A STUDY OF FRONTING, VOICING, AND STOPPING BASED ON OLMSTED'S DATA ON EIGHTY-SEVEN CHILDREN*

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1. FRONTING, VOICING, AND STOPPING AS GENERAL TENDENCIES

Charles Ferguson and David Ingram, among others, have suggested that there are three word structure-related tendencies which are widespread in children's early phonology. 'Fronting' (Ingram, 1974a) is the tendency to produce front obstruents word-initially and back obstruents word-finally, or is at least the tendency to avoid a sequence of back obstruents followed by relatively farther-front obstruents within a word. 'Voicing' is the tendency to produce voiced obstruents initially and voiceless finally, noted by Ingram (1974b) and Ferguson (1973). 'Stopping' is the tendency to produce stops initially and fricatives finally (see Ferguson, 1973; Oller et.al., 1976, for evidence from babbling). These patterns have been suggested to take various forms: regular rules, substitution errors, constraints on the selection of words to learn, and patterns in the varied rates of acquisition of different features in different word position.

To find out whether these are indeed general patterns, not idiosyncratic to a few children, it seemed necessary to study a sample of language-learning children large enough to be representative of the entire population. David Olmsted's study of 100 children between 1½ and 4½ in Out of the Mouths of Babes (1971) appeared to meet this criterion. The children's speech had been collected by uniform methods and transcribed by two workers with 90% reliability (throwing out the 10% of the data on which they disagreed).

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Therefore the data are highly comparable, unlike a collection of disparate acquisition histories from many sources. Furthermore, Olmsted was investigating whether the children were correctly acquiring the pronunciation of their mothers, not simply whether they produced certain sounds, and thus dialectal differences in their environments were irrelevant. The match between mothers' and childrens' speech was apparently made on very broad distinctions of voicing, place and manner, in any case, so that a set of broad phonemes which all the children were attempting to learn could be set up.

Figures 1 through 3 show the percentages of 87 children between 1½ and 3½ from Olmsted's sample who had acquired the phoneme classes which define fronting, in word-initial, -medial, and -final positions.[1] There are clearcut, statistically-significant tendencies in the data which are similar to the proposed fronting, voicing, and stopping tendencies. The classes of phonemes predicted to be acquired faster word-initially than -finally (front obstruents, voiced obstruents, and stops) are in fact acquired faster, while the classes predicted to be faster word-finally show about equal acquisition rates in all word positions. One could hypothesize that an independent tendency for acquisition to be more rapid word-initially might be interacting with the predicted patterns. However, breaking down stops and fricatives by voicing (Figs. 4 and 5), we see it is really only the voiced stops that are acquired faster word-initially. Voiced fricatives are actually favored word-finally. This is a departure from the earlier formulation of voicing. Thus while this finding is not incompatible with the idea that children generally acquire all word-initial features faster, the simplest description of these patterns in Olmsted's child speech data seems

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FIG. 1. Tendency for Olmsted's sample to acquire front obstruents initially more readily than finally.

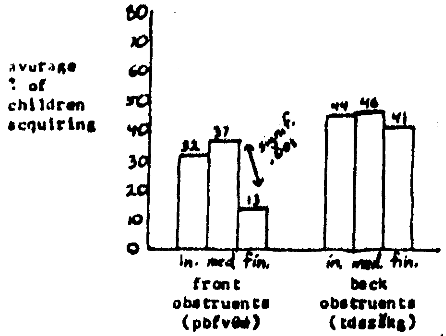

FIG. 2. Tendency for Olmsted's sample to acquire voiced obstruents initially more readily than finally.

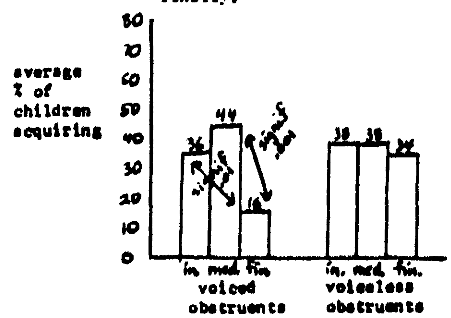

FIG. 3. Tendency for Olmsted's sample to acquire stops initially more readily than finally.

