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An Advanced Inquiry of Occupational Therapy Treatment in the Neonatal Intensive Care Unit Focusing on the Sensory Systems of the Infant

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An Advanced Inquiry of Occupational Therapy Treatment in the Neonatal
Intensive Care Unit Focusing on the Sensory Systems of the Infant

A Scholarly Project

by

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of the

University of North Dakota

for the degree of

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CHAPTER ONE

INTRODUCTION

This project focuses on occupational therapy's (OT) role in the neonatal intensive care unit. I chose to focus on neonatology as this is a specialty area of OT and the current curriculum and course work offers a general overview of this highly advanced subject. Innovations in medical science, technology and caregiving skills have increased the survival rate of young, smaller and sicker infants. This has raised concerns about the long-term effects of the NICU on infants. Sensory components of the extrauterine environment in neonatal intensive care unit are drastically different from the womb. Prior to birth, the fetus is in a warm, snug, dark environment where basic needs are automatically met. After birth, the infant has to suddenly be able to breathe, regulate temperature, move against gravity, adjust to light and cope with painful procedures. The infant's central nervous system is not ready to deal with the environmental stressors. This creates a mismatch between the neonate and the high tech world. Als has hypothesized that excessive sensory disorganization creates maladaptive behaviors that contribute to poor development later in life. OT can provide treatment to benefit the infant in the present and future.

The purpose of my scholarly project is to enhance my own knowledge in this area by focusing on what OT can provide the infant. I concentrated my project on developmentally supportive treatment that centralizes on the infant's sensory issues and the environment. My procedure has included an extensive and thorough review of

literature on the NICU infant's sensory systems, environment and current treatment utilized across medical disciplines.

Based on the literature reviewed, I have applied the information to practice by creating a reference manual of "best practices" in intervention. This manual will be for my future use and for possible use by the faculty and students in the occupational therapy program at UND.

CHAPTER 2

REVIEW OF LITERATURE

Introduction

The neonatal intensive care unit (NICU) is a complex and highly specialized hospital unit designed to care for infants who are born prematurely or are critically ill. The first special care unit for preterm newborns, established by Dr. Pierre Budin in 1893, was called the “Special Department for Weaklings” (Hunter, 2001, p. 637). This unit cared for the infants by providing warmth, small feedings and protection from infection. The innovation of technology has currently made the NICU a place of bright lights, constant loud sounds, temperature variations, painful procedures and equipment.

This is a very different environment from which the infant emerges. The intrauterine environment is a world of darkness, warmth and rhythmical movement. The infant in utero experiences the diurnal variations of the mother such as maternal sleep, temperature, heart rate, respiratory rate and the endocrine cycle (D’Agostino & Clifford, 1998). The infant hears sounds of the mother’s cardiovascular and digestive system as outside sounds are filtered and transmitted on a low frequency. The infant floats in warm amniotic fluid that has no painful stimuli. These preterm infants born early must deal with the extrauterine environment with their immature organ systems and spend their last weeks or months of gestation in a different environment (Blackburn, 1998).

This process of adaptation is potentially stressful and has an impact on the developmental outcome of the premature infant (D’Agostino & Clifford, 1998).

Individuals have studied this ‘mismatch’ of intrauterine and extrauterine environment and how it affects the neonate’s development presently and later in life.

The Evolution of Developmental Care

Three stages of developmental support have emerged over the years and have guided intervention in the NICU. These include sensory deprivation, sensory overload, or adequate but inappropriate sensory stimulation.

During the 1940s-1950s special care nurseries considered the infants as frail and followed strictly limited minimal stimulation guidelines such as low lighting, quiet environments, restricted access by family and medical professionals. This lack of stimulation launched the sensory deprivation theory of the 1960s-1970s. Intervention focused on structured programs that provided massage, stroking, passive range of motion, vestibular input and auditory input (Hunter, 2001). This intervention was based on the premise of the neuroplasticity of the brain and that it could respond correctly to appropriate stimuli and adapt to abnormal conditions. Unfortunately, the intervention was done in a “one size fits all” approach and was very inappropriate for stressed infants over stimulated by the NICU (Taquino & Lockridge, 1999).

The second approach to care that evolved in the late 1970s-early 1980s hypothesized that the preterm infants were overstimulated by the various inappropriate stimuli of the NICU (Taquino & Lockridge, 1999). Many individuals in the medical community supported a return to minimal handling and attempted to reduce the amount of auditory, tactile, kinesthetic stimulation taken in by infants.

“The emerging concern about the large quantity and variety of random stimuli caused the rise in the 1980s and 1990s of “environmental neonatology” in which the

influence of animate and inanimate environmental factors in the NICU facilities was explored” (Hunter, 2001, p. 638). Researchers hypothesized that the environmental stimuli prevents the infants from being able to organize their appropriate physiological and behavioral responses. Supporters of this approach acknowledge that physiological and behavioral responses vary from infant to infant depending upon age and illness and concluded the way the infant behaves in response to various environmental cues is the best way to plan care (Taquino & Lockridge, 1999). This type of care strives to continually structure the NICU environment and caregiving practices according to behavioral cues of each infant and promote the involvement of family members.

Developmentally Supportive Care

Developmentally supportive care for high-risk infants is based on two theories of infant development: the synactive theory of development and the concept of neurobehavioral organization. “The goal of developmental care is to support and promote the premature infant’s adaptability to external environments and events” (Ludington-Hoe & Swinth, 1996, p. 691). This approach requires a detailed assessment of the individual infant and prescribes a highly individualized method of care.

The synactive theory was proposed by Heidelise Als (1986). She proposes that the infant interacts with the environment through five subsystems: physiologic (autonomic); motor; state; attentional; and self-regulation which in turn interact with each other. The autonomic/physiologic subsystems give infants control over autonomic functions such as cardiorespiratory and hormonal production. The motor subsystem provides control over motor activity, muscle tone and posture. The state system allows the infant to experience different states of consciousness and effectively transition from

each state. The attentional subsystem provides the infant a means to become alert, attentive and respond to external stimuli. The self-regulation subsystem gives the infants the ability to control and modulate other subsystems and calm themselves when exposed to stressful situations (Als, 1986).

According to Als (1986), the subsystems are formed and develop in a hierarchical manner. The physiologic is the most primitive subsystem, the first to become functional and serve as the foundation for the stability of the entire system. The infant must have stability in the hierarchically lower subsystems in order to organize higher subsystems. When the infant lacks stability in one subsystem, he or she will provide cues of disorganization of the immediately lower subsystem (Vergara, 1993).

The synactive theory stresses that if an infant is allowed and/or assisted to become reorganized after experiencing instability, the system may regain balance and the intervention may be continued once balance is regained. The infants is able to maintain the necessary stability of the subsystem through 'time-out' breaks which are implemented by the caregiver closely monitoring the infant's individual cues of disorganization (Burns, Cunningham, White-Traut, Silvestri and Nelson, 1994).

When approached by a stimulus, the infant can respond in three ways as described by Vergara (1993). The infant can interpret the stimulus as non-stressful and respond correctly to the stimulus without affecting his or her physiologic stability. The second possibility is that the infant can experience stress when the stimulus is presented but is able to counteract the effects by engaging in calming actions which do not affect the infant's behavioral stability. The third possibility is that the infant responds to the stimulus stressfully and is not able to overcome the negative effect of the stress.

Infants therefore display three different types of behaviors: self-regulation with approach signals, self-regulation with coping signals and stress (or avoidance) reactions.

According to Vergara (1993) self-regulation approach signals mean that the infant is able to maintain control and is well organized. Typical infants signals include: smiling or mouthing, 'OOH' face, cooing, relaxed limbs, minimal motor activity, smooth body movements, alertness and a soft, relaxed facial expression. Self-regulation coping signals are to be interpreted as a warning message that the infant may be reaching maximum tolerance of external stimulation and stress. The infant at this point still has the ability to become self-organized. Self-regulation behaviors are energy expending as the infant does have to gather support from one of the lower subsystems to perform the behavior. Infants signal these behaviors by leg bracing, placing their hand on their face, sucking, hand or foot clasp, grasping, fisting, assuming a flexor pattern, bracing body against crib, and shifting to lower behavioral states (i.e. between drowsy and light sleep).

Stress signs are the most serious and may occur as a result of immaturity, disorganization of a system or a stimulus. Stress reactions can be clearly classified into physiologic, motoric, state-related, or attentional/interactional and generally occur in order of severity with the least serious of the attentional system and the most serious in the physiologic system (Als, 1986).

The following are stress signals according to subsystem: attentional interactional (inability to integrate social interaction with other sensory input, avoidance of social interaction), State (gaze aversion, gaze locking, glass eyes, irritability, lack of alertness, diffuse sleep states), Motor (sitting on air, saluting, finger splaying, squirming, frantic, disorganized movements, trunk arching, tongue thrusting, gape face, generalized

hypotonia) and Physiologic (yawning, burping, hiccuping, gagging, spitting up, sneezing, color changes and changes in vital signs) (Als, 1986). Stress prevention should be the core element of any intervention program for fragile infants (Vergara, 1993).

A vital element of intervention is knowing when the infant is in the optimal state for intervention which is based on the infant's neurobehavioral organization. "Neurobehavioral organization is the smooth interaction between the infant's physiological and behavioral systems based on the maturation and function of the central nervous system" (Taquino & Lockridge, 1999, p. 66). This organization affects how well the infant is able to interact with the environment and external stimuli. Organization is affected by the motor system, which includes autonomic and visceral functions, and behavioral system comprised of motor activities and the state system. "The infant is then able to achieve control over their states of consciousness as they develop neurobehavioral organization as a result of maturation of nervous system" (Vergara, 1993, p. 33).

Brazelton classifies states into six states of deep sleep, light sleep, drowsy, quiet alert, active awake and crying (Vergara, 1993). Premature infants sleep longer than full term infants do and their sleep is characterized by much activity, periods of alertness are brief and sporadic. As the infant matures and gains organization the proportion of time spent in light sleep decreases and periods of alertness increase. The assessment of state behavior includes range and quality of states; frequency of states and smoothness and cost of transitions between states.

The quiet alert state is the most appropriate state for intervention as the infant is able to display the best interactive/attentional abilities and is in the optimal state for responding to stimulation (Vergara, 1993). The active awake state is not as effective as

motor activity interferes with the ability to attend by the proprioceptive feedback that the infant receives.

Premature infants also develop the ability to interact socially as the nervous system matures, this process has been termed neurosocial behavioral development. According to Gorski, Davidson and Brazelton, (in Bellig, 1989, p. 17), the infants go through three developmental stages when the stability of the subsystem is achieved. These stages are known as the 'in-going' stage, the 'coming out' stage and reciprocity.

The 'in-going' stage occurs when infants are under 32 weeks post conceptional age and are physiologically unstable (Vergara, 1993). An infant at this stage requires all his or her energy to maintain a steady autonomic state, has no additional energy for interaction with the environment and is extremely vulnerable to the stimuli of his or her surroundings (Bellig, 1989). They are commonly overloaded by minimal sensory stimulation and are easily agitated. Infants in this stage should not be socially engaged (Vergara, 1993).

The coming out stage happens between 32 and 35 weeks postconceptional age and are more physiologically stable. Infants can handle some interaction but he or she must still conserve energy to maintain a steady state (Bellig, 1989). The infant needs to be highly monitored during social interaction for signs of stress and should be scheduled around the infant's best periods (Vergara, 1993).

The final stage is reciprocity and occurs in infants 36 weeks postconceptional age and have fairly well defined states, good quality alertness and tolerance for social interaction and self-regulation abilities (Vergara, 1993). When an infant has reached this

stage he or she “has achieved smooth autonomic function, allowing him or her more sustained interaction with the environment” (Belling, 1989, p. 17).

Research has been done that promotes the efficacy of developmental supportive care. Lekskulchai and Cole (2001), examined the motor performance of Thai infants born prematurely who were randomly assigned to intervention and control groups where the intervention received was based on a developmentally appropriate care to facilitate motor development. Eighty-four infants were randomly assigned to either a control or intervention group, forty-one infants comprised the control group and forty-three infants were the intervention group. Infants were of a gestational age of less than 37 weeks, free of congenital abnormalities and genetic disorders, did not undergo surgery and did not develop a serious illness. These two groups of infants were at risk of developmental delay. Twenty-seven low-risk preterm infants were included forming a comparative group for the study.

