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Developmental Progress in Premature Infants as a Function of Oscillating Waterbed and Auditory Stimulation

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DEVELOPMENTAL PROGRESS IN PREMATURE INFANTS AS A FUNCTION

OF OSCILLATING WATERBED AND AUDITORY STIMULATION

by

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In June 1964 she completed course requirements at Presentation Junior College, Aberdeen, South Dakota and obtained a teaching certificate. She then taught at the junior high school level.

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She has published the following works:

Bonding and Attachment. In Practical Hints for the Care of Children. Synapse Publications, 1979.

Checklist of perceptual-motor and language skills for developmentally handicapped preschoolers. Perceptual and Motor Skills, 1978.

The Slingerland Screening Tests: Local Norms. Journal of Learning Disabilities, 1977.

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CHAPTER I

INTRODUCTION

Rapid advances in the field of neonatology during the past 10 years have made possible the survival of prematurely born infants at very early gestational ages and have provided medical solutions for the multiple complications which frequently accompany premature birth. As this population of very young prematures increases, the reality of an increasing number of children at risk for lingering patterns of impairment and even life-long developmental delays is with us. This expected increase in the population of children with developmental disabilities has provided the impetus for the study of very young infants born at risk.

Just as neonatology has emerged as a specialization of pediatrics with concern for the care of high risk newborns, there has emerged within the field of developmental psychology a concern for very young infants born at risk and the quality of life that can be expected for these individuals. As a result research in the field of child development has begun to consider preventive measures for the very young premature that will maximize each infant's potential for normal life and development.

Prognosis Without Intervention: The prognosis for normal life and development in very young prematurely born infants is somewhat unfavorable. Researchers in the 1960's who investigated the long term effects of low-birth-weight and prematurity reported that prematurely

born infants with low-birth-weights were at high risk for developmental, neurological, intellectual and emotional problems. Drillien (1961, 1964, 1970) and Katz and Taylor (1968) reported significantly greater incidence of prematurity among mentally retarded and institutionalized children than is found in the normal population---up to three times greater according to Katz and Taylor (1968). Other studies in the 1960's went beyond just a report of lower IQ and also reported more perceptual and motor problems, poorer language development and a greater incidence of behavioral and emotional problems in children who had a low-birth-weight history (Harper, Fischer & Rider, 1959; Ribinovitch, Bibace & Caplan, 1961; Lubchenco, Horner, Reed, Hix, Metcalf Cohig, Elliott & Bourg, 1963; Wiener, 1968). Some authors (Robinson & Robinson, 1965; Drillien, 1970; Scarr-Salapatek & Williams, 1973; Sameroff & Chandler, 1975) attributed the poor outcome of the low-birth-weight infants as being more a result of low socio-economic status than a result of prematurity. They therefore concluded that socio-economic status is the key predictor of the prognosis of the low-birth-weight infant.

More recent studies reporting prognosis for the premature, low-birth-weight infant have been more encouraging (Stewart & Reynolds, 1974; Sameroff & Chandler, 1975; Grassy, Hubbard, Graves & Machman, 1976; Teberg, Bodgman, Wu & Spears, 1977; Drillien, Thomson & Burgoyne, 1980). Undoubtedly advances in neonatal medical care are responsible for these improvements. Yet, it seems reasonable to conclude that both the prematurity and resulting low-birth-weight as well as the environment have effects on the infant born at a very early gestational

age, and that these infants therefore remain at higher than average risk for developmental, medical and emotional impairment in later life (Schaefer, Hatcher & Barglow, 1980).

Prognosis With Intervention: The research cited above indicates that the outcome of the preterm infant is not only contingent upon the complications of early age and the degree of abnormality presented at birth, but is also contingent upon the environment wherein the infant must continue to grow and develop. Lawson, Daum & Turkewitz (1977) studied the intensive care nursery to evaluate the quality and quantity of stimulation preterm infants receive in the setting that they are forced to remain in during the first days and weeks of their lives. They concluded that the preterm infant received a great deal of visual and auditory stimuli. But the authors went on to conclude that the stimuli appeared to be inappropriate in both its extreme intensity and in its lack of rhythmicity and contingency. They concluded:

> ...the premature infant may be suffering from an inappropriate pattern of stimulation rather than an inadequate amount of stimulation. The pattern is clearly deficient with regard to the opportunity provided for intersensory integration and its support for orienting behavior and may be deficient in its degree of diurnal rhythmicity. Since this is the case, increased stimulation may be detrimental rather than beneficial to the subsequent development of infants maintained in such units. Indeed the current findings raise disturbing questions concerning the possible negative consequences of the conditions which routinely prevail in an intensive care unit (Lawson, Daum & Turkewitz, 1977, p. 1638).

Other researchers (Neal, 1967; Korner, 1979; Barnard, 1972) view the Special Care Nursery, where the infant must live and grow during the first weeks and months of life, as a setting that deprives the infant

of the special types of patterned stimulation necessary for normal
development. These investigators have therefore hypothesized that it
is necessary to develop stimulation programs in the nursery that can
compensate for the inappropriate stimulation inherant in the hospital
environment that provides medical care for these infants.

Another group of researchers (Klaus & Kennell, 1976; Leiderman
& Seashore, 1975; Brazelton, 1969), who view the mother-infant inter-
action as the key component necessary for the infant's development
during the first days and weeks of life, have expressed concern for
the prematurely born infant who must be separated from the mother for
long periods of time and therefore miss a vital aspect of maternal
environmental support in the intensive care units. Yet Klaus and
Kennell (1976) and Casler (1961, 1968) have suggested that the harmful
effects of this early mother-infant separation could be almost com-
pletely neutralized by the special efforts of the hospital to provide
patterns of stimulation similar in kind to those that would ordinarily
be provided by the mother.

Although the emphasis of these groups of researchers is some-
what different, they all indicate that environmental factors are
important. An ever increasing number of invistigations have been de-
signed to determine what types of environmental settings have the most
positive effects on the development of the high risk infant. Research
has established that neonates respond positively to added rhythmic
patterns of stimulation.

The present investigation was an attempt to look at a specific
type of stimulation that was provided for very young premature infants

for an extended length of time immediately after birth. The study

looked at the effects this stimulation had on the initial development

of these infants. An attempt was then made to explain the results

within a theoretical framework of development. It is the hope of the

author that the results of this study can be compared with other

stimulation research and add further information toward answering some

of the questions concerning the effects of stimulation on the pre-

maturely born infant.

CHAPTER II

REVIEW OF THE LITERATURE

The study of the effects of stimulation on the infant began with Spitz's (1945) investigation in which a group of infants reared in a penal institution with their mothers as caregivers was compared with a group of infants reared in a foundling home with custodial nurses as caregivers. By the end of the first year of life the infants reared in the foundling home, who had received only minimal nursing care in stark environments were noticeably retarded in development. They were also more susceptible to disease than the infants in the penal institution. Some foundlings became so depressed that it was difficult to keep them alive. Spitz attributed this developmental retardation to "a lack of mothering."

During the decades following Spitz's study, research efforts to specify the effects of different environments on infant development were to a great extent limited to animal studies. Harlow (1958) aroused the attention of the scientific community with his study of surrogate mother monkeys. Subsequent animal studies have demonstrated the detrimental effects resulting from a lack of stimulation in early infants (Harlow, 1958, 1964) and have shown that numerous beneficial results accompany the provision of an enriched environment. Levine (1960, 1962, 1967) found that a group of infant rats that were shocked and another group of rats that were handled both behaved normally when

under stress, but the third group of rats who were neither handled nor shocked as infants behaved deviantly. He concluded that stimulation in infancy accelerates the development of the central nervous system and produces better utilization of available food which in turn increases the growth rate. Rosenzweig, Bennett and Diamond (1972) were able to show positive brain anatomy and chemistry changes in handled rats over nonhandled rats, and found a general increase in gross brain mass, a higher ratio of cortical over subcortical tissue and an increase in synaptic junctions. Krech (1966) also showed a change in brain chemistry and anatomy in handled rats. Denenberg and his co-investigators (1961, 1962, 1966, 1967) Schaefer (1963) and Levine and Wetzel (1963) demonstrated numerous effects such as greater problem solving ability, increased exploratory behavior, and less emotional reactivity as well as earlier opening of eyes, greater adult weight and greater resistance to disease in their stimulated animal populations.

These animal studies used a variety of types of appropriate (handling) and inappropriate (shocking) stimulation as well as stimulus deprivation and found that stimulation enhanced development while deprivation resulted in behavioral deviance. This early research with animals paved the way for stimulation studies with human infants.

The Stimulation of Human Infants

Auditory stimulation: Some of the earliest controlled studies of human infants were conducted to determine the effect of different types of stimulation on the normal, term neonate. In 1960 Salk reported an experiment in which a recorded heartbeat sound was played in the

nursery for several days. When Salk compared this experimental group

of infants who received only the typical nursery care he found that

the experimental infants cried less than the controls and gained weight

more quickly in the presence of an 80dB heartbeat sound. Later Salk

(1962) theorized that the calming effects of the sound of the human

heartbeat could be attributed to early learning akin to imprinting.

According to Salk, this imprinting explained why the heartbeat sound

produced in the newborn infant a state of relative quiescence.

Any number of studies have tried to replicate Salk's study

in part or in while, with a wide variety of successes and failures.

Tullock, Brown, Jacobs, Prugh & Green (1964) examined the response of

infants to heartbeat sounds. They played a heartbeat sound at a lower

intensity (45dB) and did not find any of the results reported by Salk.

Brackbill, Adams, Crowell & Gray (1966) found significant differences

in the amount of crying between their experimental group and control

group when the continuous heartbeat stimulation was introduced. But

they also found that they got the same positive results when a metronome

beat and lullabies were presented in a similar manner. This latter

finding was not in accord with the claim made by Salk that the

effectiveness of heartbeat in quieting infants is unsurpassed by that

of any other sound. Palmqvist (1975) studied a small group of infant

in order to determine whether weight gain might be a function of heart-

beat stimulation. He used the same methodology and design as Salk

(1960) but was not able to replicate Salk's results. Spiegler and

Ourth (1967) found a greater decline in activity in their experimental

group when a loud heartbeat recording (75dB) was introduced as the

independent variable. Roberts and Campbell (1967) used five sounds with newborn term infants. Each infant heard one of five sounds: human heartbeat at 75 or 45dB and ambient noise. The loud heartbeat sound of 75dB was the only treatment group that showed significant reduction in activity. These results agree with Salk who used an 85dB recording.

More recently Detterman (1978) has attempted to replicate Salk's study without success. Detterman severely challenged Salk's methodology. When Detterman failed to replicate the study of Salk he decided to analyze 13 studies which had used duration of crying as a dependent variable. Results of this analysis indicated that it was the length of experimental treatment which affected the outcome of the experiment.

> The best explanation for this finding (longer studies had lower mean duration of crying) is probably that infants obey the law of initial values. That is, when initial arousal is high, any stimulation change becomes pacifying but when initial arousal is low, any stimulation change becomes arousing. In long-term studies, however, stimulus change is sometimes arousing and sometimes pacifying, but overall the net effect is zero. In future studies of pacification, it is suggested that initial level of arousal be treated as an independent variable instead of assuming ramdom sampling of arousal levels. (Detterman 1978, p. 46)

Detterman's rationale for the use of a heartbeat sound as infant stimulation was that it duplicated as closely as possible the rhythmic sound which the fetus heard in utero. The next question might logically be: What sounds does the infant hear during the intrauterine stimulation before birth?

