THE DEVELOPMENT OF SPONTANEOUS CRYING OF AN INFANT: THE FIRST THREE MONTHS

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INTRODUCTION

It is generally agreed that the major goal of developmental psychology is to understand how behavior develops. So long as the issue remains at an abstract level, problem does not arise. However, in prace, researchers differ not only in the topics and strategies they choose, but also in views they hold about what behaviour development is.

Take infant cry as an example. The publication of several monographs and numerous papers on this topic during the last 30 years or so testifies to the view that the topic is a significant one (Lind, 1965; Wasz-Hockert, et al., 1968; Murry & Murry, 1980; Lester & Boukydis, 1985). However, a perusal of any of the above mentioned monographs will show that even within the small group of active "cry researchers", difference is to be found on the views about the level of analysis adopted, and on what constitutes significant phenomena in the development of infant crying. For researchers whose main interent is to develop some kind of instrument for clinical screening or diagnosis, even single infant cry sounds hold the promise of providing important information about the clinical status of the infant (Wasz-Hockert, et al., 1968; Michelsson, 1980; Golub & Corwin, 1985). Partly for this reason, there is a tendency for these studies to focus on the acoustic features of single cry signals elicited by experimenter-imposed pain stimulus. While for other researchers who are interested in infant crying as an index of materal sensitivity, the main focus of analysis is in the relationship between some rating indices of maternal care-giving behavior on the one hand, and some index of the amount of crying or fussing over a long period of time on the other (e.g. Bell & Ainsworth, 1972). In addition to these topics and issues, infant cry has also been examined from various other viewpoints, such as, that of its emotional effect on the perceivers (e.g. Zeskind & Lester, 1978; Frodi, Lamb, Leavitt, & Donovan, 1978), the development of its acoustic features (Stark, Rose, & McLagen, 1975) or from the view point of its development, in terms of the amount and/or frequency over

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an extended period of time (Aldrich, Sung, & Knop, 1945a, b, c ; Barr, 1987 ; Brazelton, 1962 ; Rebelsky & Black, 1972).

While the topic of infant cry has been approached from various angles, and analyses carried out at different levels, the one aspect that has attracted the most attention has been the cry sound. In contrast, there are no adequate normative data concerning another component of crying of similar importance, the cry act. Traditionally, cry act has been taken to mean the motoric motions of the vocalizing system, the pharyngeal, laryngeal, and thoracic adaptation during crying. In this respect, the pioneer work by Bosma, Truby, & Lind (1965) remains the only source of information. In their study, " by combining cineradiography, acoustic analysis, and recording of air pressure and displacenent phenomena ", they demonstrated the detailed motions of " the pharyngeal, laryngeal, and thoracic adaptations of respiration during crying and the associated struggles " (Bosma, Truby, & Lind, 1965, p. 63).

In this paper we would like to point out that infant cry has another aspect which is seldom being examined, namely, as action. By action we mean a series of goal-directed behaviors. As an action, infant cry (or, crying) consists of both the cry sounds as well as the accompanying cry acts. A detailed observation of the crying behaviour of an older child in later infancy will reveal the fact that several behaviours, such as looking, searching, or even attacking, are being carried out while a variety of vocalizations are being executed when crying. Furthermore, these behaviors and the vocalizations are closely regulated with reference to the child's appraisal of the current state of his/her goal attainment. This state of behavioral organization is in drastic contrast with that of a young infant of the first days when crying is an exclusive loop of vocalization only (with limb movement or thrashing as a result of the struggle).

Thus, unlike views adopted in most of the previous research, infant crying will be considered here as possessing the following characteristics : 1) Consisting of a series of sounds and acts which form hierarchies of dynamic behaviour system (e. g. interaction and self-organization are to be found within and between both the sound units and the act units), 2) Directed by goal which changes with time and age.

In this paper it will be demonstrated that during the first few months, the action of infant crying develops from a state when the onset or offset is relatively clear-cut (meaning that once activated, the infant engages in full-blown rhythmic crying, and is not accessible for some time until the tension subsides), to a state where tension takes time to build up, with the initial phase of negative vocalization (or fussing) frequently interrupted as a result of the infant's paying attention to the external stimuli in the environment, and making constant reappraisal of the current state of things against his/her goal at the moment.

