RHYTHMIC PHENOMENA IN A CHILD'S BABBLING AND ONE-WORD SENTENCES

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ABSTRACT

A baby's babbling and one-word sentences, in total 2848 utterances, were tape-recorded over a four-week period when she was at the age of 1:6-1:7, and 513 examples randomly selected from the recorded data were acoustically analyzed. It was found that, 1) babbling plays a ground-breaking role for producing one-word utterances--they reveal very similar phonetic phenomena, and 2) consonant articulation is one of the most important factors to control rhythm. In addition, the following facts were also established: 1) repetition-of-two-syllable-type babbling (e.g. bakobako--) is uttered in the mode of long-short timing alternation, while simple one-syllable-repetition-type babbling (e.g. tatatata--) reveals no distinguishable rhythmic pattern, 2) acquisition of isochronism of morae is far later than that of syllables, 3) interstress intervals between syllables in both babbling and one-word utterances become greatly lengthened just before the period in which vocabulary abruptly increases.

1. DATA COLLECTION AND DATA ANALYSIS

The subject is a one-and-half year old Japanese female child, who has no known abnormalities. She was born and has been brought up in a Tokyo dialect area. Her utterances were recorded for about one month from March 3 to April 9, 1988, which corresponded to the period of her 1.6 to 1.7 years of age. This period coincided with her single word utterance stage. The recording was done by the use of wireless microphone, Panasonic RD-53 stitched into the neck of her clothes, which was electrically connected with a cassette tape recorder, Victor VD System RC-X-5 or Aiwa SW 77. The subject's vocabulary abruptly increased at about 78 weeks of her age (March 9) from about 70 words to 200 words and therefore the whole period was divided into two periods before and after March 9 as 'early' vs. 'late' periods, respectively. This is the way that Ingram and Menyuk et al. [1][3] took. Each period was again divided into two sections before and after March 25 and April 6, because of the simple reason that the recording happened to be suspended for several days before these dates. All the recorded materials, therefore, were chronologically divided into two periods and four sections.

The recorded materials were then acoustically analyzed by Interactive Laboratory System (ILS) run by Micro PDP 11/73, AD Conversion :Das-Box, but Yokokawa Electro-Oscilograph, type 2901, connected with Amplifier 3125, was also used supplementarily.

2. ABOUT BABBLINGS

2.1. Syllabic Constitution

Intervals among voice-onset points of syllables (inter-stress intervals, ISI henceforth), especially of syllables which have plosive-like sounds as consonant partners of CV constructions, were instrumentarily measured. The numbers of utterances thus measured were 130 groups, 245 successions and 864 syllables. This means that the authors analyzed the most typical syllables of babblings .

We can classify syllable structure into five groups according to the types of syllable repetition--alternate repetition of two different syllables (authentic and para types), simple repetition of mono-syllable (authentic and para types) and non-repetition type. Table 1 shows distributions of occurrences of these types classified by the syllable number of babbling succession. We can see here that the two-syllable repetition types are produced far more than the mono-syllable repetition types in this stage of language acquisition, but according to Stark [6] and Oller [4] , the latter types are more popular than the former ones in the pre-single word stage. The mono-syllable simple repetition type of babbling (Type c) occurred 29 in total in our data (Table 1), but 23 of them appeared in the early period and only 6 in the late period. As for the two-syllable alternate repetition type (Type a), on the other hand, 55 out of 72 utterances occurred in the late period and 17 in the early one. These facts support the above observations of Stark and Oller [4][5] and lead us to the fact that Type a is more typical in the one-word utterance stage. All the non-repetition type babblings took place in the early period without exception--random, nonsystematic utterance also constitutes a characteristic feature of the early period.

Table 1 Syllable constitution of Babbling

		7 syl.	6 syl.	5 syl.	4 syl.	Example
a	2 syllable alternate repetition	41	4	23	14	[bakobako-bakoba:]
b	2 syl. alternate repetition in part	7	0	16	2	[bagodago, bagodagi]
c	mono-syllable simple repetition	6	3	12	8	[tatatata-ta:]
d	mono-syl. simple repetition in part	2	0	4	4	[tatatate-to:]
e	no repetition	5	2	8	1	[pikoideo]
	sum.	61	9	63	29	

2.2 Timing Control System in Babbling

There was found some regularity in ISIs among syllables in two syllable alternate repetition type, but no regularity at all in simple repetition of mono-syllable babbling.