A program was developed which included 12 activities for infants at 40 weeks postconceptional age and at one, two and three months adjusted age, with three activities introduced each month. This was a program of home-based activities in which demonstration and a practice session were provided to provide caregiver with correct procedure. The primary caregiver (usually mother) was the person responsible for carrying out the intervention program. All of the infants had their motor performance assessed monthly with the Test of Infant Motor Performance by one of the physiotherapist research assistants who did not know the group assignment and the infant’s adjusted age.

The results revealed that the infants with intervention started with lower scores than those of the comparative group. The infants with no intervention offered showed slower motor progression at four months adjusted age than those receiving the intervention program. The intervention infants were able to catch up with those whose developmental status were normal at 40 weeks postconceptional age and showed more improvement in motor performance than the control infants.

Beuhler, Als, Duffy, McAnulty and Liederman (1995), assessed the effectiveness of individualized developmental care for low-risk preterm infants. Two groups of healthy newborns were assessed. One group were infants who were born at term and experienced normal intrauterine environment for 9 months and the second group included infants born prematurely (30-34 weeks and 2500g) being cared for in a 'special care nursery'. The preterm infants were then further divided and randomly assigned to either the preterm control group that received standard special care or the preterm experimental group, which received individualized developmental care.

Researchers conducted formal observation of each infant's behavior starting the infant's stabilization and continuing every 7 days until hospital discharge. The observation was completed for 20 minutes before a necessary medical or nursing care and for 20 minutes after the activity. Ninety-one behaviors including autonomic, motor and state organizational behaviors were then monitored every 2 minutes. Behavioral outcomes were evaluated with the Assessment of Preterm Infants' Behavior (APIB) and the Neurological Examination of the Full-Term Newborn Infant and electrophysiologic outcomes that measure cortical functioning were assessed by quantitative electroencephalography with topographic mapping.

The results revealed that the preterm experimental group was initially significantly more at risk as reflected by the lower scores on the Obstetric Complications Scale Score (OCS) which indicates a greater degree of complications. The preterm control group displayed the least well-organized behavioral performance whereas the preterm experimental and full-term groups were behaviorally comparable. Out of the 180 possible variables of the electrophysiologic outcomes 70 showed significant group difference between the preterm groups. Twenty-eight involved the right hemisphere and 24 the left hemisphere and 18 were bihemispheric. In 32 of the 41 features the preterm experimental group was comparable to the full term group and both differed from the preterm control group.

Als, Lawhon, Duffy, McAnulty, Gibes-Grosman, and Blickman (1994), studied the effectiveness of individualized developmental care in reducing medical and neurodevelopmental conditions for at risk very low-birth weight infants. A group of 38 infants admitted in a 21-month period who had a birth weight less than 1250 g at birth; less than 30 weeks and more than 24 weeks of gestational age at birth and did not have any chromosomal abnormalities, congenital infections, and fetal exposure to drugs of addiction were randomly assigned to a control or an experimental group.

Specially trained staff provided developmental supportive care to the experimental group. The formal observation periods monitoring the infant's behavior beginning with the acute phase of initial stabilization within 12 hours continuing with every 10th day until discharge. The observation periods included the infant's responses 20 minutes before and after a caregiving activity. Also during this time ninety-one behaviors were monitored every two minutes. Developmentally appropriate treatment

was based on the observations of each infant and then implemented. The control group received standard care including shielding of incubators with blanket covers and use of clothing.

The Assessment of Preterm Infants' Behavior (APIB), a developmental evaluation was given at 2 weeks after expected the expected due date along with electroencephalography. At nine months, the infants were evaluated with the Bayley Scales of Infant Development and Kangaroo Box Paradigm. Results revealed that of the 12 medical outcome variables, eight were statistically significantly different, favoring the experimental group. At the two-week evaluation, the experimental infants showed improved autonomic regulation, motor system functioning, self-regulatory abilities and higher scores on the assessments. The infants in the experimental group had significantly shorter duration of medical ventilation, supplemental oxygen support; earlier oral feeding' reduced incident of intraventricular hemorrhage, pneumothorax and severe bronchopulmonary dysplasia. They also showed improved weight gain and shorter hospital stays with an earlier age of discharge.

A retrospective study, Mouradian and Als (1994), compared an existing data set independent of the experiment. The existing set of data was 20 preterm infants' scores on the Assessment of Preterm Infants' Behavior (APIB) before care involving the developmental approach was used. These results were classified as Cohort I. Cohort II was the APIB scores from 20 preterm infants studied after developmental care was integrated into treatment. All infants were Caucasian, had no congenital or chromosomal abnormalities and were less than 34 weeks gestation at birth. All Cohort I and II infants were examined with APIB 2 weeks after their expected due date. The examiners were

blind to infant's gestation age and were experienced in the APIB. During the time period between Cohort I and II the hospital performed two developmental care studies. In this span, nursing staff was trained on developmental care and specific changes that would be implemented into caregiving. Results found that infants in Cohort II showed more modulated and competent behavioral systems organization, were autonomically and motorically more stable and well-regulated, decrease in specific extensor postures, increase in oral motor abilities and self regulatory behaviors. There are some limitations to this study as there was a lack of control and randomization, an inability to manipulate the independent variables, the risk that the data was not interpreted correctly and that changes in medical practice could have also contribute to these results.

The Sensory Systems

Research has identified the order in which sensory systems begin to develop. According to White-Traut, Nelson, Burns & Cunningham (1994) development of the sensory systems begin in this order. The cutaneous, or tactile, pathway is the first sensory pathway to develop during the first two months after conception. A fetus is able to respond to tactile stimuli as early as 8-10 weeks post conception in utero with reflexive total body avoidance reactions (Vergara, 1993, p. 66). After 10-12 weeks the fetus begins to show some differentiation of response which is hypothesized to reflect maturation of cranial nerves (White-Traut et. al, 1994).

This is followed by the development of the vestibular and olfactory (smell) pathways present and functioning by 80 days postconception. Studies of olfactory function in infants have provided evidence that premature infants have the ability to smell by the time they reach the 3rd trimester of development and at 28-32 weeks infants elicit

olfactory reflexes. The gustatory (taste) pathways begin development during the 11th week after conception. Studies have found the formation of fetal taste buds at 11 weeks and are functional by 12 weeks postconception. Finally the auditory and then the visual pathways begin to develop. The human fetus is capable of responding to auditory stimulation at 6 months postconception and full auditory nervous system functioning is achieved between the 25th and 27th weeks of gestation (White-Traut et. al, 1994). However auditory processing capabilities continue to develop with CNS organization and may be altered by auditory experiences that differ from the usual intrauterine environment (Blackburn, 1998). Vision is the last of the senses to develop during the last trimester. At this time, color vision is poorly developed. Development of the visual cortex is thought to be completed after myelination of the optic nerve at 3 months of age (White-Traut et. al, 1994). Often the least mature sensory systems of the premature infant, the visual and auditory are the two systems that receive the most random stimulation whereas the most developed systems—tactile, gustatory and vestibular—receive the least amount of stimulation (D’Agostino & Clifford, 1998, p. 17).

Tactile System

The tactile system is highly important as it is utilized at birth for the emotional development of the infant as well as for the development of parent/infant bonding. “Touch builds the foundation for the complex and intimate interchange between infant and caregiver, supplying the infant with a beginning interpretation of the world, relationships he/she will rely on for survival, and provide organization, stimulation, communication and emotional exchange” (Browne, 2000, p. 61). One of the neonate’s greatest after birth traumas is adjusting to the lack of constant tactile stimulation (Phillips

& Moses, 1996). After birth, the tactile stimulation becomes painful in the form of heel sticks, IV pricks and endotracheal tubes. Premature infants are handled approximately 82 times a day and the excessive handling is extremely stressful (D'Agostino & Clifford, 1998). Interventions for preterm infants to assist in organization of the stimuli include infant massage, kangaroo care and swaddling/containment and nesting.

Infant massage has many benefits including facilitation of the parent-infant bonding process in the development of positive relationships; reduces stress and pain responses to painful procedures; better respiration, circulation, digestion and elimination. Massage also helps to induce sleep and make the parents “feel good” while they are massaging their infants (Field, 1994). Generally, infants who benefit from infant massage are medically stable and greater than 33 to 34 weeks postconception (Vergara, 1993). Younger medically fragile infants benefit more from the firm touch and static proprioceptive input of hand swaddling than infant massage (Hunter, 2001).

Phillips and Moses (1995), studied thirty-one infants in the NICU at University Medical Center in Jacksonville, Florida that tested the effects of touching and holding on preterm infants. The infants in the study were between 28 to 34 weeks gestational age and had no major medical complications. Thirteen infants received two daily treatments of massage, 8 were held twice a day and 10 infants received only the typical routine of care. The results revealed that the massaged infants gained 42% more weight and the holding group gained 25% more weight than did the control infants (p. 43). The massaged infants were able to reach a calm state sooner, less irritable, had fewer state changes, and were better able to handle stimulation than both the holding and control groups.

In a study completed by Field (1984) had 40 preterm neonates receiving 45 minutes of massage per day (3 15-minute periods) for 10 days. The infants averaged 31 weeks gestational age, 1280 grams and 20 days in intensive care. The massage was divided into 3 five-minute phases. Tactile stimulation comprising the first and third phases which included placing the infant in the prone position and given moderate pressure while stroking the head, neck, shoulder, back, legs and arms. The middle phase involved kinesthetic stimulation which the infant's limbs were flexed and extended while lying on his/ her back.

The results of this study revealed that massaged infants gained 47% more weight; were awake and active a greater percentage of the observation time; showed better performance on the Brazelton scale on habituation, orientation, motor activity, and regulation of state behavior; and were hospitalized on average 6 days fewer than the control infants saving approximately \$3,000 per infant.

“Kangaroo care is the nickname given to the practice of parents holding their diaper clad premature infant beneath their clothing, chest-to-chest and skin-to-skin” (Hunter, 2001, p. 651). This intervention belongs solely to the parents (Ludington-Hoe & Swinth, 1996). Benefits of kangaroo care include support of autonomic stability and fostering improvement in basic physiologic functions such as cardiorespiratory stabilization and prevention of loss of body heat; body warmth is maintained or increased throughout the duration of kangaroo care. During kangaroo care, the infant is in an upright position which provides opportunities for relaxation; improved respiratory and activity functions; increased efficiency of the diaphragm; and better pulmonary function and easier breathing. Kangaroo care reduces the amount of time the infant spends in

active sleep; increases time spent in quiet, regular sleep. Increased alertness, during kangaroo care, offers opportunities for self-regulating behaviors and produces a significant reduction in crying especially during painful procedures. (Lundington-Hoe & Swinth, 1996).

Benefits of the parents utilizing kangaroo care include facilitation of maternal milk production and longer duration of breast-feeding, increased awareness of their infant's cues of well-being or distress, increased parental attachment and feelings of closeness to their infant, less focus on technical care, more confidence in their own caregiving ability and decreased maternal stress (Hunter, 2001).

Containment/Swaddling consists of using either the caregiver's hand or a soft blanket to 'contain' the infant's extremities close to the body. A hand is usually placed on the top of the infant's head while another hand or cloth gathers the infant's lower and sometimes upper extremities together and draws them close (Taquino & Lockridge, 1999). "This flexed position simulates the position in-utero where neuromuscular development is facilitated through weightlessness and containment in flexion" (Short, Brooks-Brunn, Reeves, Yeager, & Thorpe, 1996, p. 26).

Swaddling is best used to prevent disorganized movements through providing containment to restrict motor activity and facilitate self-regulation behaviors (Vergara, 1993). Containment can be offered during known stressful procedures such as venipuncture or suctioning, simple handling, checking of vital signs and diaper and position changes (Taquino & Lockridge, 1999). Swaddling has been suggested as an intervention to provide proprioceptive input and kinesthetic stimulation, support hand-to-mouth maneuvers, facilitate motor organization, and calm irritable infants (Short et. al,

1996). It also decreases physiologic arousal, prolong daytime sleep states and reduce pain-elicited distress in term infants (Short et. al, 1996).

