An Observational Analysis on the Function of Infant Vocalization: A Case of a Down Syndrome Infant

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In this article, we propose that the vocalization of pre-linguistic infants has functions as natural speech has. We apply the framework of the three term contingencies i.e. to look at the sequence of the antecedent of behavior (A), behavior itself (B) and the consequence of the behavior (C) (Skinner, 1957; Winokur, 1976). In this framework, some investigations were carried out in order to clarify the development of functions of infant vocalization.

Ichikawa (1997) observed the changes of environment before and after the end of normal infant's vocalization in mother-infant vocal interactions. The hypothesis was that the vocalization of an infant (B) must stop when his need was fulfilled (C). The results suggested that infant used vocalization functionally by the time of 3 month-old. On the other hand, infant's non-cries stopped when his mother started speaking to him and infant's non-cries stopped without mother's following vocalization only after a series of turn-taking, while mother's speech did not stop infant cries at all. Ichikawa (1997) concluded that infant's non-cries have the functions to request for her to speak to him.

Ichikawa et al. (1998) analyzed the acoustic features of normal infant vocalization in terms of fundamental frequency and duration. They analyzed infant's vocalization before and after three kinds of mother's behavior: holding her infant in her arms, feeding milk or weaning food to her infant, and speaking to her infant. They found that the features of infant vocalization changed before and after his mother's behavior, and that the infant functionally used vocalization, because longer vocalization caused holdings and feedings.

Down syndrome infants sometimes have deficiency in the development of language because of their mental retardation. Especially they have obvious deficiency in language production and mostly have disorders in articulation. Freundenberg (1978) reports that cries produced by Down syndrome infants were rated less unpleasant than cries produced by normal infants. Mahoney et al. (1981) suggest that Down syndrome infants are inferior to normal infant in vocal imitation. No past study however reveals the functions and the development of Down syndrome infant vocalization under the framework of three term contingencies.

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We will investigate the functions of infant vocalization before mother's behavior analyzing the recordings of infant vocalization (before and after mother's behavior). We also clarify the development of Down syndrome infant. In addition, we reveal the acoustic features of Down syndrome infant vocalization compared with normal infant.

METHOD

Subject

Subjects are two mother-infant pairs. Subject A is a boy with Down syndrome and the subject B is non-retarded. Subjects' profiles are shown in Table 1.

Table 1. Subjects' profile

Subject	Sex (The date of birth)	Age in days (age in weeks) /recorded time in total		
		5M	7M	9M
A	male (1997.3.)	154d (22w0d) /6h16m42s	215d (30w5d) /6h17m21s	277d (30w4d) /6h10m51s
B	male (1994.11.)	133d (19w0d) /6h10m05s	198d (28w2d) /6h10m26s	———

Procedure

The mother-infant pairs are videotaped in their houses. The area of recording includes the bed where the boys spend almost all day, and the area of the bed (approximately 1.5 meters square). The video camera is set up about three meters from the bed. The mothers start recording at a certain time and continue to record for six hours.

The first recordings were taken when the subject A was 5 month-old and the subject B was 1 month-old. We labeled the recordings "the fifth month recording" (5M) and "the first month recording" (1M). After that, the recordings were carried out once a month for a year period.

Analysis

For the purpose of this study we choose subject A's 5M, 7M and 9M and also subject B's 5M and 7M. Sixty-second infants' vocalization before and after their mother's feedings and holdings is analyzed. "Feeding point" is the time when milk or weaning food comes into infants' mouth and "Holding point" is the time when infants are lifted.

In this observation, the three kinds of mothers' behavior are picked up: holding her baby in her arms (holding), feeding milk or weaning food to her baby (feeding), and speaking to her baby (speech).

Infants' vocalization is classified into three categories: cry, non-cry and faking cry. Classification of

infant vocalization is based on Ichikawa et al. (1996). On this basis, three kinds of vocalization patterns were recorded in the unit of second.

We carried out the acoustic analysis of Down syndrome infant's vocalization. The acoustic features were analyzed by using Kay DSP Sonagraph (Model 4300B) with a 29-Hz band filter and a frequency scale up to 4000Hz. "A vocalization" was defined as a continuous vocalization of the infant bounded by pauses of longer than 0.3 seconds. Two prosodic parameters were prepared for the analysis: average fundamental frequency and duration. An average fundamental frequency is an arithmetic mean of start frequency, end frequency, maximum frequency and minimum frequency of one vocalization.

RESULTS

The change of infant vocalization before and after mothers' behavior

Figures 1 to 10 show the each subject's vocalization in thirty seconds before and after feeding point and holding point. They show the average score of every second frame of all settings.

