# Relation of Crying Activity in Early Infancy to Speech and Intellectual Development at Age Three Years [1,2]

SAMUEL KARELITZ,* VINCENT R. FISICHELLI, JOAN COSTA, RUTH KARELITZ,[3] and LAURA ROSENFELD

*Long Island Jewish Hospital* and *Hunter College*

Cries of 38 infants, age 4 to 10 days, were measured for outburst frequency during the most active 20-sec. period of crying. Crying scores showed a significant correlation (.45) with Stanford-Binet IQ at 3 years, a borderline correlation (.32) with Cattell IQ at 15 to 20 months, and a nonsignificant trend with speech ratings at 3 years. Although no correlations were adequate for individual prediction, infant crying is deemed worthy of further investigation as a possible indicator of intellectual potential.

Studies previously reported indicate that the crying activity of normal infants can be differentiated from that of infants with brain damage (2, 5, 6). Knobloch and Pasamanick (7) have presented data indicating that the Gesell Developmental and Neurological Examination is a valid and reliable diagnostic tool at age 40 weeks. Also, it is known that various measures of speech development are related to abilities of the type measured by standard tests of intelligence. Attempts to measure intelligence before the onset of speech, however, have met with little or no success (8). Spiker and Irwin (9), and Harms and Spiker (4) have uncovered small but reliable relations between intelligence test scores and certain aspects of speech sound development. The object of this investigation is to explore the relation between the crying of infants four to ten days of age and intelligence as well as speech development level at age three years. Since previous studies indicate that young normal infants respond more quickly to painful stimulation and provide more sustained crying than do brain damaged infants, it was predicted

* Long Island Jewish Hospital, 270-05 76th Avenue, New Hyde Park, Long Island, New York.

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that normal children with higher IQs would have more active cries than normal children of low IQs.

## Subjects and Procedure

The 38 subjects (18 males and 20 females) used in this study were infants born at the Long Island Jewish Hospital more than three years ago. The cry samples used in this study were taken at 4 to 7 days for 36 of the infants; one was taken at age 8 days, and another at age 10 days. (Four days of age = 96 to 120 hours.) In instances where both 4th and 5th day samples were available it was decided to select the cry of the 5th day since there is suggestive evidence that the cries of infants under four days of age may not be so sustained as those of older infants. All but six were given the Cattell Infant Intelligence Scale between 15 and 20 months of age. All 38 were retested at three years ± three months (hereafter called three years) for intelligence with Form L of the Stanford-Binet. Table 1 also gives the sex, age in days when the cry was recorded, visual cry counts as well as auditory cry counts for both the 4th and 5th day when available (described below), the Cattell score at 15 to 20 months of age and the speech rating at age three years.

The stimulation procedure used to elicit crying in the infant who was not found crying at the time of recording was a flick on the sole of the infant's foot with the experimenter's finger; this failing, the infant's foot was again flicked at intervals of a few seconds until he cried for a minute, or stimulation was terminated because it was obvious that this could not be accomplished. In subsequent investigations a standardized procedure of stimulation with the snap of a rubber band on the sole of the foot for a maximum of eight such stimulations at approximately 10-second intervals was used (2, 5).

All test sessions were recorded on magnetic tape with an Ampex 601 (Electrovoice 666 microphone), and appropriate data, including time of day, last feeding time, etc., were preserved.

The individual cry samples were then converted into Volume-Unit (V-U) charts (3). Briefly, this involves converting the magnetic tape recording of the cry into a visual graphic pattern. The magnetic tape is run through an amplifier in circuit with a 10-ohm resistor, a rectifier, and a graphic milliammeter. Ampex 620 intensity and equalization settings were 3.0 and 0.0 respectively for all charts. A V-U chart sample is shown in Figure 1. The ordinate scale ranges up to five milliamps. The synchronous motor of the graphic ammeter was set at 20 seconds to the inch. The onset of crying is indicated by the arrow in the figure. Activity to the right of the arrow represents the experimenter's voice feeding into the tape recorder appropriate identification information.