Data from one infant will be presented to show 1) Developmental changes of the length of a crying sequence, 2) The emergence of greater variations in the patterns and orders of a sequence of phonations, and 3) The change from " crying-without-looking " state to the emergence of the " crying-and-looking " state.

METHOD

Subject

The data to be reported in this paper come from one Japanese male infant (K. S.) who was a participant in a longitudinal study of infant crying. K. S. was normally delivered (birth weight=3310 g., gestational age=41 week+5, Apgar score=9 at 1 min. and 10 at 5 min.) in a private hospital in the city of Sapporo. He is the first child of a nuclear family. The mother's age was 24. They were discharged from the hospital one week after delivery. Permissions for observation was obtained from the the mother through the obstetrician and the chief nurse. On behalf of the researcher, the chief nurse approached the mother before delivery and obtained the permission for observations to be carried out immediately after the subject was born and during the one week lying-in period. Although agreement for continuing observation at home was obtained before the mother and her child were discharged from the hospital, the schedule for home visit observation was arranged before each home visit by telephone.

The first observation immediately after the delivery was carried out 24 minutes after the subject was born, in a separate room adjecent to the delivery room. Home observation took place either in the morning or in the afternoon; no observation took place after 4 PM or before AM 9:30. However, observations both in the hospital as well as at home occurred in all the days of the week.

Data Collection

Five sessions of data collection were carried out until the third month after birth: 1) First day (age=24 min.), 2) 2nd-3rd day (73 hous), 3) 4 weeks (31 days), 4) 8 weeks (59 days), and 5) 13 weeks (91 days).

Permissions to make home visit was obtained through neogotiation with the parents by telephone calls. The mother was explained about the purpose of the home visit, and the times of visit were decided at the advice of the mother. The mother was told that the researcher would like to observe the infant's crying, starting when the infant was 1) Awake and not fussing, 2) Properly fed but not immediately after feeding, 3) With clean and dry diaper. As these conditions are difficult to satisfy as planned, additional visits were made to make up missing data.

Context of Crying

Spontaneous crying is defined across all the observation periods as "crying that was not triggered by any known causes", such as the ones mentioned above (e. g. sleepiness, hunger, wet or dirty diaper).

In most cases, the subject was lying supine, on matress, carpet, or in the cot. Observation usually started when the infant was awake and not fussing. Often, the infant was put down for observation after the researcher had prepared the camera and the recording device. When no fussing or crying was observed for over an extended period of time (i. e. ten minutes), mother was asked to play with the infant for a while and then to put down and leave the infant for further observation. Whenever the subject's lower limbs were visible, the whole body was filmed; when lower limbs were covered by clothes, focus was placed on the upper part of the body.

In oder to ascertain as much as possible the mother's interpretation, mother was asked to comment on the possible cause of the crying eqisode just observed. The most

frequently made comment was that the infant wanted to be picked up. However, as the infant grew older, it was difficult to rule out the factor of the " strangeness entailed by the researcher's presence " as one possible cause for the crying although it was never mentioned by the mother.

Apparatus

Spontaneous crying was recorded using a camcorder (SONY, CCD V-200). To one audio-input jack was connected a microphone (Electro-Voice, model 613B), which was positioned about 15 cm away from the subject's mouth during the first two data collection sessions when control was easily feasible. During home observation, however, microphone was kept as close as possible towards the direction of the subject's mouth. The camcorder was supported by a tripod, and was about 1.5 meter away from the subject. When there was no convenient place for fixing the microphone, it was held by hand. The original observations were all recorded on 8 mm video cassette tapes (SONY P6-90 MP). Using a video-audio recorder (SONY, SL-HF 3000), the video and the audio signals of the original tapes were duplicated onto Beta cassette tapes, with a time code (mim, sec, 1/100 sec) generated by a video-timer (FOR-A, VTG-22k), superimposed. The duplicated Beta cassette tapes were used for analysis.