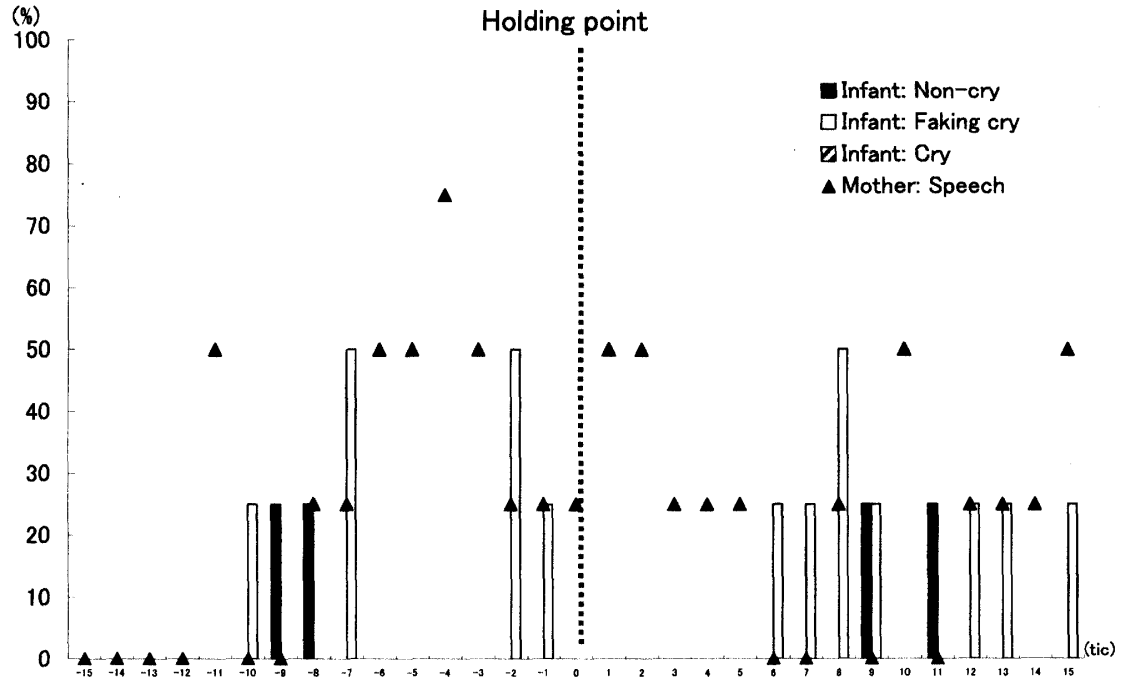

Figure 1. Infant vocalization before and after "holding" in 5M (subject A).

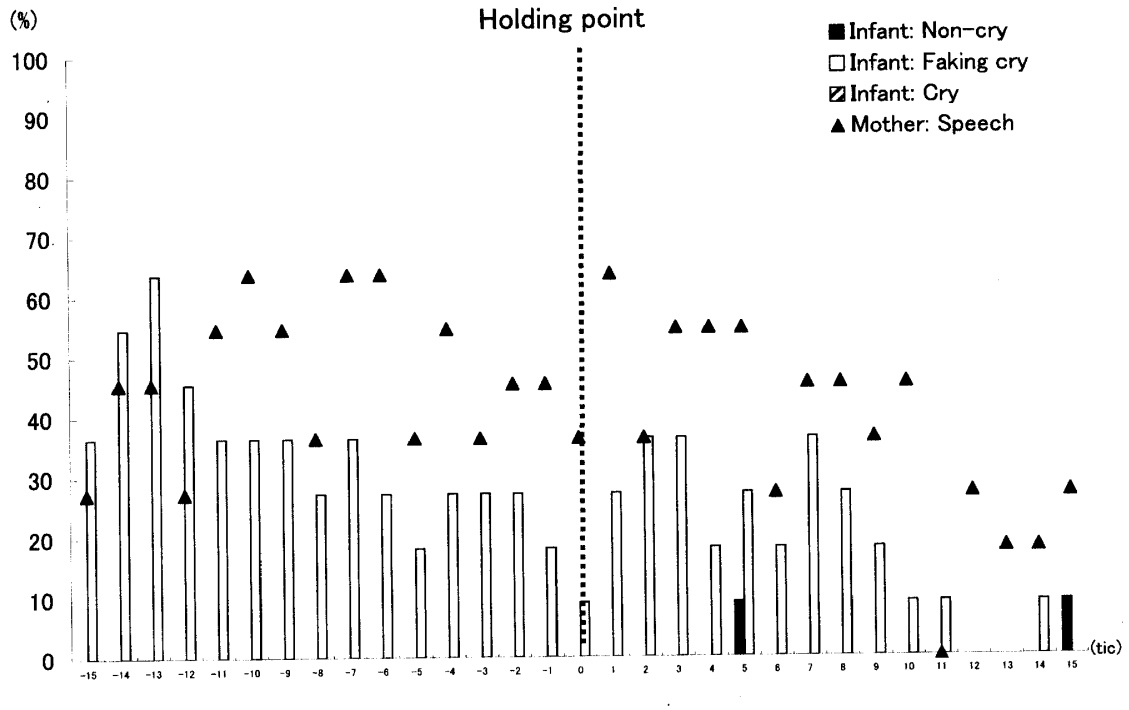

Figure 2. Infant vocalization before and after "holding" in 7M (subject A).

