



PROSODIC AND PHONETIC PATTERNING OF DISYLLABLES PRODUCED BY JAPANESE
VERSUS FRENCH INFANTS

Pierre Hallé and Bénédicte de Boysson-Bardies

Laboratoire de Psychologie Expérimentale (CNRS)
54 Bld Raspail, 75006 Paris, France

ABSTRACT

As a subset of a large scale study of American, French, Japanese, and Swedish infants' vocal productions, designed for tracing the emergence of language-specific features, we present some results on Japanese and French children. From the first words on, the consonant repertoires and some phonotactic characteristics of infants' vocalizations reflect ambient language specificities, as appearing in sets of "target" words, familiar to infants in each language group. We also examine some prosodic aspects of the disyllables produced by 3 Japanese and 4 French children at the 25-word stage, a little before the phonological stage. Fo contour and syllabic durations in disyllables (words or babbling), are also clearly language-specific. For French infants, rising Fo contours and final syllable lengthening are the rule, whereas the opposite patterns are found for Japanese children.

I. INTRODUCTION

Recent work on speech acquisition has well confirmed that there is a continuity between prespeech and speech ([18], [21], [9], [15], [16], [23]), and also, that maturational processes -- assumed to be universal -- play an important role in the development of children's vocal productions ([6], [10], [14]). However, infants' vocalizations eventually evolve into language-specific adult forms. Therefore, the question arises as to when and how maturational processes integrate language specificities, leading then to differentiation between linguistic groups.

Reports on language-specific influences on prespeech forms, based on discrimination by adult listeners, have been mixed, some claiming positive results ([5], [8], [2]), some claiming negative results ([1], [19], [22]). Some previous studies, focusing on consonantal repertoires failed to uncover language-oriented differences, and proposed that universal articulatory proclivities are sufficient to explain the development of infants' vocalizations [13].

More recent studies, based on acoustic and phonetic analyses of infants' vocalizations, support the view of an interaction between the developmental processes and the ambient language ([3], [4]; Levitt & Aydelott, personal communication).

One main finding has been the observation of systematic discrepancies between vocalic spaces produced by ten month old children raised in different linguistic communities and their close convergence towards adult vocalic spaces [3]. More recently, a large scale investigation of infants' vocalizations, both longitudinal and cross-linguistic (American, French, Japanese, and Swedish), has been jointly conducted by 3 international research teams (Boysson-Bardies, Vihman, and Lindblom). Part of the results have been reported by Boysson-Bardies in [6]. Evidence has been shown of both universal developmental

processes and of ambient language influence in the consonantal repertoires and some phonotactic properties of infants' vocal productions, from about 10 months on.

The data used in this paper is extracted from the larger study mentioned above. In addition to the phonetic results, we present new results concerning the prosodic organization of disyllables at the 25-word stage. Disyllables have been chosen in part because they cover more than 40% of all vocalizations in both languages, and in part because they allow a clearcut description in terms of Fo contour and relative syllabic durations.

In order to compare infants' vocalizations to an adult model, various adult references can be chosen. Frequency counts of the phones in a language at large are compiled from wide corpuses of adult-directed speech. In the speech directed to infants, the distribution of phonemes may be slightly different for simpler articulation schemes seem more appropriate to infants. In order to avoid such a possible bias, mother's speech may be a better adult reference. But mother's speech contains a lot of "empty" words that are not likely to shape the child's lexicon and phonetic repertoire.

On the other hand, the first vocabulary of a child consists of those words which he has been acquainted with from an early age, and therefore may be most influential on his vocalizations at phonetic as well as prosodic levels. For each language group, we have collected the words attempted at least by one child of the group. We call these words "target words" and take their adult form as an adult reference for sake of comparison to infant forms in the following.

II. MATERIAL

For the larger study on American, French, Japanese, and Swedish, 5 children from each linguistic group were audio and video recorded in bi-weekly 30-minute sessions, from about 10 month, when they could only babble, until the 25-word stage, i.e. when they could produce at least 25 words within a session. The data were further selected and grouped into four stages labelled 0-, 4-, 15-, and 25-word stages. All infants were recorded at home with one parent (usually the mother) and an assistant in charge of the recording apparatus. Care was taken to create a natural atmosphere of verbal communication. Ages of infants range from 10 to 14 months at the 0-word stage, from 14 to 21 months at the 25-word stage.

