A Study on the Vocal Behavior of Preterm Infants

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The neonatal period and the baby period are called one's prelinguistic period. The baby at this time do various utterances besides the cry. The utterance of the baby at this time can be divided into "cries utterances" originated in a mainly unpleasant situation and other "non-cries utterances". Especially, it is known that non-cries utterances are uttered when infants are active and their feelings are comparatively good. Murai (1970) insisted that non-cries utterances do not have a specific function as the communication means and they were on the basis of "Development of the behavior of the baby" and it would have plasticity as a vocal material for the following significant word formation in the respect. And, non-cries utterances are assumed as a basic process of the language formation.

In recent years, how non-cries utterances work as communication mediation has come to be referred in the research, and it has been being pointed out that there are some particular prosodic features in the utterance of the mother to non-cries utterances of the infants (Fernald & Simon, 1984). Garnica (1977) compared the utterances which mothers do to their infants with which do to adult. And it showed that there were characteristic prosodic features as follows in the utterance done to the infants. Compared with the utterances which mothers do to adult, the one done to their infants are: higher overall pitch, wider pitch excursions, more distinctive pitch contours, slower tempo, longer pauses, and increased emphatic stress. The utterances to the child of the mother which have such features are called "motherese", and some researches are performed (Garnica, 1977; Masataka, 1992; Newport, Gleitman, & Gleitman, 1977; Papousek, Papousek, & Bornstein, 1985; Stern, Spieker, & Mackain, 1982; Fernald & Simon, 1984; Shimura, 1987). Especially, Shimura (1987) examined the features of motherese by the pair of mother and infant who assumed Japanese to be a mother tongue and showed that there was a correlation between the average value and the pitch contour of fundamental frequency of mother-infant vocal interaction. And, it was suggested that motherese was an important sound environment for the baby from the point of interaction. Moreover, She insisted that the exchange by the voice between mother and infant from early infancy was important, for it could build bonds that such

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mother-infant interaction drew out the mutual reaction whose density was high.

The preterm infant which is born with shorter duration of pregnancy than the full-term infant arouses the interest in developed change in the verbal behavior. Because the interaction between mother and child can begin earlier in case of it. And in case the phonic organ developed according to months old after, preterm infants have advantage about making some utterances earlier.

However, many of the preterm infants were born with low-birth-weight (LBW), and it was reported that about 50% cases of LBW infants did catch up with full-term infants' standard body growth curve in corrected age. In case, this physical developmental retardation also occurs in infant's phonic organs, mother-infant vocal interaction must be influenced remarkably. That is, it is needed to verify what kind of acoustic features of infants' vocalization will influence to change their mothers' responses. For that, it is necessary to examine the difference of acoustic features between the vocalization of preterm infant and that of full-term infant. Masataka and Bloom (1994) reported that the quality of 3-month-old infants' vocalizations affected adult's perceived favorableness of them. And there was a difference of acoustic features between the vocalization which mother responded to and which mother did not.

In this study, mother-infant vocal interactions divided by gestational age into two were recorded by tape-recorder. Two groups were: infants who were born after full-term pregnancy duration and their mother, and low-birth-weight infants who was born by preterm pregnancy duration and their mothers. And the acoustic features of non-cries utterances of both groups of infant were analyzed with a sound spectrograph. The analyzed acoustic features were compared by some prosodic parameter and examined about maturity on the form of phonic organ.

Method

Subjects.

Seven Japanese infant-mother pairs were selected. Infant of 4 cases were born after full-term duration of pregnancy (range = 39.2-40.5 weeks, M = 39.7 weeks) and 3 other infants were born before full-term (range = 28.0-34.0 weeks, M = 30.7 weeks). Selected as a case, preterm infants were required following conditions. They were: preterm infants who were appropriate-for-gestational age (AGA) with pregnancy duration of 24 to 37 weeks, no error of auditory brain-stem responses (ABR) taken just before leaving hospital, duration of admission into neonatal intensive care unit (NICU) were more than 30 days, and their parents' mother tongue were Japanese.
Data-recording.
When the infant was 3-month-old of corrected age, the data was recorded. To utter the non-cries utterance of infant, the situation of the recording that the infant was not unpleasant. To avoid the influence of a strange situation, the tape-recorder was brought to subject's home. Recording duration was 30 minutes within 4 days. Moreover, the mothers were instructed to record under infants were following situations: after sufficient sleeping, fed, belched, not under physiological unpleasant condition and eye contact between mother and infant existed. The recording was done whether the mother was laying the infant or was holding on her lap as she was sitting. The mother and infant were left alone in the room for the recording. And the mothers were instructed to talk to her infants as she would normally do when alone together. For the recording, a studio-quality portable tape recorder (SONY TC-D5M) and high-quality electret condenser microphone (SONY ECM-959A) were used. The microphone placed within one meter from infant and the input angle of sound wave was 120°.