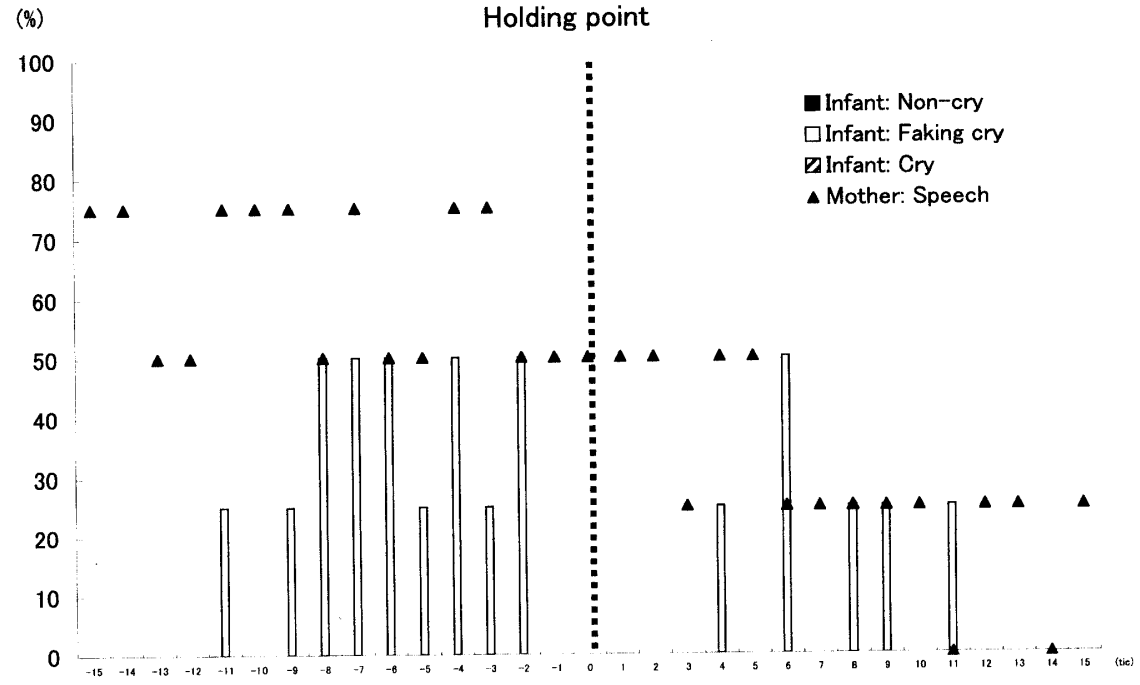

Figure 3. Infant vocalization before and after "holding" in 9M (subject A).

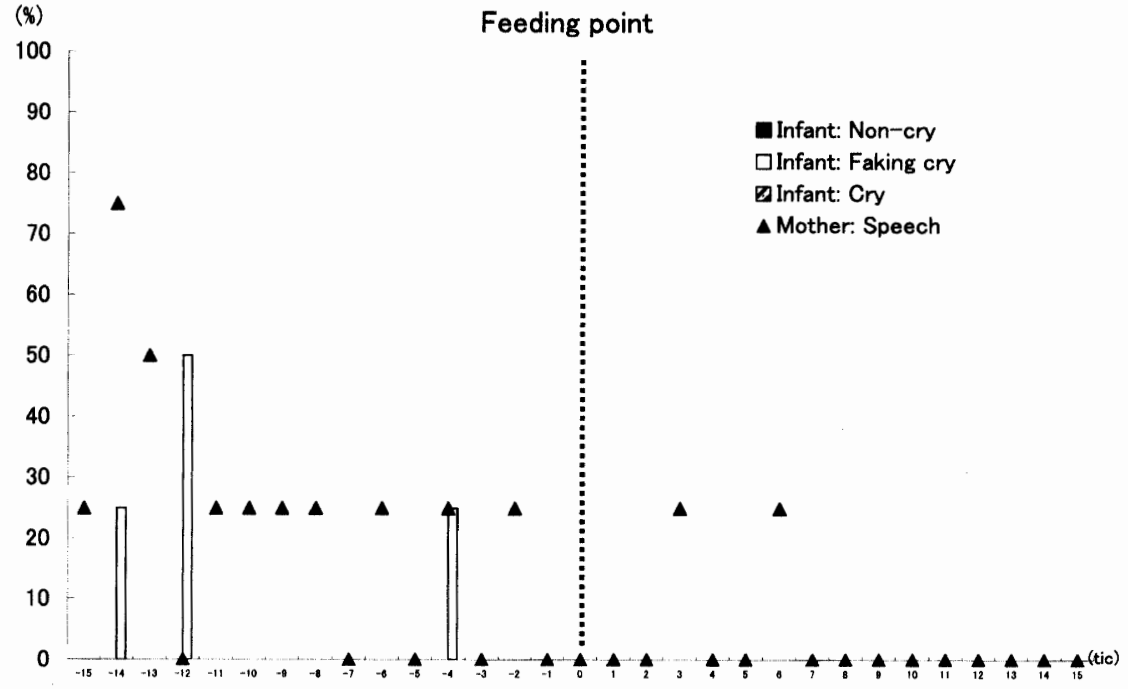

Figure 4. Infant vocalization before and after "feeding" in 5M (subject A).