Visual scanning of the individual charts reveals that some sections of the cry sample show more activity than others. Since the sample lengths varied

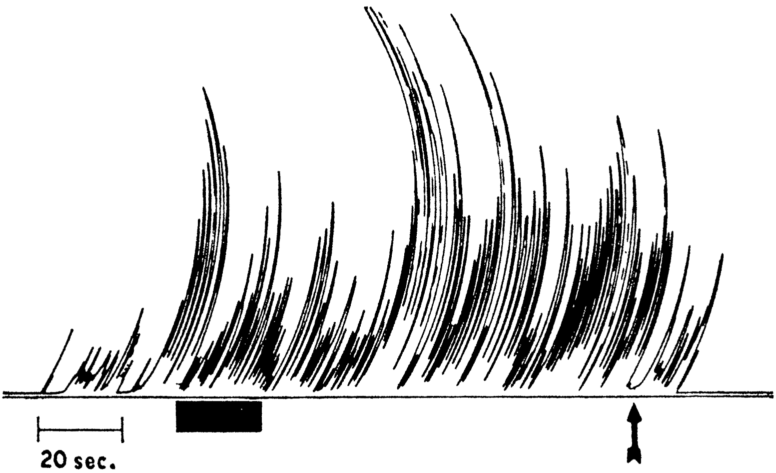


FIGURE 1—Volume-unit chart of normal girl, 5 days old, Stanford-Binet IQ of 157. The visual count is taken from above the dark bar. Chart reads from right to left and the scale is as indicated. The arrow shows onset of crying.

from infant to infant and the points of stimulation were not uniform, it was decided to base the cry count on a limited section of the cry sample, the most active 20-second area. For each infant this 20-second maximum cry count is the sum of the outburst peaks without respect to amplitude. In Figure 1 this is indicated by the area over the black bar. Whenever alternate areas were suggested they were counted and the highest figure was chosen for analysis.

As the children in the study reached their third birthday, they were given a speech evaluation test, which was primarily an assay of articulation, using a picture test, administered by a qualified speech therapist (L.R.).

## Results and Discussion

### *Early Crying and Later IQ*

The findings of this study are presented in Table 1, which, in addition to the data already mentioned, contains an outburst tally score based on audio-monitoring of the area of densest activity determined by visual inspection. It was made independently of the visual tally by one of the authors (J.C.) who did not do the visual countings.

The table reveals close agreement between the visual and the auditory scores with a few exceptions. These exceptions may be traced to the fact