III. CONSONANTS

A detailed analysis of consonant repertoires is given in [6]. Therefore we will only summarize and discuss the results concerning Japanese and French infants.

Examination of the developmental data reveals universal tendencies (see [13]). However, some features of the observed distributions fit so closely to the target words, that the common tendencies cannot override language specificities.

Tables I and II show the distribution of consonants according to manner and place in babbling, infant words, and target words, for both languages.

Table I - Distribution of consonants in babbling, words, and targets: Manner.

		Stop	Affr/Fric.	Nasal	Liquid
French	babbling	51	16	23	10
	words	62	7	22	10
	targets	48	22	22	9
Japanese	babbling	69	10	16	4
	words	58	10	27	5
	targets	45	19	31	5

Table II - Distribution of consonants in babbling, words, and targets: Place.

		Labial...	Dental...	Velar...
French	babbling	49	40	11
	words	58	31	11
	targets	54	34	12
Japanese	babbling	25	47	28
	words	30	50	19
	targets	28	55	17

Japanese and French are much more contrasted for place of articulation (in target words). This is precisely where Japanese and French vocalizations differ clearly and fit the best to the targets. Manner of articulation seem more difficult to acquire, excepted for nasals. Liquids are rare, though less rare in French vocalizations, as is the case in adult speech. Fricatives are frequently replaced by stops in vocalizations, especially in the first words of French infants, may be because the production of words entails more sequencing constraints [4]. Japanese infants also produce less affricates and fricatives than could be expected from the adult repertoire. However, the additional constraints of word production do not worsen this tendency, like for French infants. The latter observation may be explained by the higher frequency of affricates in Japanese. Also, since fricatives are very often replaced by affricates in Japanese mothers' baby-talk, Japanese infants are influenced to substitute fricatives by affricates rather than by stops.

IV. PROSODIC PATTERNS

From the first words on, we find influence of the ambient language on segmental structure. Imitation of intonational patterns by young infants have been observed before they can imitate segments ([11], [19]), and children acquiring Mandarin have been found to master Fo changes attached to lexical tones before segmental distinctions [12]. Whalen & Levitt (personal communication) find language-specific intonation patterns of Fo in American and French infants from 5 to 13 months old. If there is such a precedence of suprasegmental upon segmental production in the course of language acquisition, we expect that the Japanese and French infants of our study will also differ with respect to Fo and duration patterns in a language-specific way. It is not obvious however, whether the early successes with intonation, before those with segments, can warrant an irreversible mastery of appropriate intonation, nor, at the word level, of appropriate accentuation (which

entails specific Fo contours in Japanese). We present here some results on Fo contours and duration patterns of the disyllabic items produced at the 25-word stage by 4 of the French and 3 of the Japanese infants.

4.1 Material

We have used the speech material at the 25-word stage of Japanese and French infants. Disyllables were chosen for sake of homogeneity (and they cover more than 40% of vocalizations in both language groups). For each infant, all the disyllables produced during the 25-word session were retained provided that they were meeting a few necessary requirements: items were discarded when Fo could not be estimated (whispered voice, overlap, noise...), when an abrupt discontinuity occurred in Fo contour (change to or from falsetto or creaky voice), when the vocalization was shouted or cried. The disyllables of 2 infants were not further analysed because less than 15 items met the requirements (Nicolas and Taku). Finally, one Japanese infant did not participate to the 25-word session (Rina). The number of disyllables retained for each child is shown in Table III ("N" column).

4.2 Speech processing

The speech data was first digitized and a spectrogram editor software (author: J.L. Gauvain, CNRS) was used, in narrow band mode, in order to select tractable items. For the selected disyllables, Fo was extracted by means of a cepstral method (10 ms analysis step, no smoothing) and checked, by using spectrograms. Each Fo contour was further smoothed by grouping of values and piecewise cubic interpolation. A part of the disyllables were voiced throughout, with no voiceless gap. The other disyllables had 2 separate voiced sections. When both of them were corresponding to syllable rimes, their durations were recorded for a preliminary study of disyllable time structure.

4.3 Fo contours

From the smoothed contours, the following parameters were extracted: Fo onset value and mean value, Fo excursion, and an index of Fo change rate (sum of the second derivative absolute values of smoothed Fo, normalized by contour duration). Fo excursion was the ratio of the signed Fo range to the Fo onset value. Falling contours were given a negative Fo range, and rising contours a positive one.