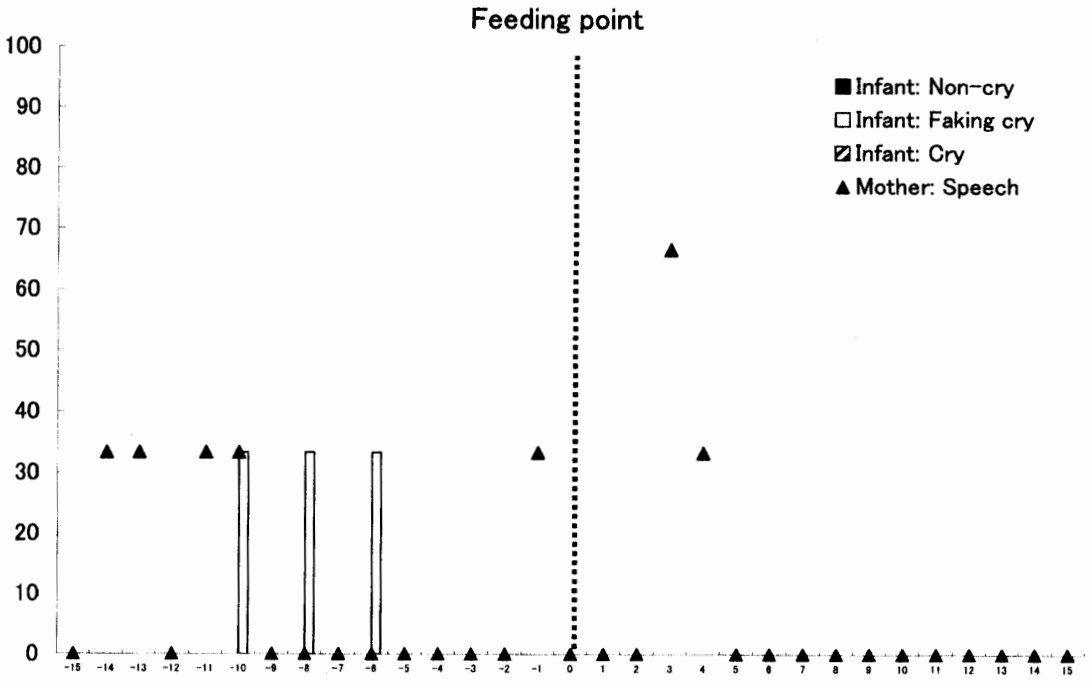

Figure 5. Infant vocalization before and after "feeding" in 7M (subject A).

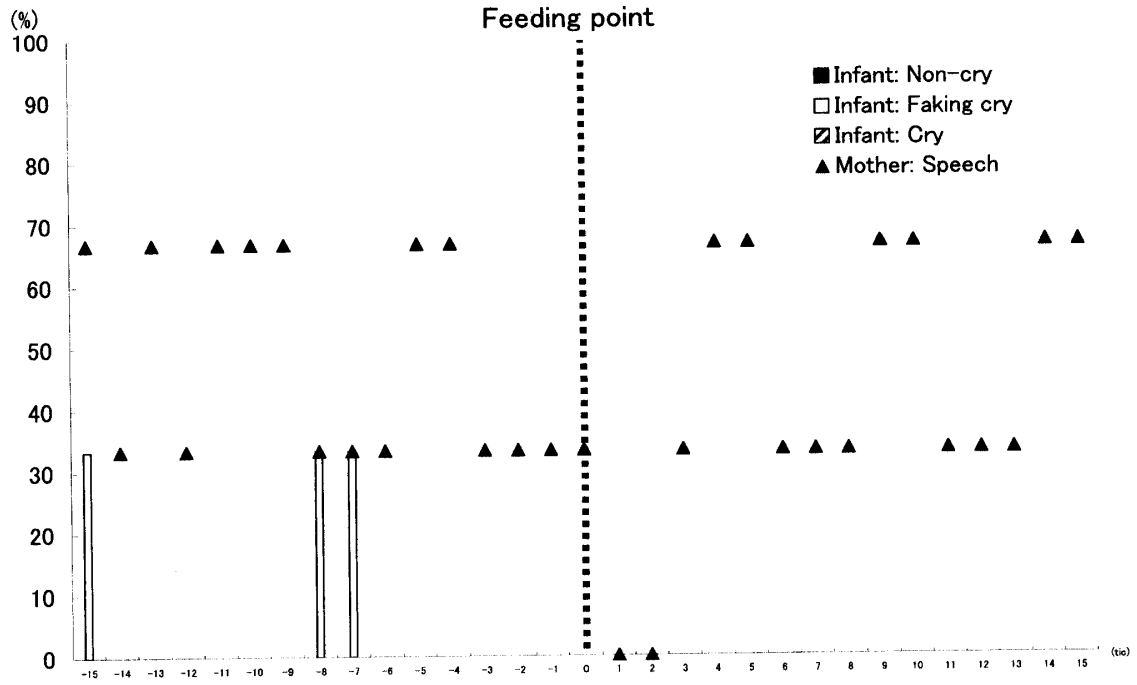

Figure 6. Infant vocalization before and after "feeding" in 9M (subject A).

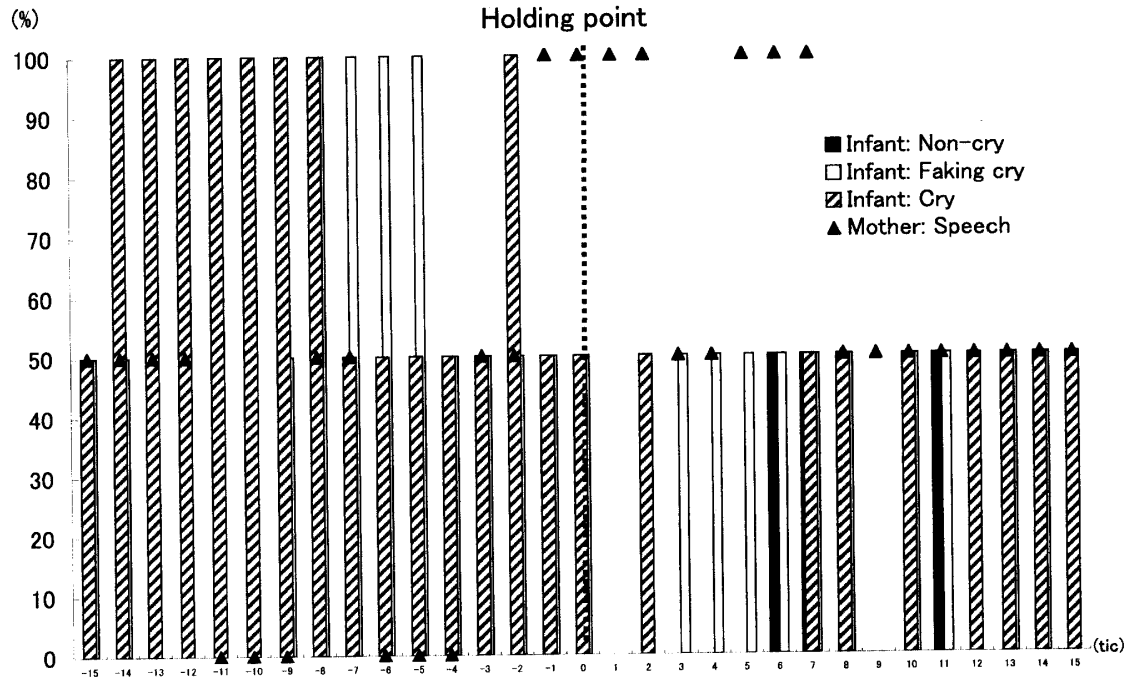

Figure 7. Infant vocalization before and after "holding" in 5M (subject B).

