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CHAPTER 3

Self-Regulation and Motor Development in Preterm Infants

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INTRODUCTION

The preterm human infant is a product of mankind's advances in neonatal medical technology and medicine. Today, many more preterms survive than ever before, and infants of 24 to 25 weeks' gestation have extended the lower limit of extrauterine viability. Coincident with such medical advances is the necessity of equally vigorous advances in creating a nurturing extrauterine environment and support system in order to ameliorate the mismatch between the environment for which the preterm organism is biologically prepared and the highly demanding and stress-producing environment into which the preterm is thrust.

A preterm infant, depending on postconceptional age at birth, may biologically be expecting up to 16 more weeks of *in utero* existence with the maternal blood flow and the placenta providing aid in the respiratory, cardiac, digestive, and temperature control functions. The infant is still fully reliant on cutaneous somasthetic input from the amniotic fluid, on motoric kinesthetic input within the amniotic sac wall, on maternal diurnal rhythms, and, in general, on a protective environment that attenuates sensory inputs to the primary sense organs. The preterm infant must not be thought of as a deficient full-term organism but, rather, as a well-equipped, competently adapted fetus, functioning appropriately

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for stage within the natural environment, the womb, yet being outside of that womb.

The preterm infant in the neonatal intensive care unit (NICU), who is, in essence, a displaced fetus, appears as keenly sensitive to all parameters of environmental impingement, hyperresponsive, because higher cortical systems, especially association cortical systems that provide buffering and differential inhibitory controls, have not yet developed. This sensitivity of the very young nervous system provides a unique opportunity for the caregiver to make it an organism-appropriate, developmentally supportive environment, rather than a hazardous place of increased stress. To improve the environmental structure and timing, the input and experiences provided by the caregiver need to be based on better understanding of the functioning of the "transitional newborn" (Desmond, Rudolf, & Phitaksphraiwan, 1966; Thurber & Armstrong, 1982), who biologically is on the way to become a full-term infant.

Because the brain of the transitional newborn is the critical organ in orchestrating all aspects of development, it is the protection and support of the immature, but rapidly evolving brain that must be a primary consideration for those providing care for preterm infants in our NICU environments. All parts of the brain are complexly interdependent. Areas that are neuroarchitectonically and temporally remote from the focus of insult or scar formation can show damage or malfunction much later, when certain connections become important in the course of the ontogenesis and evolution of complex integrative motor, cognitive, and affective functions. All areas of development are intimately interrelated, and damage in one area may have ripple effects into other areas. Yet compensatory strategies can also be developed, with appropriate developmental support, especially in the very young brain, as has been demonstrated with animal models (Goldman, 1976; Goldman-Rakic, 1981). The burden and opportunity, then, are on the identification and provision of brain developmentally appropriate and supportive environments to ensure normal developmental functioning and progression.

The synactive model of development, which I will elaborate on in the following chapter, provides a meaningful paradigm for understanding emergent brain function via observation of current infant behaviors. Autonomic, motoric, state organizational, attentional, and self-regulatory capabilities of an infant can be observed and characterized so as to identify functional thresholds and responses to stress. The caregiver(s) can evaluate the current ability levels of the individual infant in coping with evolving, increasingly differentiated agenda and can thus establish a developmentally supportive environment without overtaxing or overstressing the child.

In the following discussion, I will first provide a review of development of the full-term infant, emphasizing the important role of the social environment for normal, healthy development of newborns. Based on the insights gained from the exploration of "normal" development, I will then examine the issues confronting and challenging the preterm infant. The Assessment of Preterm Infants' Behavior (APIB), a means of identifying the preterm infant's current functional levels, is described, and our current research based on application of the APIB is presented. The objective of our research is to synthesize an evolutionarily appropriate environment to support normal development in preterm infants, characterizing appropriate environmental and social interventions. The remainder of this chapter will address these issues.

THE FULL-TERM INFANT IN DEVELOPMENTAL PERSPECTIVE

It becomes the task of the NICU to provide a nurturing yet stimulating milieu which simulates, to the extent possible, the intrauterine functions which the fetus would have normally experienced. The observation of the fullterm may aid us in understanding the differences of preterm and fullterm functioning.

The Developmental Task of the Full-Term Newborn

From our work with healthy full-term newborns examined with the Brazelton Neonatal Behavioral Assessment Scale (Brazelton, 1973) and in direct observation of newborns with their mothers over the first 3 months (Als, 1976, 1977), we learned that the differentiation of the attentional system is the most salient, most rapidly changing, and apparently newly emerging agendum of the human full-term (Als, 1978, 1979). Autonomic stability in terms of respiratory control, temperature regulation, and digestive visceral functioning is relatively quickly restabilized after the birth process, as are smoothness of movements and adaptation of well-regulated, smooth balance between flexor and extensor posture (Casaer, 1979). The same holds true for state organization in terms of the range of states available and their transitions (Sander, 1962, 1964). Most healthy full-term newborns have no difficulty achieving a robust, lusty crying state and can return to a sleep state relatively readily. The issue most full-term newborns seem to attempt to get under control in the first several weeks after birth is the increasing stabilization of the alert state in their movement from sleep to aroused crying states and back down to

sleep state. Although in the 2-day-old full-term infant the alert periods are still somewhat difficult to come by and are embedded in long stretches of sleep and episodes of crying. By 2 and 3 weeks these periods of alertness have become increasingly reliable and solidified, and by 1 month to 6 weeks many infants easily spend an hour and more at a time in an alert, socially, and cognitively available state.