Als, Lawhon, Brown, Gibes, Duffy McAnulty & Blickman (1986) stated that swaddling can be used to provide shoulder and truncal support and foot bracing. These interventions were specifically identified to aid in feeding. Swaddling also supports the flexor position which aids in facilitation of transition of states, provides boundaries and encasement as an intervention to promote sleep organization and maintain firm containment of limbs to enhance organization of alertness.

Nesting involves forming a boundary around the infant who is in a supine position with the neck slightly flexed, the extremities flexed and adducted, the shoulders protracted, and the hands closer to the facial region in order to promote hand to mouth activity (Vergara, 1993). Nests can be formed out of blanket rolls, foam or other soft materials purchased commercially such as the Snuggle-up or Bendy-Bumper and it must be secured to the supporting surface for stability. Nesting promotes symmetry, midline orientation, reduces head flattening and intracranial pressure (Hunter, 2001).

A neonatal hammock is an alternative to nesting in supine if the infant does not tolerate the nesting position well. Hammocks promote flexion, posterior pelvic tilt, shoulder protraction and midline orientation; may decrease lateral head flattening; and if elevated place the infant in a better position for visual stimulation (Vergara, 1993).

A study completed by Short et. al (1996), tested the difference between swaddling and standard positioning of 50 infants in a flexed posture. Swaddling included having the infant wrapped in a blanket to maintain the upper and lower extremities in flexion with hands positioned near the mouth. A hip roll was also used to provide flexion when

infants were in the prone position. Infants were swaddled in the supine, lateral and prone positions and were repositioned every 2 to 4 hours. The infants were swaddled at least for 15 hours per day. Infants who received standard positioning (routine nursery position) were placed in prone, lateral and supine utilizing blanket rolls to help maintain position. The infants were repositioned every two to four hours and were swaddled when necessary for irritability or thermoregulation but less than eight hours per day.

The infants sampled had a birth weight of under 1250 g, appropriate for gestational age, at least 7 days of age, approval of staff neonatologist and written consent from parents or guardians. The Morgan Neonatal Neurobehavioral Exam (MNNE) which is divided into three sections including tone and motor patterns, primitive reflexes and behavior responses measured the infants' neuromuscular development.

The results revealed that infants that were swaddled scored higher on the MNNE subscale of tone and motor, had higher scores on the behavior responses subscale indicated by an increased ability to process and respond to external stimuli and a quicker return to baseline after threshold had been exceeded and had statistically higher scores on the primitive reflexes subscale.

Vestibular/Proprioceptive System

The vestibular system provides humans the sense of balance through stimulation of the inner ear through semicircular canals and gravity receptors. This information is then processed by the vestibular nuclei and cerebellum, which are part of the phylogenetical older system of the brain (Ayres, 1979). By the fifth month in-utero, the vestibular system is well developed and along with the tactile and visceral systems provides almost all of the sensory input to the fetal brain (Ayres, 1979). The fetus

experiences strong vestibular input as they float around in-utero in which their own vestibular system is actively stimulated by their own movements and passively stimulated by the mother's movements (Vergara, 1993).

Vestibular input is believed to promote maturation of other systems, especially the motor system (Vergara, 1993). Vestibular input can be received through rocking, handling and the use of waterbeds. Gentle, rhythmic rocking has a calming effect and soothes agitated infants; fast, arrhythmic rocking increases overall activity and agitation (Ayres, 1979). Rocking can be done outside of the isolette with the caregiver and parent in a comfortable chair or with the infant placed in a hammock inside the isolette (Hunter, 2001).

Vestibular stimuli have other integrating effects on the infant as well. "Vestibular stimulation resulting from the upright position (holding the infant over the shoulder) has been found to be extremely effective in soothing crying infants. Conversely, when an infant is held upright and is given gentle vertical vestibular stimulation (moved up and down), alertness is increased. Vestibular can either increase or decrease arousal depending upon how it is used" (Vergara, 1993, p. 216).

The waterbed is viewed as a naturalistic, age-appropriate means of compensating for lack of vestibular-proprioceptive or movement stimulation experienced by pre-term infants (Deiriggi & Miles, 1995). A waterbed is a small pillow made of gel or water that is commonly covered in a soft material. Many benefits have been associated with the use of waterbeds which include improved weight gain, increases in time spent in sleep and in the quiet alert state, increases in durations of quiet and active sleep, fewer state changes, and less waking activity and fussing/crying (Deiriggi & Miles, 1995). Waterbed use has

also been attributed to improved motor coordination, greater weight gain, better sucking and more regular breathing (Ayres, 1979).

Deirggi and Miles (1995) completed an experiment focusing on the effects waterbeds had upon the preterm infant's heart rate. They stated that heart rate is a correlate of oxygen consumption and is reflective of energy consumers other than activity and wakefulness. This would imply that any reduction in heart rate has implications for increasing energy available for growth. The subjects were 27 preterm infants who were healthy and stable and no older than 36 weeks post conception. The infant's baseline heart rate was gathered on day one by a digital heart rate monitor. On day two infants were placed on the waterbed where they stayed for 4 days. They were taken off the waterbed, after the heart beat count, on Day 6 and returned to the standard incubator mattress and studied for the next four days.

The results found that the infant's heart rates on the waterbed were not lower than the baseline values but their heart rates increased when taken off the waterbed and returned to the standard mattress. The subjective impression of the researchers revealed that the infants did seem quieter on the waterbed and seemed to rest better. The researchers hypothesized that the change in the infant's environment caused the reactivity in the heart rate as the infant had become accustomed to the standard mattress, which would make the transfer to the waterbed stressful. Another concern was the heartbeat of the infant might be too variable to be useful as a means of comparison and providing meaning about energy expenditure.

Auditory System

Fetal response to auditory stimuli has been observed intermittently as early as 24-25 weeks gestational age with consistent responses present after 28 weeks (Standley & Moore, 1995). Infants hear a wide range of auditory stimuli in-utero to which they first respond with avoidance reactions and distinguish a number of sounds at birth (Vergara, 1993). These sounds are primarily low-pitched, reaching a maximum of 70 to 80 dB and consists primarily of maternal heart beat and bowel sounds (Zahr & De Traversay, 1995, p. 448). The hearing threshold has been reported as 40 dB in the infant at 28 to 34 weeks gestation, 30 dB at 35 to 38 weeks gestation and <20 dB at term (Hunter, 2001, p. 645).

Typical NICU sound levels of 50 to 90 dB (comparable with street traffic and light machinery) with peaks to 120 dB (comparable with heavy machinery) have been documented (Hunter, 2001). These noise levels far exceed the recommendation of the American Academy of Pediatrics that noise levels in the NICU should not exceed 58 dB (Zahr & de Traversay, 1995). Environmental noise (mechanical and social) is constant throughout the day and night in the NICU. “Sound inside the isolette is characterized by continuous white noise and nonspeech sounds; harsh mechanical noises penetrate clearly, whereas speech sounds are indistinct” (Hunter, 2001, p. 645).

Premature infants are particularly susceptible to loud noises leading to damage because of sensitive cochleas and the immaturity of the organ of Corti (Zahr & Balian, 1995). Newborn guinea pigs, that have cochleae structurally similar to human ones, incurred damage to their cochleae when subjected to sound intensities of an average of 80 dB (range commonly found in the NICU) for 7 days. This research which leads to the

hypothesis that premature infants who experience similar noise levels may have sensorineural hearing loss (Zahr & de Traversary, 1995).

Zahr and Balian (1995) studied the responses of premature infants to routine nursing interventions and noise in the NICU. Three different sites were chosen (one in Beirut, Lebanon-setting I and two in California –settings II and III). There were 26 subjects from setting I, 16 from setting II and 13 from setting III. The infants ranged in weight from 480 g to 1930 g and were between 23 and 37 weeks of gestation. Research was performed for 2 hours in the morning and 2 hours in the evening observing routine nursing procedures and classifying them as highly intrusive (suctioning and needle puncture), moderately intrusive (chest physiotherapy), minimally intrusive (administration of medications) and other activities (feeding and diaper changing). Other factors observed included the infant's heart rate, respiratory rate and oxygen saturation, behavioral states measured by the Anderson Behavioral State Scale and noises were recorded every five minutes.

The results revealed that noise together with nursing interventions resulted in an acute fall in oxygen saturation in 20% of infants, an acute rise in heart rate in 19% of infants and an acute rise in respiratory rate of 17% of infants. Noise alone caused acute drops in oxygen saturation in 14%, an acute rise in heart rate in 16% of infants and acute rises in respiratory rate in 13% of infants. Interventions alone caused drops in oxygen saturation in 18%, acute increases in heart rate in 16%, and acute rises in respiratory rate in 12% (p. 182).

The average number of state changes in the four hour observation period was 24 times or 6 times per hour. Seventy eight percent of infants changed their behavioral state

in response to noise and nursing interventions. Most of these were from regular or irregular sleep to the fussy and crying states and were not able to maintain a single behavioral state for an extended period of time. Forty three percent of infants changed their behavioral state from the sleep state to the fussy/crying state in response to noise alone (p. 183).

Premature infants commonly react negatively to external stimuli due to the immaturity of their sensory system. Noises can be highly arousing for preterm infants in the NICU causing agitation and crying. This then decreases oxygenation and increases intracranial pressure, heart rate and respiratory rate; disrupts the sleep state and sleep cycle and may adversely affect the newborn's recovery and growth (Hunter, 2001). Sudden loud sounds such as ringing telephones and alarms are associated with a decrease in oxygen saturation levels, an increase in blood pressure and possibly intraventricular hemorrhage (Zahr & de Traversay, 1995).

Interventions include earmuffs, isolette covers, soothing music and the mother's voice, and environmental changes. Zahr and De Traversay (1995) completed a study on the use of earmuffs with premature infants as a way of reducing sound. The study was completed at two different hospitals in Los Angeles, California. In the first setting, 17 infants were randomly assigned to control (without ear muffs) and experimental (with ear muffs). The second setting had 13 infants act as their own controls as they were observed with ear muffs on one day and without another day. The ear muffs used in the study were minimuffs that reduced noise by 7 to 12 dB by the American National Standards and were made from foam material and sealed over the infant's ears with a hydrogel adhesive. A decrease of 6 dB reduces sound pressure by approximately 50% (p. 450).

The infants weighed between 480 to 1860 gm, had a gestational age from 23 to 36 weeks, and had a variety of medical complications. The infants' responses were measured through the recording of respiratory rate, heart rate, and oxygen levels every 5 minutes. Their behavior responses were assessed through the Anderson Behavioral State Scale and states are determined by respiratory regularity, eye opened or closed, degree of limb and trunk involvement activity and intensity of crying. Data was collected every 5 minutes for 4 hours on 2 consecutive days.

The results revealed that when infants wore the earmuffs, the mean oxygen saturation was significantly higher, the fluctuations in oxygen saturation were significantly lower and a decrease in the fluctuation of the respiratory rate was almost significant. They also spent significantly more time in the regular quiet sleep state with longer duration, less time in the irregular quiet sleep state, and had significantly fewer state changes. It is to be noted that these significant results were found when infants acted as their own control.

“Maternal heart beat is widely assumed to be a calming familiar sound because of the infant's intrauterine exposure” (Hunter, 2001, p. 677). Clinical studies have demonstrated the powerful and soothing effects of heart beat sound. This may come from the infant's familiarity with the stimulus; as the infant is able to recognize it and respond with a reaction that induces calming (Vergara, 1993).

“Pregnant women commonly report that towards the end of pregnancy, listening to fast music with heavy percussion tends to agitate the fetus, whereas listening to classical or soft music seems to have the opposite effect” (Vergara, 1993, p. 70). Caine in Standley & Moore (1995) demonstrated that music played in 30 minute increments 3

times per day from time in isolette to discharge significantly reduced the total length of hospital stay for premature infants. When sound is utilized in the NICU the therapist needs to closely observe the infant's neurobehavioral cues for stress and monitor the sound so it does not affect other infants.

