Irwin, O.C. 1947. "Infant speech: variability and the problem of diagnosis." *Journal of speech and hearing disorders* 12: 287-289.

Lach, R., Ling, D., A. H., and Ship, N. 1970. "Early speech development in deaf infants." *American annals of the deaf* 115: 522-526.

Liberman, A. M., Cooper, F. S., Shankweiler, D. P. and Studdert-Kennedy, M. 1967. "Perception of the speech code." *Psychological review* 74: 431-461.

Schroeder, G. L., and Baer, D. M. 1972. "Effects of concurrent and serial training on generalized vocal imitation in retarded children." *Developmental psychology* 6: 293-301.

Stark, R. E. 1967. "Vocalizations of the pre-school deaf child." *Annual Report: Neurocommunications Laboratory, Department of Psychiatry and Behavioral Sciences.* Baltimore: John Hopkins University School of Medicine, 325-333.

Sykes, J. L. 1940. "A study of the spontaneous vocalizations of young deaf children." *Psychological monograph: studies in the psychology of the deaf* 52: 104-123.

Urbantschitsch, V. 1895. *Ueber Hoeruebungen bie Taubstummheit und bei Ertaubung im spaeteren Lebensalter.* Vienna: Urban and Schwartzenberg.

Whetnall, E., and Fry, D. B. 1964. *The deaf child.* London: Heinemann.

Zaliouk, A. 1954. "A visual-tactile system of phonetical symbolization." *Journal of speech and hearing disorders* 19: 190-207.

Respiratory patterns in infant cry

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Speech respiration requires specific and precise modification of time, airflow, air volume, and air pressure parameters, and changes in thoracoabdominal synchrony. So complex is the nature of the act that one must question whether the speech respiration pattern is present at birth or whether it develops as the result of a maturation and/or learning process. Lieberman (1967) hypothesized that the respiratory patterns associated with the infant's earliest cries reflect an "innate referential breath group [which] furnishes the basis for the universal acoustic properties of the normal breath-group that is used in so many languages." According to Lenneberg (1967), however, the category of crying vocalization is "divorced from the developmental history ... of all those sounds which eventually merge into the acoustic productions of speech." Both of these views appear to differ with the traditional assumption of a developmental sequence wherein the relatively undifferentiated vocalization characteristic of neonatal crying is eventually brought under sufficient control for the production of speech.

Only a very few studies of the respiratory patterns associated with infant vocalization have been undertaken, and of these only a small percent have dealt with infants beyond the first several weeks of life. Given the "very high degree of fine co-ordination between disparate neuromuscular systems" required in speech respiration (National Advisory Neurological Diseases and Stroke Council, 1969) and the small likelihood that such co-ordination is manifest at birth, it is surprising that there has been virtually no study of the possibility of developmental patterns in the respiratory activity underlying infant vocalization.

In order to explore the nature of the development of the respiratory prerequisites for speech, a series of studies has been undertaken to evaluate the developmental patterns of respiratory activity in normal human infants and children during vegetative breathing, crying, and non-crying vocalization. This paper deals with the time parameters and general configuration of the respiratory movements observed during crying in infants from birth to eight months of age.

Background literature: adult respiration.

Characteristic changes in adult vegetative respiration patterns have been observed during a number of activities and conditions. In some cases, these changes are related to metabolic needs (Behnke and Lanphier, 1964; Clanmar, 1964; Mead and Agostoni, 1964), while in others, such as playing a wind instrument (Bouhuys, 1968), the changes are volitional. The characteristic changes in respiratory patterns observed during speech are complex and appear to be unique to that activity (Ladefoged, 1967; Lenneberg, 1967). Lenneberg found it "astonishing ... that man can tolerate these modifications for an apparently unlimited period of time without experiencing respiratory distress." He further noted that whereas other volitional changes in respiratory pattern require instruction and/or practice, "speaking for hours seems to come all too naturally for many a three year old." Mean respiratory rates of 12 to 20 breaths per minute (bpm) have been observed in adult vegetative breathing (Lenneberg, 1967; Lieberman, 1967); one study (Meader and Muyskens, 1951) found rates ranging from 8 to as high as 60 bpm. During speech there is generally a marked reduction in the mean respiratory rate, and the rate varies with linguistic requirements. Another time parameter of respiration is the I-fraction: the ratio of the length of inspiration to the total duration of the respiratory cycle. In adult vegetative breathing, the inspiratory and expiratory phases are of roughly equal duration, and the mean I-fraction is about 0.40 (Lenneberg, 1967). During speech, however, inspiration is much shorter than expiration, and the mean I-fraction drops to about 0.13.

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In adults there is good synchrony between thoracic and abdominal expansions and contraction during vegetative breathing. But during speech a "physiologic asynchronism" is observed: "the chest curve continues to rise with its inspiratory movement, while the abdominal curve is already descending with expiration" (Luchsinger, 1965).