Walker, Grimwade & Wood (1971) attempted to answer this question. These authors recorded the sounds of the prenatal environment by inserting very small microphones into the uterus of a woman eight

months pregnant. Surprisingly, the recordings showed that there are very loud noises going on all the time within the uterus. It is a rhythmical "whooshing sound" of blood flowing through the placenta with the added sounds of stomach rumblings and air passing through the digestive system. Sounds initiated external to the mother are muffled by the mother's digestive sounds, the amniotic fluid and the rhythmic sounds of blood flow. They concluded that only extremely loud noises from outside the mother's body are heard by the developing fetus. Murooko (Fitzgerald, Stommen & McKinney, 1977) also recorded the intra-uterine body sounds of a pregnant woman and used the recordings to calm infants for physical examination. When Murooko performed an EEG with an infant he played the recording as a means of providing a comforting substitute for the womb's security and successfully quieted screaming infants. Murooko claimed that almost all infants receiving this stimulation stopped crying, most within less than a minute, and many even went to sleep. He believed this procedure to be more effective within the first month of the infant's life because the infant still had a fresh memory of the intrauterine activity.

Recently Armitage, Baldwin & Vince (1980) reported results of their research with the fetal sound environment of sheep. They placed hydrophones inside the amniotic sack of pregnant ewes and recorded the sounds that should be audible to fetal lambs. They concluded that most of the sounds recorded related to the ewe's eating and digestive activities (chewing, swallowing, gurgling, and chewing cud). Loud noises (65dB or greater) from outside the ewe were also audible. Cardiovascular sounds were not recorded. Although this is a contrast

to the intrauterine recordings, it none the less gives support to the rhythmicity of the sounds available to the fetus (chewing, swallowing, etc.).

Salk's research (1960) on the effects of heartbeat sounds on the newborn stimulated further investigation in this area. The results have been somewhat mixed. Loud rhythmic heartbeat sounds have been shown to have a quieting effect on the infants, but other rhythmic sounds have also had similar effects. Although these studies all used healthy full term newborns, it seems reasonable to speculate that these same results would occur with preterm infants.

Tactile stimulation: While Salk was completing his initial study with auditory stimulation, Ourth and Brown (1961) applied a different type of stimuli to a newborn infant in an attempt to model the intratuerine environment. They swaddled infants, held them tightly and rocked them in an effort to duplicate the mild pressure and rhythmic movements of intrauterine life. In this limited study using healthy term infants, the ten experimental infants cried less than did the ten control infants. The authors of this study interpreted the results to mean that deficiencies in mild pressure and rhythmic movement stimulation resulted in state disturbances in neonates that could be corrected for by the application of appropriate rhythmic stimulation. Although this interpretation is an over-generalization, this study laid the groundwork for later investigations of tactile and vestibular stimulation.

Three years later, Hasselmeyer (1964) reported the results of a study in which 30 premature infants were handled by their nurses

regularly for 14 days. He revealed that these infants were quieter

and cried less than control infants who received no extra handling.

Using a somewhat different procedure, Earle (1969) gave a first group

of female newborns supplimentary mechanical kinesthetic stimulation

and gave a second experimental group of female newborns maternal

kinesthetic stimulation (held by nurses three times daily for 30

minutes). Both of these experimental groups were significantly

advanced in developmental behavior when compared to a third group of

untreated controls. The maternal group also increased their auditory

and visual responsivity and they were less irritable.

Solkoff, Weintraub, Yaffe & Blase (1969), in whose study ten

premature low-birth-weight infants were stroked 5 minutes per hour for

ten days, reported that the handled infants regained their birth weight

faster, and scored higher on the Bayley Scales at 6-9 months than

control infants. Freedman, Boverman & Freedman (1975) confirmed

Solkoff's findings in their own study of a larger sample of preterm

infants. Freedman's study found that experimental infants scored

13-16 points higher on the Bayley Scales of Infant Development at 4

months. Both Powell (1974) and Solkoff and Matuszah (1975) supplied

extra tactile stimulation in the form of handling in the isolette or

being stroked to groups on low-birth-weight premature infants. Powell's

stimulated infants received extra handling twice a day for 20 minutes

throughout their hospital stay. Solkoff's stimulated group received

extra stroking in the isolette 5 minutes each hour for 10 days. Both

studies found significant differences between their experimental and

control groups in developmental progress as measured with the Brazelton

Scale. Powell also used the Bayley Scales.

All of these studies used some type of handling and/or holding
with preterm infants. Although the authors did not all specify their
reasons for choosing the type of stimulation, it is very likely that
they were attempting to provide the type of stimulation the preterm
infants would have been receiving from their mothers if it were not
necessary for them to be separated. All of the studies reported
positive developmental progress.

Multiple stimulation: A number of researchers have attempted
to compare several types of stimulation within one experiment. Birns,
Plank & Pridger (1966) applied a variety of soothing techniques using
different sensory modalities: 250cps continuous tone of 85dB,
sweetened pacifier, rocking bassinette, feet in warm water and a
control group. Behavioral ratings and heart rate measures indicated
that any one of these techniques was better than no stimulation at all,
and that no one form of stimulation was better than any other.
McNichol (1974) attempted to determine whether visual attention might
be enhanced more by tactile (stroke and massage) or more by kinesthetic
(handling) stimulation. Her finding was that both types of stimulation
showed significant increases in visual attention to three targets as
compared to a control group. Neither form of stimulation, however,
was superior to the other. Brackbill (1973), using four sensory
modalities, stimulated one-month-old infants with warm water,
swaddling, lights and white noise. She found that all of these types
of stimulation, when applied continuously, reduced behavioral and
physiological arousal and that the reduction remained consistent over

time. Scarr-Salapatek and Williams (1973), in their longitudinal study of premature infants, included a wide variety of stimulation techniques such as handling, viewing the human face, hearing the mother's voice, and seeing a mobile. Their experimental group scored higher on the Brazelton at discharge from the hospital than did the control group. Following the six weeks of stimulation in the hospital nursery, these infants continued in a program of home-stimulation for one year. Cattell IQ scores at the end of this time indicated greater developmental progress for the experimental group over the control group.

These four studies presented a variety of soothing stimuli to the auditory, oral, vestibular, kinesthetic and thermal sensory modalities. They all concluded that any type of soothing stimulation presented the human neonate is more efficacious than no stimulation and that no one type of stimulation is better than any other.

Vestibular-proprioceptive stimulation: Each of the studies cited above used a form of handling as one of the forms of stimulation, but only Birns, et. al., (1966) used a form of rocking. There are a number of studies that used this vestibular-proprioceptive effect provided by rocking as the key independent variable in their research.

In an attempt to determine the effect of rocking on a newborn premature infant, Freedman, Boverman, & Freedman (1966) studied five sets of twins. These investigators rocked one of each twin pair for 30 minutes twice each day for 7-10 days. They found that the rocked twins gained weight at a greater rate per day than did the control twins. The next year (1967), Neal completed a two year study in which she provided vestibular stimulation to premature infants. Thirty-one

premature infants between 28-32 weeks gestational age were provided

vestibular-proprioceptive stimulation in the form of a hammock hung

inside the isolette. This experimental apparatus provided body

stimulation for these infants. When she compared these 31 experimental

infants with 31 control infants, she found that they had gained

significantly more weight and had better general maturation scores on

the Graham Test.

These studies stimulated further research related to the effects

of rocking and movement stimulation on the prematurely born infant.

During the 1970's two researchers have been involved in ongoing

research in this area.

The research interests of Korner began in the 1960's and early

1970's with interests in individual differences in noenates (1964,

1969, 1971, 1973), visual alertness in neonates (Korner and Grobstein,

1966, Korner 1970; Gregg Hoffner and Korner, 1976), and the effects of

vestibular-proprioceptive stimulation on the infant (Gregg, Haffner

and Korner, 1976; Korner and Thoman, 1972). More recently, Korner

has developed a waterbed for use within the incubator to provide

vestibular-proprioceptive stimulation that is similar to that ex-

perienced by the fetus in utero. This vestibular-proprioceptive

stimulation was intended to compensate for the stimulus deprivation

which Korner believed that the premature infant experiences in a

special care nursery. Korner (1979) discussed some of the factors

that may be hampering the normal unfolding of the neurological de-

velopment of the prematurely born infant who must grow to term in a

special care setting. The infant is forced to perform physical

functions for which it is not adequately prepared--breathing, food

intake and digestion, temperature regulation, and the impact of

gravity. A preterm infant has been unnaturally deprived of the

physiologic and motor biorhythms of the mother. A preterm infant has

been deprived of those auditory, tactile, and vestibular-proprioceptive

forms of sensory stimulation that it would have normally received in

utero. At birth, the infant is placed in a highly artificial

environment where the newborn is expected to grow. Instead of the

auditory and movement stimulation rhythmically provided in utero,

the preterm infant must endure the bright lights, white noise,

sensory bombardment from the medical staff, and sensory emptiness of

a stark isolette. Korner concluded, "While nothing is known at this

time about how preterm infants deal with either sensory deprivation

or sensory overload, we know from studies with older individuals that

both under- and over-stimulation have a disruptive and disorganizing

effect on the physiological and psychological functioning of the

organism." She expressed hope that the waterbed might "lighten the

prematurely born infant's burdens and thereby, perhaps, facilitate a

more even development." (Korner, 1979)

Korner's initial research with the waterbed was a pilot study

(Korner et. al. 1975) to assure the safety of the waterbed as an

experimental procedure with premature infants. She found that water-

bed flotation was a safe procedure with no significant negative effects

on the infants' vital signs, weight, or frequency of emesis. Korner

used two types of waterbeds in this study. The basic waterbed was

filled to a consistency so that it provided slight containment for

the infant and was highly responsive to the infants' own movements. The second type of waterbed was like the first, but in addition, it provided slight head to foot oscillations at a rate of 16 ± 4 oscillations per minute. Korner said, "This study was designed to assess the clinical response of premature infants to compensatory vestibular-proprioceptive stimulation similar in kind to that prevailing in utero." (p. 361) The most significant finding reported in this pilot study was that those infants who had been placed on the gently oscillating waterbed had significantly fewer apneic spells than did the control infants. The waterbed was also found to be clinically useful for very small prematures with severe skin problems and for infants recovering from abdominal surgery. In a later instrumentation of the waterbed, Korner reported a highly significant reduction in the number of apneic spells in a study which included a larger sample of subjects (Korner, 1978).

Korner (1979) is presently beginning a developmental study with premature infants who have had major medical complications. Her research team is investigating whether the rhythm of the waterbed oscillations given in a temporal pattern similar to the maternal rhythm of rest and activity will have a more organizing effect on the infant's sleep organization and motor behavior than does the present arbitrary rhythm of her past research which involved a constant and equal amount of stimulation. To accomplish this investigation the research team is superimposing 20-40 minutes of oscillation each 90 minute cycle to simulate the mother's biological rhythms of rest and activity.

While Korner was doing her research at Stanford University, Barnard was providing rocking stimulation for infants at the University of Washington. She theorized that infants born prior to 34 weeks gestation are not able to organize and integrate behaviors, particularly sleep-wake behaviors, because of the immaturity of the central nervous system. Barnard claimed that in utero the mother's patterns of activity, inactivity, and sleep provide a source of stimulation for the infant that superimposes patterns of activity and inactivity on the developing central nervous system of the infant. If an infant is born prematurely and is placed in an incubator, it receives unnatural stimulation from the incubator sounds, nursery lights, temperature and humidity, as well as irregular intrusion from the medical staff. For the premature neonate, the incubator environment is in sharp contrast to the intrauterine life where nature provided environmental controls such as oxygen, food intake, gastro-intestinal digestion and temperature control which the infant could not provide from within himself. Although Barnard does not speculate as to how this unnatural extra-uterine environment influences the immature infant, she has found that premature infants of 33-35 weeks gestation who have had a planned program of regular recurring stimulation via rocking and heartbeat sounds did develop more quiet sleep during the immediate neonatal period and had better weight gain compared to a control group. These stimuli were given on a schedule of 15 minutes every hour to coincide with the usual duration of quiet sleep and to coincide with the length of the active-quiet-active cycle of the term infant. Results of an 18 month follow-up of this study (Barnard, 1976) revealed lasting effects

from such a stimulation program. At age 18 months, the experimental

infants showed more positive motor and mental scores on the Bayley

and better language development than did the control group. In a

current study, Barnard (1977) is testing two temporal patterns of

stimulation in order to seek support for her theory related to the

organization and integration of behavior in the premature infant. The

first temporal pattern that she is using in this current research is

an exact replication of the study cited above. This temporal pattern

provides an external control from which the infant may develop

patterned cycles of sleep and wake states. The second temporal

pattern is based on Barnard's observation that premature infants can

and do go into periods of quiet sleep, but that the neurological

organization is not developed adequately to maintain this state for

an appropriate length of time. Therefore, in this second temporal

pattern the stimulation procedure is activated by biofeedback

equipment monitoring the infant's own neurological state organization.

