

Neonatal intervention: problem, purpose, and prospects

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THE STUDY OF PRETERM infants is marked by controversy at virtually every point. Standards regarding the criteria for prematurity have been in flux for more than 30 years (Crosse & Hill, 1975; Lubchenco, 1976); the care and management of the preterm infant has been evolving since the late 1940s (Klaus & Fanaroff, 1979; Pharaoh, 1976). The neurological development of preterm infants continues to be debated (Graziani & Korberly, 1977; Parmelee, 1975; Prechtel, 1967), and ethical issues regarding the care and termination of care for preterm and other high-risk infants remain unresolved (Duff & Campbell, 1973; Stinson & Stinson, 1979).

Another of the chief controversies regarding high-risk, premature infants concerns the type of intervention that should take place during the first weeks, months, and years of these infants' lives. Reviews of research regarding neonatal intervention (Cornell & Gottfried,

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1976; Masi, 1979; Schaefer, Hatcher, & Barglow, 1980) highlight some of the problems in this area: the inconclusiveness of results, the lack of clear or consistent theoretical focus, the presence of numerous methodological problems, the proliferation of different intervention models, and the lack of longitudinal follow-up.

Although these and other criticisms can be brought to bear on neonatal intervention research as a whole, one striking finding among the approximately 25 studies published between 1964 and 1981 is that positive effects of some type are reported in every case. Whether there is variation across studies in the nature of intervention (Barnard, 1973; Katz, 1971; Korner, Kraemer, Haffner, & Cospser, 1975; Neal, 1968; Rice, 1977; Rose, Schmidt, Riese, & Bridger, 1980; Solkoff, Yaffe, Weintraub, & Blase, 1969), in the frequency and duration of stimulation (Hasselmeyer, 1964; Solkoff & Matuszak, 1975; White & Labarba, 1976), in the agent of intervention (Barnard, 1981; Klaus & Kennell, 1982; Korner, 1979; Powell, 1974; Scarr-Salapatek & Williams, 1972), or in sample characteristics and research design (Korner, 1981; Leib, Benfield, & Guidubaldi, 1980; Minde, Ford, Celhoffer, & Boukydis, 1975; Minde, Trehub, Corter, Boukydis, Celhoffer, & Marton, 1978; Rosenfield, 1980), the studies demonstrate change in a positive direction as measured by some dependent variable. Nevertheless, as Cornell and Gottfried (1976) note, "in view of the methodological differences among the studies, speculations as to mediating mechanisms and causal relationships between stimulation and

outcome would be precipitous" (p. 37). Thus it appears that it may be better to intervene with preterm infants rather than not intervene, but what the parameters of that intervention should be remain unclear.

The purpose of this article is to review the studies that have focused on preterm neonatal intervention in order to establish clearer parameters for future research and practice. Intervention strategies are proposed that are consistent with the neurological development of preterm infants and with the findings of recent research concerning the developmental outcomes of premature birth.

THE ENVIRONMENT OF THE HIGH-RISK, PRETERM INFANT

The setting in which preterm neonatal intervention takes place is a critical factor for examination in any comprehensive review of the effects of intervention. The environment in which most preterm infants spend their first days and weeks of life—the modern neonatal intensive care unit (NICU)—is such an unusual environment that it would be improbable if it did not have at least transient effects on the infant. These effects remain largely unexamined from a developmental perspective.

Medically, the high-risk infant in the NICU may be receiving artificial ventilatory assistance; nutrition via gavage feedings or intravenous means; medications to control or prevent intracranial hemorrhage, sepsis, or necrotizing enterocolitis; and various computerized and radiologic tests to ascertain neurological and respiratory functioning. The environment of the isolette in which the infant is kept is characterized by noise levels in excess of 80 to 90 db (League, Parker, Robertson, Valentine, & Powell, 1972), constant light stimulation with little or no diurnal patterning (Parmelee, 1975), contact with as many as 70 different nurses during a 7-week stay in a hospital with conventional nursing practices (Minde et al.,

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1975), and restricted opportunities for parent-infant interaction (Gottfried, 1981).

