AUDITORY STIMULATION AND DEVELOPMENTAL BEHAVIOR OF THE PREMATURE INFANT

Violet Katz

THE focus of this study was to determine whether a variation in the environment of the low-birth-weight premature infant by the introduction of the maternal voice, can influence developmental behavior.

Considerable evidence has been documented indicating that the low-birth-weight premature infant (28-32 weeks gestation) is a high risk in terms of both survival and neuropsychiatric disabilities. The survival rate has now increased and a large percentage of the survivors present problems which include retardation in growth, cerebral palsy, visual disturbances, behavior problems and mental retardation(1-4). As the birth weight of the infants decrease, the incidence of abnormalities increase.

In response to accumulating evidence concerning the incidence of central nervous system damage in prematurity, the Children's Bureau of the United States Department of Health, Education, and Welfare in 1964 classified the low birth weight infant "a high risk in mental retardation and neurological disabilities(5)."

In order to prevent infection and still simulate the normal uterine setting for these immature infants after birth, the incubator is provided which, by virtue of its design isolates the infant from organisms and from physical contact with sources of infection. At the same time, it isolates the infant from a normal exposure to multiple patterned stimuli as they exist in the prenatal and postnatal environment. The effects of this sensory deprivation have not been fully explored.

There is a body of evidence which supports the theory that interference with intellectual growth may be related to a lack of patterned sensory impressions and anatomical changes have been demonstrated due to lack of stimuli. Animal studies indicate that deprivation of stimuli alter the rates of synthesis of protein and RNA in relevant cells (6,7). Hebb states that a stimulus is a requirement for the development of a neural pattern(8).

VIOLET KATZ (Mount Sinai Hospital School of Nursing, New York New York; Ed.D., New York University, New York) is an assistant professor of nursing at Bronx Community College, New York. The study reported here was submitted in partial fulfillment of the doctoral requirement at New York University. The study was partially supported by a grant from Sigma Theta Tau.

There is renewed interest in Piaget's sensorimotor theory that sensory experience guides motor conduct(9).

There is a critical period during early life (perinatal) when maximal brain growth occurs and adequate conditions of stimulation are needed to develop genetically defined patterns of behavior. The newborn infant's first construction of reality is his organization of and response to kinesthetic, auditory and visual stimuli in his spatial world. During this period, if there are restricted perceptions, motion pattern development is likely to become impaired(10). Motion patterns are space structured and adapted to the stimulus patterns of the child's environment. Their sequential development at defined periods are indicators of total maturation.

Many aspects of our individual and social behavior have to be acquired at a particular time. If the opportunity is lost, we may never be able to repair the omission. The nature of the incubator experience may be one of many factors in the interference with the process of sequential maturation of the premature infant. Dunham states, "the emotional life of the premature infant has received very little consideration in developing methods for their care(11)."

It is now generally accepted that deprivation in infancy may produce irrevocable damage to personality structure. Freud and Sullivan both stress the

effects of mothering on the tension needs of infancy (12,13). The maternal presence and the stimuli she provides are severely lacking in the prescribed incubator setting.

An assumption of this study was that the environment of the premature infant provides a minimum of stimulation; in spite of this, he continues to exhibit a pattern of almost continuous bodily activity. The premature infant's athetoid movements are uncoordinated and faster than the full-term infant. This has been attributed to central nervous system immaturity. Changes in respiratory tracings of premature infants have been noted when under the influence of sound stimuli during the first hour of life(14). Sound was found to change the total activity of the infant and to reduce the level of arousal as reflected by body tension. Salk found that when premature and full-term infants were exposed to a heartbeat sound, they were quieter and gained weight faster in their four days in the nursery(15). During this study with the maternal voice, the nursing staff also reported a reduction in body activity during the sound stimulus period.

The phenomenon of imprinting is an example of the lasting effect of a sound stimuli experienced in a critical period of early life. In a study with chick fetuses, imprinting a patterned sound during incubation caused chicks to move in the direction of the imprint in preference to other stimuli, presumably imprinted sound reduced anxiety(16). They followed a moving model longer when it emitted a familiar sound than when it emitted a novel sound. This was also the principle of Salk's study in the nursery in which the heartbeat was intended to simulate the maternal heart sound imprinted in utero and thereby reduce the tension of mother-infant separation.

Hasselmeyer noted that increased amounts of handling of premature infants resulted in more observable quiescent behavior(17). Neal measured the effects of patterned vestibular stimulation on maturation of low birth weight premature infants (17). She found an increased level of maturation in the sample group. Earle found a significant difference between normal neonates after supplementary kinesthetic stimulation(19). The greatest positive effects were noted with human kinesthetic stimulation.