The Social Environment of the Full-Term Human Newborn

It appears that the full-term newborn is not the only one grappling to solidify these periods of alert availability. The infant's social partners from the very first postnatal contact on tend to be keen and sensitive in aiding the infant in stabilizing these periods (Als, 1977; Grossman, 1978). On the very first contact, mothers and, presumably, fathers will prod their newborn vocally and tactilely to open the eyes, even at the cost of eliciting crying. Even if the newborn then opens only one eye, the mother will typically acknowledge this initial connection and mutual recognition by an affectively positive, heightened vocal pattern for his or her accomplishment: "Hi!," she may say, over and over again, in a drawn-out, loving manner. "There you are! That's right. I knew you were in there!" (Als, 1975). Her behavior, in turn, appears to facilitate and support the infant's alertness. From a brief, initial glance, the infant may go on to widen the eyes, raise the eyebrows, soften and raise the cheeks, and shape the mouth into an "ooh" configuration. The partners mutually support and drive each other to prolong this episode. One of them will then reset or break the intensity. The infant may, for instance, avert the gaze, and may move into a yawn or a sneeze, thus resetting the intensity at a lower level by utilizing subtle attentional regulation strategies. Or the infant may avert and move into a fussy, crying, or drowsy state, thus utilizing state shifts to reset the interaction. Or the infant may not avert but may stay locked on the mother's face, become tense, and perhaps spit up or move into hiccoughs, gags, or even the strain of bowel movement, thus reacting at an autonomic visceral level in resetting the interaction. Or the infant may begin to extend and flail the arms and start to squirm, thus utilizing motoric shifts in the resetting of the interaction. If the infant is able to sustain alertness for a substantial period, keeping the respective subsystems of functioning in balance, the mother may be the one resetting the intensity of the interaction by pulling the baby close and nuzzling and kissing or stroking and patting the infant, thus changing the cyclic attentional interchange (Als, 1975). Thus, there appears to exist a predictably ordered patterning of interac-

tion of the full-term newborn on the first contact after delivery with the mother, emphasizing the connnection of the newborn alertness supported by parental affection. Figure 1 shows a schematic presentation of the results from a study of 40 full terms in initial interaction with their primiparous mothers.

It is curious that such emphasis appears to be placed on these early attentional episodes of the infant that are embedded in affectively supportive and highly positive inputs from the parent, given that later on this alertness will be much more easily available. From an evolutionary species perspective, this early valuing of the interactive attentional connection gains an added dimension. Phylogenetically, it appears that humans are at the apex of evolution for the combination of cognitive attention and affective engagement with another individual. This may be gleaned from a study of this connection in the progression through the order primate from the nocturnal prosimians via the Old and New World monkeys to the great apes and man (Bolwig, 1959a,b; Buettner-Janusch, 1966; Huber, 1931). As we move through the phylogenetic scale, we find an increasingly complex and simultaneously increasingly flexible social system. The essence of humanness and, in fact, of human species' survival appears to be in man's enormously complex capacity for social and emotional interaction, which is the prerequisite for the virtual supersystem of material culture, that is, technology we have constructed and are dependent on for our survival as humans (Vygot-

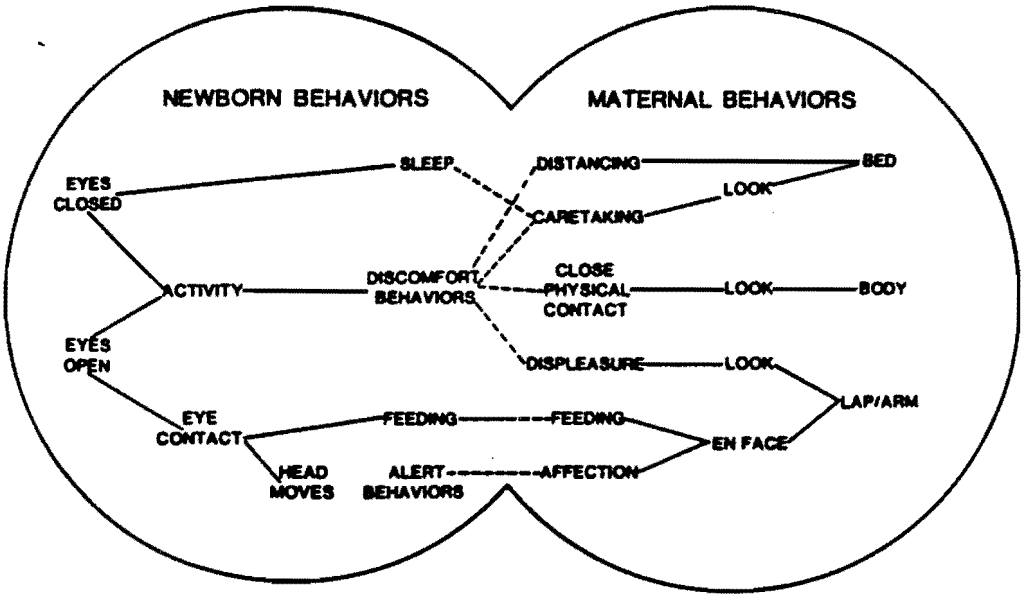


FIGURE 1. Full-term newborn and maternal behaviors and their interactive fit (from Als, 1975; reproduced with permission).

sky, 1978). Highly differentiated capacities for collaboration and cooperation of species' members are necessary to make such a complex adaptation workable. It appears that from the very beginning of extrauterine life, the full-term, well-developing newborn organism is already launched onto the species' specific, interactive, collaborative communicative track and is in turn supported and affectively rewarded by the caregivers in this capacity as a social interactor. The interactive attentional capacity of the newborn and young infant therefore becomes a salient parameter of newborn functioning. It appears to be in current ascendancy and is highly valued and supported by those around the infant (Als & Duffy, 1982).

The Full-Term Newborn's Attentional/Interactive Capacity

Not all full-term newborns are equally able to increase their interactive attentional capacity. For some, as we learned in a study of thin-for-height full-term newborns (Als, Tronick, Adamson, & Brazelton, 1976), this is a very difficult task, which impinges on the infant's other functional systems. These thin infants showed great reluctance to come into alertness, moving into hypertonic, flexed, high-guard arm position with fisted hands, while becoming pale, showing tachypneic and irregular respiration with pained and drawn facial expressions. With slow, calm support, they would eventually gradually open their eyes, but then the hypertonic high-guard fisted defendedness shifted abruptly into motoric flaccidity and tuning out, the color paled further, and breathing became slow and irregular. The mustered attention was of a glassy-eyed, strained, barely focused kind that came at great cost to the autonomic and motor regulation. The identification of this pattern of subsystem syncresis with relatively poor subsystem differentiation, in which, as one system attempts to accomplish a task, the other systems are drawn into the reaction in a generalized manner, exemplifying the relative cost to the total system on many levels, is of interest. It is one avenue toward understanding the current standing of the infant on the developmental lines of subsystem differentiation.