When the infant becomes quiet for 90 seconds, (Barnard's criteria for

quiet sleep) the mechanical system of stimulation is activated. Such

immediate provision of soothing stimuli is designed to prevent arousal

from the quiet sleep state. Barnard's stimulation consists of a

rocking bed and heartbeat sounds. She hypothesized that such

stimulation provides a necessary aid for state control at a time when

the infant is sufficiently neurologically organized from within to

begin quiet sleep, but not neurologically mature enough to maintain

it.

Kramer & Pierpont (1976), by combining aspects of both the

research of Korner and Barnard, have attempted to simulate the intra-
uterine environment by providing waterbed and auditory stimulation to
eleven premature infants and by comparing their development with nine
control infants. The experimental infants received a special program
of vestibular, auditory and proprioceptive stimulation beginning 2
through 7 days after birth and lasting for the duration of their stay
in the incubator. Each infant was placed on a waterbed and the water-
bed was rocked one hour prior to each feeding. An auditory tape of
simulated heartbeat sounds and a woman's voice was played while the bed
was rocking. The results of this study indicated that infants re-
ceiving the stimulation program showed significantly greater gains in
weight (211± 30 gm/wk for experimentals and 165± gm/wk for controls),
head circumference and biparietal head diameter than did the control
group. The anterior-posterior head diameters were not significantly
different. Kramer and Pierpont concluded from these statistically
significant differences that "as a result the premature infants
raised on the waterbed developed larger, more rounded heads." (p.
299) Although the head growth measure comparisons reached statistical
significance the actual differences between groups were very small --
0.26 cm/wk in head circumference and 0.11 cm/wk in biparietal head
diameter. It is questionable whether these small differences are
realistically interpretable.

Conclusion

It is only within the past ten years that the study of the
human infant has become a scientific endeavor in its own right
(Haith and Compos, 1977). And within this field of study there has

developed a very specialized area: the study of the infant born at risk.
Medical advances have provided the technology to enable the prematurely
born infant to survive. Increased efforts are now being made not only
to keep these infants alive, but also to provide an environment that
will enhance the developmental outcome of these infants. Past research
indicated that the long-term prognosis for the prematurely born infant
was not very favorable. But more recent research has provided
evidence for a more optimistic outlook for these infants at risk, and
has offered suggestions for changes that may effect the prognosis and
outcome. A large number of investigators cited in this chapter have
indicated that the infant born prematurely has not received the full
40 weeks of stimulation in the uterus which a term infant receives,
and that this lost uterine time has deprived the growing infant of
certain types of stimulation which may be necessary for an integrated
development. Based on the assumption that extrauterine stimulation
may better substitute for intrauterine stimulation the closer these
are in kind, many researchers have attempted to devise approximations
of intrauterine stimulation. The results of studies which have pro-
vided supplementary auditory, vestibular-proprioceptive, tactile and
kinesthetic stimulation have been encouraging. Yet these studies have
been conceived on the basis of conjecture or hunch. Effective in-
strumentation for providing appropriate stimulation is still far from
advanced. There is yet no generally agreed upon theory of infant
stimulation and no proven means for providing the infant born-at-risk
with the stimulation necessary to encourage normal development. Even
those methods which have been tried during the past 10 years are so

limited in their methodology, the size of their groups, the definition of their populations, and are so speculative in their results, that they merely suggest areas for further exploration. There have been no adequate operational definitions of basic variables such as gestational age, low-birth-weight, fetal growth patterns (Brandt, 1978) and state categories, and therefore the results reflected in the available research are difficult to compare.

Yet we must appreciate the volume of research that has been reported during the last ten years which has so vastly increased our knowledge of the period of infancy. It has made us aware of the competence of infants (Stone, Smith & Murphy, 1973) and their responsiveness to their environmental context and surroundings. It remains for us to isolate the most adequate stimuli and the most potent variables that may enrich their environment and enhance their development. This is especially important in the case of infants who are born abnormally early, with abnormally low birth weights, or with medical conditions that threaten their survival.

CHAPTER III

METHODOLOGICAL CONSIDERATIONS

Kessen, Williams and Williams reviewed the state of neonatal research in 1961 and discussed the response measures that were at that time used to study the human infant. They noted that there had emerged three ways of measuring behavior in a neonate: 1) neonatal reflexology, 2) general activity and 3) neonatal behavior seen as part of a developmental process toward adult functioning. The authors went on to suggest that the developmental approach has led to the specification of three general theories of newborn behavior: 1) Freud's theory of personality development, 2) Gesell's theory of maturation and 3) Piaget's theory of the growth of intelligence. Gesell's line of studies on normative development appears to have had the widest research impact in the area of neonatology. In their 1961 article, Kessen et. al. concluded that "...the lack of obvious and commonsense continuities between neonatal and later behavior requires that the selection of response-classes (independent variables) be directed in the first instance by hunch or preconception or theory...and those response-classes which are shown to be reliable, stable, and systematically related to other events will survive as useful parts of a system of newborn behavior." (p. 10-11). As characterized by Kessen, Williams and Williams, the field of developmental neonatology in 1961 was in the preconceptual, hunch stage, and the study of the prematurely born infant was even further behind.

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Many advances have taken place since this 1961 statement about the state of the field of neonatal research. A wide variety of independent variables have been tested to determine the effects of stimulation on the newborn infant, and theoretical considerations have been hypothesized about their merits. But another problem faces the researcher interested in infant development. It is difficult to reliably determine the effects of carefully designed stimulation procedures. The measure of the effect of stimulation on neonates is severely limited by the parsity of behaviors available to the neonate. When the newborn is also prematurely born this evaluation is even more difficult. The medical staff use physical growth measures as their central evaluation tool. Developmental psychologists look at a broader range of dependent variables to assess the effects of interventions on the infant. Two methods that are being used extensively today are: 1) state organization and development and 2) behavioral assessment. These two dependent variables will be discussed at length.

State organization: One way of evaluating the development of premature infant is to study the changes in the state patterns and state organization. The state patterns of an infant relate to the infant's level of functioning at any given moment, varying from a state of quiet sleep, through varying levels of alertness, to fussing and crying. The importance of the investigation of newborn state organization lies primarily in the relationship between the infant's state patterns and the development of alertness. Early patterns of development are often the precursors and determinants of more mature levels of functioning. It is assumed that the type of state organi-

zation observed in the newborn will to some extent determine and
regulate the developing infant's responsiveness to environmental
stimulation. Ultimately the specific pattern of state organization
may leave its mark on the developing personality of the older child.
(Berg & Berg, 1979)

State may be assessed physiologically by using an electro-
encephalogram (EEG) to measure the biorhythms of the individual, an
electro-oculogram to measure rapid eye movements (REMs), electro-
myogram (EMG) to measure muscle tone, electrocardiogram (EKG) to measure
heart rate, and respiratory pattern. State may also be assessed
behaviorally by careful visual observations of the infant's level of
arousal which are recorded with time sampling methods. (Thoman, 1975)

Although the sleep states in adults have been rather well
classified into five stages, one stage of REM and four stages of
nonREM (Williams, Holloway & Griffiths, 1973), the sleep states of the
infant are not so clearly defined. Yet, the majority of an infant's
time in the first months is spent in varying stages of sleep. The
available literature on state development in infants offers a confusing
picture because researchers have used different names for the states
they observe, different numbers of states, and different criteria for
defining the states they do identify. Berg and Berg (1979) suggest
that this lack of agreement can be partly attributed to the instability
of behavioral organization during early infancy. It is not until well
into the first year of life that the human infant develops a well-
organized pattern of activity. It is generally agreed, however, that
the term newborn has at least three distinct states of activity:

wakefulness, active sleep and quiet sleep (Berg & Berg, 1979).

A number of researchers have also recently begun to investigate the state organization of the pre-term infant. During the last 12 years Dreyfus-Brisac has studied infants born as early as 24 weeks gestational age on up through the first year of life. At the earliest ages 24-27 weeks, there appears to be only one state and it cannot be identified as either sleep or wakefulness. The eyes remain closed almost all the time, but there is little or no REM. Arm and leg movements are almost continuous, with only brief moments of total body quiet. Respiration is very irregular and uncorrelated with body activity or heartrate. Heartrate, in contrast, is very regular and unchanging. By 28-30 weeks the eye movements become more frequent and by 32 weeks two distinctive EEG patterns become recognizable (Dreyfus-Brisac, 1967). Then between 32 and 40 weeks there gradually develops a defined relationship between the different types of biophysical measures and two distinct sleep states can be defined: 1) quiet sleep and 2) active sleep (Dreyfus-Brisac, 1970).

Because the EEG used to monitor adult sleep states is so inadequate for premature and young infants, multiple measures have been used to establish the sleep states of premature infants. Parmelee, Waldemar, Wenner, Schultz & Stern (1967) used a combination of six biophysical measures: EEG, chin EMG, body EMG, eye movements, respiration, and heartrate. He used the following criteria to analyze the data obtained from these measures:

> Active Sleep: Periods of sleep when any four of the following characteristics were present:
> 1. rapid eye movements
> 2. irregular respirations

3. irregular heart rate
4. frequent small movements
5. absence of chin EMG
6. continuous, low amplitude EEG

Quiet Sleep: Periods of sleep when any four of the following were present:
1. no body movements
2. no eye movements
3. regular respiration
4. regular heart rate
5. some chin EMG activity
6. EEG "trace alternant"

Transitional Sleep: Periods that did not fit either of the above categories.

Parmelee concluded from this type of analysis that the earlier the gestational age the more time the infant spent in active sleep. However, it must also be said that the earlier the gestational age the more difficult it was for him to clearly define the state of sleep as either active sleep or quiet sleep. As the premature infant developed from 29 to 40 weeks (term) gestational age the amount of active sleep decreased and the amount of quiet sleep increased and the transitional or undefined periods diminished. According to this research, the amount of Quiet Sleep gradually increased from 10 percent at 31-32 weeks gestational age to roughly 50 percent at 3 months past term. Active Sleep decreased with maturation from 68 percent of the total sleep at 33-34 weeks gestational age and diminished to 36 percent at 3 months. Parmelee concluded from this study that "The ill-defined nature of the Active Sleep state in the early gestational ages and its subsequent delineation and diminuation in amount amplify previous characterizations of this state as a neurophysiologically primitive

state and predecessor of the later stage during which dreaming occurs."
(p. 74) In other words, the primitive active sleep state of the pre-
mature infant is the predecessor of the active REM sleep state of the
older infant and adult. Parmelee concluded further that "Nevertheless,
the figures for premature infants at term and 3 months were similar to
those for full-term infants at the same ages."

Dreyfus-Brisca and Parmelee both have used psychophysiological
measures to determine the behavioral responses of the infants. Thoman
(1975, 1976) on the other hand, has used only visual observations to
describe the sleep and wake behaviors of infants. She used the cate-
gories as defined by Anders, Emde & Parmelee (1971) to define specific
categories for assessing behavioral state organization of term infants.
She did, however, alter these categories by subdividing some of their
sleep categories because she found that the broad category of active
sleep was inconsistent across babies, while subcategories of active
sleep proved to be consistent (Thoman, 1975). Thoman's method of
collecting state data consisted of a non-intrusive procedure of visually
observing the infant and recording the infant's state every 10 seconds
according to her 11 state criteria.