TABLE I

Cry Counts, Speech Rating, and IQ for Each Subject

| *Subject & Sex* | *Age* (days) *at Time of Cry* | *Cry: Visual Tally* | *Cry: Auditory Tally* | *Speech Rating* | *Age in Mos. at Cattell* | *IQ Cattell* | *IQ S-B 3 Yrs.* |
|---|---|---|---|---|---|---|---|
| 1. F ..... | 8 | 10 | 10 | 1 | ... | ... | 87 |
| 2. M ..... | 4, 5 | 20 | 20, 20 | 1 | ... | ... | 90 |
| 3. M ..... | 4, 5 | 17 | 19, 17 | 2 | 19.5 | 105 | 94 |
| 4. F ..... | 4 | 12 | 12 | 3 | 18.5 | 94 | 94 |
| 5. M ..... | 6 | 12 | 12 | 2 | 19.0 | 95 | 97 |
| 6. F ..... | 4, 5 | 16 | 9, 15 | 4 | 18.0 | 104 | 100 |
| 7. F ..... | 4, 5 | 19 | 19, 19 | 4 | 16.5 | 112 | 103 |
| 8. M ..... | 6 | 12 | 12 | 2 | 19.5 | 101 | 103 |
| 9. M ..... | 10 | 9 | 14 | 2 | 16.0 | 72 | 103 |
| 10. M ..... | 5 | 23 | 23 | 4 | 15.0 | 93 | 103 |
| 11. M ..... | 4 | 13 | 15 | 1 | 17.5 | 107 | 104 |
| 12. F ..... | 4, 5 | 14 | 15, 14 | 4 | 20.0 | 102 | 106 |
| 13. M ..... | 7 | 16 | 13 | 3 | 19.0 | 103 | 106 |
| 14. M ..... | 5 | 27 | 27 | 1 | 15.0 | 115 | 108 |
| 15. M ..... | 4, 5 | 18 | 21, 17 | 1 | 15.5 | 83 | 109 |
| 16. F ..... | 4 | 10 | 12 | 3 | 18.0 | 122 | 109 |
| 17. M ..... | 4, 5 | 18 | 26, 18 | 2 | 15.0 | 107 | 109 |
| 18. F ..... | 4, 5 | 15 | 16, 15 | 3 | 19.0 | 111 | 112 |
| 19. M ..... | 5 | 18 | 15 | 4 | 17.0 | 111 | 112 |
| 20. M ..... | 5 | 23 | 23 | 4 | 19.5 | 103 | 113 |
| 21. F ..... | 4 | 15 | 16 | 5 | 18.5 | 112 | 114 |
| 22. M ..... | 4, 5 | 21 | 43, 21 | 4 | ... | ... | 114 |
| 23. M ..... | 4, 5 | 16 | 22, 16 | 4 | 19.0 | 114 | 118 |
| 24. F ..... | 4, 5 | 9 | 18, 12 | 5 | 18.5 | 97 | 119 |
| 25. F ..... | 7 | 12 | 9 | 3 | ... | ... | 119 |
| 26. M ..... | 7 | 12 | 13 | 5 | 18.0 | 107 | 120 |
| 27. F ..... | 4, 5 | 19 | 21, 19 | 4 | 17.0 | 104 | 120 |
| 28. F ..... | 4, 5 | 16 | 17, 18 | 4 | 17.5 | 101 | 124 |
| 29. F ..... | 4, 5 | 20 | 20, 19 | 3 | 19.0 | 101 | 132 |
| 30. F ..... | 4, 5 | 15 | 18, 16 | 4 | 20.0 | 102 | 133 |
| 31. F ..... | 4 | 22 | 22 | 4 | 19.5 | 123 | 135 |
| 32. F ..... | 4 | 31 | 31 | 4 | 15.5 | 104 | 135 |
| 33. F ..... | 4 | 16 | 16 | 4 | 15.0 | 101 | 136 |
| 34. M ..... | 4, 5 | 17 | 17, 17 | 5 | ... | ... | 141 |
| 35. M ..... | 4, 5 | 30 | 27, 26 | 4 | 18.5 | 106 | 155 |
| 36. F ..... | 4, 5 | 22 | 19, 21 | 5 | 19.0 | 146 | 157 |
| 37. F ..... | 4 | 33 | 27 | 5 | 16.5 | 109 | 159 |
| 38. F ..... | 6 | 13 | 13 | 5 | ... | ... | 162 |

that certain clearly audible bursts were not intense enough to register as peaks on the V-U chart, or because modulations in what was heard as a single burst of crying may have been registered as separate smaller peaks within a larger one. The correlation coefficient found for these two independently obtained measures of rate equals .95. In spite of the high correlation between the two measures, it is felt that the auditory count is a more accurate measure of the number of separate sounds emitted than is the visual count because the visual count is subject to variations resulting from the heating differentials in electronic equipment and pen ballistics. In addition, if the synchronous motor of the ammeter is set at faster speeds, individual spikes are spread over a wider area and intensity variations within a single burst may be counted as separate bursts, and individual bursts of low intensity would not appear as peaks but as rounded curves. On the other hand, the technique of visual inspection is clearly superior to audio-monitoring to find the area of densest activity.

The subjects used in this investigation had a mean IQ of 117.2 with a *SD* of $\pm 19$. The original standardization sample of 81 three-year-olds used by Terman and Merrill (10) had a mean IQ of 107.8 with a *SD* of $\pm 19$. This mean is reliably higher than the mean of the standardization sample ($t = 2.474$, $p < .02$).

When the product-moment correlation coefficients were computed for various relations examined in this study, the results were as shown in Table 2.