Parameters to Be Considered in Assessing the Infant's Functioning

On the basis of our observations of this subsystem interaction, we have, therefore, formulated the following parameters to be described when assessing an individual infant's functioning (Als, 1982b):

1. The infant's current, newly emerging developmental agendum and the degree of ascendancy of this agendum.
2. The infant's current level of subsystem balance and smooth integrated subsystem functioning regardless of the agendum identified as in ascendancy.
3. The threshold of disorganization indicated in behaviors of defense and avoidance, at varying subsystem levels of functioning as the developmental agendum in ascendancy is tested.
4. The degree of relative modulation and regulation of the various subsystems in accomplishing the new skill.
5. The degree of differentiation and effectiveness in rebalancing the subsystems in the accomplishment of the skill.
6. The degree of environmental structuring, support, and facilitative aid necessary to bring about optimal implementation of the new skill.
7. The degree of environmental structuring, support, and facilitative aid necessary to bring about organization at a smooth, well-integrated and ideally more differentiated new level of functioning.

This approach to the assessment of organism functioning is thought to be appropriate throughout the life span of the organism. At each stage of development, newly salient agenda are being negotiated on the backdrop of previously accomplished subsystem differentiation and modulation. Figure 2 (Als, 1982b) is a schematic attempt to visualize this conceptualization of the perspective of development applied to the fetal and neonatal stages.

Looked at from above, four concentric circles or cones are seen, represented from the innermost going outward. The first is the autonomic system in its basic position, assuring the organism's baseline functioning. Around it, as it were, is seen the motor system, unfolding from very early embryonic stages with recognizable flexor posture, limb, and trunk movements and becoming increasingly differentiated in its explication. Around it, as a third cone, lies the state organizational system, the unfolding of distinct states of consciousness from diffuse quasi-sleep states to increasingly differentiated sleep, wake, and aroused bands of consciousness. And around this cone lies the gradual differentiation of the awake state into more and more elaborated, subtly branched, and finely tuned nuances of affective and cognitive receptivity and activity, shaping the social and inanimate world, and negotiating one's own developmental progression in the process. These cones are continuously in contiguity if not interacting with one another, influencing and supporting one another or infringing on one another's relative stability. The

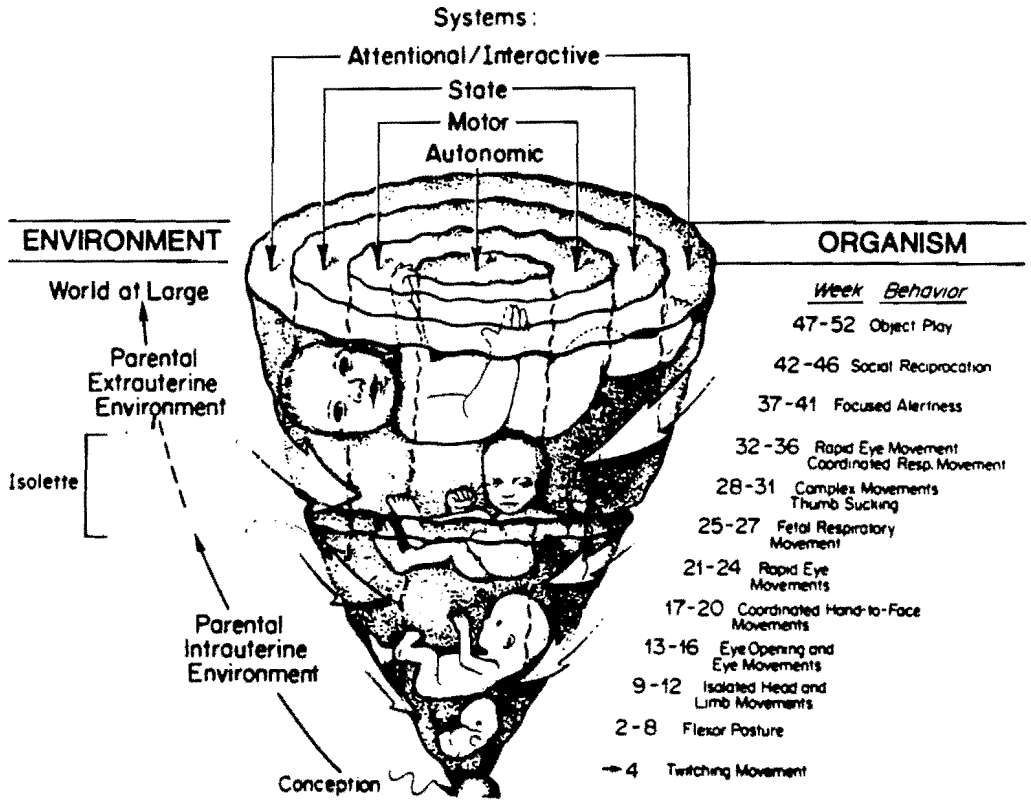


FIGURE 2. Model of the synactive organization of behavioral development (from Als, 1982b; reproduced with permission).

within-subsystem differentiation each system is striving for depends on the other subsystems' support and relative intactness. The whole organism with its intraorganism subsystem interaction is at all stages surrounded and embedded in an environment it has evolved to expect for its species-*appropriate* ontogenesis. The organism is actively shaping and selecting from this environment as it is constantly challenged and impinged upon by this environment (Hunt, 1961; Piaget, 1963, 1971).

THE PRETERM INFANT IN DEVELOPMENTAL PERSPECTIVE

A substantial body of research indicates that a broad array of physiological and emotional abnormalities are disproportionately represented in the population of children born preterm. These studies also tend to indicate that these problems are neurological in origin. Developmental