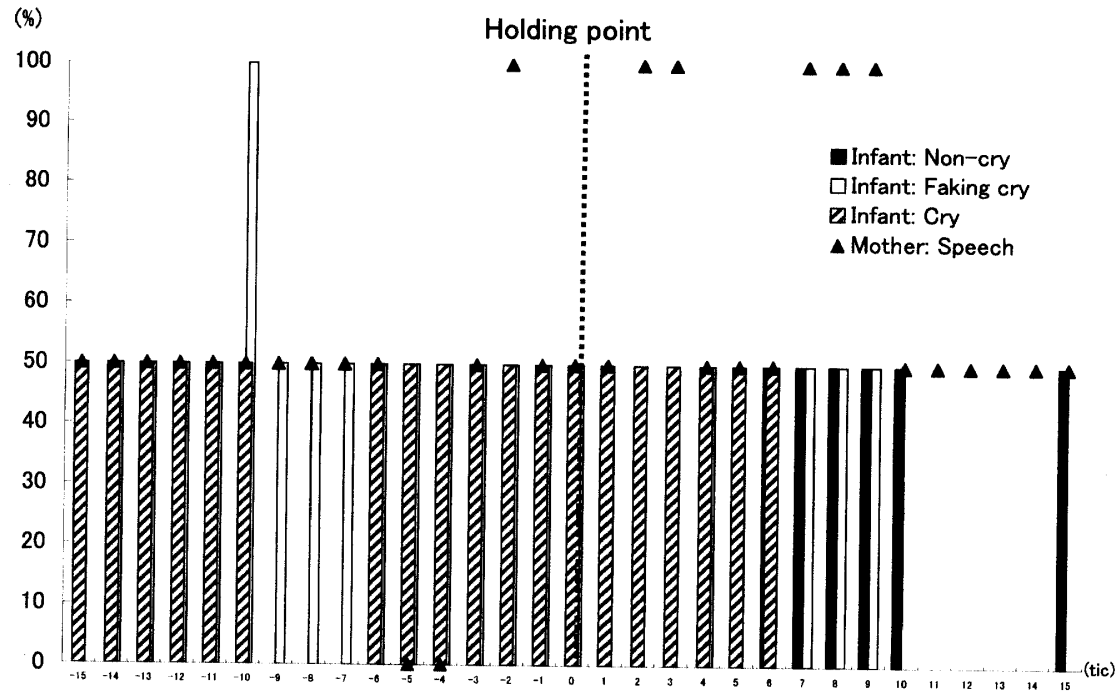

Figure 8. Infant vocalization before and after "holding" in 7M (subject B).

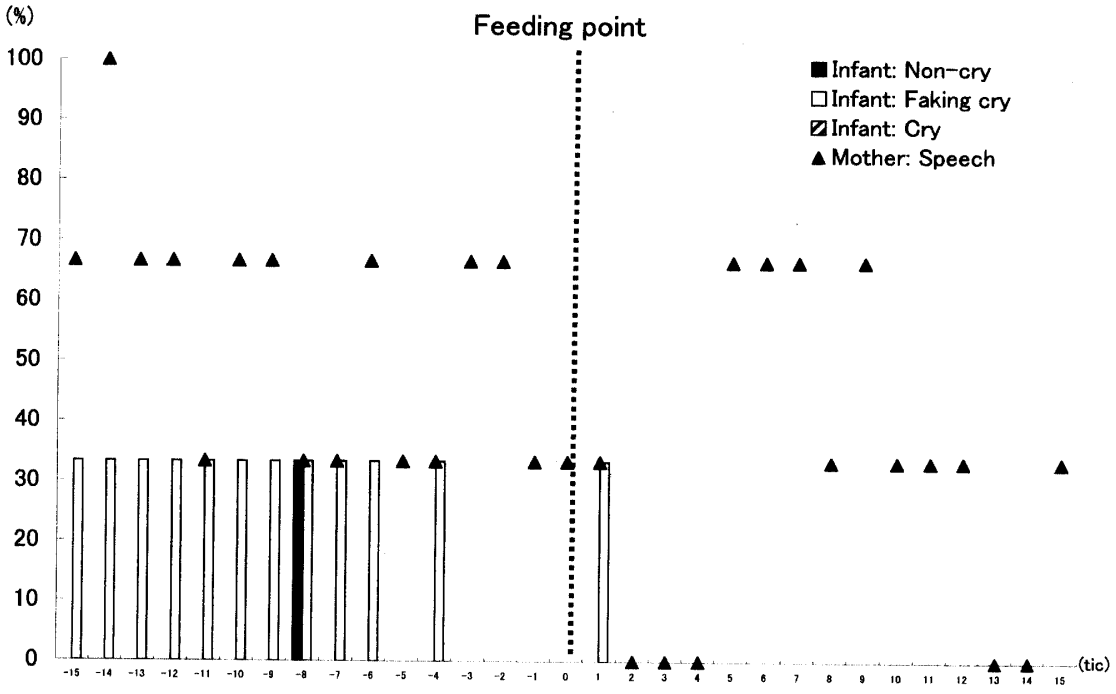

Figure 9. Infant vocalization before and after "feeding" in 5M (subject B).

