Supplemental Stimulation of Premature Infants: A Treatment Model

John N. I. Dieter and Eugene K. Emory
Emory University

Received December 15, 1995; accepted April 1, 1996

Examined the human infant literature on supplemental stimulation to delineate a course of intervention based on the ontogeny of the nervous system and the impact that systematic stimulation may have on behavioral organization in the premature infant. Effects of vestibular, tactile/kinesthetic, auditory, and oral stimulation are discussed with respect to their similarity to the intra- or extrauterine environment. Long-standing theoretical and methodological problems are discussed, and a "sequential multimodal treatment model" is introduced.

KEY WORDS: prematurity; stimulation; tactile; vestibular; kinesthetic.

Between 5 and 15% of all live births in the United States are premature (i.e., born before 38 weeks of gestation). They are disproportionately high among African American women with 18% of all live black births being premature. Only 8.5% of live births to Caucasian women are preterm. African American neonates account for 31% of all premature deaths (Emory, Hatch, Blackmore, & Strock, 1993). The etiology of prematurity is not fully understood. Preterm birth is related to fetal abnormalities, maternal age and health, parity, and multiple births: other factors include poor prenatal care, cigarette smoking, psychosocial stress, low education, and socioeconomic status (SES) of the mother (Wittenberg, 1990).

1Supported by National Institute of Mental Health Fellowship 1 F31 MH11161-01 to John Dieter and Grant RO1-HD28382 to Eugene Emory. The authors express their appreciation to Tiffany Field for her thoughtful comments and suggestions.

2All correspondence should be sent to John Dieter, Department of Psychology, Emory University, Atlanta, Georgia 30322.
Numerous reports indicate that prematurity is associated with substantial developmental impairment. Initial difficulties include problems with autonomic control, state organization, and attention regulation (Als, 1986). More long-standing problems include auditory and visual deficits and delays in cross-modal transformations (Rose, Gottfried, & Bridger, 1978); abnormal reflexes (Howard, Parmelee, Kopp, & Littman, 1976), inferior grasping and hand use; lower IQ, language and reading difficulties, academic underachievement (Cohen, Parmelee, Beckwith, & Sigman, 1986); and behavioral problems such as hyperactivity and internalizing disorders (Rose, Feldman, Rose, Wallace, & McCarton, 1992).

**SUPPLEMENTAL STIMULATION: AN OVERVIEW**

In an effort to decrease the immediate adversities and developmental deficits associated with prematurity, numerous researchers have investigated the effects of various types of supplemental stimulation. The different forms of stimulation have included vestibular, tactile, kinesthetic, auditory, oral, and various multimodal combinations. These interventions have been initiated to compensate for environmental deprivation, or to accelerate the development of the premature infant. A point of contention among the exponents of the various approaches has been whether stimulation should attempt to capture elements of the intra- or extrauterine environments (Cornell & Gottfried, 1976).

Advocates of vestibular stimulation generally view the premature infant as an "extrauterine fetus" (Als, 1986) who has been denied the full benefits of the vestibular stimulation inherent to the womb (Korner, 1990). Supplemental vestibular stimulation has been provided through spinning hammocks (Neal, 1968), rocking cribs (Van den Daele, 1970), oscillating waterbeds (Korner, Kraemer, Haffner, & Cosper, 1975), and cradled rocking (Rice, 1977). Most proponents of tactile stimulation maintain that its benefits arise from the touching inherent in the mother-infant relationship (Korner & Thoman, 1972). Supplemental tactile stimulation has included extra holding (Hasselmeyer, 1964), cephalocaudal rubbing (Solkoff, Yaffe, Weintraub, & Blase, 1969), gentle stroking (Kramer, Chamorro, Green, & Knudtson, 1975), and passive touching (Jay, 1982). Kinesthetic stimulation, in the form of passive limb movements, is usually administered conjointly with massage (Scafidi et al., 1986).