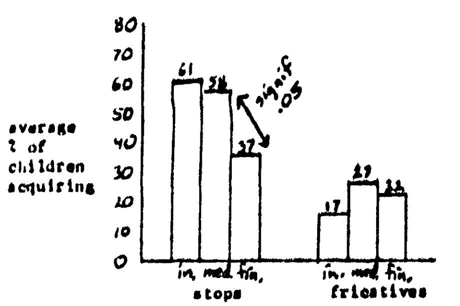

FIG. 4. Tendency for Olmsted's sample to acquire voiced stops initially more readily than finally.

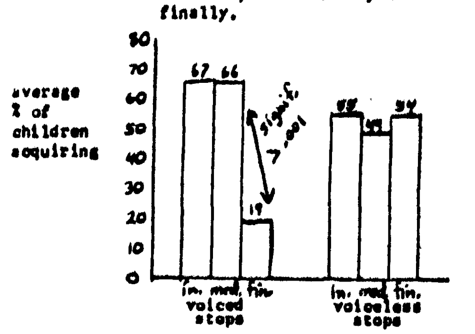

FIG. 5. Tendency for Olmsted's sample to acquire voiced fricatives finally more readily than initially.

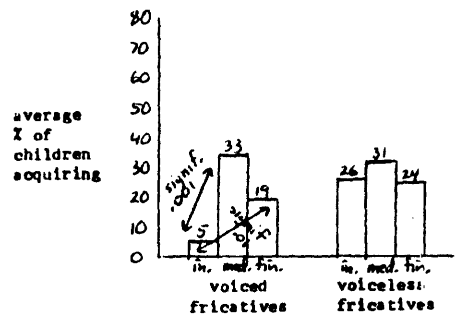

FIG. 6. Ratios of $\frac{\text{\% Olmsted's children acquiring initially}}{\text{\% Olmsted's children acquiring finally}}$ for obstruents compared with the obstruents' membership in feature classes.

3 feature classes predict initial favoring	2 feature classes predict initial favoring					1 feature class predicts initial favoring						0 feature classes predict initial favoring
+ front + vd stop - vd fric	+ front - vd stop - vd fric			- front + vd stop - vd fric		- front - vd stop - vd fric				+ front - vd stop + vd fric		- front - vd stop + vd fric
b	p	f	θ	d	g	t	k	s	š	ð	v	z
29.0	1.3	2.1	.4	3.1	1.4	.8	1.1	.7	1.2	7/0	.4	.1

to be the following: 1) front obstruents are favored initially; 2) voiced stops are favored initially; 3) voiced fricatives are favored finally.

It should be noted that even these three classes do not predict the initial-final acquisition rate ratios of all individual phonemes equally well (Fig. 6). In particular, [ð], and perhaps also [b] and [d] seem favored in initial position out of all proportion to their class membership, while [θ] seems favored word-finally to an unexpected degree. If the three word-structure patterns are actually explained by the opportunity to practice, however, as suggested below, some of this will be accounted for.

2. THE HYPOTHESIS THAT EARLY-ACQUIRED FEATURES ARE FAVORED INITIALLY

An intriguing characteristic of these patterns is that the features which are favored initially (front obstruents and voiced stops) have been suggested to be earlier-acquired than back obstruents and voiceless stops, while voiced fricatives, which are favored word-finally, seem to be later-acquired than voiceless fricatives (at least in English). This suggests that there might be a tendency for children to favor unmarked features - or ones that are easier for them to perceive or pronounce - word-initially.

Unfortunately, we do not know if the cues for the voiced/voiceless distinction which are favored word-initially are the same cues which are favored earliest over all word positions. Thus the demonstration of early favoring of short voicing lag VOT by Yeni-Komshian and Preston (1967) and Port and Preston (1972) involved only initial stops. Olmsted's data shows the rates of acquisition of voiced and voiceless stops to be approximately equal over all word positions (Fig. 7), but the cue for final voicing which the children were acquiring was probably vowel length, not VOT. The degree of VOT which is favored word-finally by young children remains to be studied.