Data Analysis

For this paper, data analysis was conducted on two aspect of infant crying; cry sounds and cry behaviour.

a) Cry sound analysis: For data extraction, the duplicated Beta cassette tapes were replayed and cry sound signals from the audio track of the tape were fed into a Sona-Graph (Kay Elemetric Corp. model 5500) through an audio amplifier via the aux input jack, The Sona-Graph was set to display both the spectrograms on the lower half of the monitor, and wave form and amplitude curve on the upper half of the monitor. video printer provides a hard copy of the graphic information. The built-in memory of the machine has the capacity for aquiring up to 38 min of signals at 4 kHz. By manipulating the appropriate keys, the entire cry signals aquired can be reviewed, audioally and visually, and measured. The movement of the cursors allows the duration of any part of the signals to be measured up to millisecond precision, although for the present analysis the effective precision was set in such as way that the smallest unit discerndble was above 75 milisec.

The type of each cry vocalization was classified into phonation, dysphonation, and hypophonation, as described by (Thuby & Lind, 1963). Each cry vocalization was further classified into one of the following categories (Table 1), taking into acount both the type of phonation and the duration. And a cry series, defined as a sequence of cry sounds within the boundaries of two silent intervals lasting more than 3000 milisec, was represented by a series of bracketed alphabet and number. Thus, for example, (A1) (B5) (L1) (C2) means that the sequence consists of one A category cry sound followed by 5 B category cry sounds, then comes an L category cry sound and ends by two C category cry sounds.

TABLE 1

Cry sound categories

A :	A long vocalization exceeding 1600 milisec
B :	A phonation above 300 and below 1599 milisec
C :	A phonation below 299 milisec
D :	A dysphonation of any duration
G :	Gasping sound
H :	A hypophonation of any duration
K :	Glottal plosive or a vocalization containing glottal plosive
L :	A low intensity vocalization
S :	A short vocalization (below 300 milisec) with sudden closure of glottis

b) Cry behavior analysis: One to four episodes lasting 4 minutes were selected from the VTR records for each data points. A secon-by-second coding of the presence or abscence of a set of pre-selected categories was performed. Table 2 shows the behavior categories employed.

TABLE 2

Cry behavior categories

V :	Vocalization
M :	Movement of the limbs
E :	Visual attention
O :	Eye open
G :	Grimacing

RESULTS

A total of 32 sequences of crying were observed during the 59 minute observation immediately after birth. The length of the sequences ranged from one vocalization unit to 40 vocalization units (Mean=8.9, SD=8.5).

Four sequences of cry vocalization were observed during the 12 minute observation on the third day after birth. Their length ranged from 61 to 177 vocalization units (Mean=114.8, SD=46.4).

At 3 weeks, 2 sequences of vocalization were observed during a 7 minute observation. These sequences consisted of 71 and 74 vocalization units respectively (Mean=72.5, SD=1.5). At 4 weeks, one cry sequence lasted for 73 cry units was observed during a 13 minute observation.

At 8 weeks 9 sequences of cry were observed during a 24 minute observation. The number of cry units ranged from 8 to 28 (Mean=15.2, SD=6.9).

Finally, at 13 weeks, 8 sequences were analysed. The number of cry units ranged from 1 to 31 (Mean=9.4, SD=13.4).

Table 3 shows the summary statistics concerning the length of cry sequence in different ages. ANOVA indicated that there was a significant difference in mean length of cry seqence at different ages ($F=49.074$, $DF=4$, $P<0.001$).

TABLE 3

Summary Statistics Concerning the Length of Cry Sequence at Different Ages

Age	No. of Observation	Mean Cry Unit (Range)	SD
0 Day	32	8.9 (1- 40)	8.5
3 Days	4	114.8 (61-177)	46.4
3-4 Weeks	3	72.6 (71- 74)	1.4
8 Weeks	9	15.2 (8- 28)	6.9
13 Weeks	8	9.4 (1- 31)	13.4

Some of the sequences of vocalization of each period are shown in Table 4.