Psychologic research has shown that infants prefer the mother's voice to all other auditory stimuli during the first few days of life (Standley & Moore, 1995). Standley and Moore (1995) observed the effect of 20 minutes of music listening across 3 days on oxygen saturation levels and occurrences of oximeter alarms compared to effects with responses to recordings to the mother's voice. Twenty 20 premature infants placed in radiant warmers or isolettes who received oxygen via nasal cannula or ventilator. Ten participants listened to 20 minutes of commercially recorded lullabies by female artists and ten listened to a recording of their mother's voice for 20 minutes proceeded and followed by 10 minutes of silence. The two groups were matched for sex, age and weight. The infants received auditory stimuli for 3 consecutive days while in their isolette or radiant warmer. Data was collected every 2 minutes throughout the 40-minute period on the infant's oxygen saturation level and the frequency of the oximeter alarms, which indicated a decreased level.

The study revealed that on day 1 the music stabilized and significantly increased oxygen saturation levels during the second 10-minute period. On day 2 and 3 there were no significant differences between the groups during the auditory stimulation. The music infants' oxygen levels were significantly depressed during the final observation period of silence after the termination of the music on both day 2 and 3. During the daily 40

minute observation period, the music group had decreased numbers of alarms during the music listening intervals with a significant decrease in the post 10 minute period.

Visual System

Visual sensory processing develops later in the fetus, as intrauterine visual sensory experiences are limited. According to Vergara (1993) full term neonates can fixate for as long as 10 seconds and may refixate on a stimulus every 1 to 1 ½ seconds when they lose contact with the stimulus. Premature infants develop the ability to focus briefly on stable objects by about 32 weeks postconception and to visually track a moving stimulus horizontally by 33 weeks postconception (p. 68). In order to facilitate visual focusing and tracking, the visual stimulus must be presented within 6 to 9 inches of the eyes. Vision is primarily monocular by this age and fixating on a stimulus may still cause physiologic instability. Premature infants have similar visual preferences to full-term infants by week 34, able to follow a moving visual stimulus horizontally as well as vertically and demonstrate neurobehavioral stability by 35 weeks and can track circularly by 36 weeks and visual accommodation develops postnatally (p. 69).

An infant's ability to respond to stimulation does not necessarily mean that stimulation is beneficial. An immature infant may stare because of his or her inability to break away; obligatory visual attention is not a preferred behavior (Hunter, 2001, p. 678). For example, increased attention to high contrast (i.e. black and white) stimuli may be obligatory rather than preferential. Generally, placement of a visual stimulus that the infant cannot escape is avoided.

According to Vergara (1993) full term neonates prefer human faces (animate visual stimulus) to nonhuman (inanimate) visual stimuli. The human face is the most

appropriate visual stimulus in early infancy (Hunter, 2001, p. 678). The “ideal” face is three-dimensional; provides slow contingent movement around the eyes and mouth; is situated at variable distances from the infant; changes to arouse or quiet the infant and is not always present (Hunter, 2001).

Long term effects of early visual experience on infant organization are inconclusive. Some studies report little or no effect of early visual experience on attentiveness where others report accelerated visual acuity. In one experiment Marshall-Baker, Lickliter & Cooper (1998), studied 20 healthy pre-term infants ages 27 to 36 weeks postconception and their response to orientating to a visual pattern in the incubator. The infants were observed in three successive 2-minute periods on two separate occasions (intervention/nonintervention days). All observation periods followed a feeding and began with each infant in supine position and a drowsy or quiet alert state.

In the first experiment, 20 healthy preterm infants (27 to 36 weeks post conception) were chosen to participate. Each infant was in the lower “step down” level of the NICU. The visual environments of the infants were unrestricted but black and white patterns or displays could not be placed in the incubators. The visual stimulus (a white acrylic disk with black stripes) was attached to a silent clock motor so it could rotate and was placed 7 inches from the infants’ face. The infants were observed in three successive 2-minute intervals on two separate occasions (one with intervention/one without). Two observers (one blind to hypotheses of study) evaluated the infant’s direction of gaze, length of time spent looking at the stimulus, behavioral state and heart/respiratory rate which are clues to visual responsiveness and nervous system functioning.

A non specific/less organized response to the stimulus was evident in the majority of infants who experienced a heart rate increase or decrease during the first exposure period. Infants did not attend more to the moving than the stationary visual display. The majority of infants oriented to the stimulus experienced periods of physiologic and behavioral homeostasis which included regular respiratory function, decreased heart rate and a bright alert state.

Marshall-Baker et. al, (1998) completed a second experiment to investigate the effects of prolonged exposure to a visual pattern on the infant's behavioral states and development of visual skills by placing a visual stimulus in the infant's incubators until discharge. Eighteen infants were randomly assigned to either an intervention or a control group which contained nine infants in each. Infants in the control group experienced routine care except that no photographs, mobiles or high contrast stimuli were placed in their incubators. The infants were assessed using the attention-interaction package of the Assessment of Preterm Infant Behavior scale.

Results found that preterm infants who had exposure to a visual pattern had higher scores, showed greater improvement on the visual component of the Assessment of Preterm Infant Behavior scale and showed significant decreases in their rates of state change. The decrease in the number of state changes indicate an increase in the length of uninterrupted time that the infants spent in behavioral states (quiet sleep, active sleep, etc.), which is hypothesized to provide opportunities for further integration and coordination of the infant's systems.

White-Traut, Cunningham, Nelson, Patel and Silvestri (1997) examined the responses of preterm infants to two forms of unimodal (auditory only and tactile only)

and two forms of multimodal sensory stimulation (auditory, tactile and visual; auditory, tactile, visual and vestibular).

The sample included 54 healthy preterm infants, clinically stable with mean gestational age of 32 weeks at birth, 33 gestational weeks into the study, birth weight between 1200 to 2353 g., could not be receiving oxygen therapy, free from congenital defects and not have seizure disorder. Infants were assigned randomly to one of five groups. Infants were assigned to either control group (C) received routine care, group ATVV received auditory stimulation (soothing female voice), massage for 10 minutes, 5 min. of rocking, and visual stimulation through eye to eye contact, Group ATV received 15 minutes of auditory, tactile and visual components of group ATVV, Group A received auditory stimulation and Group T received only tactile stimulation.

The investigators measured the pulse rate (PR), arterial oxygen saturation (SaO₂), respiratory rate (RR), and body temperature (BT) by digital displays. Data was also collected on the behavioral state of the infant (BS) (quiet sleep, active sleep, drowsy, quiet alert, active alert, crying and indeterminate) by a trained research assistant. The infants assigned to groups A, T, ATV, and ATVV received 15 minutes of stimulation once a day for four consecutive days. The immediate outcome measures included PR, RR, BT, SAO₂, and BS. The treatment was initiated for a 1 hour prior to late morning feeding. First baseline BT, PR, RR, SAO₂, and BS were obtained and were recorded every minute for five minute prior to treatment. After stimulation technique (16 minutes) those factors were recorded every 15 seconds for 1 minute, then again at 5, 10, 15, 20-minute intervals.

Group A responded with an increase in quiet (good) sleep. Group T experienced more alertness during and following intervention than Groups A and C but the fast pulse rates suggest more arousal than needed. Group ATVV had the highest percentage of maintained alertness. In this group, the infant's increased arousal was obtained more after intervention rather than during and was thought to be linked to the vestibular component, which is hypothesized to be used to modulate and organize behavior.

Olfactory System

The olfactory system has been minimally studied in infants. A few studies suggest that infants are capable of processing olfactory stimuli, can discriminate between certain olfactory stimuli and show olfactory preference for certain fragrances. The breast feeding neonate has the ability to discriminate his or her mother's breast milk on a nursing pad between a nursing pad with breast milk from another woman (Vergara, 1993). These infants can also recognize their mother by smell. Premature infants respond to odors with approach or avoidance; noxious odors can prompt physiologic instability and stress (Hunter, 2001).

Gustatory System

Most of the development of the taste system occurs postnatally and is believed to be somewhat functional in-utero. Full term neonates prefer sweet water to plain or sour water and milk to plain water, but cannot distinguish bitter or salty substances (Vergara, 1993). The preterm infant withdraws from bitter taste at 26 to 28 weeks postconception and calms to sweet taste at 35 weeks postconception (Hunter, 2001). While taste preferences are present in the newborn infant, the gustatory system is far from being fully

developed in the neonate. Not many studies have been done at the present time to investigate this system more in depth.

Environmental Demands of the Neonate

As stated previously, there is a ‘mismatch’ of the immature infant and the high tech environment. The environment that the neonate enters demands that he or she breathe, regulate body temperature, move against the effects of gravity, adjust to bright light and unmuffled noise and cope with invasive or painful procedures and frequent sleep deprivation. The infant’s immature central nervous system is competent for protected intrauterine life but not sufficiently developed to adjust to and organize the overwhelming stimuli and demands of the NICU (Als, 1986). Excessive sensory stimulation can cause insults to the developing brain and create maladaptive behaviors that contribute to later poor developmental outcomes. Three major areas of concern to the infant’s development include light, sound, and individuals working in the NICU.

Light

The infant is often placed supine and lighting is frequently directed at their eyes. Recent concerns about NICU lighting include exposure of infants to continuous, high-intensity light exposure, lack of systematic, rhythmic diurnal patterns, and the potential interaction between NICU lighting and retinopathy of prematurity (Blackburn, 1998, p. 283). This is a concern as preterm infants are not able to protect themselves from room light because they are unable to close their eyelids tightly until after 30 weeks, their thin eyelids do not adequately filter light and the iris does not significantly constrict until 30 to 34 weeks (Hunter, 2001).

The American Academy of Pediatrics has recommended guidelines of 100 foot-candles (ft-c) for adequate lighting in the NICU. Lighting comes from a variety of sources in the NICU including ceiling lights, phototherapy (300 to 400 ft-c), heat lamps, procedural lights (200 to 300 ft-c), and extensive direct window exposure that supplements artificial light (1,000 ft-c) (D'Agostino and Clifford, 1998). This varies greatly from the intrauterine environment that is generally dark with incidental light.

Continuous, intense, white fluorescent ambient light has been linked to chromosomal damage, disruption of diurnal biologic rhythms, changes in endocrine glands and gonadal function, and alteration of vitamin D synthesis in humans and other mammals (Hunter, 2001). Long-term deficits in visual acuity and color vision have been associated with biochemical and physiologic changes in the retina from lighting extremes in an NICU (D'Agostino and Clifford, 1998). Preterm infants are at an increased risk for a variety of vision problems including strabismus, refractive errors, amblyopia and vision processing deficits as well as retinopathy of prematurity (Blackburn, 1998). Light exposure has been associated with sleep deprivation of the infants in the NICU due to the lack of diurnal rhythm of light-dark cycles which may interfere with the development of normal biologic rhythms (D'Agostino and Clifford, 1998, p. 18).

Frank, Maurer and Shepherd (1991) surveyed NICUs to find their best control measures to modify the environment for light. Measures included low overhead lighting, individual lighting at infant's bedside, blinds on windows, scheduled infant rest periods, protection from phototherapy lights, positioning away from windows, shielding the infant's eyes during intervention, replacing lighting with cool-white bulbs, utilizing

isolette covers to block out noise, having tinted plastic over the isolette and staff awareness/training on the issue.

Other procedures include the use of natural lights from windows or skylights, light filtering goggles for a minimum of 4 weeks or until the infant reaches 31 weeks postconceptional age, lighting at immediate bedside be controlled to < 10 ft-c at night and 25 to 30 ft-c during the day to promote sleep (Hunter, 2001).

Sound

Sounds in the NICU come from a variety of sources; anticipated equipment noises and unanticipated sounds, including laughter, conversation and drawers closing. These sounds can range between 50 to 90 dB with peaks of 120 dB (D'Agostino and Clifford, 1998). Three concerns have been identified relating to the effects of NICU sound environment on the neonate: high intensity sound may cause damage to the cilia of the cochlea leading to hearing loss; repeated arousal of the infant to sounds in the NICU may deplete infant's physiologic resources and energy reserves, interfere with sleep and lead to fatigue and irritability and NICU noise may interact with ototoxic drugs and have an additive effect on susceptibility to hearing loss (Blackburn, 1998).

According to Hunter (2001) noise can be highly arousing for preterm and ill infants causing agitation and crying which may adversely affect the infants' recovery and growth. Loud or prolonged sounds can produce hearing loss, affecting the frequency range that corresponds to the frequency of the damaging sound at both low-frequency and high frequency ranges.