Similarly, while voiced fricatives are consistently acquired more slowly than voiceless fricatives over all word positions (Fig. 7), we do not know if the same cues are being acquired word-initially and -finally. Again, it seems likely that the word-final cue may be vowel length.

There is no such ambiguity about cues for place of articulation word-initially and -finally, of course. We know from Jakobson's survey of diary literature (1941) and from subsequent case histories that the earliest consonants in speech are usually labial, less often alveolar, seldom velar. Studies of babbling by Winitz and Irwin (1958) and Pierce (1974) show that after about one year of age, labial and, secondarily, alveolar stops are strongly favored over velar. Olmsted's data shows a slight favoring of labial over velar place in his youngest age group (Fig. 9) which probably also reflects this early tendency. Thus it can be said that front obstruents are more favored word-initially and also are earlier-acquired than back obstruents. A similar statement cannot be made about voiced stops or voiceless fricatives, however, until the distribution word-initially and word-finally of the same cues for voicing in early speech has been studied.

3. INGRAM'S HYPOTHESIS

David Ingram (1974a) has suggested an ingenious explanation for the parallel between fronting and the early acquisition of front stops, which might be applied to the parallel between initial-favoring and early-favoring generally. Since the earliest words children learn are usually CV, containing only initial consonants, it follows that the earliest-acquired consonants will tend to be those that are favored initially. Ingram suggested that these would be front consonants if fronting were a general tendency, as he though it might be. It is clear that the same explanation could be applied

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to initial-favoring of voiced stops and early-favoring of voiced stops over all word positions, if this were demonstrated. But it would not apply to final favoring of voiced fricatives and their late acquisition in all word positions.

If Ingram's explanation is correct, one would expect that the early preference for initially-favored features would fade quickly as more final consonants are acquired in the vocabulary. In fact this appears to be what happens. Jakobson found the primary favoring of labials and secondary favoring of alveolars soon shifted to a primary alveolar favoring, which presaged its unmarked status in the adult languages of the world. Olmsted's data also shows the preference for labial place giving way very quickly, but to velar rather than to alveolar place.

Thus, Ingram's hypothesis fits well with the available facts. If this is the correct explanation, it would not preclude an independent tendency for early-acquired features to be favored word-initially, but would certainly make it unnecessary as a hypothesis.

Incidentally, Olmsted's data does not support the application of Ingram's hypothesis to the parallel between initial favoring of stops and the early acquisition of stops, attested in all literature on early speech and babbling. As Fig. 7 shows, stops continue to be more readily acquired than fricatives throughout the four age groups. Thus the stop-fricative hierarchy of acquisition cannot be simply an artifact of the tendency to favor stops initially. This is consonant with the apparent unmarked status of stops relative to fricatives in the languages of the world (Jakobson, 1941; Hockett, 1955) and suggests the hierarchy is a natural and basic one which endures into older age periods in which language change takes place.

FIG. 7. Tendencies of Olmsted's children to acquire voiceless fricatives faster than voiced, and voiced stops faster than voiceless (figures from Olmsted, Contingency Tables 1-13, pp. 120-32). z not included. Difference of percents for voiced and voiceless fricatives averaged over four age groups is significant at .05 level.