Exponents of auditory stimulation have taken both an intra- and extrauterine approach to treatment. Auditory stimulation is usually a component of a multimodal protocol. Some investigators have presented recordings of heartbeat to the preterm infant (e.g., Schmidt, Rose, & Bridger, 1980); others have used recordings of the mother's voice (e.g., Segall, 1972) or the live speech of the therapist (e.g., Leib, Benfield, & Guidubaldi, 1980).

Oral stimulation facilitates nonnutitive sucking via a pacifier. This cost-
Supplemental Stimulation

effective method has proven useful for shortening the transition from tubal to bottle feeding (Porter-Measel & Anderson, 1979); maturing the suck reflex (Bernbaum, Gilberto, Watkins, & Peckham, 1983); promoting oxygenation (Burroughs, Asonye, Anderson-Shanklin, & Vidyasagar, 1978) and weight gain (Field, et al., 1982); soothing preterm infants during invasive procedures (Field & Goldson, 1984), and for regulating state (Gill, Behinke, Conlon, McNeely, & Anderson, 1988).

Multimodal strategies have included various combinations of vestibular, auditory, and/or tactile (-kinesthetic) stimulation. Although visual processing has been examined in premature infants (e.g., Allen & Caputo, 1986), very few multimodal (and apparently no unimodal) intervention studies have included visual stimulation. A common rationale for omitting visual stimulation is that this system is not fully developed at the time when most preterm infants are born.

Across studies there is considerable evidence that supplemental stimulation produces positive effects on development which include decreased apnea, more stable organization of state, increased weight gain, a decrease in abnormal reflexes, superior sensory and motor performance on behavioral assessments, and earlier hospital discharge (Field, 1980, 1988). Although the effects of stimulation upon later neurological and psychological development have been questioned (e.g., Russman, 1986), Harrison (1985) reported increased Bayley scores on follow-up, accelerated social development, and higher infant intelligent scores.

Methodological Concerns

Supplemental stimulation research arose primarily from a desire for intervention. Considering the developmental deficits associated with prematurity, a clinically oriented approach is understandable, however, numerous authors have criticized research on supplemental stimulation because it lacks theoretical direction and sound experimental methodology (Ottenbacher et al., 1987).

Subject Variables. The most persistent criticisms with regard to subjects include the use of small samples, the failure to include sick preterms, and the means with which subjects are assigned to experimental and control conditions (Harrison, 1985). An evaluation of recent studies indicates that efforts have been taken to correct these shortcomings. A problem that persists is that the range of gestational ages and birth weights which compose most samples is quite broad. These samples are generally treated as homogeneous when statistical analyses are conducted. In 14 investigations in which either tactile or vestibular stimulation (the most common forms of intervention) was the predominant treatment, the average range of gestational ages across experimental and control subjects was almost 5½ weeks. Within-sample birth weights were also quite disparate.
and varied across subjects by over 700 grams. These variations across studies make comparisons fairly difficult, and fail to consider maturity as a factor affecting the outcome of supplemental stimulation.

**Design Issues.** Two group designs have been the standard. In general, experimental groups receive supplemental stimulation and control groups do not. Efficacy has been evaluated with either pre- and posttests, or posttest-only evaluations. Dependent variables commonly include growth measures, activity levels, sleep–wake organization, and performance on developmental assessments. Independent variables have been defined along four dimensions; the sensory modalities stimulated: the form of stimulation; the use of uni- or multimodal stimulation, and the time of onset, intensity, periodicity, frequency, and duration of stimulation. The most common approach to analysis is the evaluation of the experimental and control subjects on a number of preselected variables (e.g., weight gain). Most researchers utilize various forms of analysis of variance and covariance which are then supplemented by planned comparisons. Cornell and Gottfried (1976) raised concerns about the overreliance upon two-group pre- and posttreatment designs: Specifically, they argued that standardized pretreatment assessments (e.g., the Brazelton) can serve as contaminating stimulation. As an alternative, they recommended the four-group design of Solomon and Lessac (1968) because it combines the posttest-only and pre- and posttest approaches. While a four-group design might prove fruitful, it appears that the recommendation of Cornell and Gottfried (1976) has not been followed.