Infant respiration

Mean vegetative rates from 29 to 61 bpm have been reported for infants from birth to 6 months of age (Cook et al., 1957; Cross, 1949; Deming and Hanner, 1936; Hadded et al., 1956; Peiper, 1963; Truby et al., 1965). While there are few studies of older infants, Peiper (1963) quotes Vormittag as stating that the mean vegetative rate decreases with increasing age. During the crying of neonates, a respiratory rate of 68 bpm may be calculated from the data of Long and Hull (1961). Deming and Washburn (1935) observed a mean respiratory rate of 59 bpm during crying in infants 20 hours to 13 weeks of age. Halverson (1941) reported that the mean respiratory rate in infants from 1 to 24 weeks of age changed from 34 bpm during sleep to 133 bpm during crying.

These reported increases in respiratory rate during crying contrast sharply with the decrease in rate during adult speech. No previous studies dealing with developmental changes in respiration during crying could be located.

Very little information is available concerning the I-fraction during either vegetative breathing or crying. Truby et al., (1965) reported a ratio of inspiration to expiration of between 1.2 and 1.3 during the quiet breathing of neonates. An I-fraction of 0.30 during crying may be extrapolated from the data of Long and Hull (1961). Although a number of other researchers (Karelitz, 1963; Lind et al., 1966; Ringel and Kluppel, 1964; Sedlackova, 1964; Wasz-Hockert et al., 1963) have studied other temporal factors of infant cry (such as total cry duration, latency, pause time, and minimal length of cry), little if any quantitative data is provided. Halverson (1941) described the general respiratory configuration during crying as predominantly costal but "disorganized." In infants 2 to 24 weeks of age he noted that:

Abstract

Certain respiratory parameters underlying the crying behavior of infants aged 2 to 255 days were explored using impedance pneumography. Observed respiratory rates during crying were considerably lower than those previously reported. Inspiratory times remained highly stable, while expiratory times steadily increased with age, yielding an ever-lower I-fraction, approaching that for adult speech. Possible explanations for the divergent findings of this study are provided. The findings are also evaluated in light of the Lieberman and Lenneberg hypotheses regarding the relationship of crying to speech development.

The numerous alterations from one type of respiration to another, the rapidity and irregularity of the changes, the shift of an inspiratory or expiratory movement from abdomen to thorax or vice versa, abrupt stops, marked differences in amplitude or successive inspirations and expirations, and temporary suspension of movement by either abdomen or thorax, or both, attest to the disorderly action of the respiratory mechanism.

Method: subjects

The population for this study was composed of 4 male and 6 female infants who presented unremarkable pre-, peri-, and postnatal histories, and who had 5-minute Apgar scores of 8 or higher. Each child's development was monitored during the course of the study using selected items from Gesell's developmental scales (Gesell and Amatruda, 1947); the gross motor maturation of all subjects remained within normal limits. Hearing acuity was not formally assessed, but all infants responded appropriately to auditory stimuli.

The study used a semi-longitudinal approach. The age of subjects at the time of entry into the population ranged from 2 to 161 days; each infant was observed over a period of approximately four months at intervals averaging 28 days. From the 62 individual observation sessions a statistical consultant selected four consecutive observations of each of the ten infants, providing a statistically useful sample of respiratory behavior over the age range in question (2-255 days). For data analysis these observations were grouped into eight 32-day age intervals, roughly representing age in months. Observation of each of the infants used in the analysis of data are summarized in Figure A.

Procedure

All observations took place in the infant's home, with the exception of three which were done in the new-born nursery. At the time of each observation the parent was interviewed to obtain information about the child's physical growth, general health, feeding behavior, vocal output and attention to sound. The child's gross motor maturation was also assessed. In order to eliminate possible ambiguities resulting from non-respiratory reflex responses to a painful stimulus, painful cry-inducing stimuli were never used. It is assumed

Résumé

Certains paramètres de la respiration sous-jacente aux pleurs de nourrissons âgés de 2 à 255 jours furent étudiés à l'aide d'un pneumographe d'impédance electronique. La fréquence de l'acte respiratoire observée pendant les pleurs fut inférieure à celle rapportée antérieurement. Le temps de l'inspiration demeura extrêmement stable, tandis que le temps de l'expiration augmenta régulièrement avec l'âge, produisant une fraction-I qui se rapprocha de plus en plus de celle rapportée pendant la parole chez l'adulte. Les résultats différents de cette étude sont expliqués de façon provisoire; ils sont aussi comparés aux hypothèses de Lieberman et de Lenneberg concernants la relation entre les pleurs du nourrisson et le développement de la parole.

that the infant cries recorded during the observation sessions were stimulated by hunger, since each child was observed during his habitual feeding time and his cries were stilled by feeding. By means of a written diary and an oral experimenter "banter" recording, running records of the infant's behavior, posture, movement, and waking status were maintained throughout each observation period.

Although crying was often accompanied by extraneous physical movements, there was always at least one period when the infant was crying vigorously but not moving his arms, legs, or trunk. On the basis of the running records of the infant's movements, samples of crying respiration were selected which were free from possible contamination by extraneous physical movements. One thousand such cycles of crying respiration were analyzed, 25 from each of the 40 observation sessions. For 28 of the sessions, the 25 cycles selected for analysis were consecutive; in the other 12, two groups of consecutive cycles were analyzed, the smaller of the groups consisting of at least 10 cycles.