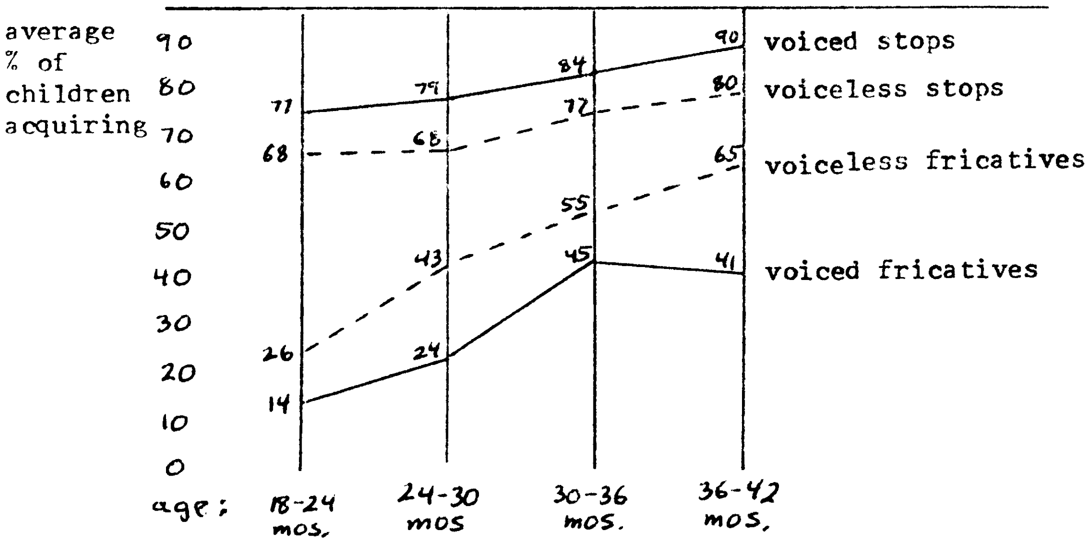
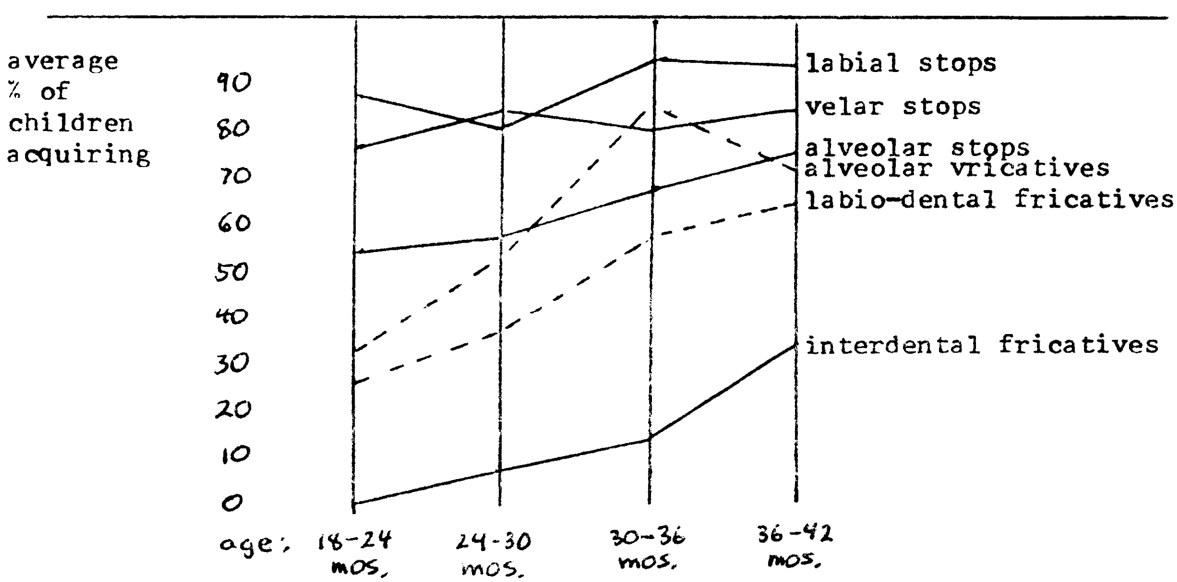


FIG. 8. Acquisition of labial stops most rapidly and alveolar stops most slowly by Olmsted's children. Acquisition of alveolar fricatives most rapidly and interdental fricatives most slowly (all figures from Olmsted, Contingency Tables 1-13, pp. 120-32). Palatal fricatives not included. Differences in percents acquiring labial and alveolar stops are significant at .05 level in first three age groups. Differences in percents acquiring velar and alveolar fricatives are significant at .05 level only in second age group.