'People noise' is the greatest offender and can be surprisingly difficult to change (Hunter, 2001, p. 646). Change can be achieved through staff education, unit policies,

peer pressure and awareness activities. Staff can be reminded with verbal cues, 'quiet' signs, and dimming the NICU's lights to reduce noise. Staff should also be encouraged to limit conversation beside the isolette and during medical rounds, place the infants in isolettes as soon as possible, disallow radio use, turn off alarms while handling infants, and close incubator doors carefully (Frank et. al, 1991).

Hunter (2001) recommended the implementation of a quiet hour during which staff members whisper at the bedside, work quietly, do not allow large equipment to enter the unit, respond quickly to alarms and crying infants and rearrange caregiving activities to minimize infant disturbances. The optimal alternative is to keep noise at a minimum all the time.

Frank et. al, (1991) reported that NICUs ways to control noise environmentally included locating desks in separate rooms, scheduling infant rest and positioning infants away from sinks, ice machines, telephones and high traffic areas adaptations to oxygen hoods, modifications to telephones, padding of garbage receptacles, cushioning incubator doors, placing rubber tips on table legs, felt on the bottom of rockers.

Central vacuum systems, bacteriostatic carpet, acoustic ceiling tiles, soundproof or sound-absorbing building materials, and 'pods' that divide space for use by individual or a small number of infants can be considered in the design of the unit (Hunter, 2001). Topf (2000) suggests the following mechanical changes: having alphanumeric paging system to replace equipment alarms and the ring of the telephone, oiling and repair of squeaky equipment, using caution closing doors and drawers, keeping safety alarms at a low as necessary volume, combining treatments involving equipment, turning off any

unused equipment, divert overhead paging system to personal pagers set on vibrate and the wearing of rubber heeled shoes by staff.

For the physical structure of the NICU Topf states that there should be carpet in high traffic areas, redirecting some foot traffic with signs if two entrances are available acoustic barrier around nurses' station, and rooms for noisy equipment (computer printer, ice machine). Topf (2000) also recommends limiting the number of visitors, rubber trash barrels and that supplies and prepared treatments should be unwrapped away from the infant's bedside. Radios and cellular phones are often against NICU policy.

Isolette covers can significantly reduce noise level within the incubator. Avoidance of tapping on the isolette, abruptly closing incubator doors and portholes, and using the incubator top as a work surface or storage area are common recommendations (Hunter, 2001).

When providing therapy in the NICU therapists can cluster their treatment sessions to reduce the number of times they are entering and re-entering the unit and collaborate in making a schedule for individual infants and routines (Frank et. al, 1991).

Long Term Effects of the NICU on the Premature Infant

Infants born prematurely are at risk for developing developmental, sensorimotor or physchoeducational deficits (Weiner, Long, DeGangi and Battaile, 1996). In the results of studies of neonates weighing less than 1500 g, 62% to 80% have been reported as normal, 16% to 21% as having mild or moderate disability, 5% to 12% as having severe disability (D'Agostino and Clifford, 1998, p. 14). As a general rule, the lower the gestational age, the higher the incidence of major disability (p. 15).

Although general developmental outcome is improving for children born preterm, concerns persist about the children in more subtle areas such as visual motor skills, visual perceptual skills, academic achievement and attention (Weiner et. al, 1996). A 20-50% rate of neuro-developmental impairment during early childhood has been reported in extremely low birth weight infants that included reduced cognitive ability, psychomotor skills, and academic achievement and higher rates of mental retardation, cerebral palsy and visual disturbances (Falk, Eliakim, Dotan, Liebermann, Regev and Bar-Or, 1997, p. 1124).

Nearly half of preterm infants require special education services, with those whose birth weights are less than 750 g requiring the most services (D'Agostino & Clifford, 1998, p. 15). Reports suggest that extremely low birth weight children have difficulties at school including learning, motor performance, attention, problems with balance, fine and gross motor co-ordination and a reduced ability in sports (Burns, Ensbey and O'Callaghan, 1999). Forty five percent of 8 year old low birth weight children studied had difficulty with one or more subjects in school, compared with 11% of full-term children studied with reading, spelling and math skills being the more common areas of deficits for the LBW children (D'Agostino and Clifford, 1998). Other common areas of deficits include language (especially receptive comprehension, expressive vocabulary and word retrieval), following directions poorly, reading comprehension, visual-perceptual-motor problems, difficulties in sequencing, organizing visual information, and deficits in cognitive functioning (memorization, logical and abstract thinking, and spatial relations) (D'Agostino and Clifford, 1998).

Burns, Ensbey and O'Callaghan (1999) completed a study to investigate the type of motor problems which continued to present in otherwise normal extremely low birth weight (ELBW) children aged eight to ten years. Twenty nine ELBW children, eight to ten years were studied. All attended a regular primary school, had no major sensory, cognitive or motor impairment. These subjects had been regularly followed up on from birth to six years of age by their physician. Twelve children eight year old children (75% of them female) born at term eight year olds were tested under the same conditions to provide a comparison group. The ELBW children were given Slosson Intelligence test to evaluate the intellectual level. A 30 minute battery of eight previously published tests was given to assess postural stability and balance, finger position sense and repetitive movement, alternating movements, writing and upper limb strength/endurance. The results of testing were recorded as 0 = fail; 1 = poor; 2 = immature or mild deviation; and 3 = age appropriate or better.

The results revealed that there was a significant difference between ELBW children and term-born children on the measured tests. The ELBW children performed significantly lower than the normal eight year olds especially in the left leg standing balance and postural hold. These findings may explain the observed differences in gross and fine motor activities, balance and coordination noted by their school teachers.

Falk, Eliakim, Dotan Liebermann, Regev and Bar-Or (1997) completed a study to assess and compare neuromuscular performance measures in 5-8 year old children born prematurely at various levels of subnormal birth weight to age matched children born at term and at normal birth weight.

A total of 22 children from 5 to 8 years of age participated in the study and were found to be functionally and mentally within the normal range. Control subjects, matched by chronological age, were recruited from local kindergartens and schools. All control subjects were full term and weighed above 2500 g. The prematurely born children were divided into three groups: extremely low birth weight (<1000 g), very low birth weight (1000-1499 g) and low birth weight (1500-2000 g). The children's body mass and skin fold thickness was measured, a modified Wingate Anaerobic Test measuring power and fatigue of muscles was administered, a sample reaction time was taken utilizing a computer game and a vertical jump was performed to measure power, coordination and velocity.

The results revealed that ELBW subjects were found to be significantly younger than LBW subjects and had a smaller lean thigh cross-sectional area compared with the control group. No statistically significant difference was observed in the simple reaction time although the ELBW subjects were on average considerably slower. The height achieved in the vertical jump was lower in the premature group compared with the control group.

Summary

The evolution of medical technology and equipment has had a profound effect on the survival rates of large numbers of infants who would otherwise have died. At this time, research indicates that a fair percentage of children who were in the neonatal intensive care unit as infants have a higher prevalence of cognitive, sensory, motor and developmental problems (Taquino & Lockridge, 1999). This has led to the implementation of developmentally supportive care. Developmentally supportive care is

tailoring the infant's environment to reduce external stressors and to base interactions and interventions on the infant's unique behavioral and physiologic cues. Developmentally supportive care of the preterm infant has proven to have many positive benefits including to assist the infant's development and the organization of behavior, improve bodily system functions, and shorten hospital stays.

Developmentally supportive care is based upon the synactive theory of infant development proposed by Heidelise Als and the theory of neurobehavioral organization by Brazelton and Nugent. The synactive theory of infant development explains how infants interact with the environment through the various subsystems: autonomic, motor, state, interactive/attentional, and self regulation which are organized hierarchically with the premise that stability is needed in the lower subsystem for higher level functioning. Infants elicit signs of disorganization when stressed which affect the infant's subsystems. Neurobehavioral organization is the smooth interaction between the infant's physiological and behavioral systems a production of central nervous system function and maturation. This is also how well the infant is able to interact with the environment and cope with external stimuli due to the mismatch of the intra and extra uterine environments.

Health professionals assist the development of the infant through providing developmentally supportive care based on the needs of the infant by the signals they portray. Occupational therapists can assist this process by providing interventions that focus on the development of the infant's sensory system. Interventions are available for use by the occupational therapist to remediate problems in specific sensory areas.

CHAPTER 3

ACTIVITIES

The student met with Gail Bass, faculty member of the occupational therapy department at the University of North Dakota. The student expressed an interest in pursuing and exploring the role of the occupational therapist in the neonatal intensive care unit because the pediatric classes in the occupational therapy curriculum only touch on this very advanced and specialized area of practice. The project was specified to investigate developmentally supportive care which is currently being practiced in the neonatal intensive care unit and to evaluate how this treatment affects the development of the infant's sensory systems.

An extensive and thorough review of literature was completed investigating developmentally supportive care, the synactive theory of development, the theory of the neurobehavioral organization of the infant, infant development focusing on sensory systems and interventions utilized to assist the development of the preterm infants. The review of literature concluded that the neonatal intensive care unit does have negative effects upon the developing infant as evidenced by a staggering number of children who later have developmental problems and delays. Developmentally supportive care is beneficial to the infant as its implementation improves the infant's development, behavior, motor performance, and self-regulation abilities. Developmentally supportive care also causes stabilization of the infant's bodily systems, improves postures, increased weight gain and a shorter hospital stay.

A manual was developed to concisely summarize what treatments and interventions are available for the occupational therapist to utilize in the neonatal

intensive care unit. The literature review led to how the manual would be developed as it provides an introduction to developmentally supportive care, the synactive theory of infant development and neurobehavioral organization. The manual is divided into the infant's sensory systems and interventions that can be utilized to remediate problems within them. Each section provides a brief background of the sensory system (why it is important, when it is developed, what in the neonatal intensive care unit affects it) in an easy to read and understand format. Interventions for that specific sensory system are listed, described in detail and a reference is given for information if desired.

CHAPTER 4

PRODUCTS

This is the text of the manual that was compiled from the literature review. A copy is available at the University of North Dakota Occupational Therapy department for student use.

Introduction

The neonatal intensive care unit (NICU) is a complex and highly specialized hospital unit designed to care for infants who are born prematurely or are critically ill. The first special care unit for preterm newborns, established by Dr. Pierre Buding in 1893, was called the “Special Department for Weaklings” (Hunter, 2001). The current NICU is drastically different, as it is a place of bright lights, constant loud noises and sounds, temperature variations, painful procedures and equipment. This is a very different environment from which the infant emerges, as the intrauterine environment is a world of darkness, warmth and rhythmical movement. The following chart contrasts the intrauterine and extrauterine sensory environment (Hunter, 2001, p. 643).

SYSTEM	INTRAUTERINE	EXTRAUTERINE
TACTILE	Constant proprioceptive input; smooth, wet, usually safe and comfortable	Often painful and invasive; dry cool air; mostly medical touching instead of social touching
VESTIBULAR	Maternal movements; sleep cycles, amniotic fluid creates oscillating movements, flexed posture	Horizontal, flat postures Influence of gravity, restraints, & equipment.
AUDITORY	Maternal biologic sounds (heart, digestive system, bowels), Muffled environmental sounds.	Extremely loud, harsh, mechanical and constant noise.
VISUAL	Dark, may occasionally have very dim red spectrum light	Bright fluorescent lights.
THERMAL	Constant warmth, consistent temperature	Environmental temperature variations, high risk of neonatal heat loss.

Preterm infants deal with the extra-uterine environment with their immature organ systems and spend their last weeks or months of gestation in a different environment (Blackburn, 1998). This process of adaptation is potentially stressful and has an impact on the developmental outcome of the infant (D’Agostino & Clifford, 1998). This mismatch of intrauterine and extra-uterine environment and its effects on the neonate’s development presently and later in life has been studied.

History

According to Hunter (2001) p.638 and Taquino & Lockridge (1999) p. 65 three theories have led to the synthesis of developmentally supportive care. They are: Sensory deprivation, sensory overload and adequate but inappropriate sensory stimulation.

