8	16.5
Child words			
M	16.42	8.28	13.75
SD	15.3	4.5	8.8

Note. Means are in percentages over total words. Target words = word types attempted by the children; all other categories are based on word tokens.

Table 7
Values of F for Difference Among Proportions as a Function of Language

Variable	Initial consonant of content word	Target words
Consonantal place		
Labial	17.56*	7.17*
Dental	11.52*	1.06
Velar	0.34	8.69*
Consonantal manner		
Stop	1.97	3.17
Fricative	9.11*	0.45
Nasal	1.76	1.68
Liquid	1.25	1.59

Note. Each F has 1 and an infinite number of degrees of freedom (Games, 1978).
* $p < .01$.

a direct sampling of mothers' input speech, based either on the content words (for final consonants and for length of vocalization, if nouns alone are used) or on the initial consonant of content words (place categories and stops in English and French but not Swedish). In some cases, direct sampling of the mothers' speech (based on running speech or content words as a whole, or initial consonant of content words for other manner categories in all three languages) does provide a significantly different distribution than does the target word sample.

Cross-Language Comparison Using Different Samples of Adult Speech

Given the differences in results with regard to some of the consonantal parameters in target words versus direct sampling of the mothers' speech, we sought to test whether the method of sampling adult speech would affect our understanding of the cross-linguistic differences in distribution of place and manner categories in the ambient languages to which the children were exposed. For each of two measures (target word and initial consonant of content word) and for each of the seven consonantal categories (three of place and four of manner), we performed a one-way (English vs. French vs. Swedish) ANOVA on the proportion of words in the given consonantal category. According to Games (1978), each of the Fs has 2 and an infinite number of degrees of freedom.

The Fs are given in Table 7. The two ways of sampling adult speech did give somewhat different results. In particular, place categories differed significantly across the three languages for labials and dentals in the mothers' speech sample but in labials and velars in the target word sample, and manner categories differed in fricatives/affricates in mothers' speech but did not differ in the target word samples. (Note, however, that the three place categories were not independent, nor were the four manner categories, because together the three place categories added up to 100% of the total distribution, as did the four manner categories.) This result supports the findings regarding the adult reference samples in de Boysson-Bardies and Vihman (1991), in which the four languages were found to differ mainly in the percentage of labials in target words. Similarly, for manner categories, only Japanese target words (not included in this study) were found to be significantly different from those of the other groups.

Source of Variability

To compare the extent of variability across the different measures of the mothers' speech samples as well as in mothers' speech as compared with the children's words, we began by considering the variability expressed in standard deviations in Tables 2 (place) and 3 (manner). In making this informal comparison, we bore in mind that an increase in the number of observations, or the total from which the proportions were derived, was related to a decrease in standard deviation. However, the totals for the consonant tokens in children's words across the five sessions in which words were produced (range = 231–935 for English, 485–843 for French, and 430–1,147 for Swedish) fell within the same range as did the totals for consonant tokens in the mothers' content words produced in a single session (range = 605–1,106 for English, 464–836 for French, and 538–1,790 for Swedish). Because the target word percentages were based on word types, not tokens, we disregarded them in this comparison.

Variability in Place and Manner of Articulation

For place, the level of variability in the children's word productions (ranging from a standard deviation of 12 to 16 for English, 13 to 17 for French, and 7 to 17 for Swedish) was consistently higher than in any of the direct measures of the mothers' speech (which ranged from 2 to 9 for English, 5 to 8 for French, and 2 to 6 for Swedish). For manner, the French children's words were nearly as variable as the place categories, but for English and Swedish, child words were relatively consistent in showing high use of stops, a moderate level of use of nasals, and low levels of fricatives and liquids. Level of use of stops in the content words in the American mothers' speech was somewhat more variable.

We used the effect size, e (discussed earlier under the *Quantitative Measures* subsection of the *Analysis* section), to formally assess the variability of the various measures across subjects. For each measure (running speech, content words, initial consonant of content words, and child words), for each language, and for each parameter (place and manner), we first computed a chi-square. For the categories of place, the data consisted of 5 (subjects) × 3 (labial vs. dental vs. velars) frequency tables, and for the categories of manner, 5 (subjects) × 4 (stop vs. fricative/affricate vs. nasal vs. liquid) tables. We found that the chi-squares were significant beyond the .001 level with four exceptions, all involving the Swedish data: running speech, manner ($p < .002$), and place ($p < .01$); initial consonant, place ($p < .005$), and manner ($p < .09$). We then computed e for each chi-square by substituting proportions for the corresponding frequencies (Cohen, 1969, p. 210).