Lodge (1976) points out that several iatrogenic effects, or effects of treatment, may emerge from care in the NICU. Retrolental fibroplasia and bronchopulmonary dysplasia are two major problems associated with excessive oxygen administration, although the disease mechanisms of these two conditions differ significantly. Lodge (1976) points out, however, that treatment of the infant for the relatively common and usually minor problem of hyperbilirubinemia, which involves phototherapy and concomitant blindfolding of the infant to prevent retinal damage, may also have deleterious effects. She suggests that the visual system of the premature infant may be susceptible to damage as a result of eye closure during the early weeks of life. Numerous other effects of treatment can be noted as well.

Als, Lester, Tronick, and Brazelton (1982) provide a more phenomenological view of life for the preterm infant immediately following birth. They note the following:

The 32-week-old organism . . . is adapted to an intrauterine environment of a regulated temperature, contained movement pattern, suspension of gravity, muted and regular sensory inputs, and physiological supports which have evolved to ensure normal intrauterine development for a large percentage of fetuses. Should a premature delivery ensue, one could predict that most fetuses would die, since their organismic adaptations do not fit the environment they find themselves in. Modern technology and medicine have changed this but are still searching for how best to provide for such organisms after birth, given the incongruence of the situation. Artificial re-creation of the intrauterine environment for the preterm infant is inappropriate since the transitions at birth automatically trigger independent functioning of organ systems necessary for survival, such as the respiratory, cardiac, and digestive systems. . . . These premature infants face survival difficulties since some subsystems have already been activated and are functioning sufficiently in utero while other necessary subsys-

tems have not matured and are not yet ready to function. (pp. 14-15)

Thus the high-risk infant occupies a place in a high-risk—albeit life-saving—environment. Infant intervention programs have been designed and implemented in part as a means of compensating for and responding to the stressful character of this environment. Yet research regarding these interventions leaves many questions unanswered and provides few conclusive directions for future intervention programs.

NEONATAL INTERVENTION: EFFECTS AMID VARIABILITY

As noted earlier, the research regarding neonatal intervention is confusing and inconclusive, and lacks comparability. Moreover, the intervention programs that have been described in the literature do not reflect a coherent view of preterm infant development; nor do they demonstrate careful consideration of the known outcomes for high-risk, premature infants.

Even the goals and objectives advanced for intervention programs lack consensus. There appear to be three major purposes served by neonatal intervention programs: (a) to compensate for intrauterine experiences lost by the neonate as a result of premature delivery, (b) to correct for the presumed sensory deprivation endured by the neonate who is confined to the NICU, and (c) to try to modify the disruptive effects of the NICU environment so that it more closely resembles the environment of full-term newborns. These purposes are represented in most studies of neonatal intervention. However, as with all other aspects of the neonatal intervention literature, there is considerable variation within and between studies concerning even their basic experimental hypotheses.

The variability in intervention programs for high-risk infants in NICUs is shown in a

review of the actual interventions, sampling procedures, and known outcomes. In a review of 16 major studies, tactile-kinesthetic stimulation—stroking, flexing, massaging, rubbing, handling—was designated as the independent variable in at least 10 different studies (Hasselmeier, 1964; Korner et al., 1975; Powell, 1974; Rice, 1977; Rose et al., 1980; Rosenfield, 1980; Scarr-Salapatek & Williams, 1972; Solkoff & Matuszak, 1975; Solkoff et al., 1969; White & Labarba, 1976). Vestibular stimulation alone was used as the independent measure in two studies (Korner et al., 1975; Neal, 1968), auditory stimulation alone in two (Katz, 1971; Segall, 1972), and vestibular and auditory together in two (Barnard, 1973; Kramer & Pierpont, 1976). Taken as a whole, these interventions relate to all three of the purposes, or experimental hypotheses, described earlier.

Interventions

Considerable variation in treatment and in stimulus parameters is apparent in a review of the studies. Neal (1968) and Korner et al. (1975) chose to assess the effects of vestibular stimulation using a motorized hammock in the former case and an oscillating water bed in the latter. The length of treatment varied from 1 week in the Korner et al. (1975) study to 4–8 weeks in the Neal (1968) study. Barnard (1973) added heartbeat recordings to vestibular stimulation, and Kramer and Pierpont (1976) used heartbeat plus a tape recording of the mother's voice. In each study there was variability in the frequency and duration of the treatments. Vestibular stimulation that is continuous, discontinuous, or contingent upon infant activity was introduced by Barnard (1981) in her most recent study.

