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ABSTRACT

Examined was the effect of low frequency auditory and kinesthetic stimulation on the sleep behavior of seven premature normal infants. Stimulation consisted of positioning in a rockerbed and exposure to a recorded heartbeat for 15 minutes an hour. Measured were Ss's sleep wakefulness, weight change, and gestational development. Analysis of the data indicated that the duration of Ss's quiet sleep was significantly increased while a control group's declined. Although not significant, positive differences were also found in measures of weight gain and maturation. Results of followup evaluations favored the six experimental Ss over the five control Ss on such measures as the Home Inventory for infants and the Bayley Infant Scales. (CL)

A PROGRAM OF STIMULATION FOR INFANTS BORN PREMATURELY

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This study was prompted by a conviction that specific "nurturing actions" could in fact provide an environment that promoted the adaptation of the immature infant. The infant born before 37 weeks of gestation has more difficulty adapting to extrauterine life than the term infant. This difficulty in adaptation is often accounted for by the infant's immature central nervous system. In addition, it is clear that premature infants, in general, show a higher incidence of later developmental problems. (Beargie, James, Green, 1970; Braine, Heiner, Wortis, Wortis, Freedman, 1966; Drillien, 1964; Drillien, 1970; Harper, Wiener, 1965; Rothschild, 1967; Sinclair, Coliron, 1969; Van den Berg, 1968.)

The incidence of morbidity among prematures has been exacerbated in recent years by improvements in their care. Thus not only is prematurity the most important cause of neonatal death, it is also the leading cause of morbidity in surviving individuals. (Drillien, 1967; Fuchs, 1968)

The current situation, then, is that higher and higher percentages of the very young and very low birth-weight prematures are surviving, but with an increasing rate of risk for later developmental difficulties. If the latter risk is to be reduced, we need to know a great deal more about the characteristics of the premature infant and about the impact of various treatment procedures on his later developmental pattern. Let us look first

[1]During this study the investigator was supported by a Research Fellowship from the Division of Nursing, National Institutes of Health, United States Public Health Service, Department of Health, Education and Research. Dr. Helen Bee Douglas was the major faculty advisor during this fellowship.

at what is known about the characteristics of the premature and his environment, particularly when compared to the characteristics of the full-term infant, and then turn to an examination of the research on the effects of various treatment strategies.

One of the first, and most obvious, difference between the term infant and the premature is the greater difficulty the latter has in adjusting to extrauterine life. The immature infant expresses this difficulty in his degree of respiratory distress, hyperbilirubinemia, temperature instability, and weight loss or slow weight gain. (Braine, 1966; Gruenwald, 1968) To understand the possible origins of such difficulties, it must be recognized that the premature differs in two rather different ways from his full-term brother: First, he is in a very different kind of environment for the last weeks or months of the normal gestational period, and second, he is physically--more particularly neurologically--less mature at the time he must face the extrauterine environment.

For the normally developing embryo and fetus the intrauterine environment provides vestibular, auditory, and proprioceptive stimuli. (Grimwade, Walker, Wood, 1970; Humphrey, 1970) These stimuli furthermore present a generalized and intensified input to the fetus because of transmission of the stimuli through the amniotic fluid. The mother's movements and vital functions represent stimuli for the fetus which have a temporal pattern. The premature who remains in an incubator, in contrast, does not experience this temporal patterning of vestibular, auditory, and proprioceptive stimuli of intrauterine existence during a potentially important period of central nervous system maturation. For the very low birth-weight infant, who requires the support of an incubator environment for a longer period, the difference is even more striking, since the incubator, while offering a supporting environment which controls temperature, oxygen, and humidity, provides a relatively changeless environment. (Rothschild, 1967)

Results from experiments with animals clearly show that sensory deprivation, particularly for the very young organism, can lead to marked later learning difficulties. (Levine, 1960; Riesen, 1961) Perhaps, then, one of the difficulties encountered by the premature infant is that he suffers from stimulus deprivation. More specifically, he may suffer from a deprivation of temporally patterned stimulation of various kinds. (Rothschild, 1967)

A second, somewhat related, line of research on the premature deals more directly with the development of the central nervous system, with the heaviest focus on the development of those neurological systems which control the infant's state of sleep or arousal or movement.

The development of the ability to suppress activity is an important aspect of the development of the central nervous system. In the normally developing embryo and fetus this development can perhaps be seen in the decrease in spontaneous activity from 14 weeks on. (Humphrey, 1970) While the explanation for this decrease is somewhat uncertain, it has been attributed to a combination of factors such as increasing central nervous system control of spontaneous discharge and the effect of increased stimulation which the fetus experiences from more constant proprioceptive stimulation as he grows bigger. In the normal neonate, the ability to handle spontaneous neural discharge and to organize periods of sleep and wakefulness can also be seen as an aspect of central nervous system control. (Wolff, 1966)