Thoman's method of observing the state development seems to
have several advantages when applied to the young premature infant:
1) This method is more appropriate for the young premature infant whose
physical responsivity is not well enough organized to fit into the
categories derived from biophysical measures. Dreyfus-Brisac (Berg
& Berg, 1979) has reported that the very young (24-30 weeks gestation)
infant's pattern of activity is deviant from that of older premature

and term infants. Eye movements are absent or infrequent; heartrate is fixed and unvarying; respiration is irregular and unrelated to body activity; and spontaneous skin potential responses are infrequent and unrelated to other events. 2) This method of observation allows for describing the infant's total repertoire of sleep and wake states which gives a more complete description of the infant's total state development. 3) This type of observation is the least intrusive method of collecting data in the midst of a medical setting that needs immediate and regular accessibility to the fragile premature infant.

There are, however, problems inherant in this method of collecting data on the state organization of infants. The basic criteria outlined for defining each state category is different for the researcher using behavioral observations than it is for the researcher using psychophysiological measures. Therefore, results from the two methods cannot be compared. This is especially true when the state organization of preterm infants is being evaluated, because their level of organization is too immature to fit into the neat packages defined by the psychophysiological researchers for older infants. The behavioral observation method can more concretely define criteria for a wider range of state variations that occur in the rapidly developing premature infant. This method can therefore, observe the changing patterns that occur as neurological maturation takes place within the young premature. This method is therefore, best suited for research with the preterm infant.

Brazelton Neonatal Behavioral Assessment Scale (BNBAS): The BNBAS is another tool that can be used to assess the level of

organization of the infant. As in the state observations of Thoman, behavioral observations are used to evaluate the elicited state control reflective of the infant's neurological organization. The BNBAS was designed to evaluate the term newborn infant.

In this assessment scale, Brazelton has made use of aspects of the neurological examinations of Prechtl (Prechtl & Beintema, 1964) and Parmelee (1973), the qualitative and quantitative behavioral responsiveness of the Graham-Rosenblith Scale (Rosenblith, 1961), the capacity of the neonate to habituate (Bridger, 1961) and the recognition of individual differences in temperament (Thomas, Chess, & Birch, 1963). In order to assess all of these areas within a short time frame, the assessment procedure has been designed to bring the infant up from a state of quiet sleep to an active state of wakefulness, to crying and then to alert inactivity. Brazelton believes that state control gives the infant the ability to shut out stimuli and therefore inhibit responses. It is also the infant's way of setting the stage for actively responding. Since an infant's behavioral responses are influenced by state of consciousness, and since these responses are thereby only meaningful within each state, the most important use of the exam is to bring the baby through his or her repertoire of states (Brazelton, 1978). In the process of doing this the following areas are assessed:

1). Neurological Intactness (by examining 20 elicited responses modeled after Prechtl's exam).

2.) Global Behavioral Dimensions (by examining the infant's social attractiveness and the infant's use of and need

for stimulation to organize his responses.)

3). Global Description and Interaction Repertoire (by examining 27 behavioral items.) These items can be grouped into four behavioral dimensions of newborn organization: a) Interactive capacities, b) Motor capacities, c) State control organization, d) Physiological responses to stress.

The BNBAS is designed to elicit the best performance on each item, often without regard for the number of trials it may take for the examiner to elicit this response. Brazelton (1978) explained that his scoring system was designed in this fashion so that examiners with different degrees of sensitivity to the responsivity of newborn infants would all obtain each infant's best performance on the scale. In the competition for highest scores on the BNBAS, some infants consistently do better than other infants. Theoretically these individual differences in best performance are a reflection of the level of competence of an infant at a particular moment in development.

The BNBAS was standardized on a group of white, full term, 7+ pound infants whose APGAR scores were at least 7 at one minute and 8+ at 5 and 15 minutes, and who required no special neonatal care. Intra-rater reliability has ranged from .85-1.0 and test re-test reliability has ranged from .6-.8. Horowitz, Sulliman and Linn (1978) have recently attempted to evaluate the test-retest reliability of the BNBAS. They took data from two previous studies that had investigated the effects of obstetrical medication on the infant (Aleksandrowezc, 1973; Horowitz, Ashton, Culp, Goddis, Levin & Reichmann, 1977). Each

of these studies had given the Brazelton Scale during the first four days after birth and again at one month. One study was completed in Kansas, the other in Israel. The test protocols were analyzed for every combination of test-retest days available (e.g. day 1 with day 2; day 4 with 1 mo.). The results showed mean reliabilities of .40 to .57 for the Kansas group and means of .56 to .69 for the Israeli group.

Sameroff (1978) claims that the BNBAS does not have enough day-to-day stability in order to be considered a reliable instrument. He also is very pesismistic about the long-term predictability of the scale. Horowitz, Sullivan & Linn (1978) went one step beyond this and said that "prediction is not only not possible, it is not a valid criterion for judging the utility of neonatal assessment." (p. 36) Horowitz argues that the influence of environmental factors on developmental outcome is so great that one cannot expect long-term prediction.

The BNBAS is a difficult test to analyze statistically because the items are not all on equal interval scales from poor to excellent and because the items are not all independent. Both univariate and multivariate parametric statistics have been used, including separate comparisons of the items, comparison of subscales and summary scales and factor analysis. More recently a priori cluster scores (Als, 1978; Lester, 1978) have been developed as an effective way of organizing these scores.

A rather complete annotated bibliography of the published research investigations that have used the BNBAS as a dependent variable to compare groups of infants is available (Sostek, 1978). At the present time the BNBAS is the most frequently chosen assessment

tool used to determine treatment effects in infant research. Thus, despite its shortcomings in terms of validity and reliability, it is considered by the majority of infant examiners to be the best infant assessment instrument available today. It is able to most accurately and most comprehensively assess the organizational processes of the newborn infant.

The repertoire of behaviors available to the newborn infant is very limited. Because of this, it is difficult to assess the effects of intervention procedures with the neonate. Physical growth measures can be used. But these do not tap the neurological development that is reflected in state organization and behavioral control. Direct observation of state control as expressed in the sleep and wake patterns of the infant have been shown to be a valuable way to assess the passive state organization of the infant. The BNBAS was designed to observe the state organization of the newborn when stimulation is provided to elicit organizational responses from the infant. When these two assessment procedures are used in combination they can provide a total repertoire of the infant's passive and elicited state organization during both sleep and wakefulness. And thus neurological maturation can be evaluated.

The Present Study

The present study has been designed to provide evidence that adequate stimulation may be easily provided for infants in nursery isolettes, and that such stimulation is beneficial to the high risk infant. The basic background for this study lies in the literature on stimulation as reviewed in Chapter II. As was noted in Chapter II,

the most recent and the most relevant influence for this investigation came from the research of Korner (1979), who hypothesized that prematurely born infants have been deprived of a period of necessary intrauterine stimulation. Based on this assumption, Korner has hypothesized that intervention in the form of rhythmic movement which closely simulated the intrauterine environment would compensate for the lack of intrauterine stimulation. Another view about the effects of infant stimulation that has been a major influence in the design of the present study was that of Barnard (1977). According to Barnard, rhythmic intrauterine stimulation enhances, in a yet undetermined fashion, neurological maturation in the developing fetus. And this enhancement aids the development of state behavior organization. It has, however, been recognized that the birth process does produce many changes in the way the infant organism functions. Scarr-Salapatek & Williams (1973) explained it this way:

> If these infants were still in utero, they would not be exposed to visual stimuli but would experience other forms of stimulation. A proper consideration, however, in comparing experiences in the third trimester fetuses and extrauterine premature infants is the different functioning of the two organisms. At birth it seems likely that sensory systems change in their organization and functioning just as respiratory and digestive systems alter their modes of operation (p. 95).

So, it cannot be said with certainty that creating stimulation procedures specifically to duplicate the intratuerine environment is the most appropriate stimulation program. However, it does seem reasonable to glean from the intratuerine setting the notion that an environment which includes rhythmic stimulation would be valuable for the infant. Research has given support to this conclusion.

The present research, then, was based on the assumption that

infants born prematurely are in need of a specific type of stimulation
in order to compensate for the period of intrauterine stimulation which
they have missed. The traditional isolette in the special care nursery
does not provide such compensatory stimulation. Therefore, the present
investigation offered a method to provide the needed stimulation, and
it also offered a way of evaluating the effects of such a program of
stimulation. The assessment of effectiveness focused on an evaluation
of the development of the central nervous system as reflected by state
organization through the observation of sleep-wake cycles, the overall
development of the organism as reflected in physical growth parameters,
and developmental progress as measured by the BNBAS.

Since one focus of this study was to use the intrauterine
environment as a source of suggestions for extrauterine stimulation,
rhythmic movements within a firm but cushioned surface and rhythmic
sounds were chosen as the basic stimulation procedures. The oscillating
waterbed used by Kramer (1976) and Korner (1979) was chosen to provide
a regulated system of vestibular-proprioceptive stimulation that in
many ways was similar to the gentle rocking that had been provided by
the rhythmic breathing of the mother. For auditory stimulation the
present study made use of intrauterine body sounds recorded from inside
a pregnant woman. A recording of these sounds played continuously
throughout the period the infant was on the waterbed.

The subjects in this study were preterm infants who had been born
at an early gestational age (28-32 weeks). Each subject participated
in the study for four weeks. Both the age of the subjects and the
length of their participation in the study offered new dimensions to

this field of research. In the research literature no use has been
made of infants born so early, with such a long duration of intervention.
Barnard's (1977) program of stimulation included infants of 33-34 weeks
gestation at the time they received the two weeks of stimulation. The
mean age of the infants used in Kramer's (1976) study was 32 weeks, but
some of the infants were as old as 34 weeks gestation at birth. The
length of infant participation in his experimental procedure was defined
by Kramer as follows: "The stimulated group received a special program
beginning two through seven days after birth and lasting for the
duration of stay in the incubator." (p. 297) Such a definition would
leave a great deal of variability in the Special Care Nursery at
Prentice where some infants are ready for open crib care by the time
they have reached 35 weeks gestational age.

A major difference between the present study and the investiga-
tions of Kramer and Barnard was the cumulative amount of stimulation
given. In both the Kramer and Barnard studies the rocking movement and
rhythmic sounds were turned on only periodically throughout the experi-
ment. Kramer's infants received one hour of rocking before each feeding,
and Barnard's infants received 15 minutes of rocking each hour. In the
present study, in order to more closely approximate intrauterine
stimulation for these young prematures, the movement and sounds were
provided 24 hours a day for the entire four weeks.

In order to measure the effect of this stimulation, regularly
scheduled state observations were made according to the categories and
procedures developed by Thoman (1975). This is the least intrusive
observational method of studying the development of state organization.

It is also the most comprehensive procedure available for premature infants whose state development is so non-specific and changing. Physical growth measures were collected on a regular basis. The BNBAS was administered just prior to discharge from the Special Care Nursery. Statistical comparisons were made for all the data collected to test the following hypotheses:

1. Weight gain will be significantly greater for the experimental group than for the control group at the end of the experimental procedure.

2. There will be a significantly greater difference between the pre- and post measures on head circumference for the experimental group than for the control group.

3. There will be a significantly greater difference between the pre- and post measures on biparietal head diameter for the experimental group than for the control group.

4. The experimental group will achieve significantly higher scores than the control group on the a priori cluster scores of the Brazelton Neonatal Behavioral Assessment Scale.

5. There will be a significant difference in the percent of time spent in each of the eight state categories between the experimental and control groups during the four weeks of the experimental procedure and at time of discharge.

CHAPTER IV

METHOD

Subjects

The subjects for this study were 25 premature infants selected

from the intensive care nursery, Northwestern University Medical Center,

Prentice Women's Hospital between February and October 1979. All the

infants were between 28-32 weeks gestational age as determined by the

Dubowitz method in combination with the mother's reported last menstrual

period. If there were discrepancies between these two methods, an

average was obtained. Infants excluded from the experiment were:

1)   those infants requiring mechanical ventilation

     beyond five days of life

2)   those infants born to drug addicted mothers

3)   those infants with major central nervous system,

     gastro-intestinal, or cardiac anomalies.