The results of these calculations are shown in Table 8. Here we see that the level of variability consistently increased across the four categories as given, the lowest in running speech, then content words (except for place categories in French and Swedish, which were virtually identical to running speech), then initial position in content words, and finally—with a large shift upward—children's words. These results clearly express the finding that for consonantal place and manner, variability was

Table 8
Effect Size, e, for Comparison of Subjects' Frequency Distribution: Consonantal Place and Manner in Mothers' Speech and Child Words

	Mothers' speech			
Variable	Running speech	Content words	Initial consonant of content words	Child words
English				
Place	0.008	0.020	0.026	0.137
Manner	0.019	0.032	0.042	0.071
French				
Place	0.027	0.025	0.040	0.232
Manner	0.022	0.035	0.064	0.175
Swedish				
Place	0.006	0.005	0.014	0.152
Manner	0.004	0.008	0.011	0.101

Note. Analysis is based on chi-square calculation on proportions (Cohen, 1969, p. 210).

greater in child words than in any direct measure of mothers' speech.

Variability in Word Length in Syllables

The standard deviations in Table 4 suggest that child words were more variable in length than mothers' content words in English and Swedish, but not French. For each language and for mothers' content words and for child words we computed the chi-square and its effect size, *e*, for the proportion of mono-, di-, and polysyllables. The data consisted of 5 (subjects) × 3 (mono- vs. di- vs. polysyllables) tables of frequencies and the corresponding tables of proportions. All chi-squares were significant beyond the .001 level. The resulting *e*'s are shown in Table 9 and support the impression derived informally from the data of Table 4.

Variability in Final Consonants

Across the three languages, the level of variability in final-consonant use in the children's words can be directly related to the children's mean frequency of use (see also Vihman, 1993b). That is, some of the American subjects were beginning to make use of final consonants by the end of the study, whereas others were not (range = 1% to 36%). In contrast, the French children ranged between 5% and 14% use. The American children thus

Table 9
Effect Size, e, for Comparison of Subjects' Frequency Distribution: Length in Syllables in Mothers' Speech and Child Words

Language	Mothers' content words	Child words
English	0.037	0.147
French	0.029	0.017
Swedish	0.044	0.073

Note. Analysis is based on chi-square calculation on proportions (Cohen, 1969, p. 210).

Table 10
Effect Size, e, for Comparison of Subjects' Frequency Distribution: Final Consonants in Mothers' Speech and Child Words

Language	Mothers' content words	Child words
English	0.023	0.147
French	0.009	0.018
Swedish	0.001	0.047

Note. Analysis is based on chi-square calculation on proportions (Cohen, 1969, p. 210).

showed high variability, the French showed considerably less, whereas the Swedish data fell in between. For each language and for mothers' content words and for child words, we computed chi-squares. The data consisted of 5 (subjects) × 2 (final consonant vs. no final consonant) frequency tables. All chi-squares were significant beyond the .001 level except for Swedish mothers' final consonants ($p > .05$). We then computed *e*'s for the corresponding tables of proportions. The resulting *e*'s are shown in Table 10, which again shows a large increase in variability in child words over mothers' content words for English; French and Swedish also show somewhat more variability for the children.

Individual Dyads

We have seen that for most measures in all three languages, child words reflect considerably more variability than do the mothers' content words. Nevertheless, some of the measures did show relatively high intersubject variability in the mothers' speech within a single language. It is of interest, then, to ascertain whether such variability as we did find in the mothers' speech was related to the variability in the children's productions. That is, we are now asking whether, for example, a child who makes unusually high use of final consonants—selecting large numbers of consonant-final words to attempt and developing a production pattern that incorporates final consonants (see the case study of an American child in Vihman & Velleman, 1989)—has a mother who stands out from the rest for her deployment of an unusually high proportion of consonant-final content words in speech addressed to the child, or similarly for fricatives, which characterize the speech of one American and one French child (Vihman & de Boysson-Bardies, 1994; Vihman & Greenlee, 1987), or liquids, which form an organizational focal point for one French child (Vihman, 1993b).