Sensory Deprivation

- ❖ During the 1940s-1950s infants were considered frail
- ❖ Staff followed strictly limited minimal stimulation guidelines (low lighting, quiet environments, restricted access by family and medical professionals)
- ❖ Was developed in 1960s-1970s due the lack of stimulation
- ❖ Staff began to implement structured programs with massage, stroking, PROM, vestibular & auditory input.
- ❖ This was based on the idea of neuroplasticity of the brain (respond appropriately to sensory stimuli & adapt to abnormal conditions)
- ❖ This theory was based on the “One Size Fits All” approach and was very inappropriate for stressed premature infants.

Sensory Overload

- ❖ Evolved during the late 1970s-early 1980s
- ❖ This theory stated that the infants were over-stimulated by the inappropriate stimuli of the NICU.
- ❖ Many individuals advocated for a return to minimal handling and reduction of sensory input.

Adequate but Inappropriate Sensory Stimulation

- ❖ Emerged during the late 1980s-1990s
- ❖ Was founded on the idea and observation that the unpredictable noise, light and handling in the NICU prevented infants from organizing an appropriate physiological or behavioral response to stimuli
- ❖ It was based on “Environmental Neonatology” which explored the influence of animate and inanimate environmental factors of the NICU.
- ❖ Physiological & behavioral responses of infant vary depending upon age & illness.
- ❖ The best way to plan care is to observe the way the infant responses to various environmental stimuli and complete care appropriately.
- ❖ This is idea is what developmental care is based on.

Developmentally Supportive Care

Developmentally supportive care is defined as “caregiving that fosters neurobehavioral and physiologic organization with individualized care for each infant based on ongoing assessment” (Blackburn, 1998, p. 284). Developmentally supportive

care is comprised from two main components: the synactive theory proposed by Heidelise Als in 1986 and the concept of neurobehavioral organization.

Synactive Model of Neonatal Behavioral Organization

- ❖ States that the infant interacts with the environment through 5 subsystems and the subsystems interact with each other.
 - ◆ **Physiologic (Autonomic)** = Biologic functions (cardiorespiratory, hormone production, etc.)
 - ◆ **Motor** = Motor activity, muscle tone & posture
 - ◆ **State** = Different states of consciousness & the transition between them.
 - ◆ **Attentional** = Refers to the infant's response to stimuli, being alert, attentive, etc.
 - ◆ **Self-regulation** = Ability to control & modulate other subsystems & calm themselves when exposed to stressful situations.

The subsystems are formed and develop in a hierarchical manner (Primitive to Self Regulation). The physiologic is the most primitive subsystem, the first to become functional and serves as the foundation for the stability of the entire system. The infant must have stability in the lower subsystems in order to be able to organize the higher subsystems. When the infant lacks stability in one subsystem, he or she will provide cues of disorganization (stress) of the immediately lower subsystem (Als, 1986).

When approached by a stimulus an infant can respond in 3 ways (Vergara, 1993, p. 31)

1. Interpret the stimulus as non-stressful & respond correctly without affecting physiological stability (**Self Regulation with Approach Signals**).
 2. Experience stress as the stimulus is presented but is able to engage in calming actions that DO NOT affect physiological & behavioral stability (**Self-Regulation with Coping Signals**).
 3. Responds to stimulus stressfully & is not able to overcome the negative effect of the stress (**Stress Reactions**).
- ❖ These are VERY IMPORTANT as these dictate whether treatment can be started, continued, or ended.

Self-Regulation Approach Signals (Als, 1982, p. 237)

- ◆ This means that the infant is able to maintain control and is well organized.
- ◆ **Signals include:** smiling or mouthing, "OOH" face, cooing, relaxed limbs, minimal motor activity, smooth body movements, alertness & a soft, relaxed facial expression.

Self-Regulation Coping Signals (Als, 1982, p. 237)

- ◆ These are to be interpreted as “**WARNING**” signals that the infant may be reaching maximum tolerance of stimulation and stress.
- ◆ An infant at this point still has the ability to become self-organized.
- ◆ These behaviors are **VERY** energy expending as the infant has to gather support from the lower subsystem.
- ◆ **Signals include:** leg bracing, placing their hand on their face, sucking, hand or foot clasp, grasping, fisting, assumption of a flexor pattern, bracing body against crib and shifting to a lower behavioral state (ex. between drowsy & light sleep).

Stress Signals (Als, 1982, p. 237)

- ◆ These are **THE MOST SERIOUS**
- ◆ May occur as a result of immaturity, disorganization of a system or stimulus.
- ◆ Can be classified by subsystem
- ◆ Changes in the attentional subsystem are the least serious and most serious occur in the physiologic subsystem.
 - ◆ **Physiologic**
Yawning, burping, hiccuping, gagging, spitting up, sneezing, startling, tremors, color changes (paleness, mottling, flushing cyanosis) & changes in vital signs (pulse rate, respirations, oxygen saturation)
 - ◆ **Motor**
Sitting on air, saluting, finger splaying, squirming, frantic & disorganized movements, trunk arching, tongue thrusting, gape face & generalized hypotonia.
 - ◆ **State**
Gaze aversion, gaze locking, glassy eyes, irritability, lack of alertness, crying & diffuse sleeping states.
 - ◆ **Attentional**
Inability to integrate social interaction with other sensory input & avoidance of social interactions.

The synactive theory stresses that if the infant is allowed &/or assisted to become reorganized after experiencing instability, the system can become balanced and intervention can be continued. Stress prevention should be the core element of any intervention program for fragile infants (Vergara, 1993).

Neurobehavioral Organization

- ❖ Is “the interaction between the infant’s physiological & behavioral systems” (Tarquino & Lockridge, 1999, p. 66).
- ❖ This organization affects how well the infant is able to interact with the environment & external stimuli.
- ❖ This is based on the infant’s states of consciousness.

- ❖ As the infant's nervous system matures, the infant can control neurobehavioral organization.

There are six states as classified by Brazelton & Nugget in Taquino & Lockridge, 1999, p. 68. They are as follows

- ◆ **Deep Sleep (1)**
The infant's eyes are closed without eye movement, regular respirations, minimal movement & delayed response to handling.
- ◆ **Light Sleep (2)**
The infant's eyes are closed with rapid eye movement, some spontaneous startles & movement, startled response to handling & stimulation may trigger a state change.
- ◆ **Drowsy (3)**
The infant is semi-dozing. The eyes are often open but may appear dull with the heavy eyelids that flutter. The infant has smooth movements and handling does trigger a change in state. This state is classified as a "Transitional State".
- ◆ **Quiet Alert (4)**
The infant is bright eyed and has minimal motor activity. This is the MOST appropriate stage for intervention & is the optimal state for responding to stimulation.
- ◆ **Active Awake (5)**
The infant's eyes are open. The infant commonly makes thrusting motions of the extremities and there is a high level of excessive motor activity, which is detrimental. The infant often has fussy vocalizations and may exhibit mildly distressed facial expressions.
- ◆ **Crying (6)**
The infant is intensely crying. Crying is a huge energy waster and should be avoided at all costs. There is also a high level of motor activity and the infant is difficult to calm and console in this stage.

The premature infant develops the ability to interact socially as the nervous system matures which is referred to as neurosocial behavioral development. Neurosocial behavioral development also affects neurobehavioral organization.

According to Gorski, Davidson & Brazelton in Bellig, 1989, p. 17-18 infants go through three developmental stages when the stability of each subsystem is achieved.

1. **"In-Going" Stage**
2. **"Coming Out" Stage**
3. **Reciprocity**

- ❖ **"In-Going" Stage**
 - ◆ Occurs when infants are under 32 weeks post conceptional age & physiologically unstable (Vergara, 1993, p. 63).
 - ◆ This stage requires all the infant's energy to maintain a steady autonomic state

- ◆ The infant has additional energy for interaction with the environment
 - ◆ EXTREMELY vulnerable to stimuli and are commonly overloaded by minimal sensory stimulation.
 - ◆ Infants in this stage are easily agitated.
 - ◆ Infants **SHOULD NOT BE SOCIALLY ENGAGED**.
- ❖ **“Coming Out” Stage**
- ◆ Occurs when infants are between 32 & 35 weeks postconceptional age & more physiologically stable.
 - ◆ Infants can handle some interaction.
 - ◆ The infant still needs to conserve energy to maintain a steady state.
 - ◆ The infant needs to be highly monitored during social interaction for signs of stress.
 - ◆ Intervention needs to be scheduled around the infant’s best periods.
- ❖ **Reciprocity**
- ◆ Occurs in infants 36 weeks postconceptional age.
 - ◆ The infants have fairly well defined states, good quality alertness & self-regulation abilities.
 - ◆ An infant in this stage has achieved smooth autonomic function which allows the infant more sustained interaction with the environment.
 - ◆ In this stage, an infant is ready for & has good tolerance for social interaction.

Infant Sensory Development

(According to White-Traut, Nelson, Burns & Cunningham, 1994)

- ❖ **Tactile/Cutaneous**
- ◆ Is the first system to develop during the first two months after conception.
 - ◆ The fetus is able to respond to tactile stimulation as early as 8-10 weeks post conception in utero with reflexive total body avoidance reactions (Vergara, 1993).
- ❖ **Vestibular/Proprioceptive**
- ◆ Is present & functioning by 80 days postconception.
- ❖ **Olfactory**
- ◆ Is present & functioning by 80 days postconception.
 - ◆ Studies have found premature infants have the ability to smell by the time they reach the 3rd trimester of development & elicit olfactory reflexes at 28-32 weeks.
- ❖ **Gustatory**
- ◆ Taste pathways begin to develop during the 11th week after conception.
 - ◆ Studies have found the formation of fetal taste buds at 11 weeks & are functional by 12 weeks postconception.

❖ Auditory

- ◆ The fetus is capable of responding to auditory stimulation at 6 months postconception.
- ◆ Full auditory nervous system functioning is achieved between the 25th & 27th weeks of gestation.
- ◆ Auditory processing capabilities continue to develop with CNS organization & may be altered by auditory experiences that differ from the usual intrauterine environment.

❖ Vision

- ◆ Is the last sense to develop during the last trimester.
- ◆ Color vision is poorly developed resulting in ‘Twilight vision’.
- ◆ Cortical responses to light have been recorded in premature infants at 26 weeks postconception.

Tactile System

This system is highly important for the emotional development of the infant and the development of parent/infant bonding. Touch builds the foundation for the complex and intimate interchange between infant and caregiver, supplying the infant with a beginning interpretation of the world, relationships he/she will rely on for survival and provide organization, stimulation, communication and emotional exchange (Browne, 2000, p. 61).

The tactile environment in utero varies greatly as the external environment is now comprised of painful tactile stimulation in the form of heel sticks, IV pricks and endotracheal tubes. The infant is exposed to this “medical” touch approximately 82 times a day and the handling is extremely stressful (D’Agostino & Clifford, 1998, p. 18). The infant begins to associate this kind of pain with touching and does not receive the “social” touch of caregivers that infants born full term receive. Interventions that assist in organization of these stimuli include infant massage, kangaroo care and swaddling/containment.

❖ **INFANT MASSAGE**

- ◆ Field (1994) describes massage as having three phases:
 - Phase 1 & 3 – Tactile Stimulation**
 - ◆ The infant is placed in a prone position & given moderate pressure stroking of the head & face region, neck, shoulders, back, legs & arms for 5 one-minute sessions.
 - Phase 2 – Kinesthetic**
 - ◆ This involves flexing of the infant's limbs (moving into flexion & then extension) while infant is in supine.

- ◆ Many benefits including facilitation of the parent-infant bonding process, reduction of stress & pain responses to painful procedures, greater weight gain, shorter hospitalizations, better respiration, circulation, digestion & elimination and helps induce sleep.

- ◆ Infants who benefit from massage are medically stable & are greater than 33 to 34 weeks postconception (Vergara, 1993).

- ◆ Younger medically fragile infants benefit more from the firm touch and static proprioceptive input of hand swaddling than infant massage (Hunter, 2001).

- ◆ Stroking can be done but needs to be done **GENTLY** but **FIRMLY** to prevent hypersensitive responses. As stroking can either increase (alert or decrease (soothe) arousal depending on the infant's state, sensory responsiveness and the way the tactile stimulation is done (Vergara, 1993).

- ◆ Touch tends to be relaxing when applied slowly & rhythmically and facilitative when done rapidly and intermittently.

- ◆ Aversive responses to tactile stimuli occur more frequently when infants are touched too softly, too long or when concentrated over one area of the body.