**Procedural Issues.** Others report that common procedural inadequacies include a reliance upon short-term follow-ups, and a lack of attention to individual needs (Field, 1980). In those cases when follow-up measures are obtained, the follow-up has been limited to the first year. A recent advance in this area has been the introduction of home-based stimulation programs (Resnick, Armstrong, & Carter, 1988) which include longer assessment periods. Field (1980) criticized individualized approaches to stimulation for research purposes. In contrast, Lester and Tronick (1990) proposed that an individual infant’s reaction to stimulation can be used to guide intervention (e.g., signs of stress or avoidance). Although this suggestion is important for clinical efforts, this approach would confound uniform administration of treatments across research subjects. Another procedural criticism is that stimulus parameters have often been arbitrarily selected (Ross, 1984). As Rose, Schmidt, Riese, and Bridger (1980) argue, “The design of intervention programs is complicated by the fact that there is no compelling rationale for selecting any specific type, quality, or patterning of stimulation” (p. 417). Furthermore, when arbitrarily selected protocols demonstrate positive results, they are often adopted without additional assessment.

**Theoretical Concerns.** While the criticism of Rose et al. (1980) may be overstated, it does highlight the need for more theoretically oriented research. The relevant theoretical issues can be grouped under three broad concerns:
Impact of Adverse Stimulation in the Early Preterm Neonate's Environment.
This issue relates to the integrity of the premature nervous system, environment
of the neonatal intensive care unit (NICU), and the impact of premature delivery
on social-emotional development. There has been considerable debate about
whether the days or weeks that most premature infants spend in the incubator are
harmful or helpful with respect to behavioral organization (Tronick, Scanlon, &
Scanlon, 1990). The NICU environment can have negative effects (e.g., Law-
son, Daum, & Turkewitz, 1977) although researchers have not documented
definitively whether developmental deficits relate to sensory deprivation, over-
stimulation, or a pattern of inappropriate stimulation.

Consensus Over Which Underlying Mechanisms Are Responsible for Im-
provement. Occasional reference to the work of Hebb (1947) and Piaget (1952)
indicates that stimulation may facilitate the development of associative cortical
tissue via sensory-motor activation (Wright, 1971). Some support for this view
comes from the work which examines the effects of environmental deprivation
and enrichment on the neurochemistry and behavior of rodents and primates
(e.g., Harlow, 1958; Schanberg, Evoniuk, & Kuhn, 1984). However, others
object to the use of animal “brain plasticity models” to interpret the findings of
human stimulation programs. (Lester & Tronick, 1990). Another important de-
bate is whether the benefits of intervention arise from techniques which arouse or
soothe the infant. Many investigators maintain that the benefits of intervention
come from its effect upon behavioral state (e.g., Horowitz, 1990; Tronick et al.,
1990). However, the relationship between modality of stimulation and its effect
on the preterm infant is not clear-cut. The complexity of this debate can be
illustrated by the example of weight gain, a common benefit of supplemental
stimulation. Using very different approaches both Field et al. 1986 (cephalocau-
dal massage) and Field et al. (1982) (oral stimulation via a pacifier) found that
their experimental subjects gained more weight than controls. These similar
findings were surprising given that tactile stimulation is thought to produce
alertness, while oral stimulation usually soothes infants and promotes quiet atten-
tiveness. Uvnas-Moberg, Wildstrom, Marchini, and Winberg (1987) has specu-
lated about why different forms of supplemental stimulation enhance growth.
They suggest that stimulation such as massage and nonnutritive sucking activate
the vagal nerve which in turn promotes the release of gastrointestinal (GI) hor-
mones such as gastrin and cholecystokinin. The effect of these hormones in-
cludes the stimulation of GI motoric and secretory activity, the growth of the GI
tract, the promotion of glucose-induced insulin release, and the enhancement of
the infant’s energy economy. Uvnas-Moberg et al. (1987) hypothesized that
sucking enhances GI functioning through the activation of sensory nerves in the
oral mucosa which stimulates the vagal nerves. Tactile stimulation is thought to
promote vagal mediation via the direct stimulation of peripheral nerves such as
the sciatica.
An Absence of Consensus Over Which Sensory Modality Should be Stimulated, and When and How Much Intervention is Appropriate. The selection of which sensory modality to stimulate and the course that intervention should take has been either an arbitrary decision, or has been based upon whether the investigator believes that stimulation should mimic the intra- or extrauterine environments. Korner (1984) has maintained that initial stimulation should be similar to that experienced in the womb (e.g., oscillations that match the frequency of the mother's respiration). As an added but related dimension, Korner (1990) and Greenough (in Rose, 1984) suggest that stimulation should reflect the ontogeny of the senses. However, no specific details have been provided as to how this suggestion might be accomplished.