Dreyfus-Brisac (1970) studied the ontogensis of sleep in the premature infant and has shown that the infant born early does not even at term age obtain the level of organization in sleep that full-term 40 week infants display. In the immature infant a lack of sleep cycling and shortened sleep periods have been demonstrated. The premature infant's sleep is characterized by undifferentiated sleep states as well as short episodes of quiet sleep. (Parmelee, Wenner, Akiyama, Schultz, Stern, 1969) Metcalf (1969) demonstrated changes in electrical activity of the brain, with an earlier appearance of sleep spindling in prematurely born versus full-term infants. Thus, evidence is accumulating which suggests that intrauterine versus extrauterine conditions promote different outcomes in both central nervous system maturation and function. The data from Dreyfus-Brisac (1970) and Metcalf (1969) are somewhat contradictory, as on the one hand we see demonstrated poor organization of sleep parameters, while Metcalf's data suggest the premature's sleep ontogenesis surpasses the full-term infant's. However, both investigators agreed on the differential effect of the preterm extrauterine environment. Dreyfus-Brisac (1970) is oriented to a dynamic concept regarding organization of the sleep cycle and therefore presented evidence regarding the central integration involved in sleep, whereas Metcalf's data related to the one parameter, that of EEG.

Furthermore, the long-term effects of the early extrauterine environment suggest the possibility that the neurological anomalies remain. Drillien (1964) reported that 25 percent of the premature population she followed had sleep disturbances through 2 years of age. The established disorganization in the premature's sleep-wakefulness pattern raises the issue of how this inability to organize and control behavior normally contributes to the significant incidence of learning and emotional problems manifested in the school-age population of children with a history of premature birth and low birth weight.

But what kind of environmental change in the life conditions of the premature would have the desired effect? Many investigators, struck by the differences in both the amount and patterning of stimulation between the intrauterine and extrauterine environments, have recommended additional stimulation for the infant which will in some respects match intrauterine stimulation. Thus, Kulka, Fay, Goldstein (1960), Rothschild (1967), Foman (1968), Neal (1967), and Segel (1970), have all recommended adding rocking movements to the stimulation provided for the premature infant in an incubator. Studies have shown that additions of environmental stimulation have affected the later behavior of the premature (Hasselmeyer, 1961; Neal, 1967; Scarr, Williams, 1971; Segall, 1972; Solkoff, Yaffe, Weingrab, Blase, 1969).

Previous work with full-term neonates and older infants provides support for the general notion that additions of particular kinds of stimulation assist in the regulation of sleep and arousal states (Ashton, 1971; Brackbill, Fitzgerald, 1969; Jouvet, 1961; Van den Daele, 1971, 1972; Wolff, 1966).

Given this evidence and assuming that increasing the incidence of quiet sleep in the immature infant can be used to improve neurological development, it seemed both desirable and feasible to attempt to modify sleep patterns of premature infants by environmental programming. The most general purpose of the investigation was to study the effect of regular controlled stimulation on neurological functioning in the infant born prematurely. Specifically, the effect of low frequency auditory and kinesthetic stimulation in sleep behavior during 33 to 35 weeks of gestational age was examined. The effect was measured by examining the differences in physiological and behavioral functioning of the premature infant studied as reflected in their general maturation sleep-wake behavior, and weight gain in the immediate post-natal period.

METHOD

The study was originally designed to include prematurely born infants satisfying the following criteria:

1. Gestational age of 32 weeks $\pm$ 0.7 (Dubowitz, Dubowitz and Goldberg, 1970).
2. Birth weight within the 10th-90th percentile for gestational age (Babson, Behrman and Lessel, 1970).
3. Consent of both parents.
4. Assessment by the pediatrician as a normal premature and his consent for including the infant in the study.

Sample Characteristics

The final sample included in the experimental portion of the study consisted of 15 premature infants. Eight subjects comprised the control group, six females and two males. The experimental group had four female and three male subjects, making a total of seven in this group. The mothers of these infants were young and had had few prior pregnancies. Generally the infants were born after short labors and no general anesthesia was required during the delivery. Ten subjects were born between 28 and 31 weeks of gestational age; the remaining five subjects were born 32 weeks of gestation. In a comparison of the average number of days the subjects were born before 32 weeks gestation, the group means show that the control subjects were born an average of 9.0 days prior and the experimental subjects a total of 15.4 days prior, a nonsignificant difference.

In comparing weights at 32 weeks of gestation the control subjects were significantly heavier (1305 grams) than the experimental subjects (1188 grams). The majority of subjects had a diagnosis of mild respiratory distress during the first few days of life. The one significant difference in medical history between the two groups was that the control group required oxygen therapy over a longer duration than the experimental subjects. Only two subjects, one in each group, displayed symptoms of infection during their neonatal course.

Both groups demonstrated clinical problems such as hyperbilirubinemia, bradycardia, heart defects, and anemia. In comparing the pediatrician's diagnosis for each subject, there was essentially no difference in the incidence of problems. Table I summarizes the characteristics of the two groups.

Experimental Apparatus and Procedure[2]

The experimental condition involved providing a regulated system of auditory and kinesthetic stimulation to infants during the thirty-third and thirty-fourth weeks of gestational age. A rocker bed was designed and built by the Medical Instrument Facility of the University of Washington according to the investigator's specifications. The rocker bed moved on a horizontal plane with a maximal displacement of 3 inches and a movement rate of 29 to 30 strokes per minute. Figure 1 shows the equipment.