TABLE 4

Comparison of the Order of Cry Sounds

0 Day:

1. (A1) (H1) (D5) (B1)
2. (B3) (L1) (D1) (B6) (L1)
3. (L4) (A1) (B2) (L1) (B5)
4. (A1) (D6) (B5) (L2)
5. (K1) (A1) (D6) (B1)

3 Days:

1. (S1) (H1) (A3) (H1) (D1) (B8) (G1) (B1) (A2) (B10) (H4) (D2) (B5) (D1) (H5) (D2) (B2) (D5) (B6)...
2. (G1) (S4) (H1) (B1) (S2) (B3) (D2) (B13) (D1) (B2) (D1) (B30) (L1) (B1) (D 4+)...
3. (S8) (A2) (D1) (B1) (D3) (B14) (A1) (B7)...

3-4 Weeks:

1. (S6) (A1) (B1) (D1) (S3) (A1) (D1) (H1) (D1) (S1) (B2) (D3) (B1) (L1) (A 1)...
2. (B1) (A2) (S3) (L2) (A2) (D+H1) (B4) (H1) (B3) (A1) (S1) (B1)...

13 Weeks:

1. (L1) (B1) (G3)
2. (K8) (G1) (A1) (K1) (A1) (G1) (K1) (B1) (G1) (H+K1) (B2) (B+K1) (B1) (D1) (B2) (L1) (B1) (L1) (B1) (G1) (B6)...
3. (K2) (L1)
4. (K4)
5. (L1) (K2) (L1) (K1) (B2) (G1) (K1) (A2) (B1) (G2) (B2) (K1) (L1) (K2) (A1) (K1) (B2) (L1) (K2) (A1) (K1)...

The result of counting the number of new categories observed at each sequence (omitting the same ones), and comparing the means for 0 day, 3 days, 3-4 weeks, and 12 weeks, respectively, showed that there was a significant difference in the mean number of categories of cry sounds between ages ($F=3.893$, $DF=3$, $P=0.04$).

The results of behavior analysis is shown in Figure 1.