To test the closeness of fit between maternal and child phonetic profiles along the parameters of interest, we constructed the distance matrix described earlier in the *Quantitative Measures* subsection of the *Analysis* section. This matrix adapts the statistical approach used in Vihman et al. (1985), in which a distance-function permutation test was developed to compare intrasubject differences in word versus nonword points with intersubject differences of the same kind. In that test, a finding of smaller intrasubject than intersubject differences was taken as support for the hypothesis of continuity between nonword (loosely, babbling) and word production patterns. In our adaptation of the test, for each language, for consonantal place and manner, we computed the distance matrix between the proportions of mothers' initial consonant of content words and the proportions of all consonants in child words.

If the mother's use of place and manner categories influenced her child's use, then the diagonal entries of these matrices should tend to be the smallest in the corresponding row and column. On the other hand, if the mother's use of place and manner categories had no unique influence on her child's use, then the diagonal entry should, on average, rank third in its row and column. The mean ranks found for row (mother → child) and column (child → mother) were as follows: (a) for place—English, 2.8, 2.0; French, 3.4, 4.2, and Swedish, 3.4, 3.6; (b) for manner—English, 3.2, 3.0; French, 3.6, 3.4; and Swedish, 3.0, 3.0. *T* tests were applied to these data to determine whether any mean was less than 3.0. None of the *t* tests was significant beyond the .05 level.

For word length in syllables, given the discrepancy already noted between nouns and other categories in French and Swedish, we applied the distance-function test to mothers' nouns only for all three languages. The mean ranks were, for English, 3.8, 3.6; for French, 3.2, 3.4; and for Swedish, 3.0, 2.6. None of the *t* tests undertaken to determine whether these means were less than 3.0 was significant beyond the .05 level.

For final consonants, we used the distribution in mothers' content words in comparison with child word shapes. The mean ranks for row and column were, for English, 3.2, 3.0; for French, 3.0, 3.2; and for Swedish, 2.8, 3.0. Again, none of the means proved significantly less than 3.0 ($p > .05$). Thus the distance matrices appeared to reflect randomly ordered distributions across the dyads on all of the measures tested.

Discussion

Our goal in undertaking the analyses reported here was twofold: (a) to ascertain the most effective way to obtain a representative phonetic profile of adult input speech as a basis for establishing the nature, extent, and timing of ambient language effects on infant vocal production, and (b) to evaluate the effect on individual differences in infant vocal production of differences in the specific input speech to which the children are exposed within a single language group. Our findings suggest that, for most purposes, a sample of the target words attempted by a group of 5 or more children may be viewed as representative of the adult language. For a more direct sample of maternal speech, content words addressed to the child are the most relevant (as discussed in the next section, *Representativeness of Samples*). With regard to the second issue, we found that children's word productions are consistently more variable than the mothers' speech (see later section, *Source of Variability*). Furthermore, within our restricted populations of five dyads per language group, we found no evidence of individual maternal effects on the children in any group. Thus, despite the size limitations of our intensive study, we see our results as strongly suggesting that the source of the broad individual differences across the children is not to be found in the relatively small phonetic variation across the mothers.

Representativeness of Samples

The target words are idealized forms, extrapolated as word types attempted (i.e., adult models) from the word tokens produced by the children, whereas the phonetic analysis of the mothers' speech is based on actual word tokens produced by the mothers. On the other hand, the target words reflect the children's word attempts over several months of lexical expansion, from the first establishment of word use to a vocabulary of some 50 words, whereas the mothers' speech is based on a single point in time. Thus, there was reason to expect that cross-sectional samples of speech addressed to 1-year-olds might yield a different phonetic profile than the broader based but idealized longitudinal sample of target words. Equally important, target words could be expected to reflect some aspects of the children's production capacities. Target words might thus stand in a closer relation to the children's word shapes than to a sample of the adult language obtained by directly transcribing maternal speech. And target words might be expected to show more similarity across languages than actual adult speech samples, reflecting the role of universal constraints in the vocal production of 1-year-old children.

The first issue in attempting to compare mothers' speech with target words was to decide which measure of the mothers' speech is most appropriate. Function words are conspicuous by their absence from early child vocabularies as well as from early syntax. For example, function words (typically embedded in formulaic routines) constituted a mere 4% of the first 50 words reported by mothers for 18 children in Nelson (1973). In our own sample of child words, function words embedded in routine phrases account for no more than 8% in any of the three languages. We can thus assume that content words are more salient to children in this early period and should have a greater influence on early production than function words. This expectation was supported by the fact that, of the three ways of analyzing the maternal speech samples phonetically, running speech, including both content and function words, generally produced the distribution of consonantal categories least like the distribution in the children's words. On the other hand, the maternal speech category whose distribution most closely resembled that of the children's word shapes was initial consonants of content words. This conforms to previous findings that the initial consonant guides children's word selection (Shibamoto & Olmsted, 1978).