The rocker bed provided the kinesthetic stimulation while a recording of a heart beat offered auditory stimulation. These modalities of stimulation are experienced by the fetus in utero and were therefore judged as appropriate supplements to extrauterine existence. The heart beat was recorded on a continuous-loop tape recording; it was played from a Realistic

[2]Equipment and salary for observers used in this study were supported with monies obtained, by the investigator, through a grant from the United Cerebral Research and Education Foundation, March, 1971-1972. Waldemar H. Wenner, M.D., was Project Director of this grant.

Stereo eight-tract player and carried to a 5-inch air-suspension high-fidelity speaker, enclosed in a plastic box and placed in the incubator. The speaker was approximately 22 inches from the infant's head. The sound intensity of the heart beat was measured and regulated by the investigator and an audiologist. The audio intensity was 85 decibels with the majority of acoustical energy below 500 cycles per second (c.p.s.); this is supported as an appropriate level by the finding of Grimwade (1970) who reported acoustical energy in the pregnant uterus to be in the range of 20 to 300 c.p.s. at an intensity of 85 to 94 decibels. The intensity level is well within the safety range of established criteria which define the levels and duration at which noise becomes hazardous to the human (Kryter, Ward, Miller, Eldredge, 1968).

Both the rocker bed and tape player were connected to a Cramer CAM Industrial Timer which was programmed to turn on each hour and operate the stimuli for a 15-minute period.

Therefore, infants in the experimental group, in addition to the regular nursing and medical care, experienced a temporally regulated program of low-frequency auditory and kinesthetic stimulation during 33 and 34 weeks of gestational age. The stimuli used were known to produce behavioral quieting and sleep (Ashton, 1971; Brackbill, 1969; Jouvet, 1961; Van den Daele, 1971, 1972; Wolff, 1966); and were offered on a schedule known to coincide with the duration of an infant's sleep cycle and the duration of stimuli was determined in accord with the usual length of quiet sleep in the newborn infant (Parmelee, 1969).

Collection of Data

Identical data were collected on all subjects during a 4-week period from 32 to 35 weeks of gestational age. These data consisted of behavioral observations of sleep-wakefulness (Parmelee, Bruck, Bruck, 1962; Wenner, 1970), gestational age assessment (Dubowitz, 1970), and clinical material regarding weight loss or gain. In addition, selected descriptive information was collated from the clinical record. The methods used are described in detail elsewhere (Barnard, 1972).

SHORT-TERM RESULTS

Physiological Assessments

Two general measures of physiological development are of interest in comparing the progress of the control and experimental infants: (a) gestational age, as assessed by the Dubowitz procedure, and (b) weight gain.

Gestational age assessments were made at birth, at the beginning of the experimental period (32 weeks), and weekly thereafter for the 4 weeks of the study, ending with the assessment at 35 weeks. The results of these assessments for the experimental and control groups are given in Table II. While the differences are not statistically significant, it is clear that the experimental group, while starting at a lower mean gestational age at the beginning of the study, exceeded the control group by the end of the study period.

The results from the analysis of weight gains for the two groups are given in Table III. This analysis is made more complicated by the fact that the control group was significantly heavier than the experimental group at the beginning of the study. In a sense, the experimentals had more room to gain during the experimental period, and as can be seen from the figures for daily weight gain, they did in fact gain significantly more during the course of the experimental period. In order to correct for initial differences to at least some extent, each infant's total weight gain was calculated using only the weight gain or loss after the infant had regained his birth weight. Using this measure, a difference score calculated by subtracting the weight after regaining birthweight from the final weight at 35 weeks, the difference between the two groups disappears. The amount of formula taken by each infant was tabulated and compared with recommended caloric intake (130 calories per kilogram). There was no difference between the groups; most infants were taking 20 to 40 calories above the recommended amount.

Behavioral Measures

The comparisons of the experimental and control subjects for each type of sleep behavior, at 32 weeks and at 35 weeks, are given in Figure 2. The two groups differed in initial amounts of quiet sleep, active sleep, and active awake: the control subjects, at 32 weeks, spent more time in quiet sleep, more time in active sleep, and less time in active awake than did the experimental group. No differences were found, however, at 35 weeks. To determine whether the initial differences were due to differences in the living ages of the subjects (since six of the seven experimental and only four of the controls had been born before 32 weeks), an analysis was done comparing the control subjects born before 32 weeks and the control subjects born at 32 weeks. Since no differences between these two subgroups of control subjects were obtained on the 32-week sleep measures, we can tentatively conclude that the difference in living age between the experimentals and controls is not the controlling variable in the 32-week sleep-pattern differences between the two groups.