Hasselmeier (1964), Rosenfield (1980), Solkoff and Matuszak (1975), Solkoff et al. (1969), and White and Labarba (1976) all examined the effects of tactile-kinesthetic stimulation using forms of stroking, flexing, and massage

for periods beginning 1–14 days following birth and lasting 1–4 weeks. "Multimodal" sensory stimulation was used by Leib, et al. (1980), Powell (1974), Rice (1977), Rose et al. (1980), and Scarr-Salapatek and Williams (1972).

Adding to the variability of the independent variables and their properties is the variability in dependent measures. The following are some of the outcome variables employed by the studies noted:

- weight gain (Barnard, 1973; Hasselmeier, 1964; Korner et al., 1975; Kramer & Pierpont, 1976; Leib et al., 1980; Powell, 1974; Rice, 1977; Scarr-Salapatek & Williams, 1973; Solkoff et al., 1969; White & Labarba, 1976);
- caloric intake (Leib, et al., 1980; White & Labarba, 1976);
- maturation or developmental status (Katz, 1971; Kramer & Pierpont, 1976; Leib, et al., 1980; Neal, 1968; Powell, 1974; Rose et al., 1980; Scarr-Salapatek & Williams, 1973; Solkoff & Matuszak, 1975);
- state stabilization (Barnard, 1981; Rose et al., 1980);
- heart rate (Rose et al., 1980; Segall, 1972; White & Labarba, 1976);
- head growth (Kramer & Pierpont, 1976; Rice, 1977);
- frequency of apnea (Korner et al., 1975);
- frequency of emesis (Solkoff et al., 1969; White & Labarba, 1976);
- change in vital signs (Korner et al., 1975; Solkoff et al., 1969; White & Labarba, 1976);
- muscle tension (Katz, 1971; Neal, 1968);
- irritability, crying, quiescence (Hasselmeier, 1964; Katz, 1971; Neal, 1968); and
- parental visitation (Minde, Marton, Manning, & Hines, 1980; Powell, 1974; Rosenfield, 1980).

None of these dependent variables has been shown to be consistently affected by a treat-

ment regimen, although short-term gains occur most frequently in the area of motor development.

Among the specific outcome measures used were the Bayley Scales of Infant Development (Powell, 1974; Rice, 1977; Solkoff et al., 1969), the Brazelton Neonatal Behavioral Assessment Scale (Kramer & Pierpont, 1976; Scarr-Salapatek & Williams, 1973; Solkoff & Matuszak, 1975), the Graham-Rosenblith Behavioral Examination for Newborns (Katz, 1971; Neal, 1968), and the Cattell Infant Intelligence Scale (Scarr-Salapatek & Williams, 1973).

Sampling techniques

Another source of considerable variability in the intervention studies is sampling procedure employed. The studies vary on every possible dimension. For example, the studies by Scarr-Salapatek and Williams (1973) and Powell (1974) used as subjects only black infants whose mothers were representative of the lowest socioeconomic status level and were urban and "typically young and unmarried" (Scarr-Salapatek & Williams, 1973). The majority of the subjects in the Rice (1977) and White and Labarba (1976) studies were also black, yet not necessarily of the lowest socioeconomic status level. Solkoff et al. (1969) studied only white subjects who spanned the social-class spectrum. The remaining studies either did not designate race or stated that the subjects were "representative" of the typical NICU population (e.g., Neal, 1968).

The issue of sample size also raises serious questions. The conclusions that were drawn from the 16 major studies reviewed were based on stimulation regimen and control procedures used with 658 infants in total. This yields a mean sample size (experimental and control) of 41, with a range of 11–104 in individual studies. All of the studies specifically focused on preterm infants, but birth weights varied from 700 grams (Neal, 1968) to

2,400 grams (Rice, 1977); gestational age varied from 24 weeks (Rosenfield, 1980) to 37 weeks (Solkoff & Matuszak, 1975). Obstetrical and medical complications varied from study to study. Other sources of variation that prevent direct comparison of results include socioeconomic status, parity, gravity, sex, multiple birth, variation in care by different hospitals, variation in care by different treatments, choice of control group, and variation by treatment regime.