For the categories involving whole-word structure—word length in syllables and percentage of words with final consonant—we found target words and mothers' content words (or nouns alone, in the case of word length) to be equivalent representatives of the adult language. Thus, for most categories typically used in early words—labials, dentals, stops, and one- and two-syllable word lengths—and for final consonants as well, target words seem to provide an adequately representative sample of adult speech, although in the case of Swedish consonants, analysis of the initial consonants of mothers' content words provides a somewhat different picture.

Source of Variability

We found greater variability in virtually every measure of the children's production as compared with the corresponding measures of the mothers' speech. This finding casts doubt on the suggestion that differences in the children's phonetic preferences or phonological organization derive to any great extent from differences in the specific input speech to which they are exposed.

One might object that the higher variability we found in children's words as compared with the mothers' speech is an artifact of our research design, because we sampled the children longitudinally whereas we analyzed the mothers' speech in only a single session. In response to this concern, we should first emphasize that our tests, based on five mothers in three separate language groups, revealed that intersubject variability was low for most of the phonetic parameters tested and high for none. Because the mothers were engaging their infants in play in their own homes, with different interactional styles and different activities and objects of interest, the high degree of similarity in the phonetic profiles of the maternal speech is quite striking and is independently characteristic of each of the three language groups. Although a test of longitudinal intrasubject variability in mothers' speech would logically complete our design, there is little reason to expect that the results would be substantially different.

With regard to the children's words, on the other hand, we observe that only a small repertoire is represented across the five or six sessions in which words were produced, with notable recurrence of the same word types from one session to the next. Specifically, the mean proportion of words repeated across sessions is 30% (English), 43% (French), and 46% (Swedish). A profile based on only one session would be less representative of the child's phonetic repertoire than the longitudinal sample we used simply because so few different words are produced in a session, even the last (roughly 25 words). Thus, we believe that we have fairly tested the proposition that the within-group intersubject variability in the children's word production reflects the different phonetic selection they have made from the adult repertoire to which they have been relatively uniformly exposed, on the basis of the similarity across the five mothers in each group.

The sole exception to the finding of higher variability in child production involves word length in French. Recall, however, that length in syllables is differently correlated with functional categories in the three languages (see Table 5). In English, monosyllables account for the majority of content words used by the mothers in all categories; in Swedish, both nouns and verbs are typically disyllabic; whereas in French, only nouns are predominantly disyllabic. Nouns are a major category in all three languages, being the most commonly used word type in both English and Swedish (35%), followed closely by verbs, and the third most common category in French (*other* accounts for 30%, nouns and verbs each account for about 25%). Thus, although differences across the mothers in proportionate use of nouns are actually somewhat smaller in French as compared with the other two languages (the range is from 19% to 35% in French vs. 25% to 51% in English and 24% to 42% in Swedish), it is only in French that functional variability translates directly into a kind of phonetic variability. The difference between nouns and other categories in typical length in syllables results in a high standard deviation for one- and two-syllable content words in the French mothers' speech.

Individual Dyads

The results of the distance function tests are the most clearcut. In no instance tested, for any of the three languages, did individual mother–child dyads show a tendency to be more closely related to one another than either child or mother to the other four mothers and children in the same language group. With regard to consonantal place and manner, length of mothers' nouns in syllables versus children's word length, and proportionate use of final consonants, then, there is little support for the idea that children differ in their production choices because the specific input speech to which they are exposed, within the home or family, biases them toward a particular path.

Conclusion: The Emergence of Phonological Organization

Here, as elsewhere, close analysis of the distribution of major phonetic categories in early word production has revealed strong individual differences even among children exposed to the same ambient language. Beyond that, we have demonstrated that variability in the words shapes of children within a language group is generally far greater than the variability in the phonetics of the mothers' speech, and we have failed to find any evidence of specific shaping of the children's choices by the speech patterns of individual mothers. We are left with a central question: What is the primary source of a child's individual path toward phonetic patterning and phonological organization?

A long-standing theoretical position regarding the origins of phonology derived from Jakobson (1941/1968), who held that babbling is marked by wide ranging and unsystematic vocal production but is replaced, with the onset of word production, by a highly constrained (and thus unrelated) phonemic repertoire. This position was reversed in a series of observational studies that conclusively demonstrated continuity in vocal production from prelinguistic vocalizations to the shapes of early words (Cruttenden, 1970; Labov & Labov, 1978; Stoel-Gammon & Cooper, 1984; Vihman et al., 1985). At the same time, other studies showed equally clearly that early word production is not based on segment-sized units (phonemes) but is holistically organized at the level of the word or syllable (Ferguson & Farwell, 1975; Macken, 1979; Menn, 1978; Waterson, 1971).