- ◆ **The infant needs to be monitored closely during intervention for stress or disengagement cues.**

❖ KANGAROO CARE

- ◆ Is the practice of parents holding their diaper clad premature infant beneath their clothing, chest-to-chest and skin-to-skin (Hunter, 2001, p. 651).
- ◆ The infant is held upright and prone against the parent's chest through which the infant receives tactile and thermal stimulation.
- ◆ This intervention is done ONLY by parents.
- ◆ Is an ancient method which become popular in South America during the late 1970s where incubators were unavailable (Vergara, 1993).
- ◆ Benefits include: support of autonomic stability, fostering improvement in basic physiologic functions such as cardiorespiratory stabilization; preventing loss of body heat which is maintained or increased during KC, reduces the time spent in active sleep, increases time spent in quiet, regular sleep
- ◆ Increased alertness, during KC, offers opportunities for self-regulating behaviors and produces a significant reduction in crying especially during painful procedures (Ludington-Hoe & Swinth, 1996).
- ◆ Benefits for parents include: facilitation of maternal milk production & longer duration of breast feeding, increased awareness of their infant's cues of well-being or distress, increased parental attachment & feelings of closeness to their infant, more confidence in their own caregiving ability & decreased maternal stress (Hunter, 2001).

❖ **CONTAINMENT & SWADDLING**

- ◆ Containment consists of using either the caregiver's hand or a soft blanket to "contain" the infant's extremities close to the body.
- ◆ A hand is usually placed on top of the infant's head while another hand or cloth gathers the infant's lower & upper extremities together & close to the body (D'Agostino & Clifford, 1998).
- ◆ This flexed position simulates the position in utero facilitating neuromuscular development by weightlessness and containment in flexion (Short, Brooks-Brunn, Reeves, Yeager & Thorpe, 1996).
- ◆ Swaddling is best used to prevent disorganized movements through providing containment to restrict motor activity & facilitate self-regulation behaviors (Vergara, 1993).
- ◆ Short et. al, (1996) state the benefits of swaddling include proprioceptive input & kinesthetic stimulation, supports hand-to-mouth maneuvers, facilitate motor organization, calm irritable infants, decreases physiologic arousal, prolongs daytime sleep states and pain-elicited distress.
- ◆ Nesting is forming a boundary around the infant & commonly used in combination with swaddling. The infant is in a supine position with the neck slightly flexed, the extremities flexed & adducted, the shoulders protracted, and the hands closer to the facial region in order to promote hand to mouth activity (Vergara, 1993, p. 155).
- ◆ Nests can be formed out of blanket rolls, foam or other soft materials. Others are available commercially such as the Snuggle-Up or Bendy-Bumper. The nests must be secured to the supporting surface for stability. Nesting promotes symmetry, midline orientation, reduces head flattening & intracranial pressure (Hunter, 2001).
- ◆ A neonatal hammock is an alternative to nesting in supine if the infant does not tolerate the nesting position well. Hammocks promote flexion, posterior pelvic tilt, shoulder protraction & midline orientation; may decrease lateral head flattening; and if elevated place the infant in a better position for visual stimulation (Vergara, 1993).

Vestibular System

The vestibular system provides humans the sense of balance through stimulation of the inner ear through semicircular canals and gravity receptors. This information is then processed by the vestibular nuclei and cerebellum which are part of the phylogenetically older system of the brain. By the 5th month in utero, the vestibular system is well developed and along with the tactile and visceral systems provides almost all of the sensory input to the fetal brain (Ayres, 1979). The fetus experiences strong vestibular input as he/she float around in utero in which their own vestibular system is actively stimulated by their own movements and passively stimulated by the mother's movements (Vergara, 1993).

Vestibular input is believed to promote maturation of other systems, especially the motor system (Vergara, 1993). Vestibular input can be received through rocking, handling, and the use of waterbeds.

Proprioceptive System

The proprioceptive system refers to the “sensory information caused by contraction and stretching of muscles and by bending, straightening, pulling, and compression of the joints between the bones” (Ayres, 1979, p. 35). In essence, proprioception is the unconscious awareness of body position and communicates to the muscles how much force is necessary for muscles to exert and grade movements. Individuals depend on the proprioceptive system to assist the brain to make sense of touch and movement experiences (Yak, Sutton & Aquilla, 1998).

❖ ROCKING

- ◆ Is particularly good for calming irritable infants especially if they are held firmly & are swaddled.
- ◆ Rocking without tactile containment increases startles and arousal in a severely irritable infant.
- ◆ Vestibular stimulation resulting from the upright position (holding the infant over the shoulder) has been found to be extremely effective in soothing crying infants. On the other hand, when an infant is held upright and is given gentle vertical vestibular stimulation (up and down movement), alertness is increased (Vergara, 1993).

❖ HANDLING

- ◆ Infant exercise programs have evolved that consist of range of motion (ROM) exercises for the extremities to be given at various times during the day. Benefits are NOT clear. ROM exercises must be used with **EXTREME CAUTION** with infants with low tone to prevent subluxation or muscle overstretching. High tone infants should NOT be given traditional exercises as it could increase tone (Vergara, 1993).

- ◆ Therapeutic handling is a more positive method to facilitate proprioception in infants. This method involves moving the infant in normal patterns to promote feedback from normal sensorimotor experiences.

- ◆ The main goal of motor development intervention/therapeutic handling with high risk infants is to decrease neck and trunk hyperextension, shoulder elevation & retraction and extension of the extremities. Emphasis is given to the facilitation of flexor patterns (Vergara, 1993, p. 220).

- ◆ The following techniques are used to elongate neck and trunk extensors in supine position (Vergara, 1993, p. 220).
 - Flex the pelvis & the lower extremities
 - Facilitate counter-rotation of the shoulder & pelvic girdles (the pelvis is rotated while shoulders are stable & head is aligned with shoulders)

- ◆ To elongate the neck & trunk extensors in prone
 - Flex the extremities (by tucking them under the body) promoting weight bearing through shoulders
 - Encourage head turning
 - Rock infant side to side

- ◆ To elongate the neck & trunk lateral flexors in sidelying
 - Roll infant side to side with the lower extremities moderately flexed to promote weight shifting & weight bearing through the shoulders, hips and feet.

- ◆ Handling can be progressed to the sitting or semi-inclined positions when the infant achieves a more advanced developmental age (at least 2 or 3 months beyond term age) by:
 - Encouraging head control
 - Rock side to side and front to back to promote head righting & weight bearing through the shoulders & upper back.

- ◆ To elongate the shoulder muscles in the supine position:
 - Apply deep pressure on the shoulders in a downward direction to elongate shoulder elevators

- Place infant's hands alongside the pelvis during other handling procedures to elongate shoulder elevators
 - Encourage midline activities in sidelying to elongate scapular retractors.
- ◆ Handling principles should be followed during routine care giving procedures such as lifting, carrying and diapering. The following principles should be kept in mind when lifting and carrying infants (Vergara, 1993, p. 221) :
- Head should be well-supported in midline with the neck in the neutral position or slightly flexed; sudden neck hyperextension should be avoided to prevent startles; excessive neck flexion may interfere with breathing.
 - Trunk should be slightly flexed
 - Shoulders should be slightly protracted with the hands in midline
 - Hips should be held in slight flexion
 - Agitated infants need to be contained firmly and moved slowly.

These are only some of the handling techniques used with newborn infants.

Physiologic stress must be closely monitored.

These techniques should only be used by adequately trained therapist and only with stable infants.

❖ WATERBED

- ◆ Is a small pillow made of gel or water that is commonly covered in a soft material.
- ◆ Are a VERY powerful source of vestibular stimulation (Vergara, 1993).
- ◆ A waterbed is viewed as a naturalistic, age-appropriate means of compensating for lack of vestibular-proprioceptive or movement stimulation experienced by pre-term infants (Deiriggi & Miles, 1995).
- ◆ Many benefits have been associated with the use of waterbeds including: improved weight gain, increases in time spent in sleep & in the quiet alert state, increases in duration of quiet & active sleep, fewer state changes, less waking activity & fussing and crying (Deiriggi & Miles, 1995).
- ◆ Waterbed use has also been attributed to improved motor coordination, greater weight gain, better sucking and more regular breathing (Ayres, 1979).
- ◆ Waterbeds must be used with **GREAT CARE**. Misused or overfilled waterbeds may increase rather than decrease physiologic instability & stress (Vergara, 1993).

Auditory System

Fetal response to auditory stimuli has been observed intermittently as early as 24-25 weeks gestational age with consistent responses present after 28 weeks (Standley & Moore, 1995). Infants hear a wide variety of auditory stimuli in utero to which they first respond with avoidance reactions and distinguish a number of sounds at birth (Vergara, 1993). These sounds are primarily low pitched, reaching a maximum of 70 to 80 dB and consists primarily of maternal heart beat and bowel sounds (Zahr & De Traversary, 1995, p. 448). The hearing threshold has been reported as 40 dB in the infant at 28 to 34 weeks gestation, 30 dB at 35 to 38 weeks gestation and <20 dB at term (Hunter, 2001, p. 645).

Typical NICU sound levels of 50 to 90 dB (comparable with street traffic and light machinery) with peaks of 120 dB (comparable with heavy machinery) have been documented (Hunter, 2001). These noise levels exceed the recommended level of 58 dB (Zahr & de Traversary, 1995). Environmental noise, mechanical and social, is constant through the day and night. Premature infants are particularly susceptible to loud noises leading to damage because of sensitive cochleae and immaturity of the organ of Corti (Zahr & Balian, 1995).

Premature infants commonly react negatively to external stimuli due to the immaturity of their sensory system. Noises can be highly arousing for preterm infants in the NICU causing agitation and crying. This decreases oxygenation and increases intracranial pressure, heart rate, blood pressure and respiratory rate; disrupts the sleep state and sleep cycle and may adversely affect the newborn's recovery and growth (Hunter, 2001).

Interventions to combat this include infant earmuffs, isolette covers, soothing music & the mother's voice, and environmental changes.

❖ EARMUFFS

- ◆ Zahr & de Traversay (1995) completed a study on the use of earmuffs with premature infants as a way of reducing sound.
- ◆ The study was completed at 2 different hospitals in Los Angeles, California. In 1st setting, 17 infants were randomly assigned to control group (without ear muffs) and experimental (with ear muffs). The 2nd setting had 13 infants act as their own controls as they were observed with ear muffs on one day and without another day.
- ◆ The earmuffs used in the study were mini-muffs that reduced the noise by 7 to 12 dB. A decrease of 6 dB reduces sound pressure by approximately 50%. The mini-muffs were made from yellow foam material and were sealed over the infant's ears with a hydrogel adhesive.
- ◆ The infants weighed between 480 to 1860 g, had a gestational age from 23 to 36 weeks & a variety of medical complications.
- ◆ Infants were measured through the recording of respiratory rate, heart rate, and oxygen levels every five minutes. Their behavior responses were assessed through the Anderson Behavioral State Scale and monitored the following factors: respiratory regularity, eye opening or closing, degree of limb & trunk involvement activity and intensity of crying.
- ◆ Results found that when the infants wore earmuffs, the mean oxygen saturation was significantly higher (good thing) and the fluctuations in oxygen saturation were significantly lower. They spent significantly more time in a regular quiet sleep state with longer duration, less time spent in irregular quiet sleep state and had significantly fewer state changes. These results were found when infants acted as their own control.

❖ MUSIC & MOTHER'S VOICE

- ◆ Maternal heart beat is widely assumed to be a calming familiar sound because of the infant's intrauterine exposure (Hunter, 2001).
- ◆ Psychologic research has shown that infants prefer the mother's voice to all other auditory stimuli during the first few days of life (Standley & Moore, 1995).
- ◆ Caine in Standley & Moore (1995) found that music played in 30-minute increments 3 times per day from time in isolette to discharge significantly reduced the total length of hospital stay for premature infants.
- ◆ Standley & Moore (1995) conducted an experiment to observe the effect of 20 minutes of music listening across 3 days on oxygen saturation levels and occurrences of oximeter alarms compared to effects with responses to recordings of the mother's voice.
- ◆ The study found that on Day 1 the music stabilized & significantly increased oxygen saturation levels during the second 10 minute period of observation time. On Day 2 & 3, there were no significant differences between the groups during auditory stimulation. The music infants' oxygen levels were significantly depressed during the final observation period of silence after the termination on Day 2 & 3. During the daily 40 minute observation period, the music group had decreased numbers of alarms during the music listening intervals with a significant decrease in the post 10 minute period.
- ◆ When using music with any infant be sure to monitor neurobehavioral cues of stress to determine whether the music is soothing or distressing. Sound vibrates in an isolette can be overwhelming; the sound should be very quiet/soft not to disturb other infants (Hunter, 2001).
- ◆ Soft human voice can be an appropriate auditory stimulus if not combined with other sensory input and if the infant is stable enough to be receptive (Hunter, 2001).