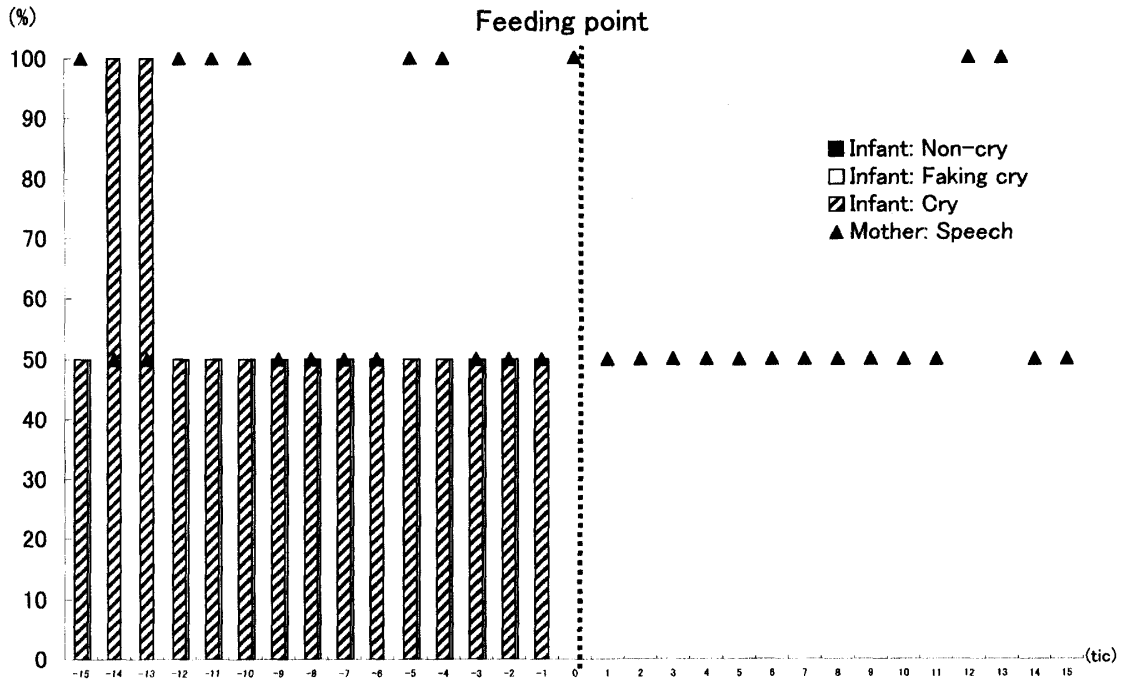

Figure 10. Infant vocalization before and after "feeding" in 7M (subject B).

The infants do not vocalize non-cries before "holding" except the data of subject A's 5M, while they vocalize non-cries before "feeding". And there is no noticeable developmental changes in subject B's data. Subject A vocalizes non-cries before and after mother's behavior in 5M, while he do not vocalize before "holding" in 7M. Regarding "feeding" data, neither subjects showed no clear developmental changes.

As for mothers' speech, mothers spoke to their infants before and after "holding", while the vocalization of subject A's mother after "feeding" decreased.

The acoustic features of infants' vocalization

Figures 11-13 show the scatter diagram of two parameters, duration and average fundamental frequency in subject A's all vocalization before and after "holding" and "feeding" each month. The vocalization of subject A has clearer boundary between three categories with the child's growth.

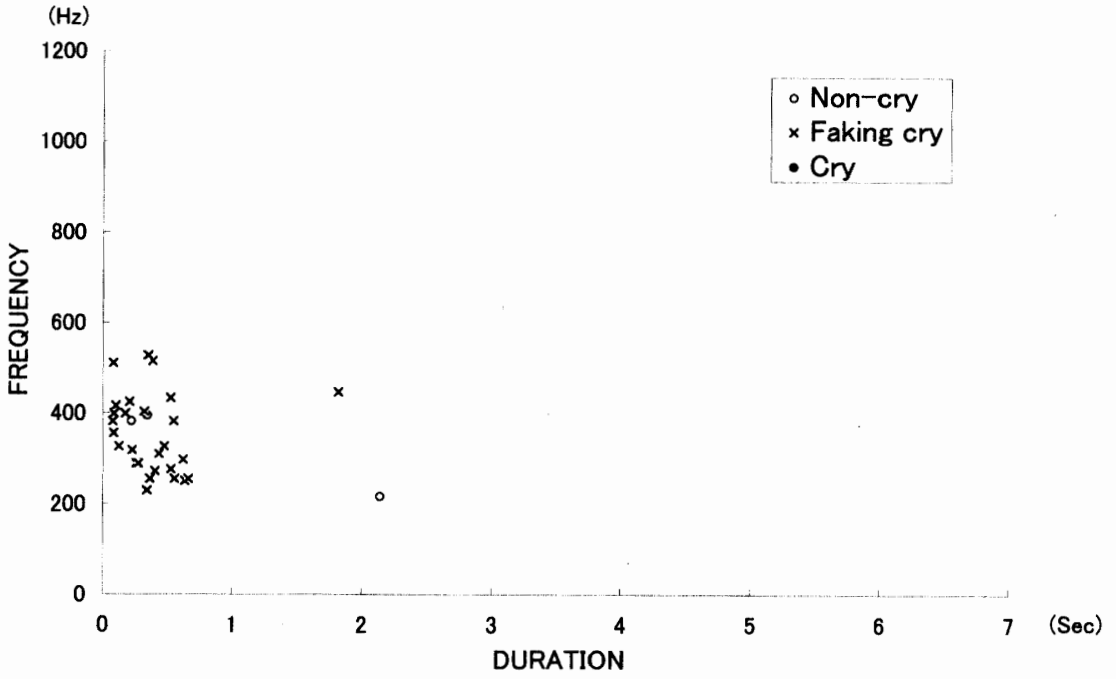

Figure 11. The scatter diagram of two parameters, duration and frequency in 5M (subject A).