Within the limits of the adult language as represented by input speech, the child has at least two possible alternatives for developing a relationship between the perception of sound patterns and their representation as a basis for production. For some children, this development is internal, presumably involving gradual advance in attention to speech, parsing of the speech signal, and learning of word forms, resulting in a somewhat later but perhaps more systematic first phonological organization. For most children, however, and particularly for the voluble babbler and precocious language user, the beginnings of word comprehension are soon followed by the production of adultlike babble patterns in the situation of use of broadly similar adult word forms. Such production may be identified by caretakers or other observers as (context limited) first word use (Vihman & McCune, in press).

Current speculation regarding the development of a perceptuomotor link in the infant is beginning to converge on a self-organizing model such as Edelman (1987) has formulated, in which auditory and proprioceptive sources of information to the organism leave a common neural trace that is strengthened with repeated use (see, e.g., Thelen, 1991). In an early precursor to these ideas, Fry (1966) outlined a mechanism that could lead a child from vocal exploration into adult-based word production, namely, the establishment, through the repeated production of similar articulatory movements in babbling, of an auditory feedback loop (see also Locke & Pearson, 1992).

According to such models, vocal responses serve to "tune" a child's perception to the ambient language. Specifically, once babbling of adultlike syllables emerges (toward the middle of the first year; Oller, 1980), vocal activity primes the child to attend particularly to the subset of adult phonetic patterns that (broadly) resemble his or her own output. That is, babbling leads to the development of a limited number of relatively stable vocal patterns, familiar vocal motor schemes that the child can produce at will (McCune & Vihman, 1987). These vocal motor schemes may then serve as an articulatory filter on adult speech, picking out from the input broadly similar words or phrases (the target words of our study) that have already been rendered potentially salient through frequency in child-directed speech, prosodic highlighting, and co-occurrence with contextual salience, or situations that attract the child's attention (Vihman, 1993a).

Such models accord an important role to action, effort, and attentional focus (Elbers & Wijnen, 1992; Vihman, 1991, 1992, 1993b). On the production side, for example, Kent (1992) suggested that early words may be based on the development of a "gestural score," a "composite of a set of sensorimotor trajectories, where each such trajectory is a neural representation of a movement and its sensory consequences" (p. 80). The variable prearticulatory representation underlying such a score arises out of the coordination of perceptual and motor experiences, perhaps based on the use of vocal motor schemes, which afford the child a quasiphonetic (or holistic) production capability that can be deployed as the child makes phonetic selections from the adult repertoire in an effort to match perceived patterns of input speech.

On the perception side, Jusczyk (1992) proposed that the matching process that underlies word recognition involves multiple-trace representations of previously encountered exemplars. More specifically, he suggested that the child may record or represent in memory just those sound patterns that have been processed with extra effort. Somewhat similarly, Elbers and Wijnen (1992) hypothesized that "a child will, in general, learn more from his or her own production processes and their output than from perception of input," particularly in the early stages "when production skills have not yet been automated and demand more effort than they do in later stages" (p. 341). Drawing on these ideas, we suggest that vocal motor schemes developed through babbling will enter into the child's first top-down processing of speech, filtering in as particularly salient those adult words whose auditory impression roughly corresponds to the preexisting traces of some individual production pattern of the child's. Whereas Jusczyk suggested that "prior to the time that the infant engages in any meaningful encoding of speech sounds, the configuration of properties selected for speech probes might be expected to vary more or less randomly" (p. 46), we suggest that vocal motor schemes begin to act as a filter on adult speech as soon as they are in place, which may be as early as 9 months or earlier for some children (McCune, 1992).

Thus, in our view, the high variability of different children's word shapes reflects the individuality of the matching process: Each child attends to the (roughly equivalent) input speech patterns afforded by the ambient language with a unique filter, on the basis of emergent production patterns. The broad motor constraints and perceptual biases of infancy set (universal) limits on those patterns. Both the auditory and the visual cues afforded by the particular ambient language shape—in a similar way for the group as a whole—the image of speech to be filtered by a given group of children. It is the encounter of particular children—each with his or her individual articulatory filter—with a particular ambient language that leads to the multiple individual paths to a first phonological organization.

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