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4. THE OPPORTUNITY-TO-PRACTICE HYPOTHESIS

Since Olmsted's children were acquiring only English, there is no assurance that the word structure-related patterns in his data were not influenced in some way by English. On a suggestion from Alan Bell (U. of Colo.), I therefore compared these rates of acquisition with the frequency of the various obstruents phrase-initially and -finally in informal speech of first graders as tabulated by Edward Carterette and Margaret Jones (1974). The assumption was that the speech analyzed by Carterette and Jones would resemble the speech the Olmsted children were learning, closely enough to give some idea which obstruents they would have had the most chance to practice initially and finally.[2]

The results show quite a strong correlation between opportunity to practice and rate of acquisition. As Figs. 9 and 10 show, the explanation for the initial favoring of front obstruents and the final favoring of voiced fricatives in acquisition could well be entirely the differential opportunity to practice them word-initially and -finally. As Fig. 11 shows, however, the initial favoring of voiced stops runs against the opportunity to practice. Initial/final ratios for individual phonemes are given in Fig. 12, showing that the discrepency between relative frequencies and relative acquisition rates in different positions for voiced stops is due mainly to [d] and probably also [b].[3] The over-all correlation between rank orders of the two sets of ratios is quite strong.

Thus it appears the only word structure-related acquisition patterns which are fairly certainly natural rather than imposed by English are the initial favoring of [d] and [b]. Of course, there might be independent natural tendencies to favor front obstruents initially and voiced fricatives finally, in addition to possible influence from the opportunity

FIG. 9. Front obstruents are more frequent phrase-initially than -finally, and back obs. more frequent finally than initially in informal conversation of first graders (Carterette and Jones).

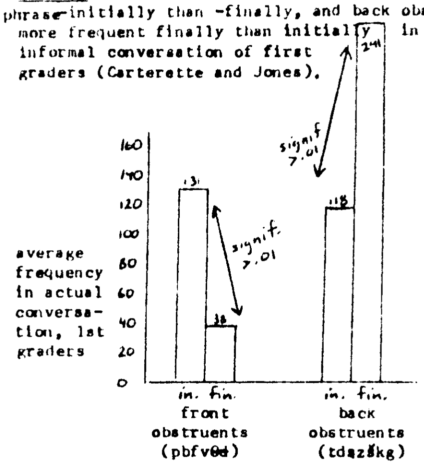

FIG. 10. Voiced fricatives are more frequent phrase-finally than -initially in informal conversation of first graders (Carterette and Jones).

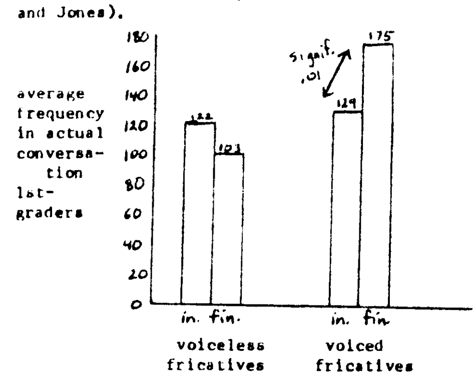

FIG. 11. Voiceless stops are more frequent phrase-finally than -initially in informal conversation of first graders (Carterette and Jones).