Infants requiring head hood oxygen were acceptable, as were infants

who were still on CPAP (continuous positive airway pressure) on day

5 but who were improving so that they were changed to headhood

oxygen within a few days. Infants were on varying types of feeding

procedures.

One infant in the control group was removed from the study

because she developed a seizure disorder during the third week of

data collection, and two 32 week infants, one from each group, were

removed because they gained weight so quickly that they were discharged before completion of the study.

Table 1 gives the gestational age breakdown for the experimental and control groups at birth. The two groups were very evenly matched on this factor, and over half of the infants in each group were in the two youngest age categories. Of the eleven subjects in each group, four were male and seven female in the experimental group, and five were male and six female in the control group. Table 2 gives a complete breakdown of subject characteristics for each infant in the study and Table 3 summarized these data for the experimental and the control groups. All of the infants either received nutrition by the parenteral route, that is, intraveneous hyperalimentation, or enteral feedings, that is, formula via gastric or nasojejunal tube. The nursery criteria for discharge included a weight of at least 2040 grams (4 lb. 8 oz.) and adequate nipple feeding at four hour intervals. Both groups of infants remained in the hospital almost equal amounts of time to achieve these requirements for discharge.

Table 4 shows the gestational age of each infant at the time of birth and time of Brazelton testing. Both groups were evenly distributed with the mean age being 36 weeks for each group. At the time of testing, each infant was in an open crib, nipple feeding on a 3 or 4 hour schedule and weighed approximately 2040 grams. No invasive procedures had been performed for at least 48 hours.

TABLE 1

SUBJECTS BY AGE AT BIRTH

Gestational Age	Number of Subjects	
	Experimental (N=11)	Control (N=11)
28	3	2
29	3	4
30	1	1
31	2	2
32	2	2
Total	11	11

TABLE 2

SUBJECT CHARACTERISTICS

SS #	Gestational Age	Male	Female	Wh	Bl	Sp	Days Hospitalization
			Experimental				
1	28		F	Wh			52
2	30		F		Bl		43
3	29	M			Bl		85
4	32	M				Sp	29
5	29	M		Wh			72
6	31		F			Sp	30
7	28		F		Bl		49
8	28		F	Wh			–
9	31	M		Wh			50
10	29		F	Wh			46
11	32		F	Wh			49
X = 29.7 SD = 1.6		Total 4	7	Total 6	3	2	X = 50.5 SD = 17.1
			Control				
1	28	M			Bl		41
2	29		F	Wh			53
3	31	M				Sp	30
4	29		F	Wh			53
5	30		F		Bl		61
6	29	M			Bl		–
7	32		F		Bl		62
8	28	M		Wh			57
9	31		F			Sp	34
10	29		F		Bl		73
11	32	M		Wh			26
X = 29.7 SD = 1.6		Total 5	6	Total 4	5	2	X = 49.0 SD = 15.5

TABLE 3

SUBJECT CHARACTERISTICS

Characteristics	Experimental	Control
Sex		
Males	4	5
Females	7	6
Race		
Black	3	5
White	6	4
Spanish	2	2
Initial Type of Feeding		
Parenteral	7	6
Enteral	4	5
Days of Hospitalization		
Mean	50.5	49.0
S.D.	17.1	15.5
Gestational Age		
Mean	29.7	29.8
S.D.	1.6	1.5

TABLE 4

GESTATIONAL AGE IN WEEKS AT BRAZELTON TESTING

Weeks at Testing

Weeks at Birth	34	35	36	37	38	39
28	1E* 1C*	1E	1C	1E		
29	1C	2E	2C		1E 1C	
30			1E		1C	
31		1C	1E 1C		1E	
32			1C	1E		1E 1C
Total	1E 2C	3E 1C	2E 5C	2E	2E 1C	1E 1C

Mean GA for Experimentals = 36.3
Mean GA for Controls   = 36.2

*E = Experimental   C = Control

<u>Procedure:</u>

All new babies entering the Intensive Care Nursery at Northwestern University's Prentice Hospital were evaluated for appropriateness for the study. Every infant that fulfilled the subjects criteria during the 9 months of study was included in the research. As soon as a selection was made, parental permission for use of the infant in the study was obtained (Appendix A). After parental permission was obtained, the infant was randomly assigned to either the experimental or the control group, and the experimental apparatus was arranged in the isolette of each experimental infant. A Classics Products waterbed filled with 22 pounds of water was placed under the infant, replacing the isolette mattress. The water was 2 degrees warmer than the isolette temperature and a one-half inch thick piece of foam was placed over the waterbed to prevent conductive heat loss from the infant. A test lung connected to a mechanical ventilator was placed under the waterbed. Inflation pressure of 20-30 centimeters of water was used with a rate of 16± inflations per minute. A 2¼ inch speaker was placed in a plastic case and connected to a Panasonic tape recorder. A continuous loop cassette played a recording of the intra-uterine sounds of a pregnant woman as recorded by Murooko (Capital Records, 1974). The experimental infants remained in this environment for four weeks. The control infants remained in their isolettes for the duration of the study. All 22 infants received routine medical and nursing care.

The following data were collected from each infant in the experiment:

1) Daily weight was recorded by the Special Care Nursery staff.

2) Weekly length, head circumference, biparietal and anterior-posterior diameter of the head were obtained by one neonatologist.

3) Weekly state organization observations of two hour durations were collected by the author during the four weeks of the experimental procedure and again at discharge. A specific criteria adapted from Thoman (1975) was used (Appendix B).

4) The Brazelton Neonatal Behavioral Assessment Scale was administered just prior to discharge from the nursery by one trained examiner who was blind to subject group assignment.

CHAPTER V

RESULTS

This chapter contains the results of all of the statistical

analyses performed in order to test each of the five hypotheses

stated at the beginning of this study. The first three hypotheses

referred to measures of physical growth. The fourth hypotheses

referred to developmental progress as measured by the Brazelton Scale

and the last hypothesis referred to the state organization as

measured by the percent of time spent in each of eight state

categories.

Means were calculated for the measures of weight, head

circumference and biparietal head diameter for the experimental and

control groups. Table 5 shows the group means and standard

deviations for these physical measures. Hypothesis 1 stated that

the experimental group would gain significantly more weight than the

control group during the four weeks of experimental procedure.

As Table 5 indicates, the mean weights for the two groups were very

similar at the beginning of the experiment (experimentals, 1240 gms.;

controls, 1201 gms.) and each group gained an average of nearly the

same amount of weight so that at the end of the study the two groups

were still very similar in physical weight (experimentals, 1604

gms.; controls 1601 gms.). Even the average amount of weight loss during

the first days of life was similar, so that the lowest average weight for

TABLE 5

Pre-Post Physical Measures

Physical Measure	Experimental (N=11)		Control (N=11)		t value*
	Mean	SD	Mean	SD	
Weight (gm)					
Birth weight	1240	193	1201	236	.24 (NS)
Lowest weight	1128	172	1105	231	
End of treatment	1604	238	1601	314	
Gain Score	364	118	400	123	.08 (NS)
Head Circumference (cm)	26.6	1.6	25.9	1.7	
Beginning of treatment	26.6	1.6	25.9	1.7	
End of treatment	19.4	1.6	28.7	2.0	
Gain Score	2.8	1.0	2.8	0.7	.00 (NS)
Biparietal Diameter (cm)					
Beginning of treatment	6.5	0.5	6.3	0.5	
End of treatment	7.2	0.5	6.8	0.5	
Gain Score	0.7	0.3	0.5	0.2	.07 (NS)

*t denoted for a 2 sample t-test for independent groups,
  df = 10, t_c = 1.81 for p $<$ .05

each group was almost the same (experimentals, 1128 gma.; controls 1105 gms.), the standard deviations were rather large in both groups with the control group having a larger range than the experimental group at all measurement points. A t-test analysis of the gain scores (t=.08, df=10, p>.05, t_c=1.81) did not give support to the first hypothesis. The experimental infants did not gain a significantly greater amount of weight than did the control infants.

Hypothesis 2 stated that there would be a significantly greater difference between the pre- and post measures of head circumference for the experimental group than for the control group. The mean head circumference for the experimental group was 26.6 cm. at the beginning of the study and 29.4 cm. at the end of the treatment. This was a gain of 2.8 cm. The control group began with a mean head circumference of 25.9 cm., and at the end of the treatment the mean head circumference was 28.7 cm. This was also a gain of 2.8 cm. The mean amount of gain in head circumference for the two groups was exactly the same. These results do not give support to the second hypothesis. The gain in head circumference was not greater for the experimental group than it was for the control group.

Hypothesis 3 stated that there would be a significantly greater difference between the pre- and post measures of biparietal head diameter. Results of these measurements indicated that the experimental group gained a mean of 0.7 cm. in biparietal head diameter growth during the four weeks of experimental treatment while the control infants gained 0.5 cm. When these gain scores were statistically analyzed, no significant differences were obtained (t=.07, df=10,

p>.05, t_c=1.81). However, these gain scores were very similar to those cited by Kramer and Pierpont (1976) who obtained significantly different weekly gains of .24 cm/week for their experimental group and .12 cm/week for their control group. They did have a smaller standard deviation than was obtained in the present study. This wider fluctuation in subjects in the present study had a negative effect on the statistical results obtained. So, although the gains in head biparietal diameter were similar to those obtained by Kramer and Pierpont, the gains did not reach statistical significance in the present study (t=.07, df=10, p>.05, t_c=1.81). These results did not give support to the third hypothesis. There was not a significant difference in gain in biparietal head diameter between the experimental and control groups.

No significant differences were found on any of the three growth parameters either at the beginning of the study or on the gain scores obtained at the end of the four weeks of experimental treatment. The two groups were in fact very homogeneous physically throughout the study.

In regard to the fourth hypothesis, the a priori clusters developed by Als (1979) were used to analyze the Brazelton Scale scores. In this analysis, the 27 behavioral scales and the 20 elicited items were grouped along the four functional dimensions listed in Table 6. By following specific rules for combining the subscale scores (Appendix C) each dimension ultimately received a score on a three point performance scale of 1=superior, 2=average and 3=worrisome. The Interactive Process dimension score was very low for both groups. This dimension included the orientation alertness, cuddliness and

TABLE 6

DIMENSIONS OF THE BRAZELTON EXAMINATION

Dimension[1]	Experimental (N=11) Mean	S.D.	Control (N-11) Mean	S.D.	$\underline{t}$ Value
INTERACTIVE PROCESS	2.72	.47	2.60	.52	0.54
MOTORIC PROCESS	2.09	.30	2.55	.52	2.50*
ORGANIZATIONAL PROCESS, STATE CONTROL	1.55	.52	2.00	.63	1.84*
ORGANIZATIONAL PROCESSES, PHYSIOLOGICAL RESPONSE TO STRESS	1.18	.60	1.45	.82	0.89

[1]Source: Als, (1978)

*t denoted for a 1 tailed t-test for independent groups, df=10
   $p < .05$, $t_c = 1.81$

consolability items. In the Motoric Process dimension, the experimental infants performed significantly better than did the control infants (6=2.50, df=10, p < .05, t_c=1.81). This dimension included all the reflex items, as well as pull-to-sit, motor maturity, defensive reaction, hand-to-mouth and activity items. Likewise, in the Organizational Processes (State Control) dimension the experimental group performed significantly better than did the control group (t=1.84, df=10, p < .05, t_c=1.81). This dimension included the habituation items, peak of excitement, rapidity of buildup, irritability, self-quieting and state lability items. In the Organizational Processes (Physiological Response to Stress) dimension the higher mean score for the experimental group was not significantly different from that obtained for the control. This dimension included the physiological response to stress items, tremor, skin color and startle.