Since the experimentals and controls did differ during the baseline period (32 weeks), the appropriate test of the effect of the experimental manipulation is an analysis of change scores. The importance of such an analysis is clearly shown in Figure 2, in which the week-by-week scores for each sleep state are given graphically for the two groups. It is clear that the pattern of change in quiet sleep is quite different for the two groups. The graphs also show a drop in transitional sleep for the experimental group during the first week on the rocker bed, and the graph for active awake shows differential changes in the two groups as well. The statistical analysis of these changes is presented in Table IV. For this analysis, the 32-week scores in each sleep-wake category were used as a baseline; each subsequent-week score was then compared to the baseline with a plus score indicating an increase in that particular type of behavior and a minus indicating a decrease in that type of sleep behavior.

In summary what was obvious from an inspection of the graphs in Figure 2 is substantiated by the statistical analysis in Table IV: the experimental subjects showed a significantly greater gain in quiet sleep while the controls actually showed a decline; the experimental subjects showed a significantly greater drop in active awake than did the controls; and in transitional sleep the two groups differed after 33 weeks, but not thereafter.

Discussion of Findings

One of the major questions asked in this research was whether sleep behavior can be influenced by manipulating the environment. It becomes clear from the analysis of the data that it was the experimental manipulation that made the difference in the amount of sleep-wakefulness, since the experimental subjects tended to show the same change in the direction of more quiet sleep and less active awake, while control subjects showed the reverse. It should be pointed out that this was in spite of the lower weight and poor sleep pattern the experimental subjects demonstrated at the beginning of the study period. The shift to more quiet sleep and longer periods of quiet sleep was accompanied by a larger weight gain and more rapid neurological development, as assessed through the gestational age assessment. While neither the weight gain nor the maturational scoring denoted differences of statistical significance between the control and experimental subjects, the findings were all in the same direction.

The fundamental questions remaining, given that the experimental manipulation worked, relate to the following: first, why did the rocking and heart-beat sound have the effect they did, and second, given that they had the effect, is it a good effect?

First, why did rocking and heart-beat sounds produce the effect of increasing the amount of quiet sleep, reducing the amount of active awake, promoting maturation, and encouraging good weight gain? In reviewing the data demonstrating the infant's response during the actual stimulation period, it was evident in comparing the infant's response from the first week of stimulation to the second week that there was decreasing activity and more quiet sleep during the second stimulation week. This finding is reflected in data already presented, which showed the more significant differences between the two groups to begin after the second week of stimulation.

In general, the results are consistent with those of Brackbill (1969), Wolff (1966), and Van den Daele (1971, 1972), in that a program of low-frequency, redundant stimulation produced general behavioral quieting and an increase of behavioral quiet sleep during the stimulation periods.

This all suggests that the infant was responding less to the stimulation, particularly during the second week. In other words, he was not alerting to the stimulus because he had learned about its properties and thus had habituated to the rocking motion and heart-beat sound. Habituation is an important mechanism, in that it demonstrates negative learning and thus allows the subject to pay no attention to incoming stimuli, since he has learned that the stimuli are not significant for him. Needless to say, steady rocking motion and heart beat do not present any threat signal to which the infant needs to respond and are stimuli which mothers, likewise, have used since the beginning of time to soothe the infant and lull him to sleep. Thus, it seems clear that the infants habituated to the stimulus, thereby releasing attention and promoting sleep.

As for the general effects the stimulation had in promoting maturation and increased weight gain, they can best be explained by calling on parallel data from animal research, which has demonstrated increased maturation in stimulated animals (Levine, 1960). Another way to examine the effect of stimulation is to look more closely at the subjects in the control group. In regard to general maturation, they demonstrated more instances of regression or plateaus in gestational age assessment, thus suggesting that at certain periods they were having to put all their energy into survival and had none left for producing maturational changes. In regard to sleep, the control infants demonstrated progressively less and less quiet sleep and more active awake behavior; perhaps this can be explained by the lack of a repetitive stimulus such as the movement and sound program of the experimental group, or the temporal vestibular, auditory, and proprioceptive stimuli program the infant would be experiencing at this important time in his development if he were in utero. Without this regulated stimulus program, perhaps it is the case that the immature infant, who cannot habituate as quickly to stimuli in the environment, attends to both the internal and external changes in his environment and therefore has less opportunity to sleep, since he is constantly alerting and attending to small changes which have no regular or temporal relationship.

Having produced an effect on the sleep behavior of premature infants, one is faced with the next question of whether this is a desirable effect. On the surface it seems hard to argue that rocking a baby and letting him hear soothing heart beats could be anything but good, or that if a baby has more quiet sleep, how can it be anything but better? The experimental data suggest that the effect was positive because of the somewhat increased weight gain and faster neurological development, insofar as these are appropriate measures of the child's health. One of the major problems with the premature infant relates to his basic immaturity, both neurological and physiological; therefore, if the infant's maturation can be hastened to help him adapt to the new external existence for which he was ultimately genetically programmed, this is desirable in that it potentially hastens the whole system of enzymatic initiation and production, which in turn regulates all physiological functioning. Therefore, encouraging the maturation of the infant would appear to facilitate postnatal adaptation to an environment into which he is thrust before he is ready.