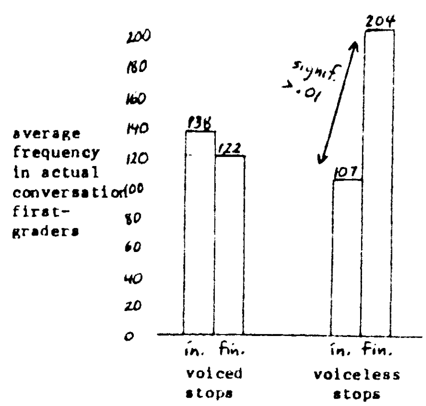

FIG. 12. Ratios frequencies of phonemes in conversation of first-graders phrase-initially / phrase-finally (figures from Carterette and Jones, Tables 8.4.1 and 8.4.2, pp. 476-77.)		rank order	Ratios averaged percents of Olmsted's children acquiring phonemes word-initially / word-finally (figures from Olmsted, Tables 38-40, pp. 194-96.)		rank order
374/1	ð	1	29.o	b	1?
9.4	b	2	7/0	ð	2?
4.0	š	3	3.1	d	3
2.1	f	4	2.1	f	4
1.3	g	5	1.4	g	5
1.0	k	6	1.3	p	6
0.9	s	7.5	1.2	š	7
0.8	θ	7.5	1.1	k	8
0.5	d	10	0.8	t	9
0.3	t	11	0.4	θ	10
0.2	v	12	0.4	v	11.5
0.05	z	13	0.1	z	13

Spearman rank order correlation r =.75

to practice. To test this we could need to study data similar to that of Olmsted's study and also of Carterette and Jones' study, from a language with quite different initial/final obstruent frequency patterns.

A few other patterns stand against the influence of English, but less strongly, so that they may be accidents of this particular data. In word-final position, Olmsted's children favor [s] and [š], and fail to favor [z], to the extent the adult frequency patterns would seem to predict. This may have something to do with difficulty in mastering the [s]/[z] alternation in the plural suffix.

It is interesting to note that [b] and [d] are also favored in babbling after about one year of age, and [b] is favored increasingly as the stage of early speech approaches (Winitz and Irwin, 1958; Pierce, 1974). Since babbling consists mainly of CV syllables, this may be largely due to the natural initial favoring of [b] and [d], perhaps reinforced by English-influenced favoring of front consonants (i.e. [b]), as imitation increases prior to the onset of recognized speech. William Labov points out that visual imitation would also favor labial place word-initially, but not word-finally, since the place-of-articulation distinction would not be seen if consonants were unreleased. Thus the primacy of the labial stop in earliest speech may be due to a combination of natural and language-influenced favoring in initial position, in addition to its inherent ease of acquisition in any word position.

5. NATURAL VS. LANGUAGE-INFLUENCED ORDER OF ACQUISITION TENDENCIES

If labial stops are acquired first partly because they are favored word-initially, rather than simply because they are inherently the easiest consonants to acquire, then which features are in fact easiest to acquire

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FIG. 13. Rank orders compared of frequencies and rates of acquisition, initially, medially, and finally. Figures taken from Carterette and Jones, Table 8.4.1, p. 476, Table 8.4.2, p. 477, and Table 7.2, p. 444, and from Olmsted Tables 38-40, pp. 194-96.
Medial frequencies computed by subtracting initial and final frequencies from to 1 frequencies.

phoneme	frequency phrase-initially 1st-graders	rank orders		% Olmsted children acquiring initially (averaged)
đ	374	1	10	7
s	256	2	8	32
b	198	3	1	87
t	135	4	7	42
d	127	5.5	3	69
k	126	5.5	2	73
f	107	7	5.5	45
g	88	8.5	5.5	45
š	88	8.5	9	22
p	61	10	4	49
θ	37	11	13	3
v	8	12	12	4
z	4	13	11	5

$r_s = .44$

phoneme	frequency phrase-medially 1st-graders	rank orders		% Olmsted children acquiring medially (averaged)
t	2236	1	9	29
s	1889	2	6	53
d	1814	3	4	58
k	1391	4	3	61
đ	1178	5	13	11
z	1123	6	8	34
b	898	7	.	77
g	866	8	2	64
f	618	9.5	7	44
p	616	9.5	5	56
v	525	11	10	20
θ	282	12	11.5	14
š	186	13	11.5	14

$r_s = .31$

phoneme	frequency phrase-finally 1st-graders	rank orders		% Olmsted children acquiring finally (averaged)
z	482	1	4	46
t	412	2	2	56
s	293	3	3	48
d	277	4	7	22
k	131	5	1	68
p	70	6	5	37
g	67	7	6	33
f	51	8	8	21
θ	44	9.5	11	7
v	43	9.5	10	11
š	22	11.5	9	18
b	21	11.5	12	3
đ	1	13	13	0

$r_s = .88$

over all word positions? Looking at Olmsted's data again (Figs. 7 and 8), we see that stops generally are more readily-acquired than fricatives, that labial - and to a lesser extent velar - stops are more readily-acquired than alveolar, and that voiceless fricatives are somewhat more readily-acquired than voiced (although, as mentioned before, quite different cues may be involved in different word positions).