Outcome parameters

A tentative grouping by four outcome parameters is presented here to provide a more coherent overview of the studies as a whole. The outcome parameters are weight gain, improved performance on developmental assessments, behavioral stabilization, and improved infant-care giver interaction.

Neal (1968), Scarr-Salapatek and Williams (1973), and Solkoff et al. (1969) reported significant weight gain in their experimental infants, whereas Barnard (1973), Hasselmeyer (1964), Powell (1974), and Leib et al. (1980) reported no differences. Follow-up of the infants in the Solkoff et al. (1969) study revealed that the weight gain advantage did not endure beyond 6 weeks of age.

Higher performance on infant developmental assessment scales was reported by Barnard (1973), Leib et al. (1980), Powell (1974), Rice (1977), Scarr-Salapatek and Williams (1973), and Solkoff et al. (1969). These gains were evident in follow-up to 1 year in some of these studies. Cornell and Gottfried (1976) noted that the mean advantage for experimental subjects on developmental indices of the Bayley and Cattell was 7.4 points for the studies they reviewed; no confidence intervals or standard deviations are available, however.

In terms of behavioral and neurophysiological state stabilization, Korner et al. (1975) reported lowered incidence of apnea among

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their subjects. Barnard (1973) found more stabilization of state; Rose et al. (1980) and Segall (1972) discussed different, more mature heart rate responses in their subjects; Rice (1977) found more mature reflexes; White and Labarba's (1976) subjects ingested more formula during feedings; and Hasselmeyer's (1964) infants were less irritable following handling.

Inferences regarding parent-infant interaction can also be drawn from some of the studies. Rosenfield (1980) found that proprioceptive stimulation of the experimental infants was significantly correlated with higher cumulative parent visiting ratios; however, Rose et al.'s (1980) regimen of handling did not result in this trend. Powell (1974) reported that increased maternal handling of the neonates through the portholes of the isolette did not

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influence later maternal behavior. Minde et al. (1980) reported a systematic progression in the mothers' abilities to interact with their very low birth weight, preterm infants. They concluded that the interactive capacity of mothers, while in part influenced by behavioral cues from their infants, is largely determined by psychological variables in the mothers' backgrounds.

Related but different findings regarding modifiability of infant-care giver interactions and characteristics are reported in two studies by Widmayer and Field (1980, 1981). In a controlled study of 30 healthy preterm infants born to teenaged, lower socioeconomic status black mothers, they found that those infants whose mothers observed the administration of the Brazelton Neonatal Behavioral Assessment

Scale and who completed the Mother's Assessment of the Behavior of Her Infant Scale (Field, Dempsey, Hallock, & Shuman, 1978) showed better face-to-face interaction ratings with their infants at 1 and 4 months of age. At 4 months of age the experimental infants had superior fine-motor scores on the Denver Developmental Screening Test and at 12 months corrected age they received significantly higher scores on the Mental Development Scales of the Bayley. These studies, while small in scale, suggest that teaching mothers about the abilities of their newborns may facilitate early interactions and may contribute to early cognitive development.

THE PURPOSE OF NEONATAL INTERVENTION

The lack of agreement at every point that is made so obvious by this review underscores the need for articulating a systematic theory on which to construct neonatal intervention programs. Given the variability exhibited in the research, it is no wonder that researchers do not know, as Gottfried (1981) maintains, whether subjects in intervention programs continue to improve or at least to maintain their gains as long as the programs are in effect, whether there are long-term beneficial effects of intervention that are exhibited beyond termination of the program, and whether the NICU is even the best place to begin intervention in order to obtain long-term and maximal effects.