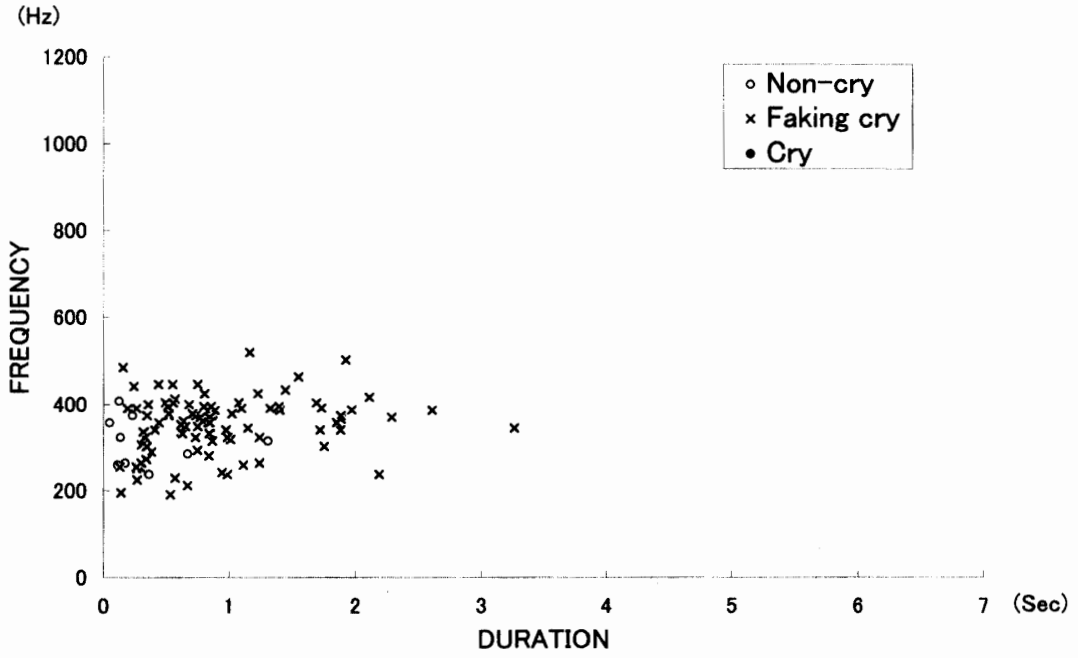

Figure 12. The scatter diagram of two parameters, duration and frequency in 7M (subject A).

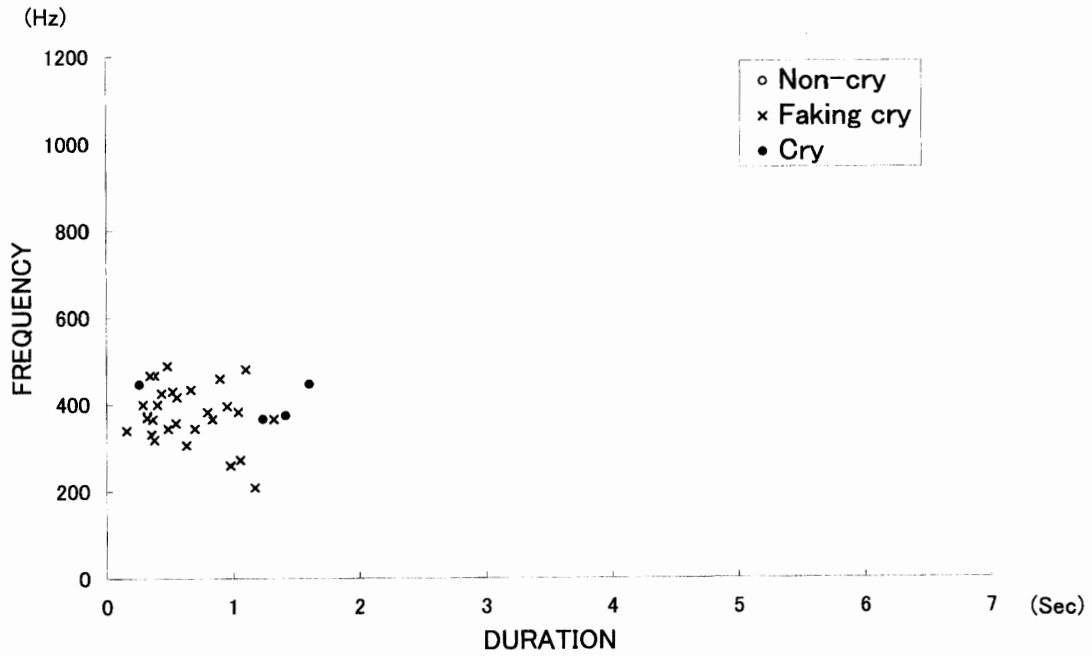

Figure 13. The scatter diagram of two parameters, duration and frequency in 9M (subject A).