Turning our attention to quiet sleep, specifically, we ask the same question: is it desirable to increase the amount of quiet sleep the infant has? Quiet sleep is the most stable sleep state with regard to physiological function; oxygen consumption is reduced and it is thought to be a period of increased production of growth hormone (Shaywitz, Finkelstein, Hellman, Weitzman, 1971). Neurologically, quiet sleep demonstrates the ability of the cortical areas in the brain to exert control over the pontine centers and thus demonstrates cortical-subcortical feedback mechanisms. While some investigators have shown an increased amount and duration of quiet sleep in neurologically abnormal infants, this is generally considered to represent an excessive increase in duration and perhaps represents a different type of problem with the feedback mechanism.

Quiet sleep increases with age for the infant and is therefore thought to increase as the infant matures. Parmelee (1970) has stated that the infant's ability to maintain a quiet sleep epoch should demonstrate his later ability to sustain visual attention, since the two processes are controlled by the same area of the brain.

This later notion of predicting later behavior leads to the necessity of looking at the subjects in this sample to examine what long-term effect might be evident from the early program of stimulation. The hypothesis suggested would be that there would be no direct later effects on the subjects; however, it is possible that the differences in behavior, would continue in making the infants more alert and responsive to their home environment. This might have the effect(Solkoff, 1969) of setting up a whole sequence of more positive interactions between the stimulated infant and his caretaker and thus have significant, enduring effects on the expression of the child's potential for development and achievement.

Results of Long Term Follow-Up

Eleven children (five control and six experimental subjects) were seen in follow-up approximately one year after the last subject in the sleep study was born and studied. Since the subjects were born at intervals throughout the year of data collection, there was a 4.4 month age difference at the time of follow-up between the experimental and control subjects, with the control subjects being older. The purpose of the follow-up evaluation was to determine if there were any long-term effects for the experimental subjects. Since infancy is noted to be a period of rapid growth and development, it is logical that the infant experiences in early life could have an impact on subsequent events. The infants and their mothers were studied by an interdisciplinary team[3] both in their own home and at the University of Washington Child Development and Mental Retardation Center. Data was collected on physical growth, health status, mental and motor, receptive and expressive language development, as well as certain information about the child's behavior from the mother as well as an observation of the general stimulation qualities of the home environment. Appendix A lists the specific measures reported in the paper.

The follow-up data is presented in Table V and VI. From inspection of this data, it becomes obvious that there are differences in the experimental and control groups which favor the experimental subjects in most measures, particularly the age adjusted mental scale score and expressive language development. It is without question that with such a small sample the results are merely suggestive, and the need for further study is clearly indicated. It is the opinion of the investigator that while the experimental rocking-heartbeat program demonstrated immediate effects on sleep behavior, weight gain, and general maturation, the long-term positive effects are a result of the experimental infant's being more alert and therefore

[3]The members were: Dr. Mary Abbs, Speech and Hearing; Dr. Constance Macdonald, Pediatrician; Susan Malody, Nurse; Judy Solie, Medical Student; Dr. Gary Thompson, Audiologist; Dr. Beverly Van der Veer, Psychologist.

eliciting more interaction with their caretakers or mothers starting at an earlier period and continuing. Thus, while a specific early stimulation program may not have direct long-term effects, the short-term benefits serve as a catalyst to subsequent environmental differences for the infant, since the infant is more alert and responsive to the environment. If we are to improve the quality of survival of the low birth-weight, preterm infant, we must swiftly begin to develop ways to improve the post-partum care of those infants who have benefited from the marvels of intensive medical care; furthermore, as medical care improves, more immature babies will survive; and therefore, it is a priority that more energy be directed into providing a supporting environment for the infant at risk.

As a result of this investigation a tentative program called "Hospital Start" has been formulated and will be implemented and tested on a larger group of low birth-weight, preterm infants ($<$1500 grams; $<$34 weeks). The plan includes the rocking-heart beat program from birth through 34 weeks, visual stimulation, and the use of a primary care nurse to help the parents make a better adaptation or attachment to their infant. A continuing program of care is scheduled with emphasis on the parent and child through the first three years of life. It is anticipated that a program of this type will begin within the next year at the University of Washington.

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TABLE I

Maternal and Neonatal Characteristics

Characteristic	Control (n = 8) Mean (S.D.)	Experimental (n = 7) Mean (S.D.)	Difference
Maternal age	21.7 (6.1)	22.0 (3.6)	0.3
Number of pregnancies	2.0 (0.9)	1.7 (0.9)	0.3
Number of living children	1.3 (0.4)	1.1 (0.3)	0.2
Infant's Apgar score at 1 minute (1 C, 1 E unknown)	6.2 (1.5)	4.1 (1.4)	2.2
Infant's Apgar score at 5 minutes (2 Cs, 3Es unknown)	7.3 (5.6)	4.0 (1.2)	3.3
Diagnosis of respiratory distress at birth 1 = no, 2 = yes	1.7 (0.4)	1.8 (0.4)	0.1
Highest percentage of oxygen administered	35.1 (11.0)	25.0 (23.7)	10.1
Duration of oxygen therapy in hours--all concentrations	105.6 (38.1)	43.5 (38.6)	62.1****
Highest level of bilirubin	8.6 (1.6)	11.1 (3.2)	2.5
Diagnosis of infection during neonatal course (1 E unknown) 1 = no, 2 = yes	1.2 (0.4)	1.1 (2.9)	0.1
Number of days prior to onset of study infant was born	9.0 (12.0)	15.4 (7.9)	6.4
Number of days in incubator	33.0 (25.5)	39.0 (8.5)	6.0
Number of days in hospital	38.2 (30.0)	46.2 (11.2)	8.0