impairment is due to direct insult to the brain, as in hemorrhage, or indirect insult, as in anoxic and hypoxemic events and metabolic imbalances, all of which are the consequences of mismatch of extrauterine environment and the capacity of the central nervous system of the fetal newborn adapted for an intrauterine existence. The fact that developmental impairment is also present in those infants spared the more massive insults of hemorrhage or hypoxemic anoxic events forces one to consider that the environment influences the development of the brain in additional ways, namely through the various senses of the organism—the visual, auditory, cutaneous, tactile, somatesthetic, kinesthetic, olfactory, and gustatory senses. The interplay of sensory information and experience is thought to form species-appropriate ontogenetic integration patterns, on the one hand, and deleterious adaptation patterns leading to malfunction or distortion of functioning, on the other hand (Piaget, 1971). Given the rapid development of the brain from the twenty-fourth to the fourtieth week of fetal life and the emergence and differentiation, especially of association cortical areas in this period, the impact of biologically, ontogenetically unexpected experience should not be surprising. Animal models have given substantial evidence of the fine-tuned specificity of environmental inputs necessary in the course of sensitive periods of brain development to support normal cortical ontogenesis (Duffy, Burchfiel, & Snodgrass, 1978; Mower, Burchfiel, & Duffy, 1982; Spinelli, Jensen, & Deprisco, 1980; for a review, see Duffy, Mower, Jensen, & Als, 1984). The mechanisms leading to developmental distortions implicated by this work are largely active inhibition or suppression of normal pathways through overactivation of currently functional pathways, thus leading to less differentiated and less modulated overall later functioning. The suppressions appear to be mediated by endorphin mechanisms inferred from the successful experimental reactivation by morphine antagonists. This hypothesis is particularly appealing, given the hierarchical ordering of endorphin receptor sites in primates, with substantial increase in evolutionarily and ontogenetically later structures, that is, more recent, association cortical areas, culminating in frontal cortex (Lewis, Mishkin, Bragin, Brown, Pert, & Pert, 1981), which is one of the areas strongly implicated in attentional learning and behavior deficits in the school-age population (Denckla, 1978).

In trying to understand the preterm infant's functioning, our first question, then, must be: What is the species-appropriate adaptation that the organism is equipped with, and what from the central nervous system and other systems' perspective is he or she adapted for? The preterm infant is biologically expecting 13 to 16 more weeks of *in utero*

existence, with respiratory, cardiac, digestive, and temperature control aided by the maternal blood flow and placental functioning. The infant is expecting total cutaneous somatesthetic input from the amniotic fluid. The infant is expecting motoric kinesthetic input from the contingently reactive amniotic sac, preventing full extensor patterns and assuring flexor inhibition and flexor maintenance for the typical head–trunk extremity adjustments and movements of soft modulated limbs, trunk, and head movement, so vividly described by Birnholz, Stephens, and Faria (1978) and Milani-Comparetti (1980). The infant is expecting maternal diurnal rhythms presumably entraining the gradually differentiating states of consciousness; and the infant is expecting presumably muted sensory inputs to the primary senses of vision and audition, being readied for the experience of the extrauterine world. The preterm infant is not an inadequate or deficient full-term organism, but is, rather, a well-equipped, competently adapted fetus appropriately functioning at this stage and in the natural environment.

Suddenly the infant is in a vastly different environment, the passage to which has irreversibly triggered subsystem functioning in an environment only poorly matched to the infant's expectations. Instead of the maternal organism, medical technology attempts to take care of respiratory, cardiac, digestive, and temperature control functions. The motor system, the state organizational system, and sensory functioning intimately dependent on an adaptive environment are largely left to their own devices. The center in our schematic model of Figure 2, the autonomic functioning, is currently largely the primary focus of medical care. When a preterm infant reactivates body movement and state organization after a period of virtual shock, what Bottos (1985) calls the "apostural-akinetic phase," we hypothesize that the infant is trying to reestablish a level of developmental activity that the infant was capable of before the shutdown. In this context, we need to ask with what supports and in what situations is the infant already able to bring about the smooth and balanced functioning that will be critical for the realization of new pathways. The freeing-up of the small strands of the next developmental agenda in the offing must occur on the background of well-integrated functioning in order to set and maintain the path of development in a positive direction. This is necessary to avoid the unwitting reinforcement of only the disturbing, distorted defense behaviors that are all too readily concommitant of a discrepant organism–environment fit. All too easily, this poor fit can lead to a vicious cycle of increasing and reverberating distortion and disorganization (Herzog, 1979), possibly mediated neurosynaptically (Duffy & Als, 1983). From this perspective, it is not surprising that the number of autistic children

and children with organizational, visual motor integration, spatial, impulsivity, emotional, and attentional deficits (OAID) (Denckla, 1978; Hertzig, 1981; Hunt, Tooley, & Harvin, 1982; Siegel, 1982) is made up of a disproportionately high number of prematurely born infants. The developmental agendum that we have identified for the full-term newborn, namely to increasingly free-up the ability to maintain an alert state, may not as yet be the appropriate issue for the preterm infant. The mutual regulation of autonomic functioning with motoric balance and equilibrium in a well-defined sleep state may well be the salient agendum for a while, before further state differentiation becomes possible.

Subsystems of Functioning

The model of development we propose (Als, 1979, 1982b) here specifies the degree of differentiation of behavior and the ability of the infant at a given moment in time to modulate and organize behavior. The level of differentiation and ability to modulate behavior are the dominant parameters of an infant's individuality and personal uniqueness, recognizable over time. The conceptualization of development presented here focuses on the way the individual infant appears to handle the experience of the world, rather than on the assessment of skills *per se*. The infant's functioning is seen in a model of continuous intraorganism subsystem interaction, and the organism, in turn, is seen in continuous interaction with its environment. We have termed this view of development *synactive*, because at each stage in development and each moment of functioning, the various subsystems of functioning discussed are existing side by side, often truly interactive, but often in a relative supporting holding pattern, as if providing a steady substratum for one of the system's current differentiation (synaction).

The systems we are speaking of include, as seen in Figure 2, the autonomic system, the motor system, the state organizational system, the attention and interaction system, and a self-regulatory balancing system. The functioning of all these systems is reliably observable without technical instrumentation. The autonomic system is behaviorally observable in the pattern of respiration, color changes, and visceral signals such as bowel movements, gagging, hiccoughing, and the like. The motor system is behaviorally observable in the range of states of consciousness available to the organism, from sleeping to alert to aroused states, in the pattern of state transitions exhibited and in the clarity, robustness, and definedness of the states. The attention and interaction system is exemplified in the organism's ability to come to an alert, atten-