THE POTENTIAL ROLE OF ONTOGENY IN SUPPLEMENTAL STIMULATION

When reference to a possible relationship between ontogeny and supplemental stimulation is made (e.g., Greenough in Rose, 1984), the seminal work of Gottlieb (1971) is most often cited. Gottlieb proposed a sequential development of sensory systems which was essentially invariant across mammalian and avian species. Based upon work on chick embryos, and later synthesized with findings from other research, he proposed a chronological sequence of sensory development consisting of cutaneous/tactile, vestibular, auditory, and visual. Furthermore, sensory stimulation plays a major role in regulating "species-typical" maturation, especially with development of perceptual abilities. Gottlieb proposed that variation in the developmental rate in any one system could alter the rate in another system.

An Intervention Caveat

Turkewitz and Kenny (1985) warned that supplemental stimulation of immature sensory systems has been shown to have detrimental effects on more mature systems in animals (e.g., surgically opening the eyes of rat pups prior to age limited the rats' ability to differentiate scent and produced abnormalities in homing patterns). These authors proposed that the sequential development of sensory functions provide a basis for their organization and integration. Stimulation of a less mature system creates a condition of sensory competition which disrupts development. In an investigation of ducklings, Gottlieb, Tomlinson, and Radell (1989) found that premature experience with pattern vision suppressed these animals' learning of a maternal call.

Findings on full-term healthy human newborns further indicates that supple-
mental simulation that is inappropriate to a system’s level of maturity is detri-
mental. Using a multimodal approach which consisted of vestibular (a spinning
hammock), auditory (stimulated heartbeat), and tactile (massage) stimulation,
Koniak-Griffin and Ludington-Hoe (1987) found that after 1 month of daily
treatment (lasting hours at a time), the performance by the treated infants on the
Brazelton Scale (Brazelton, 1973) showed less mature orientation, motor, and
state regulation behaviors than the control group. The authors concluded that
while attempts to provide stimulation that is similar to that experienced in the
womb might be beneficial to the immature CNS of the preterm, such efforts
appear to retard the development of full-term infants.

GUIDELINES FOR INTERVENTION

As indicated, there is little current agreement across investigators about the
course that premature infant stimulation should take. Authors seem to be leaning
towards the direction that the type of stimulation may be less important than
whether it promotes state regulation (Horowitz, 1990). This is typified by Rose’s
(1984) statement that “intervention in any modality can provide the ‘fuel for
organization’” (p. 97). However, others canvas for a unimodal approach (in
order to avoid overstimulation, e.g., Lester & Tronick, 1990) and because pre-
terms lack multimodal contingencies (Turkewitz & Kenny, 1985), and a few
argue for a specific treatment (e.g., Korner for vestibular). The suggestion of
Thoman, Ingersoll, and Acebo (1991) that stimulation should be adapted to the
individual needs of the infant offers an important alternative to how one might
plan intervention. The best approach towards intervention may be one that avoids
overstimulation of the visual and auditory systems and focuses instead upon
more mature systems (e.g., tactile and vestibular).