Information concerning thoracic and abdominal circumference was obtained with the impedance pneumograph described by Baken and Matz (1973). Transducers were positioned at the lowest palpable point of the sternum and at a point midway between the lower ribs and the umbilicus, and were held in place by Velcro strips fastened behind the subject's back. The child was placed in an infant seat and a microphone was suspended in front of his face. The subjects showed no discernible sign of discomfort. Respiratory data were recorded on one channel of a Sony model 255 tape deck; the infant's vocal output and experimenter "banter" were recorded on the other channel. A Grass III-D electroencephalograph was modified to provide simultaneous readout of both vocal and pneumographic signals.

Truby et al. (1965) noted that infant cry is a "compound phenomenon" consisting of "intricate motor activity singularly involving the respiratory tract" plus an acoustic signal, the cry sound. In order to accurately reflect the compound "cry act," the temporal parameters in the present study were determined through consideration of both respiratory and vocal signals. When there was a cry burst in which voicing was continuous from the end of one inspiration to the beginning of the next inspiration, the vocal signal was used to determine the boundaries of that expiratory phase. When fluctuations occurred during an expiratory movement defined in this manner, they were identified as subcycles of the major expiratory movement (Figure B). If the temporal aspect of such cry acts had been analyzed without reference to the acoustic signal, expiratory subcycles might have been mistaken for complete respiratory cycles, leading to an inflated respiratory rate. On the otherhand, there were times (particularly during the longer cry bursts) when the cry momentarily became voiceless, yet no inspiration was audible and the respiratory tracings indicated continuous expiratory effort. In such cases the respiratory signal was used to determine the boundaries of the expiratory phase (Figure C). It is readily apparent that if cry duration were evaluated from the acoustic signal only, the voiceless intervals might lead to spuriously short estimates of the duration of the cry act. Regional predominance of respiration was determined by considering two major factors: relative amplitude of thoracic and abdominal movements and correlation of movement with the onset and cessation of the vocal signal.

Results: time factors

At all age levels the mean respiratory rates were significantly lower than those in the three previous studies reporting respiratory rates during infant cry. The mean rate of respiration decreased steadily as a function of age; the rate during the eighth month was roughly half the rate observed during the first month of life. In the presence of steady increases in the mean duration of the total respiratory cycle, the mean length of the inspiratory phase remained remarkably stable, fluctuating minimally around 0.28 second. This is reflected in a steadily decreasing I-fraction. Time factors are summarized in Table 1.

General configuration

Although the pneumographic wave-form during crying was complex, it could not be termed "disorganized" to the extent described by Halverson (1941), even during the most intense crying. There was typically a brief, sharply defined inspiratory phase followed by a longer expiratory phase, the configuration of which ranged from a simple steep slope (Figure D) through increasing degrees of complexity which included periods of fixation of the abdomen and/or thorax and the presence of subcycles (Figures B and C). The number of these subcycles was found to be highly correlated ($r = 0.99$) with the duration of the expiratory phase which, in turn, steadily increased with increasing age. The stability of inspiratory duration in the presence of the steady developmental increment in expiratory duration also appears to reflect rather well-organized behavior.

The thorax participated consistently in respiration during crying, but in contrast to Halverson's description of such respiration as "predominantly costal," less than 1 per cent of the cycles could be defined as predominantly thoracic. Either the thorax and abdomen contributed equally to the respiratory pattern, or it was predominantly abdominal. At the onset of the inspiratory phase, thoracic and abdominal movements were coincidental (within 0.1 second) during the majority of the cycles at all ages. When there was a phase lag at the onset of inspiration, the abdominal movements more often preceded the thoracic movements. During expiration there were somewhat fewer cycles with coincidental onset. When phase lag did occur at the onset of expiration there was an even stronger tendency for abdominal movement to precede thoracic movement, a pattern reminiscent of the physiologic asynchrony observed in adult speech respiration.

Discussion

Three major methodological differences, either singly or in combination, may account for the significantly higher respiratory rates reported in previous studies of infant cry: (a) instability of instrumentation; (b) contamination of data by extraneous physical activity of the infant; and (c) failure to consider the acoustic signal in establishing the bounds of individual respiratory cycles. Deming and Washburn (1935) noted that measures of crying "were somewhat less accurate than those obtained during sleep, because kicking and struggling of the crying infant jarred the spirometer." Long and Hull's

(1961) "reverse plethysmograph" required an air-tight face seal, and the authors noted that they could not state positively that the face seal was completely leakproof. They also observed that "owing to movements of the child's face during vigorous crying, some shift in baseline occurred." Pneumatic linkage pneumography of the type used by Halverson (1941) is extremely sensitive to movement artifacts. The problem may have been compounded by placement of the thoracic transducer immediately over the main bulk of the pectoralis major, thereby increasing the risk that artifacts might result from movements of the infant's arm. This tranducer placement may also explain why the respiratory tracings appeared to be "predominantly costal." Halverson's description of extraneous physical movements during data collection suggests that there was a great deal of such activity. In all three of these studies, therefore, it seems distinctly possible that certain instabilities in the instrumentation may have interacted with physical movements of the child to produce artificial fluctuations in the respiratory signal. Since the respiratory measurements were apparently made without reference to the acoustic cry signal, these fluctuations may have been erroneously interpreted as separate respiratory cycles, with a consequent inflation of respiratory rate. Whether or not produced artificially, Halverson reported "small secondary respirations" which, according to his description, may be the equivalent of the subcycles observed in the present study:

> *The breathing curves during crying abound with spikes, dents, and notches ... A notch ... signifies that the inspiratory or expiratory movement, as the case may be, has been interrupted by an abbreviated, opposed, respiratory movement. Hence the arc of the breathing curve lying between two notches, or between a notch and a dale, represents a respiratory movement and is herein so regarded. The frequency of these small secondary respirations has the effect of greatly increasing the respiratory rate.*

Thus it seems quite probable that failure to consider the cry signal in determining the boundaries of a respiratory cycle contributed directly to the highly inflated rate (133 bpm) obtained in Halverson study. The validity of the rates obtained in the present investigation is supported by the following factors: (a) the instrumentation was both sensitive and stable; (b) the sampling method eliminated the possibility of movement artifacts; and (c) the cry signal was considered in defining the respiratory cycle.

The findings of this study do not appear to lend strong support either to Lieberman's hypothesis that the respiratory pattern underlying infant cry is directly related to the development of linguistic intonation, or to Lenneberg's suggestion that the developmental history of infant cry is totally divorced from the development of speech. Rather, the results imply that the developmental relationship between infant cry and speech acquisition may be more complex than is suggested by either theory and that it is, as yet, poorly delineated.

Lieberman (1967), in essence, hypothesized "the existence of activity involving respiratory and laryngeal muscles which forms a basic breath-group that characterizes the intonation of a language." He further suggested that, as a result of the respiratory-laryngeal pattern, infant cry had an innately determined rising and falling fundamental frequency contour similar to that of simple declarative sentences, arising from a basis of "least articulatory control." At least two characteristics of the respiratory patterns observed in the present study, however, appear to be inconsistent with a condition of least articulatory control. As previously mentioned, there were numerous cries during which the acoustic signal became voiceless, yet the respiratory signal indicated continuous expiratory effort. Truby et al. (1965) noted similar intervals of silence during the egressive phases of cry, suggested that in such cases "silence does not indicate muscular inactivity [least control] but precisely the reverse: maximal physical effort can apparently have its acoustic counterpart in minimal acoustic intensity." The expiratory subcycles found in the present study are also difficult to reconcile with a condition of least articulatory control. Because of their high correlation with duration of expiration, the most tenable explanation for these fluctuations in expiratory movement is that they represent the infant's unskilled attempts to prolong expiration by controlling the elastic recoil forces of the chest. Further analysis of this phenomenon is in progress.

Although a pattern compatible with an "innate referential breath group" was not readily apparent, one very important adaptation for speech emerged and became stabilized during crying in the first eight months of life: the ability to maintain a pattern of rapid inspiration and prolonged voiced expiration over a long period of time without experiencing respiratory distress. The mean I-fraction during cyring approached the values reported for mature speech at about three months of age and remained close to those values through the eighth age level. Lenneberg (1967) noted that while it was extremely difficult to volitionally alter the I-fraction associated with vegetative breathing for more than a few moments without experiencing the symptoms of hypo- or hyperventilation, "man can tolerate this modification of respiration during speech for an apparently unlimited time." Because this characteristic modification of I-fraction is so firmly established during crying well before the onset of babbling, it is difficult to see how the developmental histories of these two types of infant vocalization can be thought of as totally unrelated.

Limitations

Due to the difficulty of obtaining infants meeting the selection criteria who would be available for observation over a period of four months, the population in the study is small. However, it is not appreciably smaller than the populations in several other studies reporting on the temporal characteristics of infant cry behavior (Deming and Washburn, 1935; Long and Hull, 1961; Ringel and Kluppel, 1964). The only other studies which covered an age range roughly comparable to that in the present study were non-longitudinal in nature (Halverson, 1941; Wasz-Hockert et al., 1963). With respect to the number of cry-bursts analyzed, the sample size of 1,000 in the present study compares quite favorably with previous studies using a larger number of subjects, but in which cry-burst samples of only 197 (Sedlackova, 1964) and 270 (Wasz-Hockert et al., 1963) were reported. As evidence that gross differences between individual infants did not bias the data at any given age level, standard deviations for the egressive phase of the cry were lower in the present study than those presented in the only other investigation to report this statistic (Wasz-Hockert et al., 1963). In the present study there was an unequal distribution of observation sessions among the eight age levels, but because of the relatively large number of cry bursts analyzed for each session, the longitudinal distribution was considered satisfactory for descriptive purposes.

The selection of cry bursts for analysis was, of necessity, somewhat arbitrary. It is possible that cry bursts which occur when the infant is not otherwise moving differ significantly from those which are accompanied by extraneous movements. However, movements themselves produce artifacts which make analysis of the respiratory data so dubious as to override the possible benefits of a more comprehensive sampling method. In addition, requiring that the infant be physically still corresponds to constraints placed on adult subjects in comparable experimental situations. It is difficult to determine whether differences in findings in relation to previous studies can be explained on the basis of sampling technique because of the manner in which sampling is described in other studies. It would seem unlikely that the differences can be explicated on the basis of the type of cry stimulus used, since only Deming and Washburn (1935) reported the use of painful stimuli.

References

Baken, R. J. and Matz, B. 1973. "A portable impedance pneumograph." *Human Communication* 2 (Autumn 1973)

Behnke, A., and Lanphier, E. 1964. "Underwater physiology." *Handbook of physiology: Respiration I,* edited by W. O. Fenn and H. Rahn. Washington, D.C.: American Physiology Society, 1964.