Purpose

The purpose of this study was to determine whether, during a select period of development, the inclusion of auditory stimulation by the use of a recording of the mother's voice may influence the developmental behavior of the low-birth-weight premature infant. The hypotheses tested in this study were that the 28-32 week gestational age infant who is subject to a regimen of maternal auditory stimulation will demonstrate significantly greater 1) maturational development, 2) greater auditory and visual response, and 3) less irritability than those infants of similar prematurity who were not exposed to this regimen. It was also hypothesized that there would be no significant difference in the muscle tension responses of the two groups studied.

Methodology

This study was conducted in four hospitals in the metropolitan area of New York City. All the premature centers provided comparable medical and nursing care. Since admission to the centers was dependent upon available space, the infants were representative of the various racial and ethnic groups found within the city premature centers.

Sixty-two premature infants between 28-32 weeks of gestational age were followed. After a random start, they were assigned on a systematic basis, according to birth order, into an experimental group who were exposed to a pattern of maternal auditory stimulation (from the fifth day of life) and a control group who were subject to routine nursery care. Infants with severe neurological or physiologic disturbances evident within the first four days after birth were not studied.

Auditory stimulation consisted of a five-minute tape recording of the maternal voice obtained on a high fidelity tape recorder (frequency range of 50-10,000 H_z). A continuous tape was developed on a 120-minute cassette and the mother's voice was presented by a two inch speaker placed in the incubator about eight inches from the infant's ear at 70 decibels—sound pressure level (db-SPL) (re: 0.0002 dyne/cm^2), a volume considered adequate to elicit a response from an infant. A General Radio sound level meter (C scale) was used to establish the decibel rating. The tape recorder was adapted with timing devices which were set to activate the recorder for five minutes, six times a day, at two hour intervals. The regimen began on the infant's fifth day of life, at which time the risk of infant mortality is considerably reduced, and continued until the infant's total gestational age at the completion of the regimen was 252 days. The time period of the regimen was dependent upon the infant's gestational age when he entered the study.

Taping of the mother's voice was done by the investigator. The mother was approached in the hospital within the first three days postpartum and was asked to record her voice. Written permission was obtained in all instances, after an explanation of the study. For the sake of uniformity, a prepared monologue was used and a continuous tape (cassette) was developed which could run for 60 minutes on each side.

The nursing personnel in each institution cooperated fully in activating the timing devices each morning, which automatically initiated the maternal voice tape regimen for 12 hours. Frequent trips to the institutions verified this by the position of the tapes in the cassette.

At 36 weeks gestation (252 days), the infant's developmental level was assessed by the Rosenblith Modified Graham Behavior Scale(20). This scale classifies the developmental level of the neonate in terms of general maturation, audio-visual response, muscle tension and irritability. This test is

also being used by the Collaborative Perinatal Research Project which is supported by the National Institute of Neurological Diseases and Blindness of the United States Public Health Service.

The measurement of infant responses is difficult because of their limited repertoire and lack of clarity in their stimulus-response patterns. The Rosenblith Test is a revision of the Graham Behavior Scale which elicits responses that represent essentially the most complicated behavior exhibited by the neonate. The test is devised to measure sensorimotor ability by the capacity to respond to particular stimuli and the extent to which it is specific to those stimuli. The original test by Graham was standardized and reliability and validity were established. Rosenblith, in her revised form established test reliability with that of the Graham Test. The revised form made it possible to predict a relationship between the newborn's developmental behavior and subsequent testing at eight months of age. The revised form met the criteria established by Rosenblith: 1) behaviorally oriented 2) requires a minimum of equipment 3) relatively quantitative and 4) takes a minimum amount of time to administer.

Two individuals were taught the Rosenblith scale and they rated the infants. Both raters had postmasters education in public health nursing and in maternal and child health and were experienced in research and the care of the newborn. The raters were not aware whether the infants were in the experimental or the control group.

Reliability was obtained for interscorer agreement between the testers and the investigator. Interscorer agreement was obtained on nonstudy subjects before the raters participated in the scoring in the study. A Pearson r of .80 which represents a high correlation, was required for interscorer agreement. Periodic checks were done for reliability throughout the study period in order to control for variations in the techniques of the testers.