Average values of these parameters are summarized in Table III, with standard deviations.

Table III - Parameters describing Fo contours.

		Onset	Mean	Excursion	Change	N
Japanese	Taiga	286 (38)	270 (29)	-3% (21)	43 (22)	35
	Toshiya	337 (57)	347 (50)	-25% (41)	90 (56)	99
	Yuki	383 (56)	389 (48)	-5% (26)	82 (49)	138
French	Camille	344 (36)	410 (40)	+32% (40)	89 (45)	93
	Myrtille	292 (37)	316 (31)	+20% (40)	64 (37)	95
	Louis	342 (49)	356 (54)	+10% (38)	91 (69)	64
	Charlotte	317 (37)	335 (33)	+22% (23)	59 (32)	63

The most striking difference between the 2 language groups lies in Fo excursion. Japanese infants tend to produce more falling contours, French infants to produce rising contours. Histograms in Fig. 1.a-b illustrate this difference: infants have been pooled by language group, but

individual data show the same tendencies. The difference between mean and onset F_0 values tend to be larger for French than for Japanese infants (averages +30 versus 0 Hz). This is in agreement with French children having generally rising contours and Japanese falling or rather flat ones. The index of F_0 change rate is sometimes misleading because sensitive to microprosodic accidents, like F_0 dips in voiced stops and the like, which are not relevant for whether perceived or voluntarily produced pitch contours. Toshiya has a lot of vocalizations with large amplitude microprosodic accidents, and his index of F_0 change rate is therefore over-evaluated. Nevertheless, this parameter tends to have larger values for French infants' vocalizations.

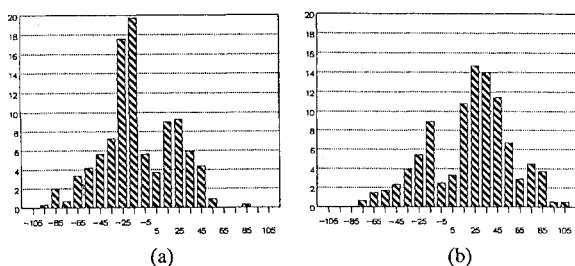


Fig. 1 - Histograms of infants F_0 -excursions (in %): pooled Japanese (a) and pooled French (b). Ordinate is percent of contours.

For French infants, F_0 contours cannot be compared directly with adult contours in target words, but the most typical intonation contour in French is a continuation rising contour ([7], [20]).

For Japanese infants, adult forms of the target words have specific F_0 contours attached to their lexical word accent. Among the 87 disyllabic target words, only 2% have a complex rise-fall lexical contour in Standard Japanese (of Tokyo area), 36% have a rising contour and 62% have a falling lexical contour. However, "accent concatenation" may take place within a spoken sentence, resulting in flat F_0 contours on certain words. Still, rising F_0 contours in target words remain the minority. The small number of non-rising F_0 contours in Japanese infants' disyllables is thus in agreement with the main trend found in Japanese target words. A closer inspection of the words approximated by Japanese infants reveals a significant trend for target words with a rising lexical contour to be approximated with a rising contour, even if infants' realizations of F_0 contours are still often incorrect. This is shown in Table IV for pooled infants. All individual data show the same trend.

Table IV - Realization of lexical tones in Japanese infants' vocalizations (3 infants pooled)

	Infants' F_0 contours			% of rising
	rising	falling	total	
rising tone words	39	45	84	46%
falling tone words	21	66	87	24%
babbling	33	68	101	33%
total	93	179	272	34%

A test of χ^2 indicates that the proportion of F_0 contours realized as rising is significantly higher in infants' words whose adult form should be rising. About 46% of

these words are realized with a correct F_0 contour. The proportion of rising F_0 contours is almost the same in infants' vocalizations and target words.

4.4 Duration patterns

Rime durations have been chosen to give a rough indication of the temporal balance of disyllables. They have been estimated only for those contours that consisted of 2 voiced sections separated by a voiceless gap, and only when both sections were not including a voiced initial consonant (spectrogram inspection was used in order to check the latter requirement). For the Japanese infants, 151 out of 272 disyllables were retained (56%), and for the French, 109 out of 315 (35%). For the contours retained, the ratio of the second to the first rime duration (henceforth r_2/r_1), was computed. The r_2/r_1 ratio was found consistently greater than 1 for French infants, indicating a strong tendency to produce a longer second syllable. In French adult speech, accentuation on the last syllable is predominant, and results in final syllable lengthening. Fig. 2.b shows the histogram of r_2/r_1 ratio for pooled French infants. Individual data are similar.