TABLE 2

Pearson Product-Moment Correlation Coefficients Obtained for the Various Relations Studied

| *Variables* | *N* | *r* | *p* |
|---|---|---|---|
| Cattell IQ (15–20 mos.) and visual count (4–10 days) | 33 | .32 | $> .05$* |
| Cattell IQ (15–20 mos.) and auditory count (4–10 days) | 33 | .31 | $> .05$* |
| Stanford-Binet IQ (3 yrs.) and visual count (4–10 days) | 38 | .45 | $< .01$ |
| Stanford-Binet IQ (3 yrs.) and auditory count (4–10 days) | 38 | .44 | $< .01$ |
| Cattell IQ (15–20 mos.) and Stanford-Binet (3 yrs.) | 32 | .44 | $< .01$ |
| Visual and auditory count | 38 | .95 | $< .001$ |

* These values border on the .05 level of significance.

For the 38 infants the product-moment correlation coefficients for auditory and visual cry counts and Stanford-Binet IQ at age three years were .44 and .45 respectively. All but two of the correlation coefficients in Table 2 were statistically significant (but not high enough for individual predictions) at the levels indicated. Inspection of a scatter plot of the coordinates, cry and IQ, indicated that the correlation was largely the result of the high scoring babies.

The age at which the Cattell test was administered to each infant is shown in Table 1. Chronological age was computed to the nearest half-month. Of the 32 infants who received the Cattell test 16 were 15 to 18 months of age and 16 were 18.5 to 20 months of age. When subjects were dichotomized in this manner and correlation coefficients were computed for each group separately, results shown in Table 3 were obtained. The coefficients for the older group were statistically significant (one-tail hypothesis) or borderline, while the coefficients for the younger group diminished to the point of nonsignificance.

TABLE 3

Pearson Product-Moment Correlation Coefficients for Cry Counts and Dichotomized Cattell Test Data

| | Age at Cattell Test | |
|---|---|---|
| | *15–18 Mos. Inclusive* ($N=16$) | *18.5–20 Mos. Inclusive* ($N=16$) |
| Visual count (4–10 days) and Cattell score | .24 | .42* |
| Auditory count (4–10 days) and Cattell score | .01 | .52 |
| Stanford-Binet (3 yrs.) and Cattell score | .17 | .63 |

* Borderline reliability (one-tail hypothesis).

The reliability of the cry count on consecutive days of testing remains to be established and the authors are presently engaged in gathering the necessary data using uniform procedures to elicit crying. In this study 19 of the subjects tested had their cries recorded on both the fourth and fifth days of life. The cry on the fifth day was selected for analysis in each case. When the auditory cry count for the densest 20-second segment of the V-U chart at four days of age was compared with the same measure at five days of age for the 19 infants who were tested twice, a product-moment correlation coefficient of .56 was obtained. One infant (subject 22 in Table 1) yielded an auditory count of 43 separate sounds in the 20-second interval. This value was more than twice the mean for the entire group. If he were excluded from the computations the correlation coefficient would be .62. For these same 19 infants the correlation between auditory cry count at four days and IQ at age three years was .13 while at five days it was .44. These values would become .30 and .47 in that order if subject 22 were omitted from the computations.

Thirty of the subjects were either four or five days of age when their cry was recorded. The Pearson product-moment correlation coefficients obtained for visual and auditory cry counts at this age level and Stanford-Binet IQ at age three years were .50 and .47 respectively. Both were significant at the .01 level. For this same group of subjects the relation obtaining between the Cattell test at 15 to 20 months and the Stanford-Binet at age three was only .17.

### *Speech Rating and IQ*

The picture test already mentioned was administered to all children at age three years ± three months. The words were chosen from the preschool vocabulary, compiled by the Child Study Committee of the International Kindergarten Union as cited in Fairbanks' *Voice and Articulation Drill Book* (1). (See Figure 2.)