Boyhuys, A. 1968. "Pressure flow events during wind instrument playing." *Annals of the New York Academy of Sciences,* 155: 264.

Clanmar, H. G. 1964. "Space physiology." *Handbook of physiology: Respiration II,* edited by W. O. Fenn and H. Rahn. Washington, D.C.: American Physiology Society.

Cook, C., **Sutherland, J., Segal, S., Cherry, R., Mead, J., McIlroy, M., and Smith, C.** 1957. "Studies of respiratory physiology in the newborn. III. Measurements of the mechanics of respiration." *Journal of clinical investigation* 36: 440.

Cross, K. W. 1949. "The respiratory rate and ventilation in the newborn baby." *Journal of physiology* 109: 459.

Deming, J., and Hanner, J. 1936. "Respiration in infancy." *American journal of diseases of children* 51: 823.

Deming, J., and Washburn, A. 1935. "Respiration in infancy." *American journal of diseases of children* 49: 108.

Gessel, A., and Amatruda, C. 1947. *Developmental diagnosis.* New York: Hoeber.

Haddad, H., Hsia, D., and Gellis, S. 1956. "Studies on respiratory rate in the newborn." *Pediatrics* 17: 204

Halverson, H. M. 1941. "Variations in pulse and respiration during different phases of infant behavior." *Journal of genetic psychology* 59: 259.

Karelitz, S. 1963. "Infant vocalizations." *Journal of the Indian Pediatric Society.* 2: 1.

Ladefoged, P. 1967. *"Three areas of experimental phonetics."* London: Oxford.

Lenneberg, E. 1967. *Biological foundations of language.* New York: Wiley.

Lieberman, P. 1967. *Intonation, perception, and language.* Cambridge, Massachusetts: Massachusetts Institute of Technology.

Lind, J., Wasz-Hockert, O., Vuorenkoski, V., Partanen, T., Theorell, K., and Vallanne, E. 1966. "Vocal response to painful stimuli in newborn and young infants." *Annales paediatricae Fennae* 12.

Long, E., and Hull, W. 1961. "Respiratory volume-flow in the crying newborn infant." *Pediatrics* 27: 373.

Luchsinger, R. 1965. "Physiology of respiration," edited by R. Luchsinger and G. Arnold. *Voice-speech-language.* Belmont, California: Wadsworth.

Mead, J. and Agostoni, E. 1964. "Dynamics of breathing." *Handbook of physiology: Respiration I,* edited by W. O. Fenn and H. Rahn. Washington, D.C.: American Physiology Society.

Meader, C. L. and Muyskens, J. H. 1951. *Handbook of biolinguistics,* part 1, section A. Toledo: Weller.

National Advisory Neurological Disease and Stroke Council. 1969. *Human communication and its disorders: an overview.* Bethesda, National Institutes of Health.

Peiper, A. 1963. *Cerebral function in infancy and childhood,* New York: Consultants Bureau.

Ringel, R. L. and Kluppel, D. D. 1964. "Neonatal crying: a normative study." *Folia phoniatrica,* 16: 1.

Sedlackova, E. 1964. "Analyse acoustique de la voix de nouveau-nés." *Folia phoniatrica* 16: 44.

Truby, H., Bosma, J., and Lind, J. 1965. *Newborn infant cry.* Uppsala: Almqvist and Wiksell.

Wasz-Hockert, O., Valanne, E., Vuorenkoski, V., Michelsson, K., and Solvijari, A. 1963. "Analysis of some types of vocalization in the newborn and in early infancy." *Annales paediatricea Fennae* 9.

Zemlin, W. R. 1968. *Speech and hearing science: anatomy and physiology.* Englewood Cliffs, New Jersey: Prentice-Hall.

TABLE 1

Mean respiratory rate, mean duration of the respiratory cycle and its inspiratory and expiratory phases, and Mean I-fraction.

Age (Months)	Rate (bpm)	Duration (seconds(Total cycle mean	Total cycle s.d.	Insp. Phase mean	Insp. Phase s.d.	Exp. Phase mean	Exp. Phase s.d.	I-fraction
1	50.00	1.20	0.13	0.23	0.01	0.97	0.14	.191
2	40.00	1.50	0.35	0.28	0.05	1.22	0.33	.184
3	37.04	1.62	0.41	0.26	0.06	1.35	0.37	.160
4	35.29	1.70	0.50	0.27	0.04	1.42	0.52	.158
5	34.48	1.74	0.83	0.28	0.05	1.45	0.78	.158
6	31.41	1.91	0.40	0.28	0.06	1.62	0.36	.148
7	28.98	2.07	0.38	0.29	0.04	1.79	0.39	.127
8	23.35	2.57	0.58	0.29	0.05	2.26	0.55	.113