**** $p < .001$

TABLE II

Baseline and Poststimulation Assessment Scores for Gestational Age and the Neurological Component of Gestational Age Assessment

Time-Age	Control (n = 8) Mean (S.D.)	Experimental (n = 7) Mean (S.D.)	Difference[a]
Total gestational age assessment			
32 weeks (baseline)	32.0 (0.2)	31.6 (1.2)	0.4
35 weeks (poststimulation week)	34.5 (1.1)	35.2 (1.3)	0.7
Neurological-component score			
32 weeks (baseline)	13.6 (2.2)	12.7 (1.1)	0.9
35 weeks (poststimulation week)	17.8 (2.6)	18.2 (1.8)	0.4

[a]No significant difference

TABLE III

Infants' Mean Weights at 32 and 35 Weeks;

Average Gain and Corrected Weight Gain

Time-Age	Control (n = 8) Mean (S.D.)	Experimental (n = 7) Mean (S.D.)	Difference
	Weight (grams)		
32 weeks	1305.0 (358.8)	1188.0 (620.9)	117.0**
35 weeks	1633.5 (803.0)	1664.2 (176.0)	30.7
	Average daily weight gain (grams)		
32-35 weeks	14.2 (7.2)	22.5 (8.1)	8.3**
	Corrected weight gain (grams)		
Following regain of birth weight	24.6 (4.4)	25.7 (6.4)	1.1

** $p < .05$

TABLE IV

Comparison of Baseline Means and Difference Scores After The Initiation of Stimulation For The Total Amount of Time (Minutes) in Sleep States During a 150-Minute Observation

Score	Control (n = 8) Mean (S.D.)	Experimental (n = 7) Mean (S.D.)	Difference
Quiet sleep (minutes)			
Baseline: 32-week score	41.7 (10.9)	26.2 (19.0)	15.5***
33-week difference score[a]	-6.5 (17.0)	+1.0 (12.0)	7.5
34-week difference score[b]	-14.0 (14.1)	+12.0 (11.9)	26.0****
35-week difference score[c]	-9.5 (10.2)	+11.4 (13.8)	20.9****
Active sleep (minutes)			
Baseline: 32-week score	22.0 (8.9)	10.0 (8.2)	12.0**
33-week difference score	-0.8 (6.1)	+2.1 (3.8)	2.9
34-week difference score	+3.2 (11.9)	+2.4 (9.5)	0.8
35-week difference score	+5.2 (13.7)	+5.5 (11.0)	0.3
Transitional sleep (minutes)			
Baseline: 32-week score	46.5 (5.2)	50.7 (6.1)	4.2
33-week difference score[a]	+2.5 (7.0)	-12.8 (15.0)	15.3***
34-week difference score[b]	-3.2 (10.6)	-4.4 (15.0)	1.2
35-week difference score[c]	-6.3 (11.5)	-6.0 (19.0)	0.3

[a] Week 33 mean score - baseline

[b] Week 34 mean score - baseline

[c] Week 35 mean score - baseline

* $p < .1$

** $p < .05$

*** $p < .01$

**** $p < .001$

TABLE V

Birth Information and Developmental Follow-up Data

Characteristic	Control (n = 5) Mean (S.D.)	Experimental (n = 6) Mean (S.D.)	t
Birthweight (grams)	1292.0 (175.9)	1132.7 (242.5)	1.2
Weeks of Gestational Age at Birth	32.0 (0.0)	30.7 (0.8)	3.6
Days in Incubator	30.6 (10.7)	38.8 (9.7)	1.3
Living Age in Months at Follow-up	19.6 (1.1)	14.8 (1.8)	5.3
Bayley Mental Score	78.2 (13.2)	77.2 (15.1)	0.1
Age Corrected	93.4 (13.2)	105.2 (18.1)	1.2
Bayley Motor Score	72.8 (11.8)	74.6 (16.8)	0.2
Age Corrected	83.4 (11.2)	92.8 (18.0)	1.0
SILD (Months ↑↓ Living Age)			
Expressive	-1.8 (2.4)	+0.2 (2.9)	1.2
Age Corrected	-0.2 (1.9)	+2.3 (3.0)	1.6
Receptive	-3.0 (3.8)	-2.5 (3.4)	0.5
Developmental Profile Quotient Equivalency Scores			
Academic-Communication	90.0 (27.0)	89.1 (39.4)	1.3
Physical	90.6 (20.8)	97.6 (17.9)	0.6
Social	116.8 (25.5)	115.2 (44.8)	0.1
Maternal Education (years)	12.6 (2.5)	11.6 (1.6)	0.7
Caldwell Home Inventory (percentile)	73.4 (6.4)	80.0 (10.3)	1.2