Potential clinical guidelines for the supplemental stimulation of preterms
may lie in an examination of the effects the different treatments have upon the
behavioral organization of the infant. The crucial factor may be how well the
infant tolerates stimulation in relationship to its gestational age and health status.
Although little research has been directed towards confirming this hypothesis,
the findings of representative studies of vestibular, auditory, oral, and tac-
tile/kinesthetic stimulation do delineate possible treatment strategies.

Vestibular Stimulation

Across full-term and preterm infants, vestibular stimulation (e.g., cradled
rocking, spinning hammocks, oscillating waterbeds) reduces state level. Further-
more, in full-term infants, the reduction of activity and distress appears to be a
positive function of the speed and amplitude with which stimulation occurs (Van Den Daele, 1970). Using rocking boxes, Pederson and Ter Vrugt (1973) found that higher rocking amplitudes and frequencies soothed infants regardless of their initial state. Often infants who were awake and restless would be in quiet sleep at the conclusion of the 15-minute treatment interval.

In premature infants, Korner and associates found that protracted waterbed treatment had profound effects upon behavioral stability across the awake and sleep domains. Beginning when preterm infants were 4 days old, and continuing vestibular stimulation (i.e., head-to-toe oscillations of 12–14 cpm, amplitude 2.4 mm) until the 34th or 35th conceptual week, Korner and Schneider (1983) observed reduced irritability and/or hypertonicity, fewer and shorter incidences of crying, and less tremulousness and frenetic activity. Furthermore, these infants were twice as often in a visually alert inactive state. Likewise, Korner, Ruppel, and Rho (1982) found that 4 days of continuous waterbed stimulation significantly reduced the number of mixed or transitional states in preterm infants sick with respiratory distress syndrome. These preterms also fell asleep faster, exhibited greater and longer durations of quiet and active sleep, and demonstrated increased periods of rapid eye movement. From her extensive research program, Korner hypothesized that vestibular stimulation reduces the intensity of internal needs (e.g., crying or state disorganization) which permits the infant to turn outward and attend to external events (through the promotion of quiet alertness).

Although tentative, and in need of experimental confirmation, higher rocking speed (e.g., 25–30 cpm; Kramer & Pierpont, 1976) may produce a state of “restorative quiescence” which should promote the stability of state across the sleep and awake domains, as well as help preserve physiological reserves. As the premature infant exhibits greater state organization (as assessed through formal behavioral observation), a slower rocking speed (e.g., 12–16 cpm; Korner & Schneider, 1983) could be initiated in an effort to enhance the infant’s interface with the environment through the promotion of quiet alertness. Such a state would be expected to increase the frequency of integrated sensory/social experiences which underlie early learning.

**Auditory Stimulation**

Preterm unimodal auditory stimulation has not been extensively studied. The investigation of Schmidt et al. (1980) appears to be the sole experiment to examine the impact of auditory stimulation on state. In preterm infants who had not received prior supplemental stimulation, a one-trial presentation of heartbeat increased the duration of sleep states by decreasing the length of the first active sleep epoch and increasing the duration of the first quiet sleep epoch.
As is the case with vestibular stimulation, auditory intervention also seems to enhance environmental adaptation. Using a methodology offered by Katz (1971), Segall (1972) concluded that several weeks of auditory stimulation (a tape-recording of the infant’s mother reading a prepared monolog) enhanced adaptation as demonstrated by cardiac response. Experimental subjects showed a greater amount of cardiac acceleration (generally viewed as an avoidance response) in reaction to a novel stimulus (i.e., white noise), and greater cardiac deceleration (accepted as an orienting response) to their mother’s voice.

Although in need of empirical examination, the similarity between auditory and vestibular stimulation may lie in their rhythmic patterning. The fact that all of the major forms of supplemental stimulation (vestibular, auditory, oral, tactile/kinesthetic) involve repetition has led T. Field (personal communication, January 24, 1996) to suggest that rhythmic patterning may be a common therapeutic parameter.