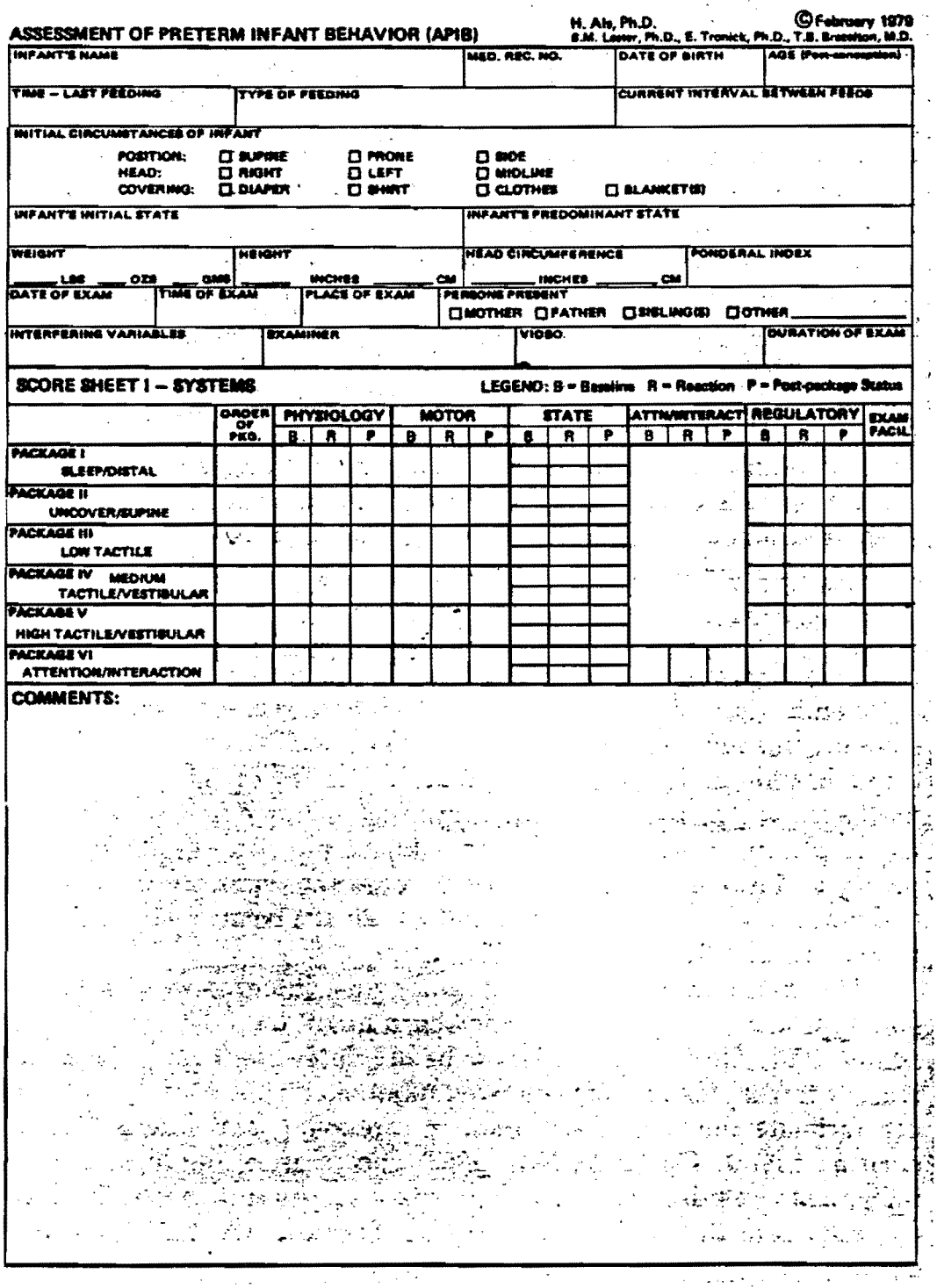
tive state and to utilize this state in order to take in cognitive and socioemotional information from the environment and in turn elicit and modify these inputs from the world. The regulatory system is behaviorally exemplified in the observable strategies the organism utilizes to maintain a balanced, relatively stable and relaxed state of subsystem integration or to return to such a state of balance and relaxation. If the infant's own regulatory capacity is exceeded momentarily and the infant is unable to return to an integrated balanced subsystem state, a further parameter of functioning is identifiable in the kind and amount of facilitation from the environment that is useful to the infant in aiding the infant's return to balance.

The question posed to the organism in this synactive model of development is consequently: How well differentiated and how well modulated are the various subsystems in their functioning and their mutual balance, given varying demands placed on the organisms and given varying developmental tasks the organism attempts to master driven by intrinsic biological developmental motivation? Where are the thresholds of functioning beyond which smoothness and balance become strained or coping behaviors become stressed and eventually behavioral organization becomes so costly that only bare subsistence protections remain and finally even counterproductive maladaptations set in? Which subsystem is differentially vulnerable at which level of environmental and endogenous demand? How severe is its kindling of other systems' imbalance by virtue of its own current disorganization? How much or how little does it take in terms of environmental modification to reinstitute a more balanced integrated state?

Description of the Assessment of Preterm Infants' Behavior (APIB)

In an attempt to systematically identify the infant's relative standing in terms of differentiation and modulation of behavioral subsystems, we have formulated the Assessment of Preterm Infants' Behavior (APIB) (Als, Lester, Tronick, & Brazelton, 1982). This instrument is appropriate not only for preterm infants but also for otherwise at-risk infants and for healthy full-term infants. It is a substantial refinement and extension of Brazelton Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973), in that it provides an integrated subsystem profile of the infant, identifying the current level of smooth, well-balanced functioning in the face of varying developmental demands. In the APIB, the maneuvers of the NBAS are used as graded sequences of increasingly vigorous en-

vironmental inputs or packages, moving from distal stimulation presented during sleep to mild tactile stimulation, to medium stimulation paired with vestibular stimulation to vigorous tactile and vestibular stimulation. The social interactive attentional package is administered at



ASSESSMENT OF PRETERM INFANT BEHAVIOR (APIB) H. Als, Ph.D. ©February 1979
B.M. Lester, Ph.D., E. Tronick, Ph.D., T.B. Brazelton, M.D.