Hypothesis 4 stated that there would be a significant difference between the experimental and control groups on the a priori cluster scores of the Brazelton Scale. This hypothesis was partially confirmed.   The Motoric Process and Organizational Processes (State Control) dimensions showed statistically significant differences between the two groups.

Hypothesis 5 stated that there would be significant differences in the percent of time spent in each of the eight state categories between the experimental and control groups during the four weeks of experimental treatment and at the time of discharge.

The percentage of time spent in each of eight state categories was calculated for each subject for each two hour observation period.

The mean percentage of time spent in each state during each weekly observation was then computed for the experimental and the control groups. The mean percentage of time spent in each of the eight categories, each week and at discharge for the experimental and control groups are shown in Figure 1. The percentage of time spent in quiet sleep and in REM sleep for the experimental group was consistently above that of the controls during the four weeks of experimental procedure. And the percentage of time spent in the drowsy and cognitive alert states were consistently below that of the controls during the four weeks of experimental procedure. However, at discharge, after the infants had been taken off the waterbeds and were ready for discharge, this relationship was reversed.

State organization observations were analyzed as an 8 x 2 x 2 factorial with repeated measures on the third factor (Winer, 1972). There were eight levels of state organization (Table 7), two levels of group (experimental and control) and two levels of time (week 1 and discharge). Table 8 gives a summary of the analysis of variance. There were two significant findings in this analysis: the significant main effect for factor C (state) and the significant BC (weeks x states) interaction.

. The main effect for factor C (states) was found to be statistically significant ($F = 295.20$, $df = 8/128$, $p < .001$, $F_c = 2.66$). Despite the highly significant difference obtained in the main effect between the various state categories, the finding is of dubious importance. An inspection of Table 9 makes it obvious that there was a great deal of difference in the mean percentage of time spent in
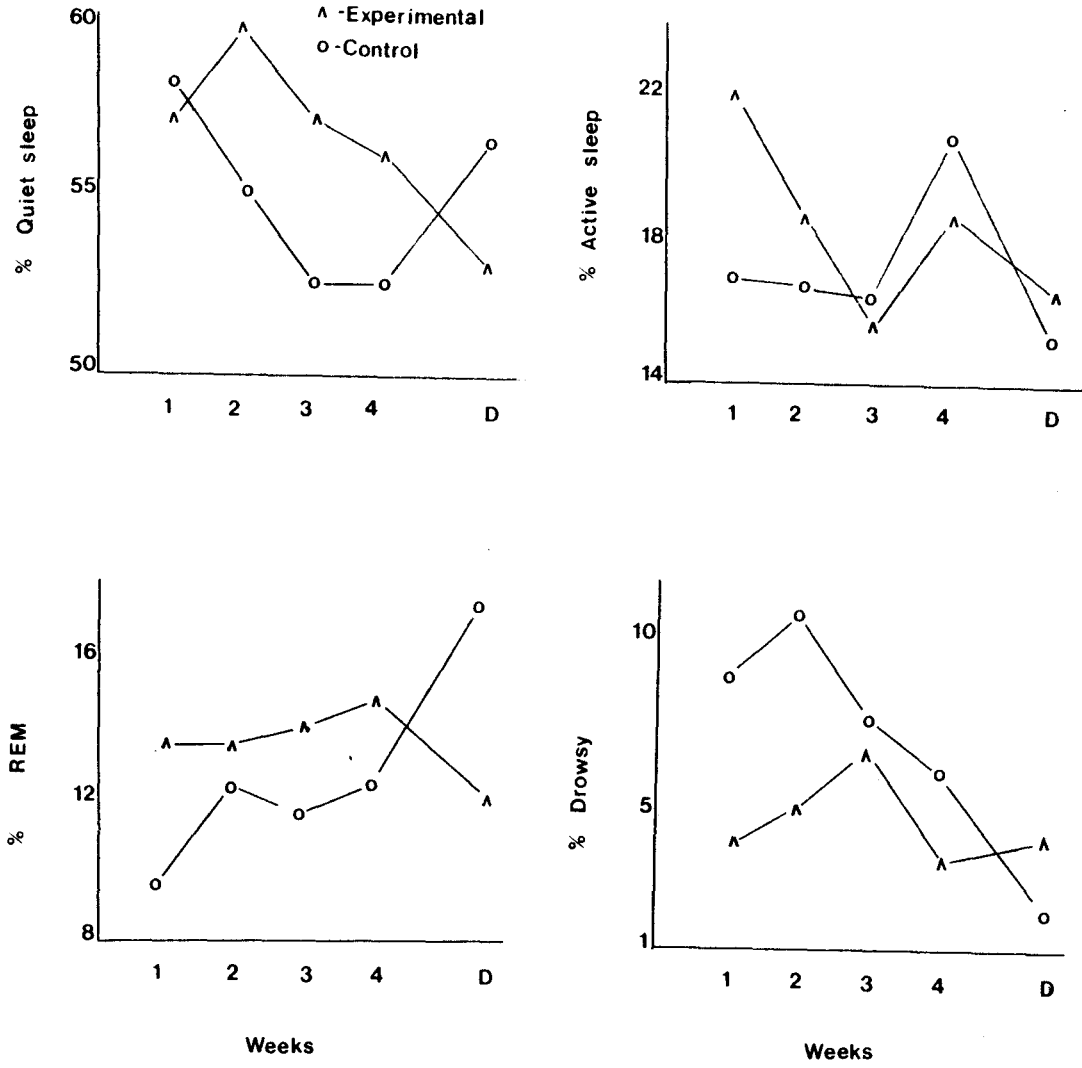
Figure 2.   Percent of time spent in each state by weeks.
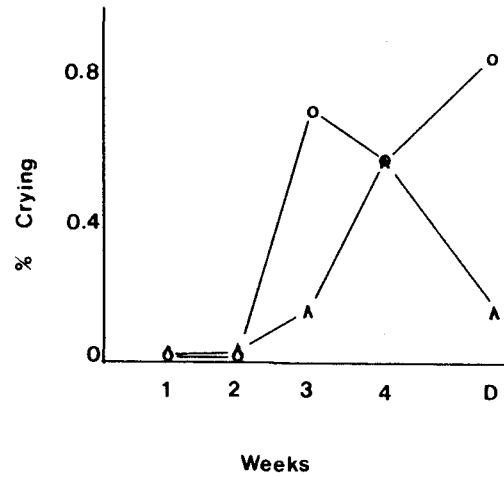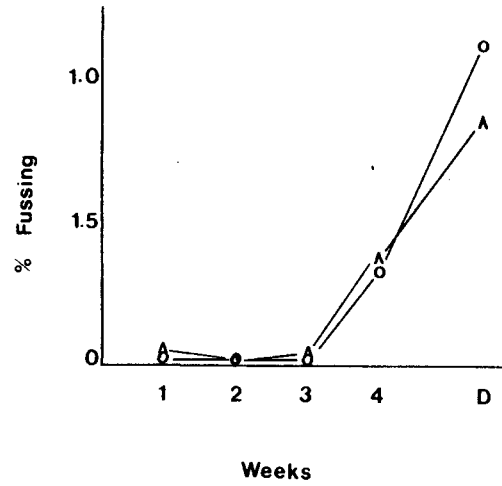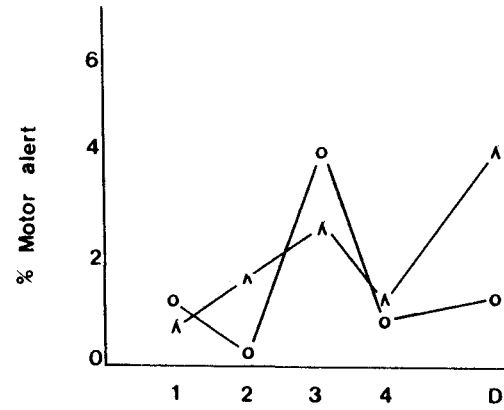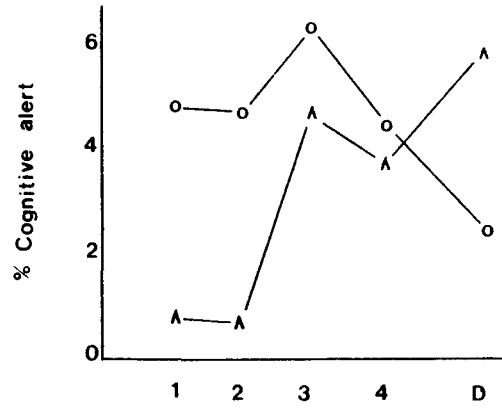
Figure 2 . (Cont.)

TABLE 7

STATE CATEGORIES

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1. Quiet sleep

2. Active sleep

3. REM sleep

4. Drowsy

5. Cognitive alert

6. Motoric alert

7. Fussing

8. Crying

TABLE 8

SUMMARY OF STATISTICAL ANALYSIS OF STATE DATA FOR

WEEK 1 AND DISCHARGE

Source of Variance	SS	df	MS	F
Between subjects	6.37	17		
A (groups)	.01	1	.01	.02
error (a)	6.37	16	.40	
Within subjects	99052.7	306		
B (weeks)	.19	1	.19	
AB (groups x weeks)	.02	1	.02	.57
B x subj. w. groups error (b)	5.41	16	.34	.05
C (states)	91144.95	8	11393.12	295.20*
AC (groups x states)	487.45	8	60.93	1.58
C x subj. w. groups error (c)	4940.30	128	38.60	
BC (weeks x states)	545.75	8	68.22	4.72*
ABC (groups x weeks) x states)	79.21	8	9.90	.69
BC x subj. w. groups error (BC)	1849.43	128	14.45	

*$p < .01$ df (8,128) $F_c = 2.66$

TABLE 9

MEAN % OF TIME SPENT IN EACH STATE AT THE END OF
WEEK 1 AND AT DISCHARGE

Groups (A)	Weeks (B)	State (C)							
		1	2	3	4	5	6	7	8
Experimental	Week 1	58.5	23.0	11.7	2.8	1.1	1.0	0	0
	Discharge	53.1	19.6	12.1	3.6	4.5	3.0	2.0	.1
Control	Week 1	56.7	18.4	7.3	9.5	4.9	1.4	0	0
	Discharge	52.1	21.2	15.5	2.7	2.5	1.3	1.5	.7

each of the eight states. For example, infants of both experimental and control groups remained in state 1 for more than 50% of the time, while all infants in both groups spent less than 1% of their time in state 8. This is not a new finding since it is a generally accepted fact that preterm infants spend a majority of their time sleeping.

There was a significant interaction between weeks (B) and states (C) for all subjects (F=4.72, df-(8,128), p <.01, F_c=266). The percent of time spent in each state depended upon whether the measurement was made at the beginning or end of the study. There were no significant differences between experimentals and controls as to percent of time spent in each state for week 1 and discharge when all eight state categories were used in the analysis. Table 9 shows the mean percent of time spent in each state at week 1 and discharge.

The percent of time in active sleep was analyzed as a 2 x 2 factorial with repeated measures on the second factor (Winer, 1972). There were 2 levels of group (experimental and control) and 2 levels of time (week 1 and discharge). The percent of time subjects spent in states 2 and 3 (REM sleep and Active sleep) were combined in order to obtain a pooled percent of active sleep time. Table 10 gives a summary of the analysis of variance of this pooled percent of time spent in active sleep. A significant interaction was obtained between groups (A) and weeks (B) in the percent of time spent in active sleep at week 1 and discharge (F = 4.53, df=(1,16), p <.05, F_c = 4.49). An inspection of Table 11 suggests that there may be a difference in the amount of time spent in active sleep between weeks 1 and discharge depended upon whether the subjects were experimental or control. Although statistical

TABLE 10

SUMMARY OF STATISTICAL ANALYSIS OF ACTIVE SLEEP DATA

FOR WEEKS BY GROUPS

Source of Variance	SS	df	MS	F
Between Subjects	3015.24	3		
A (groups)	49.71	1	49.71	.27
Subj. within Groups (error)	2965.53	16	185.35	
Within Subjects				
B (weeks)	120.64	1	120.64	1.15
AB (groups x weeks)	474.51	1	474.51	4.53*
B x Subj. within groups (error)	1675.05	16	104.69	

*$p < .05$ df (1,16) $F_c = 4.49$

TABLE 11

MEANS AND STANDARD DEVIATIONS FOR PERCENT OF TIME SPENT IN

ACTIVE SLEEP FOR EXPERIMENTAL AND CONTROL INFANTS AT

WEEKS 1 AND DISCHARGE

| | % of Time in Active Sleep | | | |
| | Week 1 | | Discharge | |
Group	Mean	SD	Mean	SD
Experimental	34.0	13.8	30.4	12.9
Control	24.4	9.8	35.3	11.1

significance was not obtained, experimental subjects decreased the amount of time spent in active sleep from week 1 to discharge (see Figure 2). .