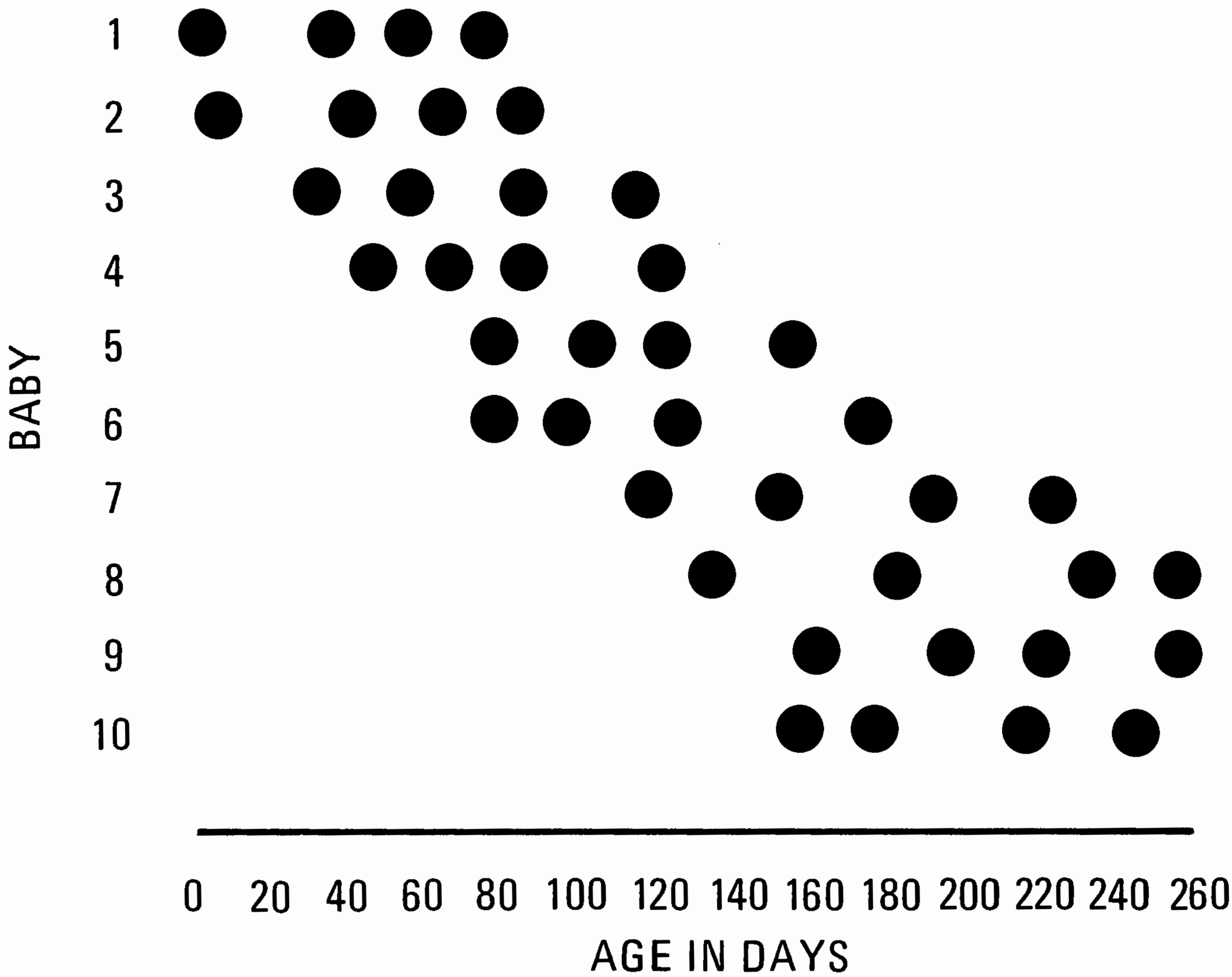

FIGURE A — Distribution of the forty sample observations among the study population.