Environmental Effects

The environment that the neonate enters demands that he or she breathe, regulate body temperature, move against gravity, adjust to bright light and unmuffled noise, cope with invasive or painful procedures and frequent sleep deprivation. The infant's immature central nervous system is competent during intrauterine life but not sufficiently developed to adjust to and organize the overwhelming stimuli and demands of the NICU (Als, 1986). Excessive sensory stimulation can cause insults to the developing brain and create maladaptive behaviors that contribute to later poor developmental outcomes. Three major areas of concern to the infant's development include light, sound, and health care personnel working in the NICU.

❖ **LIGHT**

- ◆ The infant is often placed in supine & lighting is frequently directed at their eyes. This position exposes infants to continuous, high-intensity light exposure.
- ◆ Lighting is a concern as preterm infants are not able to protect themselves from room light because they are unable to close their eyelids tightly until after 30 weeks, the thin eyelids do not adequately filter light & the iris does not significantly constrict until 30 to 34 weeks (Hunter, 2001).
- ◆ The American Academy of Pediatrics has recommended guidelines of 100 foot-candles (ft-c) for adequate lighting in the NICU.
- ◆ Lighting comes from a variety of sources in the NICU including ceiling lights, phototherapy machines (300 to 400 ft-c), heat lamps, procedural lights (200 to 300 ft-c), & extensive direct window exposure that supplements artificial light (1,000 ft-c) (D'Agostino & Clifford, 1998).
- ◆ Continuous, intense, white fluorescent light has been linked to chromosomal damage, disruption of diurnal biologic rhythms, changes in endocrine glands & gonadal function and alteration of vitamin D synthesis (Hunter, 2001).
- ◆ Prolonged exposure to light also has negative effects on the infants vision by posing an increased risk of developing strabismus, refractive errors, amblyopia, vision processing problems, retinopathy of prematurity, and difficulties with visual acuity and color vision (Blackburn, 1998).

❖ LIGHT

INTERVENTIONS FOR CONTROLLING LIGHT IN THE NICU

(According to Frank, Maurer & Shepherd, 1991)

- ◆ Low overhead lighting.
- ◆ Individual lighting at infant's bedside.
- ◆ Blinds on windows.
- ◆ Scheduled infant rest periods (to assist with sleep/wake cycles).
- ◆ Protection from phototherapy lights.
- ◆ Positioning the infants away from windows.
- ◆ Shielding the infant's eyes during intervention.
- ◆ Replacing lighting with cool-white bulbs.
- ◆ Utilizing isolette covers to block out noise.
- ◆ Having tinted plastic over the isolette.
- ◆ Staff awareness/training on the issue.

Hunter (2001) also made the following suggestions:

- ◆ Use natural lights from windows & skylights
- ◆ The infants should use light filtering goggles for a minimum of 4 weeks or until the infant reaches 31 weeks post conceptional age
- ◆ Lighting at bedside should be controlled to < 10 ft-c at night and 25 to 30 ft-c during the day to promote sleep.

❖ NOISE

- ◆ Sounds in the NICU come from a variety of sources, anticipated equipment noises and unanticipated sounds including laughter, conversation and drawers closing. This can range between 50 to 90 dB with peaks of 120 dB (D'Agostino & Clifford, 1998).
- ◆ Concerns have been identified relating the effects of NICU sound on the neonate including high intensity sound may cause damage to the cilia of the cochlea which can lead to hearing loss, repeated arousal to sounds can drain the infant's energy and physiologic resources, interfere with sleep and lead to fatigue & irritability (Blackburn, 1998).
- ◆ Noise can be highly arousing for preterm & ill infants causing agitation & crying which may adversely affect the infant's recovery and growth. Loud or prolonged sounds can produce hearing loss, affecting the frequency range that corresponds to the frequency of the damaging sound at both low-frequency and high frequency ranges (Hunter, 2001).
- ◆ Noise is divided into three types: people, physical and mechanical.

❖ PEOPLE NOISE

- ◆ “People noise” is the greatest offender and can be surprisingly difficult to change (Hunter, 2001, p. 646).
- ◆ Change can be achieved through staff education, unit policies, peer pressure and awareness activities.
- ◆ Staff can be reminded through verbal or ‘quiet’ signs & dimming of the lights to signify a reduction in noise.

Frank, Maurer & Shepherd, 1991 Suggest:

- ◆ Staff should also be encouraged to limit conversation beside the isolette and medical rounds.
- ◆ Staff should place the infant in the isolette as soon as possible & close the incubator doors carefully.
- ◆ There should be no cell phones, radios or pagers used in the NICU.
- ◆ Staff should cluster treatment sessions to reduce the number of times they are entering and re-entering the unit & base scheduling on infant.

Hunter, 2001 suggests:

- ◆ The implementation of a quiet hour during which staff members whisper at the bedside and work quietly.
- ◆ That large equipment should not be allowed to enter the unit.
- ◆ Staff should respond quickly to alarms and crying infants.
- ◆ Caregiving activities should be rearranged to minimize infant disturbances.

**THE OPTIMAL ALTERNATIVE IS TO KEEP NOISE AT A MINIMUM ALL
THE TIME.**

❖ PHYSICAL

- ◆ This refers to the structure of the environment that the infant is in.

Frank, Maurer & Shepherd 1991 suggest:

- ◆ Placing desks in separate rooms.
- ◆ Scheduling infant rest periods
- ◆ Positioning infants away from sinks, ice machines, telephones and high traffic areas.
- ◆ Bacteriostatic carpet
- ◆ Acoustic ceiling tiles
- ◆ Have the area made of soundproof or sound absorbing materials.

Topf, 2000 suggests:

- ◆ Redirecting some foot traffic with signs if two entrances are available.
- ◆ Carpet should be placed in high traffic areas to cut down on noise.
- ◆ An acoustic barrier should be placed around the nurses' station to block noise.
- ◆ Noisy equipment (computer printer, ice machine, etc.) should have and be stored in a separate room.
- ◆ The number of visitors should be limited
- ◆ Supplies and prepared treatments should be unwrapped away from the infant's bedside.

❖ MECHANICAL

- ◆ This refers to the actual machinery commonly located in the NICU.

Frank, Maurer, & Shepard, 1991 suggest:

- ◆ Adaptations to oxygen hoods.
- ◆ Modifications to telephones.
- ◆ Padding of garbage receptacles
- ◆ Cushioning incubator doors.
- ◆ Placing rubber tips on table legs.
- ◆ Putting felt on the bottom of rockers.

Topf 2000 recommends:

- ◆ Having an alphanumeric paging system to replace equipment alarms and the ring of the telephone.
- ◆ Regular oiling and repair of squeaky equipment.
- ◆ Using caution closing doors and drawers.
- ◆ Keeping safety alarms at a low as necessary volume.
- ◆ The combining of treatments involving equipment
- ◆ The wearing of rubber heeled shoes by staff.
- ◆ Turning off any unused equipment.
- ◆ Diverting overhead paging system to personal pagers set on vibrate.
- ◆ Rubber trash barrels.

Hunter 2001 suggests

- ◆ The use of isolette covers. An isolette cover is commonly made of a soft material and is placed over the isolette. It can significantly reduce the noise level within the incubator.
- ◆ Avoidance of tapping on the isolette, abruptly closing incubator doors and portholes, and using the incubator top as a work surface or storage area.

VISUAL SYSTEM

The visual sensory processing develops later in the fetus, as intrauterine visual sensory experiences are limited. Full term neonates can fixate for as long as 10 seconds and may refixate on a stimulus every 1 to 1 ½ seconds when they lose contact with the stimulus (Vergara, 1993). Premature infants develop the ability to focus briefly on stable objects by about 32 weeks postconception and to visually track a moving stimulus horizontally by 33 weeks postconception. In order to facilitate visual focusing and tracking, the visual stimulus must be presented within 6 to 9 inches of the eyes (Vergara, 1993). Vision is primarily monocular by this age and fixating on a stimulus may still cause physiologic instability.

An infant's ability to respond to stimulation does not necessary mean that stimulation is beneficial. An immature infant may stare because of his or her inability to break away; this obligatory visual attention is not a preferred behavior (Hunter, 2001). For example, increased attention to high contrast stimuli (i.e. black and white) may be obligatory rather than preferential. Generally placement of a visual stimulus that the infant cannot escape is avoided.

According to Vergara, 1993, full term neonates prefer human faces (animate visual stimulus) to nonhuman (inanimate) visual stimuli. The human face is the most appropriate visual stimulus in early infancy. The "ideal" face is three-dimensional; provides slow contingent movement around the eyes and mouth; is situated at variable distances from the infant; changes to arouse or quiet the infant and is not always present (Hunter, 2001).

❖ VISUAL STIMULUS

- ◆ Long term effects of early visual experiences on infant organization are inconclusive. Some studies report little or no effect of early visual experience on attentiveness where others report accelerated acuity.
- ◆ An experiment by Marshall-Baker, Lickliter & Cooper (1998) studied 20 health pre-term infants ages 27 to 36 weeks postconception and their response to orientating to a visual pattern in the incubator. This visual stimulus was a white acrylic disk with black stripes attached to a silent clock motor so it could rotate and was placed 7 inches from the infant's face.
- ◆ The results revealed that a disorganized response to the stimulus was evident in the majority of infants who experienced a heart rate increase or decrease during the first exposure period.
- ◆ Infants did not attend more to the moving than the stationary visual display. A majority of the infants oriented to the stimulus and experienced periods of physiologic and behavioral homeostasis (regular respiratory function, decreased heart rate and a bright, alert state).
- ◆ Another experiment by Marshall-Baker, Lickliter & Cooper (1998) investigated whether prolonged exposure to the visual pattern would affect the infant's behavioral states and development of visual skills.
- ◆ Eighteen infants were randomly assigned to an intervention or control group.
- ◆ The results revealed that preterm infants who had exposure to a visual pattern had higher scores, showed greater improvement on the visual component of the Assessment of Preterm Infant Behavior scale and showed significant decreases in their rates of state change.

OLFACTORY SYSTEM

The olfactory system has been minimally studied in infants. A few studies suggest that infants are capable of processing olfactory stimuli, can discriminate between certain olfactory stimuli and show olfactory preference for certain fragrances. The breast feeding neonate has the ability to discriminate his or her mother's breast milk on a nursing pad from a nursing pad with another woman's breast milk (Vergara, 1993).

GUSTATORY SYSTEM

Most of the development of the taste system occurs postnatally and is believed to be somewhat functional in utero. Full term neonates prefer sweet water to plain or sour water and milk to plain water, but cannot distinguish bitter or salty substances (Vergara, 1993). The preterm infant withdraws from bitter taste at 26 to 28 weeks postconception and calms to sweet taste at 35 weeks postconception (Hunter, 2001). While taste preferences are present in the newborn infant, the gustatory system is far from being fully developed in the neonate. Not many studies have been done at the present time to investigate this system in more depth.

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CHAPTER FIVE

SUMMARY

At the conclusion of the literature review and completion of the manual there are many recommendations. A recommendation is made for more research on the infant's vestibular, proprioceptive, gustatory, and olfactory systems to know how the environment of the neonatal intensive care unit affects these aspects. Research needs to be completed in the areas of interventions and treatments for the vestibular, proprioceptive, gustatory and olfactory systems. Infant neurological development and the integration of sensory stimulation should be investigated as this may lead to the development of more appropriate and improved interventions and treatments. An analysis of the neonatal intensive care unit environment and how it specifically affects the infant's development and maturation should be conducted as it would allow professionals to understand how and why this 'mismatch' leads to later deficits in life.

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