It is interesting that one of these patterns, the labial-velar-alveolar hierarchy, departs from the observations that Jakobson (1941; 1972) draws from European literature on acquisition. Jakobson quotes students of child language to suggest that the favoring of alveolar place in fricative acquisition does not have to do with fricatives, but is part of a general of primacy in production from labial place to alveolar place, which occurs after the very earliest stage of speech (1972, p. 87).[4] In Olmsted's data alveolar place is favored for fricatives (though labial and velar places do not compete, of course) but is not favored for stops. One wonders if this difference could be an effect of English in some way. One possibility is that alveolar stops are difficult to acquire, but that dental stops such as those in many European languages are much easier. Another possibility, which we can test, is that opportunity to practice introduces differences in acquisition rates across all word positions in different langages.

To explore this idea, it is only necessary to compare the rank orders of frequencies in different word positions directly with the rank orders of children's acquisition rates for each phoneme. However, various factors, most notably higher absolute frequencies of phonemes word-medially than -initially or -finally, would bias over-all frequency counts in favor of phonemes that were relatively more frequent phrase-medially. Therefore, Fig. 13 gives the compared rank orders broken down by word position. In

Fig. 14, then, the added rank orders for each phoneme are given, thus equalizing the effects of word position.

What emerges is that over all word positions, labial and velar obstruents are acquired much more rapidly than opportunity to practice would predict, while alveolar obstruents are acquired considerably more slowly than opportunity to practice would predict. This is particularly striking with the alveolar fricatives, which are the most rapidly acquired fricatives in absolute terms, but which are still far more slowly acquired than might be expected in view of their very high frequency in English. Stops are also acquired more rapidly relative to fricatives, and voiceless fricatives more rapidly relative to voiced fricatives, than opportunity to practice would predict. Thus all the significant rate-of-acquisition differences over all word positions that were noted earlier in Olmsted's data appear to be natural, and are not explainable by opportunity to practice.

Therefore, one might predict that these three tendencies will emerge as highly general tendencies across a series of acquisition studies in different languages. Comparing frequencies in the adult languages with fairly large-scale acquisition data similar to Olmsted's, one would expect to find more rapid acquisition of labial and velar obstruents relative to other points of articulation, of stops relative to fricatives, of voiceless fricatives relative to voiced, than opportunity to practice in each language would predict.

FOOTNOTES

[1]Only Olmsted's four youngest age groups were used, as the two oldest were too small to representative of any differences that might develop with age in the general population. Percentages given are averaged over the four age groups, as the chronological development of the word structure processes did not show much variation. They are also averaged for each set of phonemes. 'Acquired' is used here in the technical sense of being pronounced like the mother's model 50% of the time.

[2]Judy Mitchell (U. of Arizona) points out that children often practice single words modeled in citation form by their parents; therefore frequencies word-initially and -finally in a list of single high-frequency words might give a better idea of the actual opportunity to practice than frequencies phrase-initially and -finally in running conversation, as used here.

[3]Rank orders of ratios rather than simple rank orders were used in Fig. 12 because the latter would have been distorted by order of acquisition factors which affected Olmsted's data but did not affect the first-grade data, such as the slow acquisition of fricatives relative to stops over all word positions.

[4]Jakobson's explanation is that labial consonants offer maximal contrast, visually and in auditory 'chromaticity', with wide vowels, hence they are the focus of the first broad vowel/consonant opposition perceived by children. However, once contrasts are learned within that general consonant phoneme, the auditory 'lightness' of alveolars contrasts with the 'darkness' of both labials and velars, and thus alveolar place is more salient, (1972, pp. 87-88). Since Jakobson's theory deals with acquisition of phonemic perception, evidence of production does not prove or disprove it.

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