The sleep data was also analyzed in terms of the difference between the two groups in the percent of sleep time spent in active sleep (state 2 $+$ state 3 / state 1 + state 2 + state 3). A 2 x 2 analysis of variance with repeated measures was performed with two levels of group (experimental and control) and two levels of time (Week 1 and discharge). Table 12 gives a summary of this analysis. No significant differences were obtained.

Hypothesis 5 stated that there would be a significant difference in the percent of time spent in each of the eight state categories between the experimental and control groups at each week and at discharge. Significant differences between the two groups were not obtained. However, a significant interaction effect was obtained between the percent of time spent in active sleep at week 1 and discharge for the two groups.

Because the experimental and control groups were not matched for sex and race, state organization data was analyzed using sex and race significantly affected the state organization findings. Results of students t-tests of the difference between the mean percentage of time spent in each state by males and females are shown in Table 13. Table 13 also included a similar analysis for white versus black infants. There were 9 males and 13 females in the study and 9 whites and 8 blacks in the study. No significant differences were found for either sex or race on any of the eight state categories.
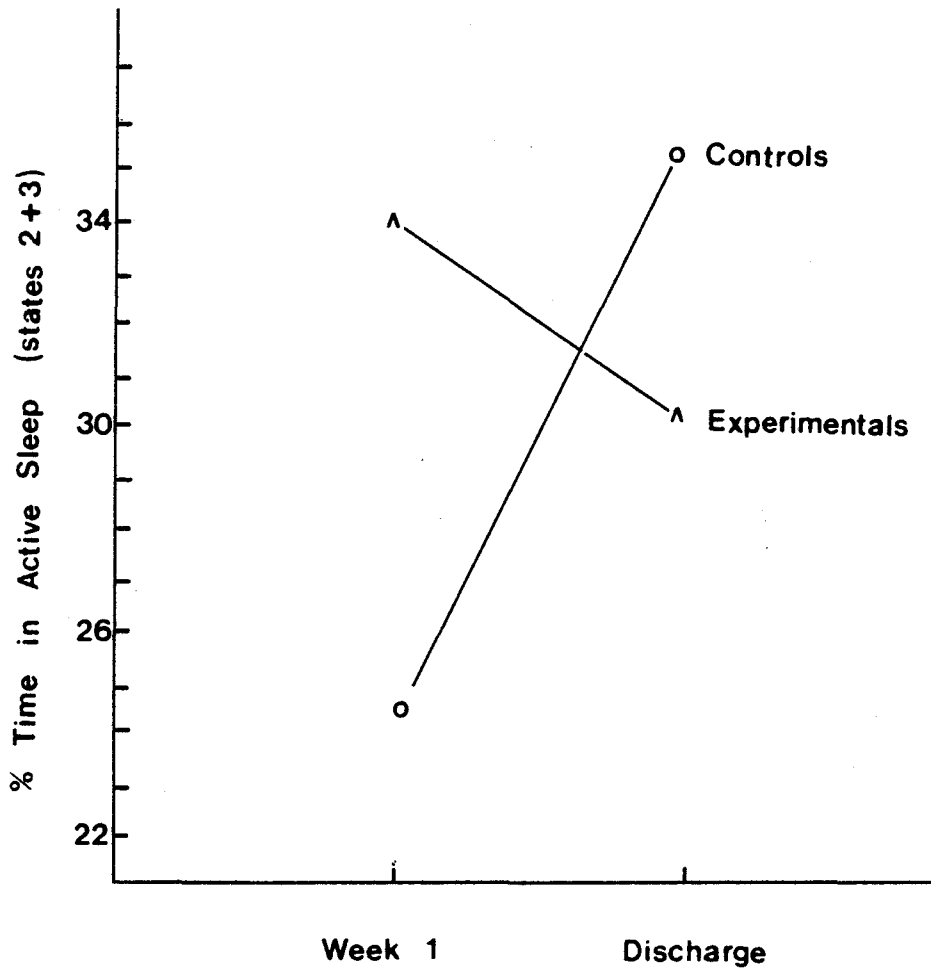
Figure 2. Interaction between groups and weeks for time spent in active sleep.

TABLE 12

SUMMARY OF STATISTICAL ANALYSIS OF % OF SLEEP SPENT IN ACTIVE SLEEP

FOR EXPERIMENTAL AND CONTROL INFANTS AT WEEK 1 AND DISCHARGE

Source of Variance	SS	dF	MS	M
Between Subjects	2476.97	3		
A (groups)	106.70	1	106.70	.72
Subj. within groups (error)	2370.19	16	148.14	
Within Subjects				
B (weeks)	3.10	1	3.10	.02
AB (groups x weeks)	577.06	1	577.06	3.42
B x Subj. within groups (error)	2695.03	16	168.93	

df (1,16) F_c = 4.49

TABLE 13

MEAN % OF TIME SPENT IN EACH STATE BY SEX* AND RACE*

State		Sex Mean	S.D.	t value		Race Mean	S.D.	t value
1	M	55.3	14.6	0.42	W	52.8	18.0	1.32
	F	54.0	15.1		B	57.7	12.0	
2	M	18.1	7.0	0.18	W	15.6	6.1	1.26
	F	18.4	9.0		B	17.9	8.9	
3	M	11.0	6.2	0.15	W	10.8	5.6	0.90
	F	11.0	5.4		B	9.6	5.0	
4	M	6.2	5.4	0.56	W	7.1	6.0	0.25
	F	6.9	7.0		B	7.4	6.6	
5	M	3.2	4.0	0.91	W	4.3	7.1	0.06
	F	4.3	6.4		B	4.2	4.5	
6	M	1.3	2.4	0.60	W	2.8	5.2	1.80
	F	1.8	4.4		B	0.9	2.2	
7	M	0.4	1.4	0.20	W	0.5	1.4	1.62
	F	0.3	1.2		B	0.1	0.1	
8	M	0.2	0.9	0.42	W	0.4	1.1	0.92
	F	0.3	0.9		B	0.2	0.4	

* Males = 9, Females = 13   ** Whites = 9, Blacks = 8

Summary: The three hypotheses related to physical measures of weight gain, head circumference and biparietal head diameter were not confirmed. The fourth hypothesis stating that there would be a significant difference between the experimental and control groups on cluster scores of the Brazelton Scale was partially confirmed. The fifth hypothesis stating that there would be a significant difference between the two groups in the percent of time spent in each of the eight states was not confirmed.

CHAPTER VI

DISCUSSION

The principle stimuli used in this study were the gentle

rolling movement of an oscillating waterbed and rhythmic sounds. It

was hypothesized that this rhythmic movement and pulsating sound would

provide a beneficial climate for the enhancement of physical growth

parameters, developmental progress, and state organization. Although

no significant differences were found in the physical parameters

measured, there were several important findings in the measures of

development and state organization.

Significant differences were obtained on the motoric and the

organizational processes state control dimension of the Brazelton

Scale. These positive findings on two dimensions of the Brazelton

Scale offer partial confirmation of the hypothesis that scores on this

scale would reflect differences between the groups. These findings

show that there was an enhancement of developmental progress in the

experimental group as compared with the controls. There are other re-

searchers who have obtained findings similar to these. Among those who

have obtained significant results on neonatal assessment scales are

Scarr-Salapatek and Williams (1973) and Powell (1974) who cite the

significant effects of stimulation on scores of an early version of

the Brazelton Scale. Neal (1968) has cited significant differences in

the motor portion of the Graham-Rosenblith test for neonates between

her stimulated and control groups. Katz (1971) found developmental

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enhancement in the area of muscle tension. Barnard (1972) and Rice (1977) in their investigations of infant stimulation found significant enhancement of the reflexive aspects of psychomotor functioning. Walters (1965) found that the motor activity of the fetus before birth was related to developmental scores after birth. Walters recorded fetal movements in 35 mothers during the last 3 months of pregnancy, and found positive relationships between these movements and Gesell developmental test scores at 12, 24 and 36 weeks of age. He concluded that the rapid brain growth and maturation during the third trimester accelerated the developmental processes of differentiation and integration.

There are several reasons why it was the motoric and state control dimensions that were affected by the stimulation provided in this study rather than the other aspects of development measured by the Brazelton Scale. In regard to the motoric processes, term infants go through movement experiences in utero of which the prematurely born neonate is deprived. The infant in utero has been characterized as an aquatic creature whose movements have the relaxed grace of an underwater scuba diver. The amniotic fluids support the fetus in a gravity free state so that like an astronaut, he has freedom to move without the inhibition of friction and gravity (Smart & Smart, 1973). Theoretically the waterbed reproduced for the experimental infants, at least partially, some of the gravity free aspects of their former fluid environment. Part of the effect of a waterbed surface is to provide a better distribution and equalization of the forces of the infants' weight on that surface than would normally occur on an

ordinary mattress, because the fluid content of the waterbed tends to

mold the mattress around the body rather than remain rigid under it.

In addition to the greater distribution of pressure points under the

body provided by the waterbed, the present study included a rhythmic

movement of the fluid in the waterbed. Theoretically, the effect of

this oscillating movement was not only to reproduce some of the ex-

perience of rhythmic movement which the infant had in utero, but also

added a greater distribution of the forces of the infant's weight on

the mattress surface by constantly shifting that weight from one part

of the infant's body to another. The ultimate effect of providing this

reduction of the inhibition of gravity in the present study would be

the reproduction of some of the freedom of movement which the term

infant has in utero during the third trimester. Thus, enhanced

motoric process would logically be a specific developmental effect of

an oscillating waterbed treatment which provided for greater ease of

active practice of movement, since the experience of sensorimotor

feedback to rapidly developing brain maturation of neural control of

psychomotor processes is the central issue in psychomotor development.

In addition to this provision of a climate of greater freedom

to learn active psychomotor movements, the oscillating waterbed also

provided a consistently repetitive experience of passive movement,

which is similar to that experienced by the fetus during the third

trimester. Administrators of the Brazelton Scale are often confronted

with the need to induce active movement by using passive movement

exercises. Thus, passive movement is an elicitor of active movement.

Possibly the experience of passive movements similar to those received

in utero during the early months prior to birth are crucial to the

development of active movements that also develop prior to 40 weeks

gestational age. In the present study the provision of this passive

movement experience for the experimental infants, was most likely

another reason why motoric processes were enhanced.

In regard to the finding of enhanced organization of state

control, it should be noted that the effect of rhythmic movement and

sound have repeatedly been found in research to have a soothing effect

on the state of infants. It is not surprising then, that state control

was affected here. Moreover, it was one of the major findings of the

present investigation that the percent of time spent in active sleep

as observed in time samples was significantly affected by the experi-

mental procedure. Therefore this finding on the Brazelton Scale is a

parallel finding to that obtained using another measure. The BNBAS

tapped the positive effects of the stimulation procedure on the elicited

state control of the infants and the behavioral observations tapped the

positive effects of the stimulation procedures on the passive state

organization of these infants. These two findings with different

measures compliment one another and reconfirm the presence of a

treatment effect in the matter of state organization.