INFANT'S NAME | MED. REC. NO. | DATE OF BIRTH | AGE (Post-conception)

TIME – LAST FEEDING | TYPE OF FEEDING | CURRENT INTERVAL BETWEEN FEEDS

INITIAL CIRCUMSTANCES OF INFANT
POSITION: ☐ SUPINE ☐ PRONE ☐ SIDE
HEAD: ☐ RIGHT ☐ LEFT ☐ MIDLINE
COVERING: ☐ DIAPER ☐ SHIRT ☐ CLOTHES ☐ BLANKET(S)

INFANT'S INITIAL STATE | INFANT'S PREDOMINANT STATE

WEIGHT ____ LBS ____ OZS ____ GMS | HEIGHT ____ INCHES ____ CM | HEAD CIRCUMFERENCE ____ INCHES ____ CM | PONDERAL INDEX

DATE OF EXAM | TIME OF EXAM | PLACE OF EXAM | PERSONS PRESENT ☐MOTHER ☐FATHER ☐SIBLING(S) ☐OTHER ____

INTERFERING VARIABLES | EXAMINER | VIDEO | DURATION OF EXAM

SCORE SHEET I – SYSTEMS LEGEND: B = Baseline R = Reaction P = Post-package Status

	ORDER OF PKG.	PHYSIOLOGY B	R	P	MOTOR B	R	P	STATE B	R	P	ATTN/INTERACT B	R	P	REGULATORY B	R	P	EXAM FACIL.
PACKAGE I SLEEP/DISTAL																	
PACKAGE II UNCOVER/SUPINE																	
PACKAGE III LOW TACTILE																	
PACKAGE IV MEDIUM TACTILE/VESTIBULAR																	
PACKAGE V HIGH TACTILE/VESTIBULAR																	
PACKAGE VI ATTENTION/INTERACTION																	

COMMENTS:

FIGURE 3. APIB Systems Sheet (from Als *et al.*, 1982; reproduced with permission).

any time in the course of the examination that the infant's behavior organization indicates availability for this sequence. It receives priority in the examiner's attempts to facilitate the infant's organization. The systems sheet (see Figure 3) of the assessment permits one to then read off which tasks are already handled with ease by the infant in terms of maintaining well-regulated, balanced functioning of all subsystems; which tasks begin to stress the infant and trespass the balance and modulation of various subsystems yet can be handled with enough environmental facilitation; and which tasks are clearly as yet inappropriate for the infant. In this fashion, developmentally appropriate supportive facilitations can be instituted so that the infant is not continuously overtaxed or, less likely, underchallenged.

Aside from the systems sheet, the APIB provides detailed information on each individual item of the tasks presented in documenting the behavior of the immature, the dysmature, as well as the mature full-term organism. Particular attention has been given, moreover, to the reliable body language of the developing organism, and a catalog of specific regulation behaviors has been established that can be helpful in understanding the infant's current functioning. The signals can be classified as signals of stress and signals of stability. Table 1 gives a list of stress and defense behaviors; Table 2 gives a list of self-regulatory and approach behaviors readily observed in the preterm, at-risk full-term, and/or healthy full-term, respectively (Als, 1982a, 1984). They are grouped into autonomic/visceral stress signals, motoric stress signals, and state-regulation stress signals, on the one hand, and signals of autonomic/visceral stability, signals of motoric stability, and signals of state organizational stability, on the other hand (Als, 1982b). The conceptualization underlying this approach is that the organism will defend itself against stimulation if it is inappropriately timed or inappropriate in its complexity or intensity. If properly timed and appropriate in its complexity and intensity, stimulation will cause the organism to seek it out and move toward it, while maintaining itself at a balanced level (Denny-Brown, 1962, 1972; Schneirla, 1959, 1965).

The formulation of this dual antagonist integration of avoidance and approach as applied to the newborn infant (Als, 1982b; Als & Brazelton, 1981; Als & Duffy, 1983) can be helpful in identifying the infant's current thresholds of balanced, well-modulated functioning. In turn, it can facilitate the individualization of caregiving and interaction with such an infant. Figure 4a (Als, 1983) shows an example of a poorly integrated, withdrawn, and flaccid infant at 1-month postterm during optimal interaction with a social partner. Figure 4b (Als, 1983) shows an example of a well-integrated, robust, and animated infant at the same

TABLE 1
Stress and Defense Behaviors (APIB)[a]

1. Autonomic and visceral stress signals:
   a. Seizures
   b. Respiratory pauses, irregular respirations, breath holding
   c. Color changes to mottled, webbed, cyanotic, or gray
   d. Gagging, choking
   e. Spitting up
   f. Hiccoughing
   g. Straining as if or actually producing a bowel movement
   h. Gasping
   i. Tremoring and startling
   j. Coughing
   k. Sneezing
   l. Yawning
   m. Sighing
2. Motoric stress signals:
   a. Motoric flaccidity, or "tuning out"
      (1) trunkal flaccidity
      (2) extremity flaccidity
      (3) facial flaccidity (gape face)
   b. Motoric hypertonicity
      (1) With hyperextensions of legs: sitting on air; leg bracing of arms: airplaning; saluting of trunk: arching; opisthotonus fingerplays; facial grimaces; tongue extensions; and high guard arm position
      (2) With hyperflexions of trunk and extremities: fetal tuck; fisting
   c. Frantic, diffuse activity; squirming
   d. Frequent twitching
3. State-related stress signals:
   a. Diffuse sleep or awake states with whimpering sounds, facial twitches and discharge smiling
   b. Eye floating; roving eye movements
   c. Strained fussing or crying; silent crying
   d. Staring
   e. Frequent active averting
   f. Panicked or worried alertness; hyperalertness
   g. Glassy-eyed, strained alertness; lidded, drowsy alertness
   h. Rapid state oscillations; frequent buildup to arousal
   i. Irritability and prolonged diffuse arousal
   j. Crying
   k. Frenzy and inconsolability
   l. Sleeplessness and restlessness

[a]Als, 1982b.



FIGURE 4. (a) Optimal alerting during social interaction (1-month postterm): poorly integrated infant (withdrawn and flaccid) (from Als, 1983; reproduced with permission).

age in social interaction. The difference of flexibility and modulation is quite apparent.

The APIB requires extensive training in developmental psychology, a working knowledge of developmental neurology and neonatology, and extensive experience and training in the observation and handling

TABLE 2
Self-Regulatory and Approach Behaviors (APIB)[a]

1. Autonomic stability:
   a. Smooth respiration
   b. Pink, stable color
   c. Stable viscera
2. Motoric stability:
   a. Smooth, well-modulated posture
   b. Well-regulated tone
   c. Synchronous, smooth movements with efficient motoric strategies: hand clasping, foot clasping, finger folding, hand-to-mouth maneuvers, grasping, suck searching and sucking, hand-holding, and tucking
3. State stability and attentional regulation:
   a. Clear, robust sleep states
   b. Rhythmical robust crying
   c. Effective self-quieting
   d. Reliable consolability
   e. Robust, focused, shiny-eyed alertness with intent and/or animated facial expression: frowning, cheek softening, mouth pursing to ooh-face, cooing, attentional smiling

[a]Als, 1982b.