Analysis of Data

The General Maturation Scale score of the Rosenblith Test consists of two subscores, a) motor and b) tactile-adaptive. Motor score consists of four responses, head reaction, crawl, vigor, and grasp. The response to prone positioning in terms of a classified response of head and limbs in 20 to 60 seconds relates to head reaction and crawl motion, with each response given a numerical score. The scores are on a continuum with relation to degree of complexity. The grasp is measured by the weight of the infant's pull on a scale (0-4 pounds). The tactile-adaptive score consists of persistence and reaction to paper and cotton on nose and mouth. The presence of specific movements of head, mouth and arms to each stimulus and its persistence is rated by a numerical score. The General Maturation score is a total of the two subscores. Both subscores indicated that the experimental group scored higher. The differences were statistically significant at the .01 level. The method selected was the analysis of variance (see Table 1). In order to calculate this, an equal number of individuals within the hospital groups was required, therefore a random discard of one control and one sample for proportional numbers was carried out. For chi-square and other statistical analysis not based on individual hospitals, the total sample size of 62 was used.

Results of the motor test indicate a mean score of 5.3 for the group of infants who experienced patterned auditory stimulation and a mean score of 2.9 for the control group. In the tactile-adaptive data, the experimental group had a mean score of 8.3 while the mean of the control group was 3.8 (see table 2). Rosenblith in her eight-month examination indicates that the higher the neonatal score, the smaller the proportion of abnormal cases at eight months of age(21).

The auditory test measures responses to a bell and rattle and the visual test measures responses to a red rattle. An analysis of variance for auditory responses indicated significance at the .01 level (see Table 3). The responses varied from eye blinking or a moro to decrease in motor movement (0-5). In the experimental group 21 infants scored at the level of four or above for auditory responses and five control infants scored four or above. Fourteen infants in the experimental group and one infant in the control group scored seven or more on the visual test (see Table 4). The test was scored on the basis of the infant's ability to visually fix upon and pursue a moving object. The degree of visual follow, vertical and horizontal were graded (0-10).

On the basis of the findings, it can be stated that the experimental group achieved greater auditory and visual function at 36 weeks of age than the control group ($p < .01$).

The comprehensive tension rating includes an overall rating of trembling, displacement of upper and lower limbs, pushing of the infant's feet against the examiner's hands, activity position assumed,

Table 1. Analysis of Variance for Motor Behavior for 30 Premature Infants who Received a Regimen of Auditory Stimulation and 30 Premature Infants who did not Receive this Regimen

Source of Variation	DF	SS	MS	F	Significance
Between groups	1	105.34	105.34	57.25	$p < .01$
Between hospitals	3	4.24	1.4	.76	n.s.
Interaction	3	6.02	2.20	1.19	n.s.
Error	52	95.72	1.84		
Total	59	211.92			

and pull to sitting position. The ratings (1-9) were designed to measure deviations in the direction of either increased flaccidity or increased rigidity. The experimental group scored significantly higher than the control group ($p < .01$). However, the differences in muscle tension were accepted with some reservations for there were also significant differences in muscle tension test results as well as significant interaction between hospital nurseries.

In the experimental group no infants scored below five in the comprehensive tension dating (flaccid and poor tone range), while in the control group there were 21. In the pull to sitting item, 18 infants in the control group scored 2 or below, which indicate marked head droop, while no experimental infants fell into this category (see Table 5).

The irritability scale has 5 intervals. Using chi square, since the ratings were not on a continuum, no statistically significant differences were found between the 2 groups studied (Table 6).

Discussion

This study supports previous findings which indicate that variations in behavioral development are evident after changes in sensory input (22). The

Table 2. Analysis of Variance for Tactile-Adaptive Behavior of 30 Premature Infants who Received a Regimen of Auditory Stimulation and 30 Premature Infants who did not Receive this Regimen

Source of Variation	DF	SS	MS	F	Significance
Between groups	1	319.70	319.70	83.59	$p < .01$
Between hospitals	3	8.73	2.91	.76	n.s.
Interaction	3	2.49	.80	.21	n.s
Error	52	199.07	3.82		
Total	59	529.99			

Table 3. Analysis of Variance for Auditory Responses for 30 Premature Infants who Received a Regimen of Auditory Stimulation and 30 Premature Infants who did not Receive this Regimen

Source of Variation	DF	SS	MS	F	Significance
Between groups	1	86.40	86.40	77.83	$p < .01$
Between hospitals	3	2.81	.93	83	n.s.
Interaction	3	8.46	2.82	2.54	n.s.
Error	52	58.97	1.11		
Total	59	156.64			

Table 4. Analysis of Variance for Visual Responses for 30 Premature Infants who Received a Regimen of Auditory Stimulation and 30 Premature Infants who did not Receive this Regimen

Source of Variation	DF	SS	MS	F	Significance
Between groups	1	244.02	244.02	73.94	$p < .01$
Between hospitals	3	2.58	.87	.26	n.s.
Interaction	3	5.49	1.83	.55	n.s.
Error	52	171.81	3.30		
Total	59	423.90			