Answers to these questions are not available in any published research. Even the goals and objectives selected for the intervention programs are not free from major controversy. Als et al. (1982) noted that the intrauterine environment cannot be re-created for the preterm infant because the process of birth irrevocably initiates the extrauterine functioning of the respiratory, cardiac, and digestive systems. Thus the first rationale for intervention men-

tioned, to compensate for intrauterine experiences lost by the neonate, may be unachievable. In terms of the second rationale, that of correcting for sensory deprivation, researchers, such as Gottfried, have suggested that preterm infants suffer not from inadequate amounts of stimulation, but more likely from inappropriate patterns of stimulation that may impair sensory development and integration.

There is also little consensus regarding the third rationale, that of altering the unusual environment of the NICU. Although most experts suggest that the NICU environment is in need of humanizing and normalizing (see Brimblecombe, Richards, & Robertson, 1978), the NICU is different from the environment of full-term neonates because it reflects the medical needs of its patients. Als et al. (1982) noted that procedures used with preterm infants should be different from those in use with full-term infants. Nevertheless, they noted that when one realizes "the current organizational issues for the preterm infant, one becomes aware of the flaws and possible dangers of intervention programs which consider preterm infants to be deficient full-term infants and which, therefore, are intended to 'train' infants in behavior appropriate for full-term babies" (Als et al., 1982, p. 17). Thus although there is some agreement that the stressful environment of the NICU should be altered to facilitate infant development, the research to date has not demonstrated how this objective can best be achieved.

Based on the information presented, it is the authors' contention that appropriate intervention for high-risk, premature infants should (a) recognize the unusual physiological stress being endured by the infant who is prematurely extrauterine; (b) screen out grossly bombarding and unnecessary light, sound, and tactual stimuli; (c) recognize and facilitate the continuing subsystem differentiation of the preterm infant; and (d) gradually facilitate reciprocal visual, tactile, vestibular, and social

feedback. Such an approach must be individualized, flexible, modifiable, and sensitive to the neurodevelopmental status of the particular infant, and may facilitate positive infant-care giver interactions.

A PROPOSED FRAMEWORK FOR NEONATAL INTERVENTION

An approach to neonatal intervention such as that described would focus simultaneously on a number of features of preterm infant development. These features should represent critical aspects of developmental advance for preterm infants; they should also serve to facilitate positive interactions between infants and care givers. Building on the work of Brazelton (1973) and articulated by Als et al. (1982), these features include the following:

- *Maintaining the infant's level of balance and smooth, integrated functioning.* Inputs from the environment (e.g., positioning, holding, light, and sound) should be identified that will help the infant to be relaxed, comfortable, and physiologically stable, rather than frantic, struggling, and exhausted.
- *Building the threshold of motoric and state organization of the neonate.* The infant should be assisted, through environmental manipulations, to overcome motoric and state disorganization, so that energy that would otherwise be imparted to stress and frustration reactions can be used to increase motoric control and modulation.
- *Enhancing the degree of differentiation within the level of integrated functions.* The neonate must be helped to maintain and generalize his or her organization and modulation of state and of subsystems when environmental inputs and supports are slightly modified.
- *Expanding the differentiation of modulated and regulated behavior.* The neo-

nate must learn to move beyond regulation and modulation in a single dimension of behavior to maintenance of internal control when organization of general physiological, motor, and state issues are involved.

- *Expanding the strategies and the effectiveness of self-regulation of which the infant is capable.* The neonate should be helped to maintain self-regulation with a minimum of environmental input.
- *Facilitating optimal social functioning.* The infant should be assisted, through environmental structuring, support, and facilitation, in interacting with his or her environment in such a way that he or she confirms expectations for positive parent-infant social elicitation and feedback.

These six foci serve as the parameters for assessment of the preterm infant as developed by Als and her colleagues and as objectives for intervention as well. Taken as a framework for the development of a neonatal intervention program, these foci should make an important contribution to an interactive system of communication and adjustment. For example, when the preterm infant becomes "overloaded" with stimuli, he or she may withdraw or become rigid, or may have apneic spells. In each of these cases the infant becomes unavailable to the environment for obtaining information or for giving positive feedback and in turn may cause parental care givers to feel less competent and less efficacious.