(b) Optimal alerting during social interaction (1-month postterm): well-integrated infant (animated and motorically modulated (from Als, 1983; reproduced with permission).

of preterm and full-term newborns in order to identify and modulate their integrative capacities and to know when systematic examination is inappropriate or even dangerous. The continuous identification of the thresholds of balance and stress is the key feature of this examination. Scoring and administration require extensive training,[1] and reliability needs to be achieved before the assessment can be safely used.

Research with the APIB

The validity of the APIB has been recently documented in the identification of stable, reproducible behavioral patterns in a group of 98 preterm and full-term newborns at 2 weeks after expected due date (Als, Duffy, & McAnulty, 1988a,b) and in the identification of orderly electrophysiological (BEAM) correlates to those behavioral patterns implicating differential vulnerability of the right hemisphere and the frontal lobe (Duffy, Als, & McAnulty, in press). Furthermore, predictive validity to 9 months (Als, Duffy, & McAnulty, in press) and to 5 years has been shown (Als, Duffy, McAnulty, & Badian, in press) in a subsample, identifying the low-threshold, easily disorganized newborn as at greater risk for later organizational difficulties than the well-modu-

[1]Training is available on an individual basis in Boston by writing to the author or in Tucson, Arizona, by writing to Dr. Elsa Sell, Associate Professor of Pediatrics, University Medical Center, Tucson, Arizona 85724.

lated stable newborn and again differentially implicating right hemispheric and frontal lobe functioning.

ENVIRONMENTAL AND SOCIAL INTERVENTION IN SUPPORT OF PRETERM INFANT DEVELOPMENT

If the synactive model of development improves our understanding of the immature infant, it should provide a testable formulation for the amelioration if not prevention of some of the neuro-organizational sequelae associated with prematurity. We hypothesize that attention to the individual infant's behavioral cues with the goal of environmental and behavioral modification in order to bring about reduction in specific stress behaviors and increase in specific self-regulatory behaviors will improve the medical and developmental outcome of the infant. To test this hypothesis, we focused on the most vulnerable preterms in our NICU, the <1250-g respirator-dependent infant at high risk for bronchopulmonary dysplasia (Als, Lawhon, Brown, Gibes, Duffy, McAnulty, & Blickman, 1986). These are the infants with highest mortality and morbidity. The study was conducted in two phases: Phase I, the control phase, and Phase II, the experimental phase. Because the infants were initially too sick to be manipulated in a systematic way to administer the APIB, a behavioral observation method was devised based on the conceptualizations of the APIB. Each infant was observed on Days 10, 20, 30, and so forth throughout nursery stay. The behavioral observations conducted were based on the assumption that the behavior of infants is their primary route of communicating their thresholds to stress or their relative functional stability. An observation began with the recording of a minimum of 20 minutes of baseline observation before the infant under study received any medical or nursing caregiving manipulations, continued throughout a caregiving manipulation (e.g., IV line placement, suctioning, spinal tap, vital sign taking, feeding, bathing, diaper changing, etc., or any combination of these) and was followed by an additional 20 minutes of postmanipulation observation in order to assess the infant's return to baseline or continued stress. An observation typically lasted from approximately 90 minutes up to 3 hours. The behavioral observation sheet used, based on the conceptualization of the Assessment of Preterm Infants' Behavior, focuses on behaviors thought to indicate stress and behaviors thought to indicate self-regulatory efforts and maintenance (see Tables 1 and 2). Each observation sheet is segmented into five 2-minute time-sampling columns,

covering a total of 10 minutes. Digital readouts of the transcutaneous oxygen level ($TcPO_2$) and heart rate monitors were also sampled and recorded every 2 minutes. Ongoing respiratory rate was collected by counting chest wall expansions every 2 minutes for 30 seconds and multiplying the figure by 2. Behavioral categories were checked as to their presence in the course of any given 2-minute epoch. A manual of definitions of all behavioral categories is available (Als, 1981).

For the intervention group infants, the observation record formed the basis for a narrative description of the infant's behavior before, during, and after the respective caregiving procedure observed, with interpretation of behavioral signals as stress versus self-regulatory behaviors, as outlined in Tables 1 and 2. On the basis of this description, we developed strategies for the reduction of stress behaviors and the increase of self-regulatory behaviors, yielding specific inputs for an individualized developmental care plan. This care plan was executed by the nurse and the parent caregiver, with the hypothesis that their social regulation of the individual infant's behavioral organization would result in the enhancement of overall development.

Three major areas of caregiving were attended to: the physical distal and proximal environment of the infant, direct caregiving to the infant, and discharge planning.

Considerations regarding the *physical environment* included (1) location of the infant's crib or isolette (e.g., avoidance of proximity to X-ray screen, faucets and sinks; reduction in telephone and radio-noise level, lighting, traffic, and activity levels); (2) bedding and clothing (e.g., provision of water mattress, sheepskin, boundaries, "nesting," shielding of isolette or crib; clothing, hat, swaddling, bunting, hammock); (3) specific aids to self-regulation (e.g., opportunity to suck during and between feedings [gavage feedings]; opportunity to hold on during manipulations; finger rolls to grasp, foot rolls, hammock); (4) reduction of stress on the treatment table (e.g., by covering and shielding); and (5) consideration of optimal position of infant (e.g., prone, side lying; supports to maintain position ["nesting," back rolls, bunting, etc.]).

Considerations regarding *direct caregiving* to the infant included (1) timing and sequencing of manipulations (e.g., bathing and feeding in one or two separate sessions; reduction of unnecessary vital sign taking, weighing, chest physical therapy, suctioning; adjustment of timing of blood drawing, X rays, ultrasound, spinal taps; with supported positioning of infant for such procedures); (2) feeding (e.g., gavage inside the shielded isolette; supported by holding on and with opportunity to suck; bottle or breast feeding in quiet, shielded corner or parent room; feeding without simultaneously talking to or looking at infant; position-