Table 5. Analysis of Variance for Muscle Tension Responses for 30 Premature Infants who Received a Regimen of Auditory Stimulation and 30 Premature Infants who did not Receive this Regimen

Source of Variation	DF	SS	MS	F	Significance
Between groups	1	13.53	13.53	27.61	$p < .01$
Between hospitals	3	6.70	2.23	4.55	$p < .01$
Interaction	3	5.89	1.93	3.93	$p < .05$
Error	52	25.53	.49		
Total	59	51.65			

Table 6. Irritability Rating for Premature Infants, 31 Experimental who Received a Regimen of Auditory Stimulation and 31 Control Infants who did not Receive this Regimen

Group	No Cry	Cries Rarely (Normal)	Cries More Than One Half the Time (Irritable)
Experimental	4	22	5
Control	6	20	5

$x^2 = .495$ $df = 2$

"stimulus hunger" manifested has many implications for nursing care. The science of nursing is concerned with the reciprocal relationship between field forces and the individual in space and time. These interactions create biophysical and psychosocial adjustments. The incidence of physical and neuropsychiatric disability of prematurity and its impact upon the family and society may be a consequence of these forces.

Nursing research has the responsibility to examine the therapeutic setting provided for these vulnerable infants. The fact that an infant can be confined to an incubator for extended periods of time despite the evidence of deprivation should lead us to evaluate how long it remains a requirement for survival, as well as forms of enrichment that can be provided to improve the experience. The premature infant is critically dependent upon nursing actions and the appropriate utilization of nursing theory may influence his biological integrity.

Summary

The human infant at 28 to 32 weeks gestational age is in the midst of a critical phase of neurological development. It was postulated that deprivation of normal sensory experiences can act as developmental modifiers to the neuromotor system. To determine this, a patterned stimulation in the form of the maternal voice was provided in the incubator.

The independent variable was the regimen of auditory stimulation administered to the individual subjects by means of a tape recording of the maternal voice. The dependent variables were the measures of behavioral development, namely, general maturation, audio-visual, irritability and muscle tension response (as measured by the Rosenblith Test).

The hypotheses tested in this study were that the premature infants subjected to a regimen of maternal auditory stimulation will demonstrate significantly greater maturational development, auditory and visual response and less irritability than those not exposed to this regimen. No differences in muscle tension was anticipated in the two groups.

The study population consisted of 62 low-birthweight premature infants. Thirty-one infants from the fifth day of life were exposed to a patterned presentation of their own mother's voice, while the remaining 31 infants received routine nursery care. The taped voice was presented within the isolette through a speaker at 70 decibels, for five minutes duration, six times daily. This regimen was continued until the infants had reached 252 days of gestational age.

At that time, the Rosenblith Test was administered to measure developmental behavior. The premature infants who were subject to the patterned regimen of auditory stimulation achieved greater maturation (motor and tactile-adaptive) and greater auditory and visual function on the tests. The infants showed significantly different muscle tension responses but were not less irritable than those infants who did not receive this regimen, according to the index used in this study.

These findings suggest that in our attempt to achieve physical sterility, we have created a sensory deficit. Studies of both human and animal subjects lead us to the conclusion that separation from maternal figure and loss of sensory stimuli can lead to adaptive mechanisms in the form of developmental variations.

References

1. Lubchenco, L. O., and others. Sequelae of premature birth. *Amer J Dis Child* 106:101-115, July 1963.
2. Evans, P. R. Antecedents of infantile cerebral palsy. *Arch Dis Child* 23:213-219, Dec. 1948.
3. McDonald, A. D. Neurological and ophthalmic disorders in children of very low birth weight. *Brit Med J* 1:895, Mar. 31, 1962.
4. Harper, P. A., and others. Neurological and intellectual status of prematures at three to five years of age. *J Pediat* 55:679, Dec. 1959.
5. Lesser, A. J. Mental retardation and maternal and child health amendments of 1963. *Pediatrics* 33:3-4, Jan. 1964.
6. Hyden, H., and Egyhazi, E. Nuclear RNA changes of nerve cells during a learning experiment with rats. *Proc Nat Acad Sci USA* 48:1366, Aug. 1962.
7. Brattgaard, S. O. Importance of adequate stimulation for the chemical composition of retinal ganglion cells in early post natal development. *Acta Radiol* (Suppl. 96):1-80, 1952.
8. Hebb, D. O. *Organization of Behavior*. New York, John Wiley and Sons, 1949.
9. Illinois Mental Health Department, Institute for Juvenile Research. *Perceptual Development; its Relation to Theories of Intelligence and Cognition*. Proceedings of a conference cosponsored by the U.S. National Institute of Child Health and Development, organized by Noel Jenkins. Chicago, The Department, 1966, p. 6.
10. Reisen, A. H. Stimulation as a requirement for growth and function in behavioral development. In *Functions of Varied Experience*. ed. by Donald W. Fiske and S. R. Maddi. Homewood, Ill., Dorsey Press, 1961, pp. 57-80.