As for Japanese infants, 2 out of 3 show the opposite tendency of shortening the second rime. Toshiya however, produced longer second rimes (Toshiya). Fig. 2.a shows the histogram of r_2/r_1 ratio for the 2 other infants pooled. In Japanese adult speech, terminal lengthening occurs mainly with interrogative intonations. It occurs rarely with continuation or termination intonations, as in French [17]. Rime durations also depends on its phonetic composition. Rimes can be short (one mora), or long (two moras). Among the disyllabic Japanese target words, 72% had both rimes short, 11% both rimes long, 11% had the first long, the second short, and only 6% had the first short and the second long. Though actual durations may not derive arithmetically from the number of moras, e.g. are influenced by intrinsic vowel lengths and initial consonants [17], we can take the figures given above, as an indication that target disyllables are balanced in rime durations as a rule, with a slight trend to have a longer second rime. Examining further the words produced by Japanese infants, we do not find indication that they already produce "correct" rime durations. (But target words with unequal rime durations that infants could tend to realize correctly were too few to draw any reliable conclusion). Thus, we can only conclude that the durational patterns produced by 2 out of 3 Japanese infants are congruent with a general trend in the phonetic composition of target words.

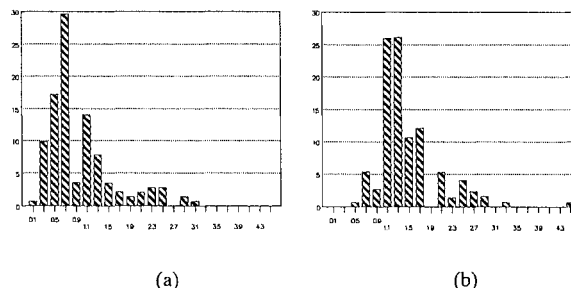


Fig. 2 - Histograms of r_1/r_2 ratios: pooled Taiga and Yūki (a), and pooled French infants (b). Ordinate is percent of contours

4.5 Discussion

To summarize, we find that French and Japanese infants differ clearly with respect to Fo contours and also rime durations (with the exception of one Japanese child), and reflect closely the specific trends of Japanese and French adult intonation patterns. Japanese infants also reflect the main trends in Japanese target disyllabic words: falling lexical tones (62%), and balanced rime durations (71%).

There is a risk that the differences found be related to certain differential use of intonation by children for communicating their emotions or desires. Rising intonations for example have been found to be used for requests. However, it seems unlikely that French infants systematically make more requests than Japanese. This use of intonation should rather appear quite randomly.

A more interesting question is whether the specific Fo contours and duration patterns found for Japanese children reflect not only adult intonation, but also adult tones. The falling contours and absence of final lengthening can be viewed as characteristic of standard continuation or termination intonations [17]. On the other hand, it also fits closely with the lexical tones and phonetic structure of the target words. Short second rime items seem over-represented. However, since segments with "high toneme" are normally lengthened [17], the first rime in disyllables with a falling contour (High-Low) should be lengthened. Japanese children tend to produce correct tones (see Table IV), but with not enough accuracy to explain the match between realized and expected Fo contours. Rather, children seem to have been influenced by the main trends in target words at large, with respect to lexical tone. This also holds for rime durations (excepted for one infant).

V CONCLUSION

Evidence for language-specific influence on infants' vocalizations before the phonological stage have been found in various studies and have come in support of the "interaction hypothesis". From the data used here, it appears that consonant repertoire of infants' vocalizations are congruent with the adult forms of the words normally used for and by the children, the "target words". However, the congruence is not much better in infants' words than in the babbling that they still conjointly produce. A regression in the capacity of producing fricative consonants is even observed for French children. Therefore we cannot conclude that the convergence towards the adult model is irreversible in every aspect. Perceptual studies have suggested that infants' vocalizations were reflecting their ambient language intonation as early as at 8 months [2]. This was found for long stretches of babbling, and infant's short utterances, because they were "poorer in prosodic cues", could not be judged as conveying adult intonation specificity. We have presented here some results showing that, at the end of the transition from babbling to vocabulary spurt, even disyllables, which should be very poor in prosodic cues, are strikingly congruent with adult prosody. Japanese infants' disyllables reflect closely Japanese adult speech intonation and tones. However, the detailed application to individual items, i.e. the production of correct word tones, is just emerging.