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CRY STUDY

Name: Date:

Birth date:

*Speech Examination*

| | |
|---|---|
| 1. monkey .................. | 18. fork ...................... |
| 2. knife ...................... | 19. violin ..................... |
| 3. swing ..................... | 20. television ................ |
| 4. pail ....................... | 21. stove ...................... |
| 5. airplane .................. | 22. bathtub ................... |
| 6. balloon ................... | 23. toothbrush ................ |
| 7. book ...................... | 24. spoon ..................... |
| 8. baby ...................... | 25. ice cream cone ............ |
| 9. telephone ................. | 26. zebra ..................... |
| 10. teddy bear ............... | 27. shoe ...................... |
| 11. dog ...................... | 28. chair ..................... |
| 12. cake ..................... | 29. orange .................... |
| 13. girl ...................... | 30. fire engine ............... |
| 14. rabbit .................... | 31. hat ....................... |
| 15. elephant .................. | 32. watch ..................... |
| 16. lamp ..................... | 33. bicycle ................... |
| 17. fish ...................... | 34. house ..................... |

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FIGURE 2

The child's ability to produce sounds was measured according to the position of a sound in a particular word, whether at the beginning, in the middle, or at the end of the word. An attempt was made to elicit as much connected speech as possible from the child, rather than single word responses. As the child was tested, the examiner's questions and the child's responses were tape recorded and phonetic transcriptions were made simultaneously by the examiner.

Each child was rated on a six-point scale devised by L.R., using the following criteria:

| *Rating* | *Speech Level* |
|---|---|
| 0 | Nonlinguistic vocalizations. |
| 1 | Little verbalization; uses single words or at most 2- to 3-word phrases; infantile primitive structure; very numerous articulation errors (often hit or miss); difficult for the listener to comprehend; often even the mother has difficulty in understanding and must guess at what the child is saying. |
| 2 | Child verbalizes; uses short phrases; infantile structure ("me go" or "he gotem"); numerous errors of articulation (usually consistent); listener can comprehend with effort. |
| 3 | Child verbalizes freely; speaks in sentences; some infantile forms; some articulation errors (usually consistent and consisting of substitutions of a simpler visible sound, like "th" for a more difficult and not readily visible sound, like "s"); able to communicate thoughts and needs through speech and language. |
| 4 | Child verbalizes freely and in full sentences; structure correct; very few articulation errors (may be correct in some words); able to communicate with a good vocabulary; has memory for songs, stories and nursery rhymes. |
| 5 | "Adult-type" speech; no articulation errors; excellent vocabulary; superior ability to communicate in language. |

The data presented in Table 1 are arranged in order of IQ, subject 1 the lowest, 38 the highest. Inspection of the table reveals a general progression of speech developmental score with IQ. This progression is made more evident when the data are arranged according to IQ quartile divisions as in Table 4.

TABLE 4

Mean Cry Counts and Mean Speech Rating According to Sanford-Binet IQ Quartile Divisions at 3 Years

| *IQ Quartile* | *N* | *Visual Count* | *Auditory Count* | *Speech Rating* |
|---|---|---|---|---|
| I | 10 | 15.0 | 15.4 | 2.5 |
| II | 9 | 16.6 | 16.2 | 2.4 |
| III | 9 | 15.9 | 16.3 | 4.2 |
| IV (highest IQ) | 10 | 21.9 | 20.8 | 4.3 |

The biserial correlation coefficient obtained for speech developmental level and IQ at age three years is .70.

In order to check on the reliability of the ratings given by the speech therapist, an independent analyst was asked to rate some of the recordings. The therapist had completed 60 evaluations, 22 of which could not be used in the present study because they did not have cry samples within the 4 to 10 day period or because the infants were brain damaged (two cases). One-third of these 60 recordings of speech tests were selected by tables of random numbers, stripped of identifying information and forwarded to Professor Orvis Irwin for independent rating, using the same criteria. The results were as follows: six instances of perfect agreement, ten cases one step apart, two cases two steps apart, and two cases not rated by Irwin because of the presence of foreign accents. Moreover, it should be noted that the agreement between raters was high in spite of the fact that one set of ratings was made directly from the infant, and the other from tape recordings.

An effort was made to determine what relation exists between the cry counts at 4 to 10 days and speech ratings at age three years. The biserial correlation coefficients obtaining for speech rating and visual and auditory tallies are .24 and .18 respectively. Neither of these coefficients is statistically significant. Inspection of Table 4, however, reveals some systematic progression for the visual and auditory counts and mean speech ratings. The relatively high mean cry count for the ten infants in the highest quartile is significant. These are infants whose IQs at age three years range from 132 to 162. They are clearly gifted children with comparatively high cry counts at age 4 to 6 days and high speech ratings at age three years.

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