TABLE VI

Physical and General Health Status
On Follow-up Examination

	Control (n = 5)	Experimental (n = 6)
<u>Head Circumference</u>		
↑ 50th percentile	4	4
↓ 50th percentile	1	2
<u>Height</u>		
↓ 10th percentile	2(2)*	5(0)
↑ 10th percentile	3(3)	1(6)
<u>Weight</u>		
↑ 10th percentile	4(4)	3(3)
↓ 10th percentile	1(1)	3(3)
<u>Neuromuscular status</u>		
normal	4	5
suspect	1	1
<u>Sleep pattern</u>		
Wakes during night at least four nights in seven	2	1

*Numbers in parentheses are the correction made for weeks of prematurity

FIGURE I

INCUBATOR WITH OSCILLATING BED

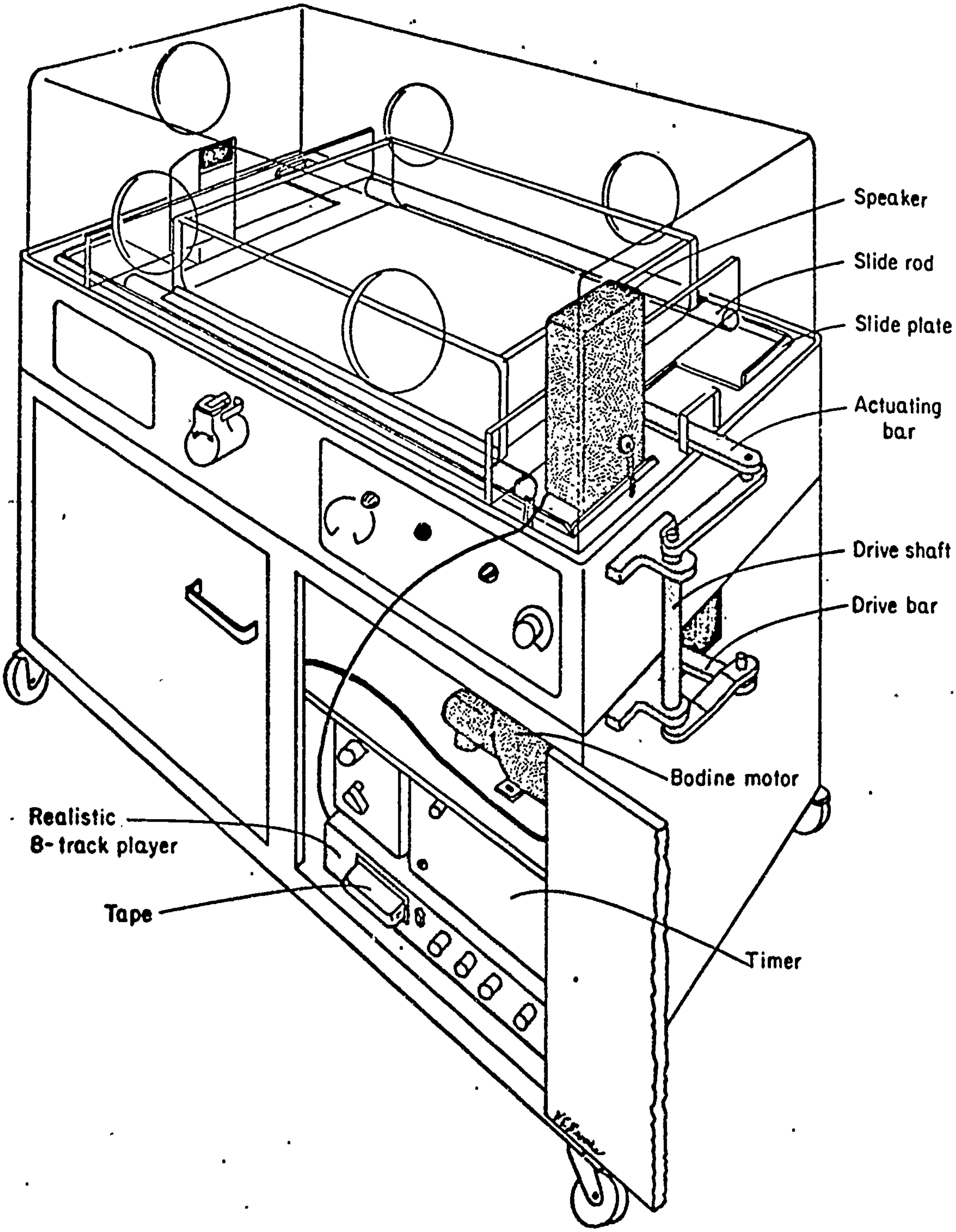
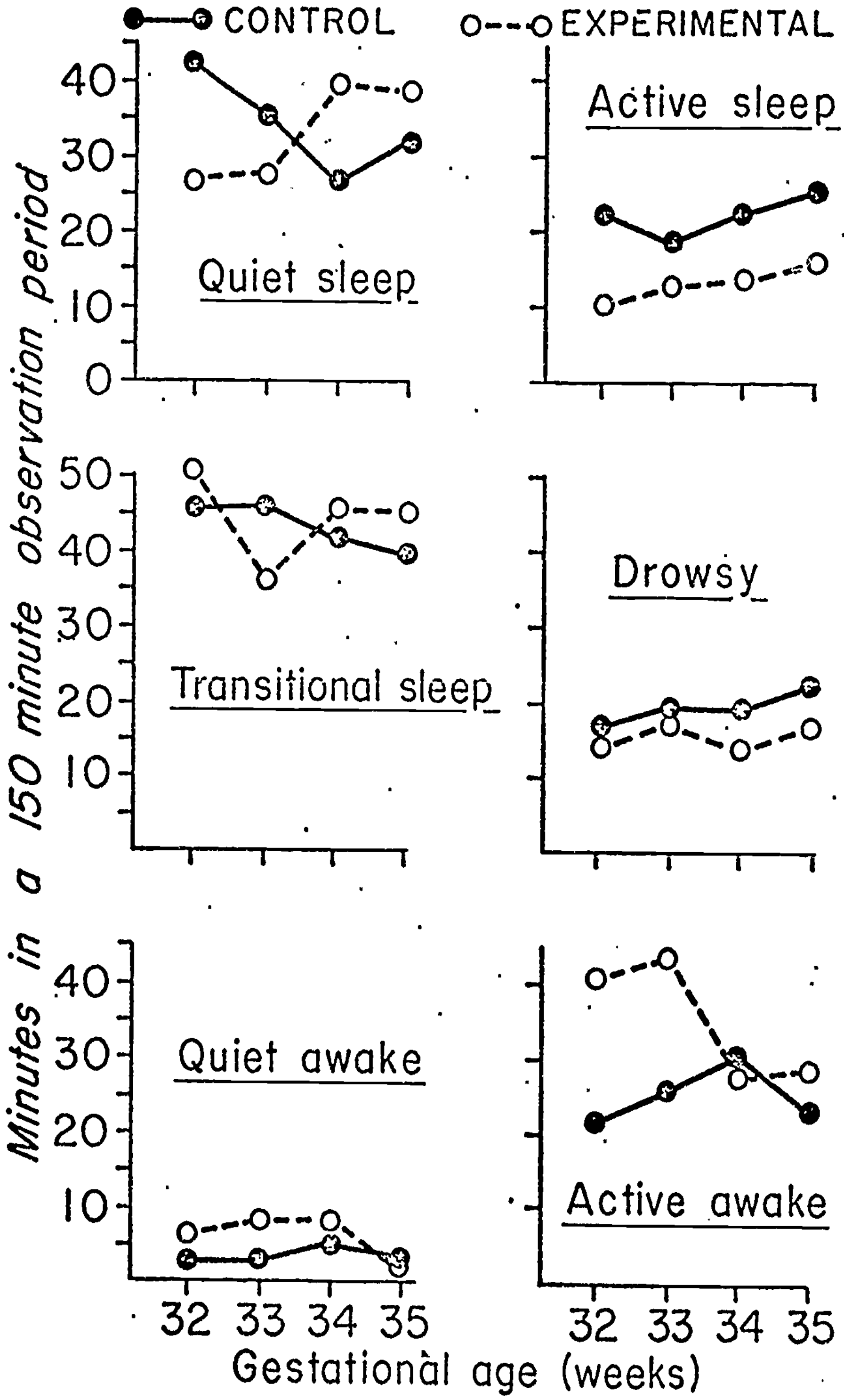