Data analysis.
From recorded 30 minutes mother-infant interaction of each infant, 3 minutes which was seemed mother and infant interacted by vocalization very closely was chosen as sample. Only about the non-cries utterance of infant, the acoustic features of each sample was analysed by using a Kay DSP Sonagraph (Model 4300 and Model 4300B) with a 29-Hz band filter and a frequency scale up to 4000 Hz. Three prosodic parameter were prepared for the analysis. They were: average fundamental frequency, pitch excursions, and duration. An utterance was defined as a continuous vocalization of the infant bounded by pauses of longer than 0.3 seconds. An average fundamental frequency was an arithmetic mean of start frequency, end frequency, peak frequency and minimum frequency of one utterance. Pitch excursion was what peak frequency minus minimum frequency of one utterance.

Results
Figure 1-3 presented the distributions of three prosodic parameter analysed of both preterm infants' and full-term infants' non-cries utterances. The fundamental frequency of preterm infants (range = 181.3-647.0Hz, M = 369.0Hz) was higher than that of full-term infants (range = 222.0-1050.5Hz, M = 347.9Hz) (Fig. 1). This difference was statistically significant; t = 1.87, df = 285, p<0.05. The pitch excursion of preterm infants (range = 0.0-545.0Hz, M = 133.6Hz) were wider than than of full-term infants (range = 0.0-949.0Hz, M = 108.7Hz) (Fig. 2). This difference was statistically signifi-
Fig. 1. The average fundamental frequency of full-term infants and preterm infants.

Fig. 2. The pitch excursion of full-term infants and preterm infants.

cant; \( t = 1.86, \) df = 282, \( p<0.05 \). The utterance duration of preterm infants (range = 0.10-2.14sec, \( M = 0.739\) sec) were longer than that of full-term infants (range = 0.084-2.283sec, \( M = 0.516\) sec) (Fig. 3). This difference was statistically significant; \( t = 4.67, \) df = 294, \( p<0.01 \).
Fig. 3. The utterance duration of full-term infants and preterm infants.

Discussion

The purpose of this study were following two. First, we conducted an analysis of difference between the utterance of full-term infants and that of preterm infants at 3-month-old of corrected age. Second, we considered what factors influence to this difference of mother-infant vocal interaction. Various studies of the interaction between an infant and a mother who was main care-giver of infant were conducted. And the infant recognized their mother as an object of communication partner from an early stage after the birth. Condon and Sander (1974) reported that the infant moved their body to the accompaniment of the rhythm of adult's utterance from sixteen hours after the birth. If the development of the recognition begins from the birth, the preterm infant would be disadvantaged. Because most of the infant whose duration of pregnancy were between 27 and 37 weeks were born with low-birth-weight (Battaglia and Lubchenco, 1967), and they were admitted to NICU. The mother-infant separation is inevitably performed to the child by a present newborn baby medical treatment, and it occurs the difficulty that the mother-infant interaction begins from the birth. From the point of view of this, the mother also is disadvantaged. It has been argued for a long time that mother separated from her infant at neonatal period, she would have difficulty to give maternal behavior to her infant. And it was reported that many children who were ill-treated from their mothers in their childhood were born with
low-birth-weight. That is, the factors, low-birth-weight and preterm-birth, will increase the possibility to cause the parenting disorders more than the normal full-term infant. In this study, we examined the difference of utterances between the full-term infant and the preterm infant at 3-month-old of corrected age.

Comparing both groups, the average fundamental frequency of the preterm infant were higher than that of full-term infant. Both groups were compared with the same corrected age. So, in case, the average fundamental frequency develops in proportion to the corrected age, the frequency will not have any differences. Masataka (1991) also reported that the average fundamental frequency of AGA preterm infant caught up with that of AGA full-term infant in proportion to the corrected age. But the subjects of Masataka's study were preterm infant (33.4 weeks) and the average weight of them were 2,485 gm. From the definition, low-birth-weight is the infant whose birth-weight is under 2,500 gm, the birth weight of 2,485 gm is the very limit to be categorized to low-birth-weight. Most of AGA preterm infant defined on the medicine (the duration of pregnancy is between 27 weeks and 34 weeks) are categorized into low-birth-weight infant on the standard infant growth curve. All the preterm infant of this study were categorized into low-birth-weight, and that the average fundamental frequency of them could not catch up with that of full-term infant. This means that there is a difference in the structure of the phonic organ between the full-term infant and the preterm infant. This suggests that the factor of low-birth-weight makes it to be slow to the frequency of utterance. That is, the factor low-birth-weight has a possibility to cause the physical developmental retardation of the phonic organ. But this suggestion must be considered in relation to the admission to NICU.