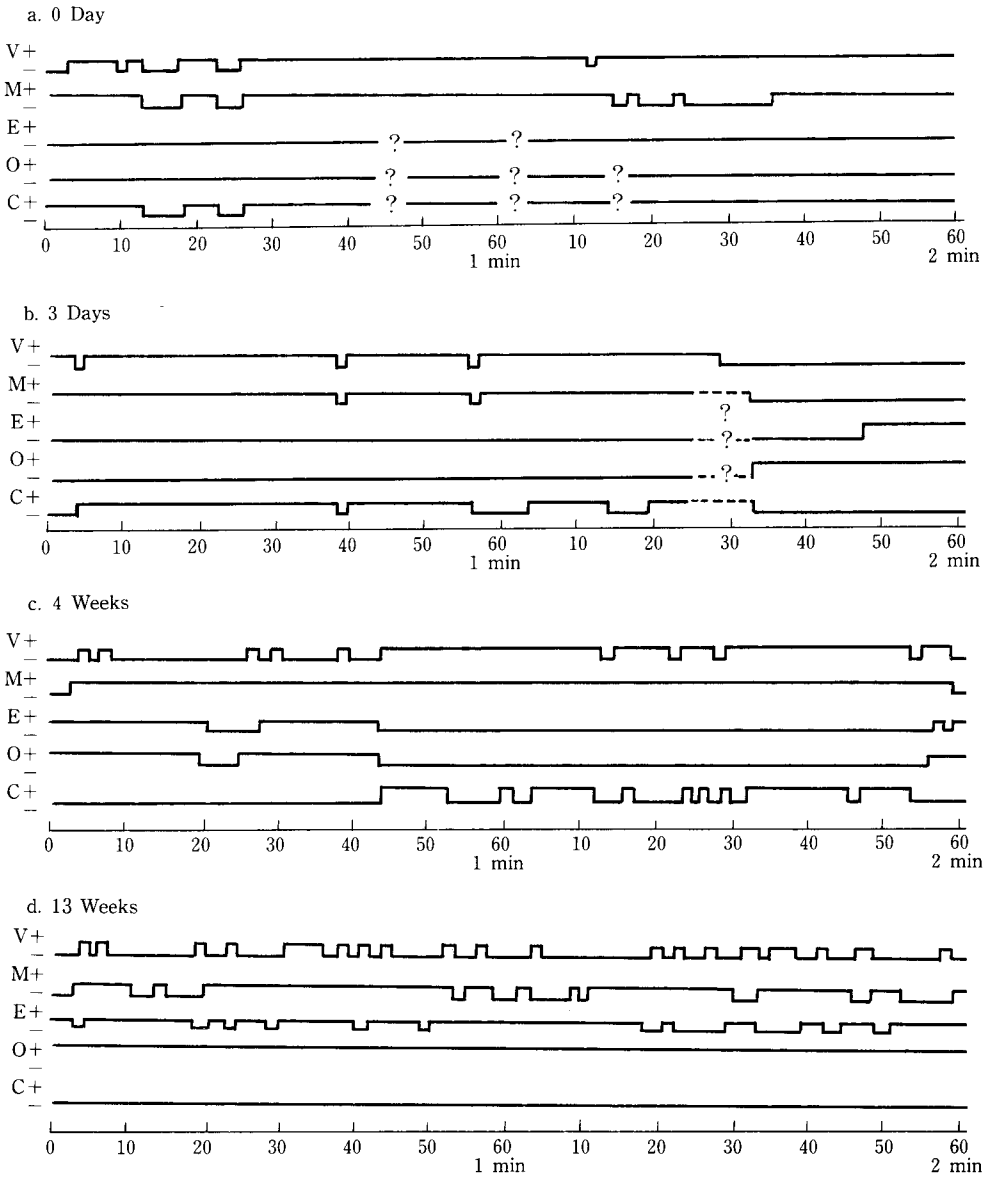

FIGURE 1 Actograms for 2-min periods of crying of infant K. S. at 0 day, 3 days, 4 weeks, and 13 weeks, respectively.

DISCUSSION

As shown in the summary (Table 3), the length of a sequence of cry rised from 8.9 (units) at birth, reached the peak of 114.8 units on the third day, and around 4 weeks stablized at about 72 units and fell to 15.2 units at 8 weeks. This pattern tends to agree with results obtained from 9 other participants of the longitudinal study (to be reported in another paper under preparation).

Table 4 shows the developmental change in the orders of cry phonation from immediately after birth to 3 months. The first period (0 Day) was characterized by the appearance of very long cry phonation in the very beginning of the sequence, and the relatively simple structure (as indicated by the relatively small number of elements). The second and the third pedriods (3 Days, 3-4 Weeks) saw the frequent employment of glottal plosive in initiating the cry sequence. At 4 weeks, unlike the previous periods, where categories such as D or B tended to repeat themselves many times before phonations of other category took over, phonation under the same category appeared only a few times. Finally, at three months, the frequent appearance of short phonations characterized by sudden clousure of the glottis (auditorily, they sounded like self-imposed cough), and short repetition of same-category phonation seemed to be the pattern of the period.

Although the length of a cry bout is not the same as the amount of crying which, according to some studies (e. g. Barr, 1987; Brazelton, 1962) showed a tendency of peaking at 6 to 8 week, the tendency observed here seems to suggest that it reflects some aspect of the mechanism underlying the activation and the suppression of crying in the young infant. This suggestion can further be supported by the following observations: 1) That during the first days, the length of cry bout remained remarkably stable for each individual through out the observation period, 2) That after 8 weeks, the length of cry bout changed with the level of activation, with the initial several minutes showing short bouts, followed by longer bouts, if the crying or fussing was not suppressed, either by the caregiver or the infant himself. The latter point can also be supported by the result of the behavior analysis. These observations considered together seem to suggest that, in contrast with the early days, after 8 weeks the system underlying crying behavior becomes capable of redefining its control boundaries as a function of its state of activation.

The emergence of the "crying-and-looking" state at about 4 weeks was observed in other, but not all, subjects in the longitudinal study not reported here. Further, this state was observed in the beginning phase of the observation, usually lasting for several minutes. However, if the infant was left to cry for some time and if the fussing or crying reached a certain level of activation, the infant would revert to the "crying-without-looking" loop of the earlier age. This "crying-and-looking" state, very similar to the "interrupted fussing state" observed around 3 months and described by Hopkins (1987). This newly emerged skill of the infant seems to suggest a milestone on the way to a more integrated, goal-directed action to be achieved later in the first year.

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