The scatter diagram in subject B's 5M vocalization of two parameters, duration and average fundamental frequency are shown in Figure 14. (reprinted from Ichikawa et al., 1996).

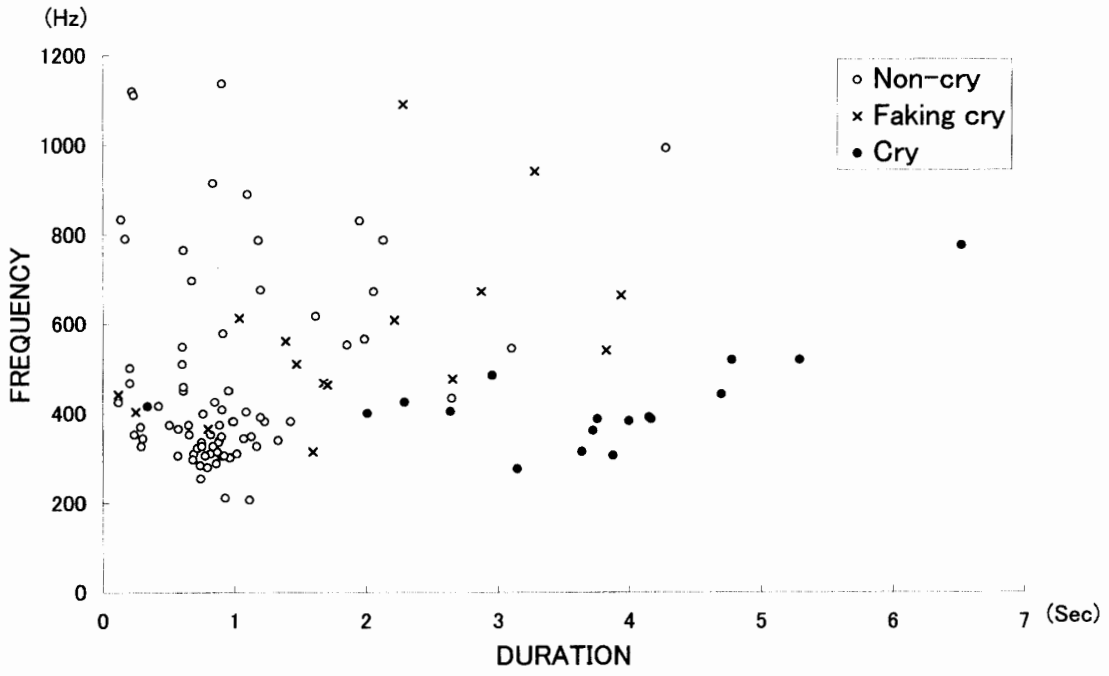

Figure 14. The scatter diagram of two parameters, duration and frequency in 5M (subject B)

Compared with subject B, subject A's vocalization has more vague boundary between the three classes of vocalization. And subject A's vocalization has shorter duration than subject B's.

DISCUSSION

Generally speaking, the Down syndrome infant in this research has some backwardness in the development of functional use of vocalization.

The non-retarded infant and the Down syndrome infant vocalized non-cries and faking cries before and after "feeding". But both infants did not vocalize non-cries except the data of subject A's 5-month. Non-retarded infants in 3 month-old, however, usually vocalize cries and faking cries before "holding" that indicated that they use their vocalization functionally (Ichikawa, 1997; Ichikawa et al., 1998). Subject B starts to vocalize faking cry from 7 month-old. In conclusion non-cries do not have a function of request to "holding", and subject A with Down syndrome has backwardness in the time when he start to use faking cry for request "holding".

Subject A's vocalization does not have clear differentiation compared with subject B. Because of settings of video-recorder, we could not analyze the amplitude of voice. But when we heard vocalization of subject A and subject B, we noticed that the vocalization of subject A was more faint and more vague than that of subject B. There is possibility that the infant cannot be reinforced by mother's relevant behavior to his vocalization because of these features.

Now in April 2000 subject A can not produce any words, but he can use some voice to communicate with some people around him. This research could not reveal whether the difference of vocalization between subject A and subject B is caused by Down's specific shape of vocal tract or by the retardation of development. But that difference of vocalization must be an obstacle in the process of differentiation, so that the specific vocalization will have function. An investigation of his development of vocalization functions is in progress.

Further study, with more subject and more recordings, is necessary to reveal how to develop the functions of vocalization and to relate the development of functions of vocalization to the development of functions of language.

Summary

This study reveals the functional development of the Down syndrome's vocalization in his early infancy. Subjects were two mother-infant pairs: one infant was with Down syndrome and the other infant was non-retarded. They were videotaped for six hours when the infants were 5- and 7 month-old and when the Down syndrome infant was 9 month-old. In the observation, the three kinds of mothers' behavior were picked up, holding her baby in her arms (holding), feeding milk or weaning food to her baby (feeding), and speaking to her baby (speech). Sixty-second infants' vocalization before and after their mother's feeding and holding were analyzed. Infants' vocalization was classified into three categories, *cry, non-cry* and *faking cry*. Three kinds of vocalization patterns were

recorded in the unit of second. The acoustic features of fundamental frequency and duration in Down syndrome infant's vocalization were analyzed. Three results were obtained. 1) There were no non-cries of 15 seconds before holding except in the data of the 5 month-old Down syndrome infant. 2) Developmentally Down syndrome infant's non-cries before holding existed longer than the "normal" one. 3) Down syndrome infant's vocalization could not be classified into clear categories compared to the non-retarded infant. From these results, we conclude that the Down syndrome infant has some backwardness in the development of functional use of vocalization.

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