**Oral Stimulation**

Oral stimulation focuses upon the use of pacifiers to promote nonnutritive sucking (NNS). Nonnutritive sucking also has a substantial effect upon state and behavioral organization. As with vestibular and auditory stimulation, NNS increases restfulness and decreases activity (Field et al., 1982). Woodson, Drinkwin, and Hamilton (1985) showed that ad lib. access to a pacifier increased the time term and preterm infants spent in quiet states; decreased the number of state transitions, and reduced motoric output.

As previously indicated, the rhythmic pattern of oral stimulation may underlie such immediate benefits as increased quiescence. In addition, there may be an inherent “hedonic” quality to sucking (Crook & Lipsitt, 1976). Although the work of Lipsitt and his colleagues focuses on the pleasures of nutritive oral stimulation (i.e., a pacifier delivering sucrose solution), their findings provide further evidence that sucking can have a significant physiological impact beyond the area of the mouth (e.g., on heart rate, vagal tone, respiration, and gustatory functioning; Lipsitt, Reilly, Butcher, & Greenwood, 1976; Porges & Lipsitt, 1993).

**Tactile/Kinesthetic Stimulation**

Across investigations, tactile/kinesthetic (T/K) protocols have been quite similar and usually reflect minor derivations of the method introduced by White and Labarba (1976). Tactile (rubbing and/or stroking) and kinesthetic (passive flexing and extending of limbs) stimulation are administered sequentially (e.g., first tactile, then kinesthetic) during a session and the procedural sequence is often quite precise (e.g., Field et al., 1986).
Early studies of tactile-only stimulation failed to include formal state analysis. Regardless, there is evidence that the benefits obtained from tactile intervention involve heightened alertness and increased activity. Using a procedure consisting of nonrhythmic massage of the neck, back, and arms (5 minutes, each hour of the day for 15 days), Solkoff et al. (1969) found that stimulated infants were more alert and active than controls. Similarly, Adamson-Macedo (1985) found that providing cephalocaudal massage to sleeping very low birth weight (VLBW) preterms produced a state change which ranged from drowsy to alert. On Brazelton exam, Solkoff and Matuszak (1975) reported that premature infants who had received 1,200 minutes of extra stroking (7 1/2 minutes per hour for 16 hours per day for 10 days) were more alert and changed state more often.

In two recent investigations, Scarfidi et al. (1986, 1990) examined the effect of T/K on state. In both studies, it was found that during T/K stimulation, preterms became more active as evident by significant increases in multiple limb movements and facial expressions. Unlike vestibular and oral stimulation, T/K did not appear to promote an inactive alert state. In posttreatment examinations of behavioral organization, Scafidi et al. (1986) demonstrated that stimulated infants exhibited a greater amount of awake time. Once again, T/K did not enhance periods of inactive alertness. Overall, T/K appears to energize the infant towards activity: Scafidi et al. (1986) found that treated preterms exhibited an active alert state 14% of the time, while nonstimulated infants failed to show such a state during observation.

The persistent finding that during massage infants often become alert and exhibit increased motor activity raises the question of whether T/K should be administered to preterms who are very sick or who are state disorganized. Although the impact of T/K on state during periods of treatment and nontreatment needs further investigating, it is clear that T/K can be administered to preterms of younger gestational ages (e.g., 23 weeks) and lower birth weights (e.g., 630 grams) as long as they are clinically stable (Acolet et al., 1993); likewise, Wheeden et al. (1993) found that medically stable preterms who were exposed to cocaine in utero responded positively to T/K (i.e., enhanced weight gain, fewer postnatal complications, fewer stress responses).

Along with such benefits as enhanced weight gain, T/K has been found to have positive effects upon the biochemistry of premature infants. Kuhn et al. (1991) reported preterms who received 10 days of T/K demonstrated significant increases in urinary excretion of norephinephrine and epinephrine. These findings were interpreted as indicating maturation of the sympathetic nervous system. Massage has also been shown to reduce plasma cortisol levels. This led Acolet et al. (1993) to conclude that the procedure is both pleasurable and valuable for ameliorating pain. More recently, Moyer-Mileur, Luetkemeler, Broomer, and Chan (1995) found that a 4-week kinesthetic procedure (i.e.,
Supplemental Stimulation

passive limb movements) led to increases in bone width, mineral density, and content.