Figure 2


CONTROL
EXPERIMENTAL
Minutes in a 150 minute observation period
Quiet sleep
Active sleep
Transitional sleep
Drowsy
Quiet awake
Active awake
0
10
20
30
40
50
32 33 34 35
Gestational age (weeks)

APPENDIX A

MEASURES OR INSTRUMENTS USED IN THE PREMATURE SLEEP STUDY FOLLOW-UP

1. Interview of Mother
(demographic data and questions about the initial adjustment of the infant when he or she came home)

2. Home Inventory for Infants (Bettye M. Caldwell, unpublished scale, University of Arkansas, Copyright 1970)

3. Bayley Infant Scales. The Psychological Corporation, New York, Copyright 1969

4. Sequenced Inventory of Language Development (D. L. Hedrick and E. M. Prather, unpublished scale, University of Washington, Copyright 1970)

5. Developmental Profile (G. D. Alpern and T. J. Boll, Psychological Development Publications, Indianapolis, Indiana, Copyright 1972)

6. Sleep-Activity Record (Nursing Child Assessment Project, University of Washington, 1972)

7. Anthropometric Chart - The Children's Medical Center, Boston, Massachusetts, (form distributed by Mead Johnson Laboratory)

8. Head Circumference Graph, G. Nellhaus, Composite International & Interracial Graphs, Pediatrics 41:106, 1968

9. Standard Pediatric Physical Examination