The significant differences obtained on the Brazelton Scale

were somewhat surprising since the mean age of the infants at the time

of testing was 36 weeks and the exam is designed to assess infants at

40 weeks. Since the scores of premature infants tend to cluster at the

lower end of most of the 9 point scales on the Brazelton Scale, the

restricted variability makes it difficult to obtain significant

differences unless there was a very significant impact from the treatment variable. Evidently the experience of the auditory sounds and the gently rolling movement of the oscillating waterbed during early life had a great impact on the maturation of these young infants.

The finding of a statistical interaction between experimental and control groups at the beginning and end of the study in percentage of time spent in active sleep is the most important result of this study. The groups differed in whether percent of active sleep time increased or decreased from treatment to discharge. The experimental infants decreased the time in the active sleep states and the control infants increased the time in the active sleep state. The control infants, at discharge time, were spending a greater percent of time in the active sleep state and the experimental infants were spending a greater percent of time in other states. It becomes clear from the analysis of the data that it was the experimental manipulation that made the difference in the pattern of increasing or decreasing percentage of time the infants spent in active sleep. It should be pointed out that these results were obtained when physically the two groups were almost identically matched on the physical measures.

Although there are no well established explanations for the percent of time infants should spend in sleep, a number of researchers have hypothesized that it is necessary for the positive development of the central nervous system. And the more advanced is the development of the nervous system, the better the young infant is able to habituate to internal and external distractions and remain in a state of quiet sleep. Barnard (1978) has hypothesized that the early premature infant

has sufficient neurological development to efficiently enter quiet
sleep, but the neurological development is not sufficient to remain
in this state for adequate lengths of time. Therefore she provided
a stimulation procedure which would offer the infant external support
for remaining in a quiet sleep state. It would appear from the results
of the present study that the neurological development of the experi-
mental infants was, in fact, enhanced because the experimental infants
did spend a greater percent of their time in quiet sleep. It seems
that an essential ingredient of neurological maturation is to remain
in sleep states for longer lengths of time. Since the experimental
infants were able to do this during the first four weeks following
birth the central nervous system development of these infants was
better prepared for the next stage in development. By the time they
were ready for discharge they were neurologically developed to a
point where they could begin to spend more time in a cognitive alert
state and begin to interact with their environment in a more directed
and positive way.

Furthermore, it might be speculated that their advanced central
nervous system development in the matter of state control combined with
the more advanced motor development found on the Brazelton Scale better
prepared them for discharge from hospital care.

Although at this time the underlying mechanism of the inter-
action effect found in the state data of this study is not understood,
one can speculate about the meaning of these findings. The consistent
interaction pattern of the two groups between the period of experimental
procedure and the time of discharge is very striking. One can apply

the theoretical explanations that have been hypothesized about the development of the central nervous system to evaluate the treatment outcome obtained here. Because the exchange in the percentage of time spent in active sleep was significant, it appears that the experimental procedure had a profound effect on the state organization of the experimental group of infants. And because the percentage of time spent in active sleep for the control group was at the time of discharge at a level similar to what the experimental infants had maintained during the experimental treatment period it appears that the control infants were just beginning to reach a stage of central nervous system development that the stimulation procedure helped the experimental infants achieve early on. The organizational influence of the waterbed movements and rhythmic sounds helped the experimental infants to attain a higher level of organization than that of controls. Then when the movement and sounds were removed these infants had adequately organized their own use of sleep time and were now able to use the other states. The control infants, who did not have the stimulation procedure to help them organize their sleep state were only beginning to attain the level of sleep organization at the time of discharge that the experimental infants had achieved during the four week treatment period.

The results of infant stimulation experiments in the past have been interpreted as having only temporary effects on the experimental groups. It is possible that these past results could actually have been the same interaction effects that were found in this present study. The interaction effects obtained in the present study were not in-

dications of the temporariness of the stimulation effect, but rather were indicators of a restructuring of the central nervous system. The interaction does not indicate that the effect obtained during the experimental procedure was diminished or lost, but rather that there was a forward moving development of the central nervous system in such a way that the state organization was redirected at a more advanced level of functioning. When extra stimulation is provided for an organism, it offers the possibility for the organism to grow and perhaps restructure its internal organization which in turn may result in developmental progress. I would like to suggest that this is what occurred within the experimental infants in this study. When they were provided with a well designed pattern of stimulation which may have counteracted the stressful medical procedures they encountered during their stay in the special care nursery, they were able to develop more successfully.

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APPENDIX A

APPENDIX A

NORTHWESTERN MEMORIAL HOSPITAL

CONSENT FOR INVESTIGATIONAL PROJECT

Some of the infants in our Intensive Cafe Nursery will be used to
conduct a study on the effects of a gently moving waterbed on the
development of prematurely born infants. There is some evidence
from studies conducted in other nursery settings, that the premature
infant makes equally as good, if not better, progress when placed in
this type of a setting.

Your infant is of the appropriate age and weight to be studied in
this project. One half of the babies chosen for this study will be
placed on a waterbed in the isolette, and the waterbed will be gently
agitated to produce a rhythmic motion. Some rhythmic sounds of re-
cording of a mother's heartbeat will also be played for the baby.
These babies will receive ALL of the normal care given each infant in
our nursery. The other one-half of the babies studied in this
project will be placed on the traditional type isolette bed, and will
also be given the normal care given each infant in our nursery.
At the end of the study we will compare the development of all the
infants used in this study. Eventually we hope this information will
help us design the most positive setting for infants born prematurely.

We will be happy to answer any questions about this study or the
results as they become available. Your participation in this project
is purely voluntary. If you consent to enroll your baby in this
project, you are free to withdraw your consent at any time. En-
rollment in or withdrawal from this project will in no way influence
the care your baby receives.

I certify that I have read the above and understand its contents.
My permission is freely given without duress, reward, or promise
of reward.

I (We) _____ hereby request the admission of our
_____ to the investigational project "Waterbed
Stimulation of Premature Infants" under the direction of
_____.

                                 _____Signed

                                 _____Signed

                                 _____ Relationship

_____   _____ Date
      Witness

NORTHWESTERN MEMORIAL HOSPITAL

INVESTIGATOR'S STATEMENT

I certify that I have explained the above to _____

and believe that _____ fully understand(s) its
                        he, she, they

contents and that _____ signature(s) was(were)
                        his, her, their

affixed freely, without duress, reward or promise of reward.

I also agree to answer any questions which may arise.

_____   Signed

_____   Title

_____   Date

APPENDIX B

APPENDIX B

STATE CATEGORY CRITERION

(1) Quiet Sleep: The infant's eyes are firmly closed and still;
he shows little or no motor activity with the exception of
occasional startles or rhythmic mouthing.

(2) Active Sleep: The infant's eyes are closed, but slow,
rolling movements may be apparent. Bodily activity can
range from minor twitches to writhing and stretching.
Respiration is irregular, costal in nature, and generally
faster than seen in Quiet Sleep. Facial movements may
include frowns, grimaces, smiles, twitches, mouth movements
and sucking.

(3) Active Sleep with REM: Respiration and movement charac-
teristics are the same as those of Active Sleep, except in
theis state Rapid Eye Movements occur during the 10-second
epoch.

(4) Drowsy: The infant's eyes may either open and close, or
they may be partially or fully open but very still and
dazed in appearance. The infant may show some generalized
slow motor activity. Respiration is fairly regular, but
faster and more shallow than that observed in Quiet Sleep.

(5) Cognitive Alert: The infant's body and face are relatively
quiet and inactive, but the eyes are bright and shining in
appearance as if attending to his environment.

(6) Motoric Alert: The infant's eyes are generally open, but
may be closed; he shows generalized motor activity,
accompanied by grimacing, grunting, or brief vocalization.

(7) Fussing: The characteristics of this state are the same
as those for Motoric Alert but mild, agitated vocalizations
are continuous; or one vigorous cry burst may occur.

(8) Crying: The characteristics of this state are the same
as Motoric Alert, but generalized motor activity is more
intense, and cry bursts are continuous.

APPENDIX C

CRITERIA FOR A PRIORI CLUSTERING

Dimension I: Interactive Processes

Assign a score of:
1—i.e., exceptionally good performance if *all* the following criteria are met
   a) four of the five orientation items (inanimate visual, inanimate auditory, animate visual, animate auditory, and animate visual and auditory) are scored at 7 or above for the visual, at 6 or above for the auditory responses, and none is below a score of 4
   b) the alertness score is 6 or above
   c) either cuddliness is 6 or above, or consolability is not applicable or is 6 or above, or both are true.
Assign a score of:
3—i.e., deficient performance if *two* of the following criteria are met
   a) three of the five orientation items are scored at 5 or below, or were not administered
   b) the alertness score is 4 or less, or not scorable
   c) either cuddliness or consolability or both are scored 4 or less
Assign a score of:
2—i.e., adequate performance, if the criteria for neither 1 or 3 are met

---

Dimension II: Motoric Process

Assign a score of:
1—i.e., exceptionally good performance if *all* the following are met
   a) no more than one deviant reflex (excluding 0 or 1 on clonus, TNR and nystagmus), and counting passive movements of the arms as one item and passive movements of the legs as one item
   b) if motor tone is scored 5 or 6
   c) if three of the following scores are obtained: 7 or above on pull-to-sit, 5 or above on motor maturity, 7 or above on defensive reaction, 5 or above on hand-to-mouth activity
   d) if activity is scored 4-6
Assign a score of:
3—i.e., deficient performance if *two* of the following criteria are met
   a) motor tone is scored 1-3 or 7-9
   b) three of the following scores are assigned: maturity 1-3, pull-to-sit 1-4, defensive reaction 1-4, activity 1-3 or 8-9, hand-to-mouth 1-3
   c) more than three deviant reflexes (excluding 0 or 1 on clonus, TNR and nystagmus and counting passive movements of the arms as one item and passive movements of the legs as one item)
Assign a score of:
2—i.e., adequate performance, if the criteria for neither 1 nor 3 are met

---

Dimension III: Organization Processes, State Control

Assign a score of:
1—i.e., exceptionally good performance if *all* the following criteria are met
   a) state 4 is scored as one predominant state
   b) habituation items if all done, are all 5 and above: if two done, both are 5 and above; if only one done, do not consider
   c) peak of excitement is 5-7, or 4 if predominant state is 4 and not 1, 2, or 3
   d) three of the following are true: lability of states is 3 or less, rapidity of buildup is 4 or less, irritability is 4 or less, self-quieting is 6 or more, or NA
Assign a score of:
3—i.e., deficient performance which can be either very *labile* (*L*) or very *flat* (*F*) if the following criteria are met
   L: labile (*L*) if *three* of the following scores are true
   a) rapidity of buildup is 7-9
   b) irritability is 7-9
   c) self-quieting is 1-4
   d) state lability is 6 or above
   e) peak of excitement is 8 or 9
   f) habituation scores are all 4 or below if done
   g) pinprick is 1 or 2
   flat (*F*), if *all* the following is true
   a) peak of excitement is 1-4
   b) one of the following is true: rapidity of buildup is 1-3, irritability is 3 or less, state lability is 1 or 2
   c) predominant states are *not* 4 or 6
Assign a score of:
2—i.e., adequate performance if the criteria for neither 1 nor 3 are met

---

Dimension IV: Organization Processes, Physiological Response to Stress

Assign a score of:
3—i.e., deficient performance, if *two* of the following criteria are met
   a) tremulousness is 6 or above
   b) skin color is 1, 7, 8, or 9
   c) startles is 6 and above
Assign a score of :
1—i.e., good performance if the criteria for 3 are not met

APPROVAL SHEET

This dissertation submitted by KAYREEN ANN BURNS has been read
and approved by the following committee:

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The final copies have been examined by the chairman of this
dissertation and the signature which appears below varifies the
fact that any necessary changes have been incorporated and that
the dissertation is now given final approval by the Committee with
reference to content and form.

The dissertation is therefore accepted in partial fulfillment of
the requirements for the degree of Doctor of Philosophy.

_12/8/80_

Date

Jack A. Kavanagh

Chairman's Signature