In fact, about 50-percent of the infant who admitted to NICU has some physical developmental retardation (Hack and Fanaroff, 1984). As cause of that, it is suggested that the admission to NICU causes the lack of care from care-givers, and the environment in NICU is not so appropriate for the best condition to grow up. And what is more, it was supposed that some neonatal disease cause a chronic pulmonary disease and a malnourishment, then magnum consumption calorie must required infant. In fact, when these problems are solved and an appropriate home environment is given, about 80-percent of preterm infants' growth catch up with the standard physical growth curve (Hack and Fanaroff, 1984).

The pitch excursion of utterance of the preterm infant were wider than that of full-term infant. Especially, the full-term infant utters in the level tone (Fernald and Simon, 1984) whose pitch excursion are less than 50-Hz. To utter the level tone, the infant need to maintain the pressure of expiration stably. That is, the maturity of the phonic organ makes it possible to utter with the level tone. Therefore, from the point of view of the pitch excursion, it is suggested that some preterm infant have a
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developmental retardation of the maturity of vocal organ. It has been known recently that mother talked to her infant with utterances which have features of motherese, i.e. higher average fundamental frequency and wider pitch excursion than utterance to adult. Then the difference of pitch excursion was examined, which mother talk to her infant at 3-month-old of corrected age between utterances to preterm infant and to full-term infant (Maeda, 1994). As a result, the acoustic feature of mothers’ utterance did not have a remarkable differences. However, when infant grow up to 3-month-old of the corrected age, their vocal organ begin to change structurally. Then the infant begin to lose the status “obligate nose breather” (Netsell, 1981) and they are able to produce utterance with oral resonance. These utterances have features of “syllabic sound” (Bloom, 1990) and were speech-like. And it was reported that Mother and other adults respond to this syllabic sound more than the other sound, i.e. “vocalic sound” (Masataka and Bloom, 1994). As the utterance of syllabic sound requires the maturity of vocal organ, it is very significant to examine the utterance of the preterm infant from this point of view. It is interesting to examine which mother-infant separation or the prematurity of infant influence the mothers’ rate of responses to the utterance of infant. But, some results suggest that there was no relationship between mother-infant separation and paresting disorders (Cater and Easton, 1980; Collingwood and Alberman, 1979; Egeland and Vaughn, 1981). The problem in the future is to conclude to examine from the point of timing such as a mothers’ rate and latency to the utterance of their infant, and it should be a longitudinal observation.

Summary

This study investigated the vocal behavior of preterm infant in 3-month-old of corrected age. The former study suggested that the average fundamental frequency was not different between the full-term infants and preterm infants compared by the corrected age. But, in this study, the preterm infants who admitted NICU for a certain duration has higher average fundamental frequency than that of full-term infants in spite of same corrected age. As it was reported that the average fundamental frequency fell in proportion as the infant grew up, this result would suggested the developmental retardation of phonic organ. And the preterm infants were observed the prematurity to control their pitch excursion of utterances. Hereafter, we should observe the developmental change of these prematurity and the influence of these prematurity to the mother-infant vocal interaction.
References

Battaglia, F. Lubchenco, L. 1967

Bloom, K. Lo, E. 1990

Cater, J. I. & Easton, P. H. 1980
Separation at birth and the mother-child relationship. Developmental Medicine and Child Neurology, 21, 608-617

Condon, W. & Sander, L. 1974

Fernald, A. & Simon, T. 1984

Garnica, O. K. 1977

Hack, M. & Fanaroff, A.A. 1984

Maeda, Y. 1994
A study on mother-infant vocal interaction of preterm infant. MA dissertation, Yokohama National Univ.

Masataka, N. 1991
Kotoba no Tanjo, Kinokuni-ya Shoten.

Masataka, N. 1992
Pitch characteristics of Japanese maternal speech to infants. Journal of Child Language, 19, 213-223

Masataka, N. & Bloom, K. 1994
Acoustic Properties that determine adults' preferences for 3-month-old infant vocalizations. Infant Behavior and Development, 17, 461-464

Nurai, J. 1970
Gengo Kin no Keisei to Hattatsu, Kazama Shobo.

Netsell, R. 1981

Shimura, Y. 1987
The relation between “Motherese,” as the auditory environment of mother-infant interaction, and infant vocalization. The Japan Journal of Logopedics and Phoniatrics, 28, 162-169