A PRESCRIPTION FOR STIMULATION OF PREMATURE INFANTS

The differential effects which the various interventions have upon behavioral state point to a "sequential multimodal approach" to the supplemental stimulation of preterms. The specific sequence and duration of each treatment component would be determined by the status of the neonate, and its reaction to each stimulation modality (determined by formal behavioral assessment). In consideration of the problems that premature infants commonly encounter, the goals of this approach might include (a) promoting state regulation, (b) facilitating the infant’s interface with the environment, (c) enhancing general neurobehavioral development. What is unique about this hypothetical model is that it is directed towards clinical treatment. Unlike most research paradigms, the course of intervention does not rely upon the infant having reached a clinically stable state: In fact, the early stages of treatment are aimed at assisting in achieving such ends.

Tronick et al. (1990) reported that extremely low birth weight preterms are very disorganized in all aspects of behavioral functioning. As these infants become more homeostatic they predominately exhibit a persistent state of still sleep which the authors have christened “protective apathy.” It is argued that this state protects physiological reserves, aids in the recovery from the stressors of prematurity and the NICU, and leads to the emergence of differentiated behavioral states. Therefore, for premature infants who are suffering from significant behavioral disorganization and ill health, those forms of intervention that soothe and promote deeper and restorative sleep states might first be initiated. Potential regimes could include the unitary or conjoint use of auditory stimulation and stable or oscillating waterbed stimulation. Since findings from full-term infants suggest a positive relationship between speed of rocking and level of quiescence (Van Den Daele, 1970), research is necessary to determine if less stable preterms can tolerate higher oscillation rates (e.g., 25–30 cpm) and whether such speeds promote state organization.

Once homeostasis is achieved, slow oscillating (e.g., 12–16 cpm) waterbed stimulation should further facilitate the preterm’s interface with the environment through the promotion of quiet alertness and visual pursuit. This stage might also introduce oral stimulation since it too promotes environmental engagement and has the added benefit of enhancing weight gain.

Once increased alertness is well-tolerated, T/K stimulation should be initiated. Besides the further promotion of weight gain, it has been argued that there is an inherent therapeutic quality to touch (Montagu, 1978). In addition, since
T/K elicits greater activity, it may be superior to the other approaches for enhancing motor development.

A preterm's point of entry into this treatment model would depend upon an assessment of state regulation: For example, a very unstable infant might begin with unitary auditory stimulation, whereas a more stable preterm might begin with slow oscillating rocking or T/K. Furthermore, the infant’s reaction to each treatment stage would determine its progress along the algorithmic pathway: An adverse reaction to a newly introduced stage would result in a return to the previous form(s) of supplemental stimulation (or in more serious cases, no stimulation at all).

Comment and Future Directions

In light of the considerable evidence that supplemental stimulation programs are effective, it is surprising that the number of published reports on this topic has decreased in the last decade. Theoretical and methodological problems probably contribute to the apparent reduction in interest. Regardless, the demonstrated decrease in length of hospitalization, enhanced development, and potential financial savings should eventually capture the interest of the cost-conscious health care community. Moreover, supplemental stimulation of preterms infants in a salient research avenue for furthering our knowledge of the relationship between human brain plasticity and the impact of the environment on development.

At present, we have undertaken a direct comparison of vestibular and tactile/kinesthetic stimulation on premature infants. Specifically, we are attempting to determine if fast vestibular stimulation (i.e., waterbed oscillations of 25–30 cpm) promotes more frequent and deeper sleep states; slow vestibular stimulation (i.e., 12–16 cpm) increases periods of quiet alertness; and if tactile/kinesthetic stimulation (massage/passive limb movement) promotes alertness and motoric output. Support for these hypotheses will delineate the important components of the treatment model and lay the groundwork for its application with unstable or ill premature infants. We feel an important part of this effort is to determine if the three treatment approaches have differential effects upon development.

REFERENCES


Supplemental Stimulation 295