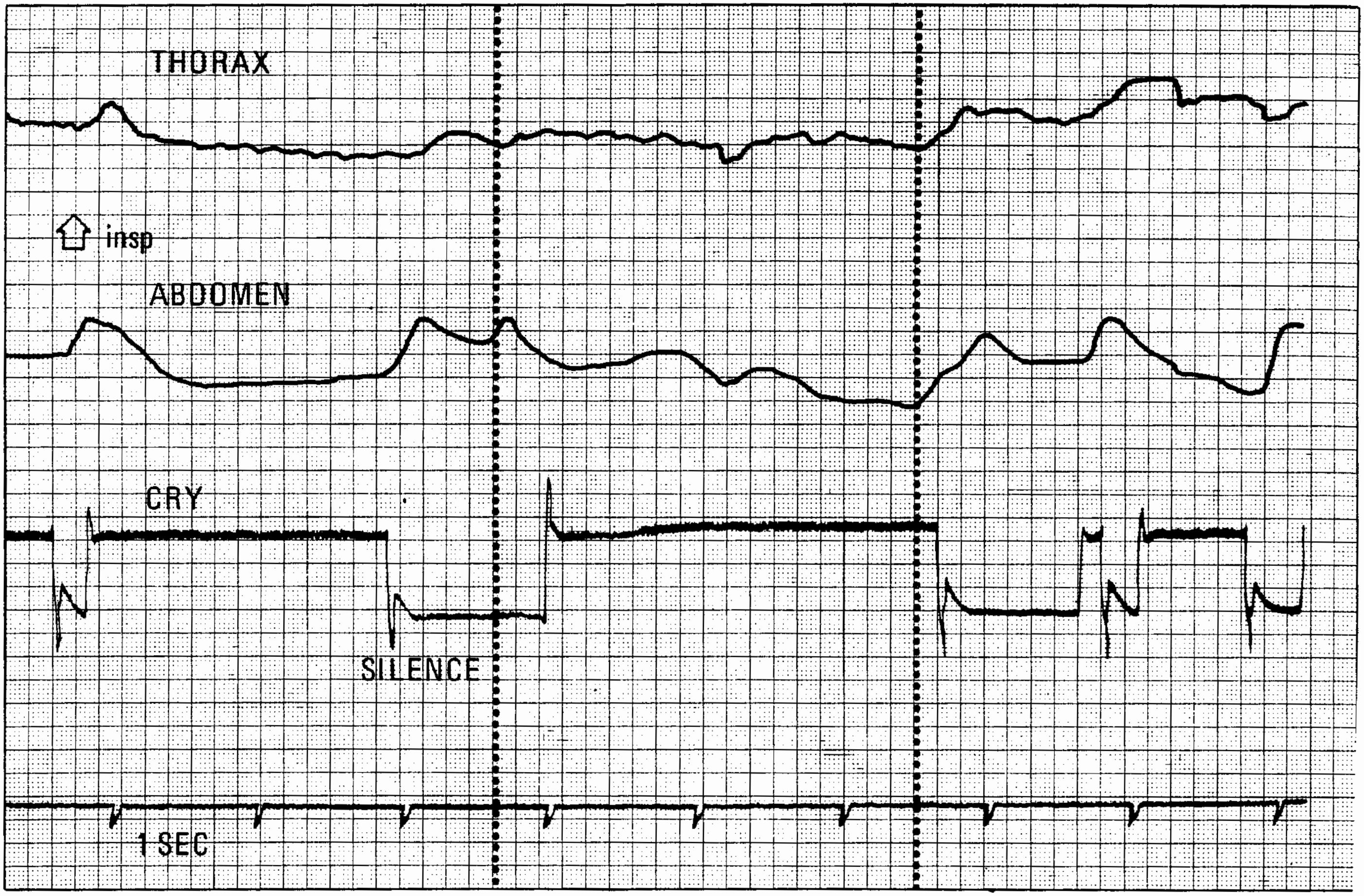

FIGURE B — Pneumogram showing respiratory behavior during several cry bursts. The area within the dotted lines shows a single respiratory cycle with subcycles during the expiratory phase.