Table 2 ISIs among syllables in babbling

		repetition of one syllable	repetition of two syllables
4 syllables	AVERAGE	313.9	335.8
	S.D.	63.3	118.3
	N	7	14
	CORRELATION	r=-0.23	r=-0.58
5 syllables	AVERAGE	400.9	417.8
	S.D.	113.1	82.2
	N	13	23
	CORRELATION	r=-0.05	r=-0.25
6 syllables	AVERAGE	461.3	414.3
	S.D.	109.1	259.9
	N	3	6
	CORRELATION	r= 0.40	r=-0.05
7 syllables	AVERAGE	498.4	416.5
	S.D.	174.1	91.3
	N	6	41
	AVERAGE	r=-0.46	r=-0.37

In Table 2 which shows means of ISIs (ms) among syllables, S.D. and auto-correlations among the adjacent ISIs in each type of babbling, we can see that the values of auto-correlations in two syllable babblings are all negative, while those in mono-syllable babblings are positive except those in the cases of five syllable babblings, whose absolute value is very small and of seven syllable babblings. The negative auto-correlation, if its absolute value is large enough, may suggest that the ISIs of the syllables occur more or less in long-short alternation but the positive one shows no such regularity. We should notice that the seven mono-syllable babblings which show rather high negative auto-correlation in Table 2, contrary to other mono-syllable ones, all occur in the late period, especially in Session IV, except that one example occurred in Session II. This kind

of babbling therefore, despite its similarity in form with the babblings which appear in pre-single word utterance stage, may play the same role as two-syllable alternate repetition type of babbling.

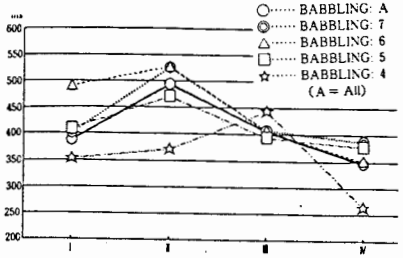

Fig. 1. Chronological Changes of ISIs

Observing chronological change of the ISIs among syllables except the last ones, we can see the ISIs in the early period are longer than the ones in the late period and statistical significance at the level of $p<0.05$ was detected between them. If we examine this phenomenon more precisely according to the units of session, they become longer ($\bar{x}$=387.7 ms to 493ms) during the time lapse from Session I to Session II, immediately before the term in which the subject's vocabulary sharply increases, and then the ISIs become shorter again to Session IV. Fig.1 illustrates this phenomenon graphically.

The vowel lengths were also measured and the fact was found that they scarcely change chronologically from the early to the late periods and so does the S.D.. As shown in Fig. 1, on the other hand, the ISIs among syllables vary very much in the passage of time. These facts suggest us that consonants, not vowels, cause chronological changes of ISI such as shown in Fig.1 --in other words, the subject concentrates her attention on the articulations of consonants very much before she can produce plenty of single word utterances in session III, and this results in the expansion of ISIs at session II.

Number of syllables of one succession was counted 2 (minimum) to 7 (maximum) throughout all the recorded data of 455 babbling groups. The same was the syllable number of one word sentences appeared in all the recorded data. Interestingly, these numbers also coincide with the syllable numbers(7 ± 2) of perceptual sense unit (cf. [4]), that is, the chunking unit of utterance which is holistically perceived with its meaning and stored in echoic memory in an unprocessed form in the process of listening comprehension[2].

Table 3 Recorded and Analyzed Data (single word utterances)

	All	Early	Late	Subject's Renditions (broarily transcribed)
Recorded Tokens	2394	888	1506	
Analyzed Tokens	268	101	167	
2−2 moare				
aka	57	16	41	[aka], [aga]
kabu	18	0	18	[kobu], [gabu]
choko	4	0	4	[koto]
kiku	2	0	2	[geku]
choki	1	0	1	[didi]
heso	1	0	1	[edo]
jyajya	1	1	0	[dada]
kore	1	1	0	[kode]
Sum	85	18	67	
3−3 morae				
akete	42	22	20	[aketɛ], [agetɛ]
okashi	7	0	7	[okaʃi]
kinoko	2	0	2	[gigogo]
osoto	2	0	2	[ototo]
poteto	2	0	2	[poketo]
asoko	1	0	1	[akoko]
Sum	56	22	34	
2−3 morae				
dakko	46	23	23	[gaˣ ko], [gago]
totte	30	15	15	[toˣ te], [doˣ te]
choːdai	47	23	24	[toː de], [doː de]
denwa	4	0	4	[deː ba], [deː ba]
Sum	127	61	66	

3. ABOUT SINGLE WORD UTTERANCES

Table 3 shows the number of the recorded data of single word utterances and the contents of acoustically analyzed data.