REFERENCES

- [1] K.B. Atkinson, B. MacWhinney & C. Stoel, "An experiment in the recognition of babbling". *Papers and Reports in Child Language Development*, 1, 71-76. 1970.
- [2] B. de Boysson-Bardies, L. Sagart & C. Durand "Discernible differences in the babbling of infants according to target language". *Journal of Child Language*, 11, 1-15. 1984.
- [3] B. de Boysson-Bardies, P. Hallé, L. Sagart & C. Durand, "A cross-linguistic investigation of vowel formants in babbling". *Journal of Child Language*, 16, 1-17. 1989.
- [4] B. de Boysson-Bardies & M. Vihman "Prespeech or first speech: a cross-linguistic phonetic study" in C. Ferguson, L. Menn & C. Stoel-Gammon (Eds.) *Phonological Development: Research, Models and Application*. (in press).
- [5] R. Brown, "Words and Things". New York: Free Press. 1958.
- [6] R. Buhr, "The emergence of vowels in an infant". *Journal of Speech and Hearing*, 23, 73-94. 1980.
- [7] P. C. Delattre "La leçon d'intonation de Simone de Beauvoir, étude d'intonation déclarative comparée". *The French Review* 35, 59-67. 1961.
- [8] M. C. Dinger & J. G. Blom, "An investigation of infant babbling". *Proc. from the IPO* (University of Amsterdam), 3, 42-50. 1973.
- [9] R. D. Kent & H. R. Bauer, "Vocalizations of one year olds". *Journal of Child Language*, 12, 491-526. 1985.
- [10] R. D. Kent & A. D. Murray, "Acoustic features of infant vocalic utterances at 3, 6 and 9 months". *JASA*, 72, 353-365. 1982.
- [11] M. M. Lewis, "Infant speech: a study of the beginnings of language". New York: Harcourt Brace. 1936.
- [12] C. N. Li & S. A. Thompson, "The acquisition of tone in Mandarin-speaking children". *UCLA Working Papers in Phonetics* 33, 109-130. 1976.
- [13] J. Locke, "Phonological Acquisition and Change". New York: Academic Press. 1983.
- [14] M. Mack & P. Lieberman, "Acoustic analyses of words produced by a child from 46 to 149 weeks". *Journal of Child Language*, 12, 527-550. 1985.
- [15] P. Menyuk, "The acquisition and development of language". Englewood Cliffs, N.J.: Prentice Hall. 1971.
- [16] P. Menyuk & L. Menn, "Early strategies for the perception and production of words and sounds" in P. Fletcher & M. Garman (Eds.), *Language Acquisition*. N.Y.: Cambridge University Press. 1971.
- [17] Y. Nishinuma, "Un modèle d'analyse automatique de la prosodie". Paris: Editions du CNRS. 1979.
- [18] D. K. Oller, "The emergence of the sounds of speech in infancy" in G. H. Yeni-Komshian, J. F. Kavanaugh & C. A. Ferguson (Eds.), *Child Phonology, Vol 1: Production*. New York Academic Press. 1980.
- [19] R. Olney & E. Scholnick, "Adult judgments of age and linguistic differences in infant vocalizations". *Journal of Child Language*, 3, 145-150. 1976.
- [20] M. Rossi, "Prosodical aspects of speech productions". *Travaux de l'Institut de Phonétique d'Aix* 6, 49-72. 1980.
- [21] R. Stark, "Stages of speech development in the first year of life" in G. H. Yeni-Komshian, J. F. Kavanaugh & C. A. Ferguson (Eds.), *Child Phonology, Vol 1: Production*. New York Academic Press. 1980.
- [22] D. M. Thevenin, R. E. Eilers, D. K. Oller & L. Lavoie, "Where's the drift in babbling drift. A cross-linguistic study". *Applied Psycholinguistics*, 6, 3-15. 1985.
- [23] M. Vihman, M. Macken, R. Miller, H. Simmons & J. Miller, "From babbling to speech: a re-assessment of the continuity issue". *Language*, 61, 397-443. 1985.
- [24] R. H. Weir, "Some questions on the child's learning of phonology" in F. Smith & G. A. Miller (Eds.) *The genesis of language* (pp 153-168). Cambridge, MA: MIT Press. 1966.