11. DUNHAM, ETHEL C. *Premature Infants.* 2d ed. New York, Harper and Brothers, 1955, p. 89.

12. FREUD, SIGMUND. *Problem of Anxiety.* New York, W. W. Norton and Co., 1936, p. 100.

13. SULLIVAN, H. S. *Interpersonal Theory of Psychiatry,* ed. by Helen S. Perry and Mary L. Gawell. New York, W. W. Norton and Co., 1953, p. 44.

14. PEIPER, ALBRECHT. *Cerebral Function in Infancy and Childhood.* New York, Plenum Publishing Corporation, 1963, pp. 85-89.

15. SALK, LEE. Effects of the normal heartbeat sound on the behavior of the new-born infant; implications for mental health. *World Ment Health* 12:168-175, Nov. 1960.

16. GRIER, J. B., AND OTHERS. Prenatal auditory imprinting in chickens. *Science* 155:1692-1693, Mar. 31, 1967.

17. HASSELMEYER, EILEEN G. *Handling and Premature Infant Behavior.* New York, New York University, 1963, p. 218. (Unpublished doctoral dissertation)

18. NEAL, M. *The Relationship Between Vestibular Stimulation and the Developmental Behavior of the Premature Infant.* New York, New York University, 1967. (Unpublished doctoral dissertation)

19. EABLE, A. *Effect of Post Natal Kinesthetic Stimulation on the Developmental Behavior of the Normal Female Newborn.* New York, New York University, 1969. (Unpublished doctoral dissertation)

20. ROSENBLITH, J. F. Modified Graham behavior test for neonates; test-retest reliability, normative data, and hypotheses for future work. *Biol Neonat* 3:174-192, Apr. 1961.

21. ———. Prognostic value of behavioral assessments of neonates. *Biol Neonat* 6:76-103, 1964.

22. HUNT, J. M. *Intelligence and Experience.* New York, Ronald Press, 1961, pp. 107-108.

General Research Support Received by Two Schools of Nursing

Frances Payne Bolton School of Nursing at Case Western Reserve University and the Yale University School of Nursing have been awarded General Research Support Grants from the General Research Support Branch, Division of Research Facilities and Resources, N.I.H. These two grants are the first ever awarded to schools of nursing. An institution must have a minimum of $100,000 in allowable N.I.H. and N.I.M.H. research grants annually and its research activities must be sufficiently broad and diverse to be eligible for funding. The institution must also submit a proposal for use of the funds.

The General Research Support program is intended to permit wide flexibility in the use of the grants awarded. Funds may be used to support research, especially those activities for which other funds are either not available, or where project-type support is difficult to formulate; for personnel, resources, health-related research training, alterations, renovations, and supplies. The institution is responsible for establishing priorities and allocating grant funds in support of its health related research and research training activities.

At Case Western Reserve, the funds will be used to aid the school in continuing to develop a broad program of research in relation to: 1) nursing practice, 2) the system through which health care is delivered, 3) changes in social systems in which nursing care is delivered and nursing education takes place, 4) the educational process through which nurse-professionals are prepared, 5) administrative processes, and 6) advancing and structuring knowledge in the "basic" disciplines and in nursing. It is envisioned that the school will in the near future have a Division of Research to which investigators with diverse backgrounds will be appointed to engage in independent and collaborative research. Funds from the General Research Grant will support research during its pilot phases, research personnel (including students serving as research assistants), and specific research equipment.

At Yale, the grant will be used to build toward a "center for nursing research" within the school of nursing. Recognizing that one barrier to research activity in nursing is the over-commitment of nursing school faculties in the essential activities of teaching and clinical practice, Yale will use its grant to recruit and appoint qualified full-time researchers interested in patient care problems. These persons will be free to develop sustained lines of inquiry and multidisciplinary approaches to clinical problems. Eventually a core of such persons will constitute a "center" to conduct research and offer research services to clinical agencies and the school of nursing. Recruitment is underway. Interested persons should contact the Principal Investigator, Dean Margaret Arnstein, or the Project Directors, John A. Wolfer or Donna Diers, at Yale School of Nursing, New Haven, Connecticut.