Table 4 shows syllable intervals (ISIs) in 2 syllables and 2 morae words (2-2 words, henceforth) and in 2-3 words. Just like the case of babbling, the ISIs in one word sentences are longer in the early period than in the late one ($p<0.01$), and the general means of ISIs through the both periods are again similar with the ones of babbling (300-400ms). It might be rightly said, therefore, that the same timing control mechanism is working in babbling and one-word utterances.

Table 4 Chronological Changes of ISIs (single word utterances)

	2-2 morae	3-3 morae	AVERAGE
AVERAGE: A (ms)	334.0	328.7	331.9
AVERAGE: E (ms)	359.4	378.5	369.8
AVERAGE: L (ms)	327.2	296.5	316.8
S. D.: All	71.2	63.6	68.1
S. D.: Early	82.8	50.7	66.8
S. D.: Late	66.9	48.8	62.8
N: All	85	56	141
N: Early	18	22	40
N: Late	67	34	101

Fig. 2 illustrates the chronological change of the ISIs in single word utterances, and for comparison, the behavior of ISIs in babbling is also shown in the thick line. We can also see here amazing similarity between the two modes of sound production,--short, long, short, shortest intervals in Sessions I, II, III and IV, respectively. More precise observation however, makes it clear that 2-3 words shape this pattern most remarkably,--'dakko' (hold me in your arms), for instance, takes longer time for the transit from 'da' to 'ko' than 'cho' to 'ko'in 'choko' (chocolate). This suggests that the infant already notices the existence of mora in Japanese timing system, but this timing is soon vanished in Sessions III and IV. Has the subject, in the world, mastered the Japanese mora system? In order to make it clear, we carried on the following investigation.

As shown in Table 5, the ISIs in 2-3 words were significantly longer than the ones in 2-2 or 3-3 words ($p<0.01$) not only in the early period but also in the late period (Table 8). Throughout all the periods from the early to the late periods, the means of ISIs in 2-3 words were 457.3ms and the ones in 2-2 words were 334ms and statistical significnce at the level of $p<0.01$ was also detected.

We asked a Japanese adult, a university student, on the other hand, to say 'kabu' (stump), 'aka' (red) (2-2 words), 'dakko', 'totte' (Take it) and 'keːki' (cake) (2-3 words) in citation form and in a carrier sentence 'watashiwa ---- to iimasu' (I say ----.), and after having recorded these utterances, the authors instrumentally measured the ISIs between the first and second syllables of these words by the use of ILS. The results were 158.3 and 184.2ms in 'kabu' and 'aka' (2-2 words) respectively, but in the case of 2-3 words, 'dakko' 'totte' and 'keːki', the ISIs were 387.5, 382.0 and 363.3ms, that is, the ratio of ISIs was roughly 1:2 between 2-2 and 2-3 words. The infant's ISIs in these words ($\bar{x}$ throughout the whole period) were 'aka': 341.3ms, 'kabu': 307.2ms, 'dakko': 396.6ms and 'totte': 407.8ms, and the ratio between 2-2 words and 2-3 words were therefore 1:1.2-1:1.3. Even in the Session II, in which ISIs widened most, the ratio is only 1:1.6. All the above data show us that the infant, although she perhaps knows the existence of mora, cannot produce isochronism per mora. As for the isochronism per syllable, on the other hand, she has already mastered: in 'akete' for example, the ISIs between 'a' and 'ke', and 'ke' and 'te' were 324 and 367ms respectively, and their ratio is 1:1.1. Mora, isochronous timing system peculiar to Japanese, is so difficult to be mastered in comparison with the one among syllables.

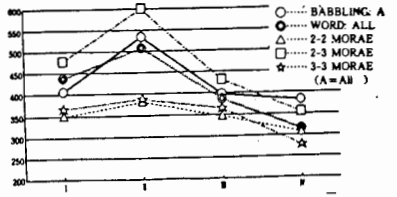

Fig. 4 Chronological Changes of ISIs (single word utterances)

Table 5 Comparison of Mora Lengths

Early

	2-2 morae	3-3 morae	2-3 morae
2−2		t=0.83	t=5.22**
3−3			t=5.45**

Late

	2-2 morae	3-3 morae	2-3 morae
2−2		t=2.59	t=7.59**
3−3			t=5.30**

** $p<.01$