This last point may provide the justification for formulating an additional rationale for preterm neonatal intervention. That is, to the extent that reciprocal social transactions are contingent upon the "readability" and "predictability" of the infant's signals (Goldberg, 1977), in addition to the care giver's ability to respond appropriately to these signals, it becomes critical for infants at risk to engage in interactions without experiencing great expense to physiologic, motor, and state regula-

tion. A preterm neonatal intervention program that is based on a framework such as that outlined would have the potential for enhancing infant-care giver interactions and thus reducing the probability of subsequent caretaking and developmental casualties.

Numerous studies have implicated infant-care giver interactions as a major source of variation in the developmental outcomes of preterm infants (e.g., Field, Sostek, Goldberg, & Shuman, 1979; Field, Goldberg, Stern, & Sostek, 1980; Friedman & Sigman, 1981; Sawin, Hawkins, Walker, & Renticuff, 1980; Sell, 1980). Sameroff (1975) has been one of the chief exponents of this view. He has shown that, in analyses of the outcomes of high-risk infants, the two critical variables that best explain outcomes are the family socioeconomic status and the nature of the infant-care giver interactions. For example, in analyzing data regarding 4-year IQ of 26,760 subjects in the Collaborative Perinatal Project, Broman, Nichols, and Kennedy (1975) reported that only 28% of the variance in IQ was explained by the mother's education and socioeconomic status and by birth data and 4-, 8-, and 12-month assessments of the infant. However, more than 50% of the variance in 30-month IQ was explained when additional characteristics of the mother and of her behaviors toward the child were added to the analysis (Sameroff, 1978, 1979).

DEVELOPMENTAL INTERVENTION PLANS

Enhancing infant-care giver interactions should be a major focus during the neonatal period for preterm infants. All too often, in the midst of the emergency medical ambience of the NICU, the infant as an interactive, social being is lost. Richards (1979) notes that the infant is lost to himself or herself because one of the first steps in becoming a social self depends on the association in time between the

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expression of changing needs and their satisfaction by a caretaker. For caretakers—be they nurses, parents, or others—to be able to satisfy an infant's needs, they must become aware of the infant's specific, individual patterns in such a way that they can regulate and modulate their behavior in conformity with the infant's behavior and current state of development (see Meisels, 1981).

In the Appendix the parameters of Als's approach to preterm assessment are translated into developmental intervention plans. These plans were developed by a parent/infant educator working with Project Welcome, a hospital-based neonatal demonstration project that focuses on enhancing the development of preterm infants. The role of the consultant in the NICU, as well as the objectives of Project Welcome, are described in Cole and Gilkerson (1982).

The developmental intervention plans are based on data obtained from the Assessment of Preterm Infant Behavior (Als et al., 1982). They represent an individualized approach to neonatal caregiving designed to support and encourage the infant's emergent physiological, motoric and state stabilization. The plans also serve as important tools for explaining the infant's behavior to parents and to other caregivers.

Developmental plans such as these have been used in several NICUs and special care nurseries throughout the United States. Thus

far no data have been reported that would permit a comparison of this approach with the more traditional forms of intervention reviewed earlier. An appropriate research design would entail studying the impact of this form of intervention on the dependent variables selected for examination in other studies. However, at least one critical dimension of this approach can be evaluated only through the collection of longitudinal data; that is, the enhancement of infant-care giver interactions is fundamental to this approach. It is assumed that by facilitating infant subsystem differentiation and stabilization, parents will be (a) assisted in modifying their perceptions of their infant's medical status, (b) more successful in implementing programs of brief behavioral intervention, and (c) assisted in constructing a positive and enhancing psychological environment for themselves and their high-risk infants. These outcomes can be studied only from a longitudinal perspective.

The research concerning neonatal intervention is confusing when taken in the aggregate, because individually and collectively it lacks theoretical focus and integration. An approach to intervention based on the work of Als, Brazelton, and their colleagues provides this focus and systematic integration. It is designed to enhance preterm infant development by improving the conditions of infant-care giver interaction. It is also intended to provide an individualized approach to intervention that is sensitive to individual differences of high-risk neonates and their families. Although the theory and procedures on which this approach is based await empirical and longitudinal validation, they promise to begin to bridge the gap between medical technological advance and developmental knowledge and intervention.

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