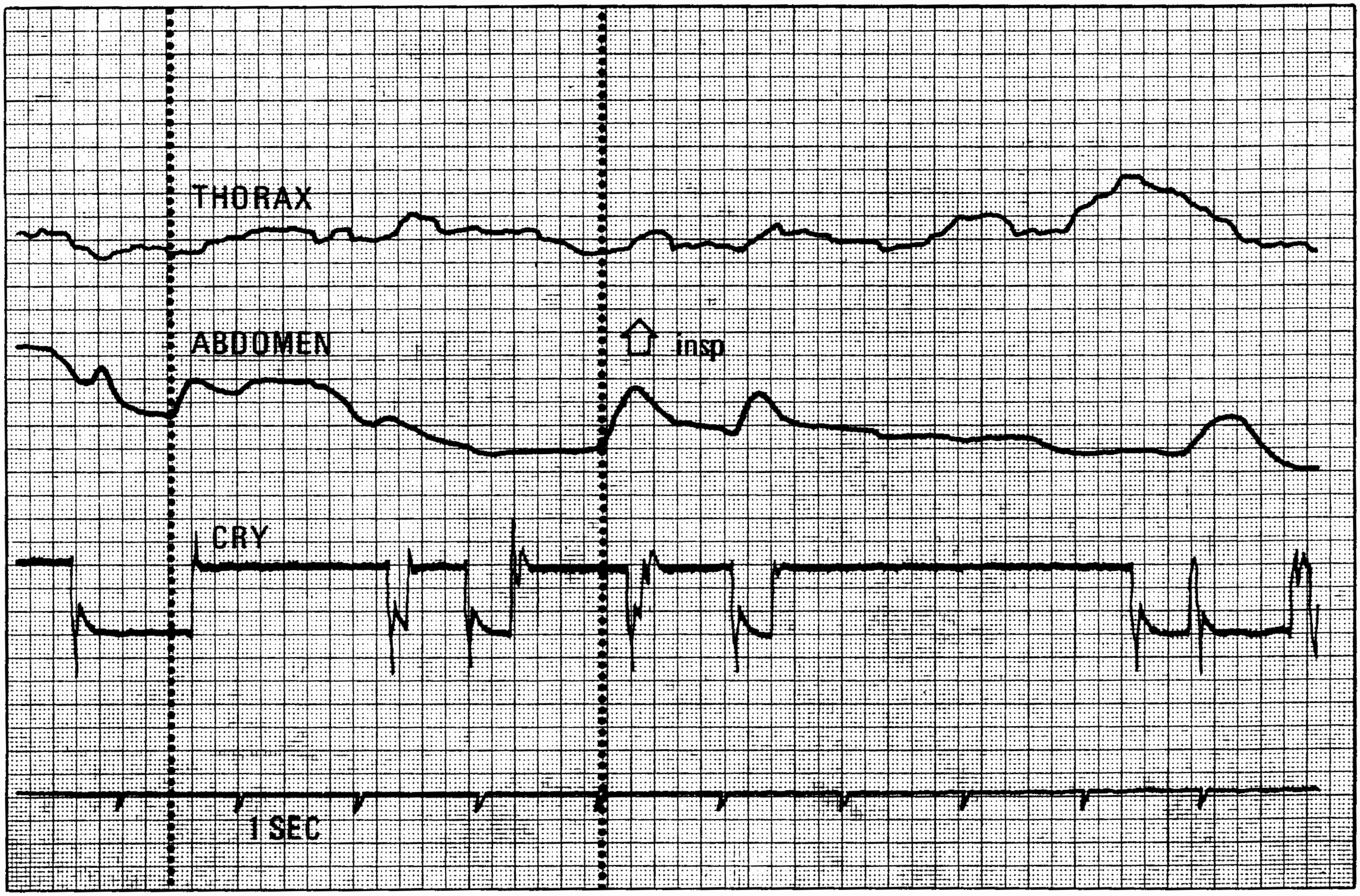

FIGURE C — Pneumogram showing respiratory behavior during several cry bursts. The cry signal produced during the single respiratory cycle marked off by dotted lines contains two silent intervals.

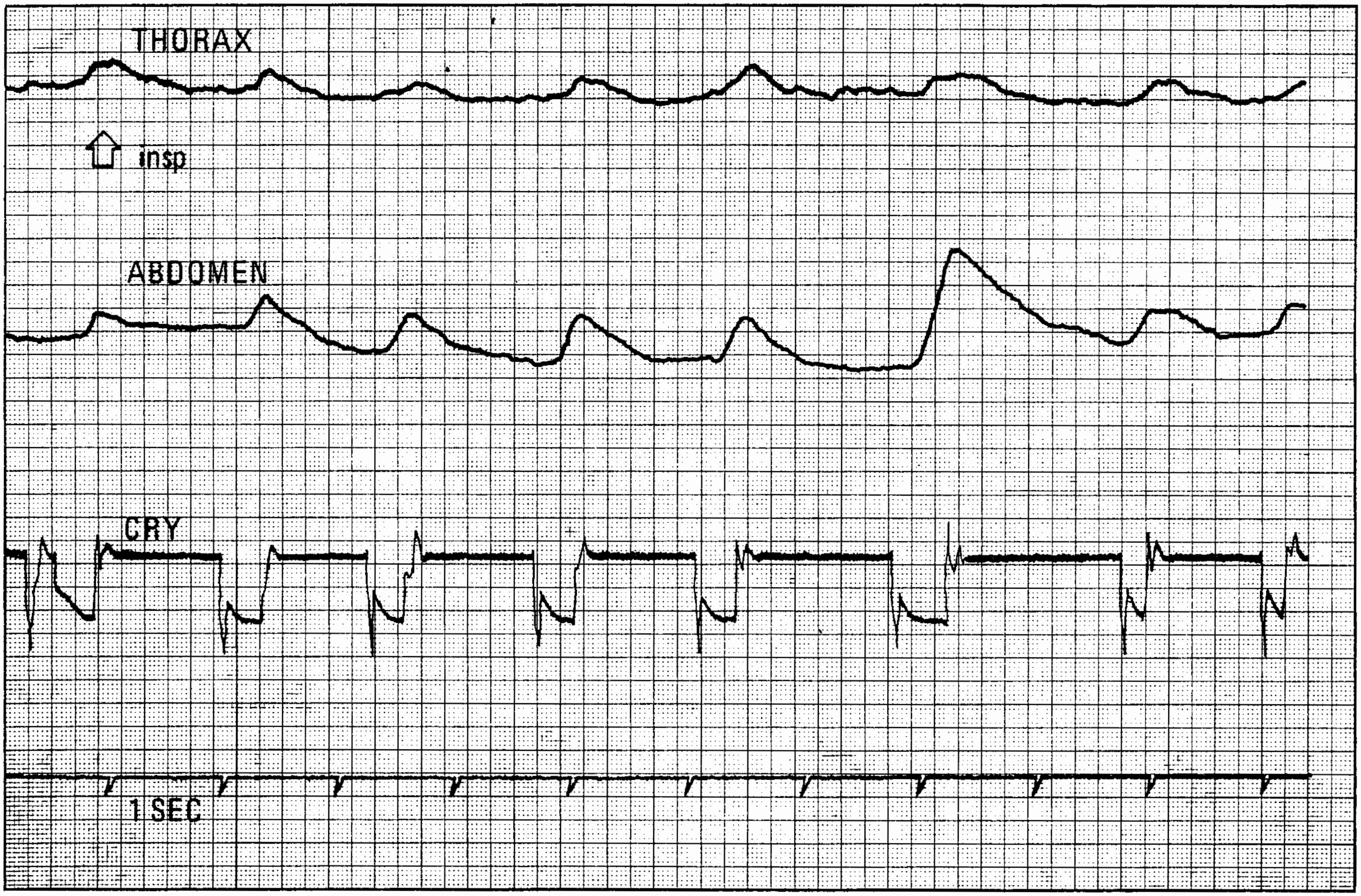

FIGURE D — Pneumogram of a relatively simple respiratory pattern during crying.