ing with shoulder and trunkal support, foot bracing; provision of hand holding, use of bunting; timing of feeding with natural sleep cycle, without periods of exhaustive crying preceding feeding); (3) bathing (e.g., immersion, due to its soothing effect, instead of sponge bathing; increased temperature of water; contained position during bathing); (4) transition facilitation (e.g., preparation of the infant's state and calmness in situations definitionally painful and stressful but necessary, such as spinal tap, suctioning, etc., plus support to flexor positioning, with a facilitator present to give inhibition to hands and feet; efficient and quick execution of the necessary manipulation; opportunity for holding onto caregiver's finger and for sucking; encasement of trunk and back of head in caregiver's hand; inhibition provided to soles of feet; unhurried reorganization and stabilization of the infant's regulation with provision of prone placement; removal of all extraneous stimulation such as stroking, talking, position shifts, etc., in order to institute calm restabilization securely; gradual removal of one aid at a time to assure continued maintenance of stabilization); (5) sleep organization (e.g., attention to the sleep cycle of the infant, with prevention of interruption, especially of deep sleep; structuring of transitions into sleep and structuring of sleep maintenance by avoidance of peaks of frenzy and overexhaustion; continuous maintenance of a calm, regular environment and schedule; establishing a reliable, repeatable pattern of gradual transition into sleep in prone or side lying in the isolette or crib; use of the caregiver's body initially and gradual transfer to the crib; use of the isolette with provision of steady boundaries and encasing without any additional stimulation; use of soothing, gentle instrumental music); (6) organization of alertness (e.g., prevention of bright light, shielding of eyes and of isolette or crib; prevention of overstimulation by a cluttered visual environment in the isolette and when outside of the isolette; careful titration of social input modalities: looking, talking, touching; low animated facial expression with quiet looking without movement while providing firm containment to limbs and trunk for optimal maintenance of alertness; prevention of talking while looking; prevention of patting, stroking, rocking, etc.; provision of quiet containment; tactile vestibular inputs while removing visual and auditory inputs; prone position with provision of steady, firm extremity and mouth containment; careful titration of social inputs during and after other activities such as feeding, to avoid hiccoughing, gagging, spitting, aspiration, etc.); and (7) social contact (e.g., involvement of parent and other family members; provision of continuous containment by soothing, quiet inhibition by the parent's steady hands and/or body for the hands, feet, and mouth of the baby; avoidance of unnecessary touching, stroking, taking out of the isolette,

holding and talking to the infant to avoid frenzy, apnea, and/or other withdrawal behaviors; individualized careful timing of inputs in support of increasing self-regulatory stability and differentiation of the infant).

Considerations regarding *discharge planning* to the infant included taking into account the behavioral stability and reactivity of the infant, sleep and wake cycle organization and internal regulatory capacities; avoidance of discharge during persistence of volatile, poorly regulated, hypersensitive, and overreactive behavior patterns; and implementation of discharge after establishment of self-regulatory ability. It was considered to role of the primary caregiver to support behavioral stability by developing a carefully structured, systematic care plan for the experimental infants that would be adhered to by all caregivers. Results of the study showed that the experimental infants showed significantly briefer stays on the respirator (18 days vs. 43 days; $p<.01$) and in increased levels of oxygen (32 days vs. 66 days; $p<.05$). Their feeding behavior was normalized significantly earlier (50 days vs. 79 days; $p<.01$).

Developmental outcome after discharge from the NICU was assessed at 1, 3, 6, and 9 months post-EDC.[2] All observations were performed at the Neurobehavioral Observation Laboratory at The Children's Hospital. Assessments included, at 1 month, the APIB (Als *et al.*, 1982) described earlier; and at 3, 6, and 9 months, assessments with the Bayley Scales of Infant Development (Bayley, 1969). In addition, at 9 months post-EDC, the infants were observed and videotaped in a 15-minute play observation with one of their parents (Kangaroo Box Paradigm) (Als, 1983, 1985b; Als & Brazelton, 1981).

The kangaroo box paradigm was developed from the theoretical basis of the APIB (Als *et al.*, 1982) to provide better documentation and quantification of dimensions of functioning, such as the differentiation and modulation of various subsystems of performance. These include autonomic modulation, gross and fine motor modulation, affective expressive and social interactive modulation as well as self-regulatory capacity, among others. The paradigm consists of a clear plexiglas box in which there sits a windup kangaroo that can be obtained via various access routes: a porthole with a swinging latch door, the top lid, or the two open sides of the box. The box is placed in the center of an otherwise completely empty yet carpeted play-observation room. Mother and child are instructed to play with the toy and box in whichever way they would like, so that both of them have a good time. Six minutes of play ("Play Episode") are videotaped by a two-camera remote control color

[2]Estimated date of confinement.

recording system. After 6 minutes, the mother is instructed to now sit at the edge of the room, facing the child, but no longer smiling, talking, or in any other way reacting to the child. The child is observed in the 6-minute "Still-Face Episode" in efforts to attempt to obtain the windup toy on his or her own and/or solicit the nonreactive parent's reaction and help. Three minutes of reunion in play of parent and child are then videotaped. The videotapes are analyzed using a behaviorally specified manual (Als & Berger, 1979), yielding 20 scores for the infant's performance in the play episode, 19 scores for his or her performance in the still-face episode, 12 scores for the parent's performance in play, 1 still-face and 1 reunion score, and 3 interactive measures, Degree of Turntaking Ability, Synchrony of Interaction, and Overall Quality of Interaction. All scales range from 1 (poorly organized performance) to 5 (well-organized performance).

All assessments were performed by trained examiners not familiar with the goals of the study nor the group membership of the infants nor their performance at previous assessment points. This was easily accomplished, because, in the course of the 2 years of subject intake and the 2 years thereafter, over 120 preterm and full-term infants from other projects were examined at the same data points, allowing for complete blindness of the examiners to a given infant's group and study status.

Developmental outcome after discharge from the NICU showed significantly better behavioral regulation scores at 1 month post-EDC, as measured with the APIB, significantly better Mental and Psychomotor Developmental Indices at 3, 6, and 9 months post-EDC, as measured with the Bayley Scales of Infant Development, and significantly better behavioral regulation scores at 9 months post-EDC, as measured in the videotaped play observation.

APIB: One Month Post-EDC

As Figure 5a shows, of the six APIB System Scores, four are significant at greater than the .1 level; of these, one at better than the .05 level and one at better than the .02 level, all favoring the experimental infants. The parameters involved describe the experimental infants as more well-modulated with higher thresholds to disorganization in terms of motor system (MOTOR, $p<.05$),[3] state maintenance (STATE, $p<.1$), attentional competence (ATTENT, $p<.1$), and self-regulation ability (SREGU, $p<.02$). Figure 5b supports the results shown in 5a. Of the 18 summary

[3]Acronyms for summary variables of the APIB are briefly defined in the test. For a more complete description, see Als (1981).

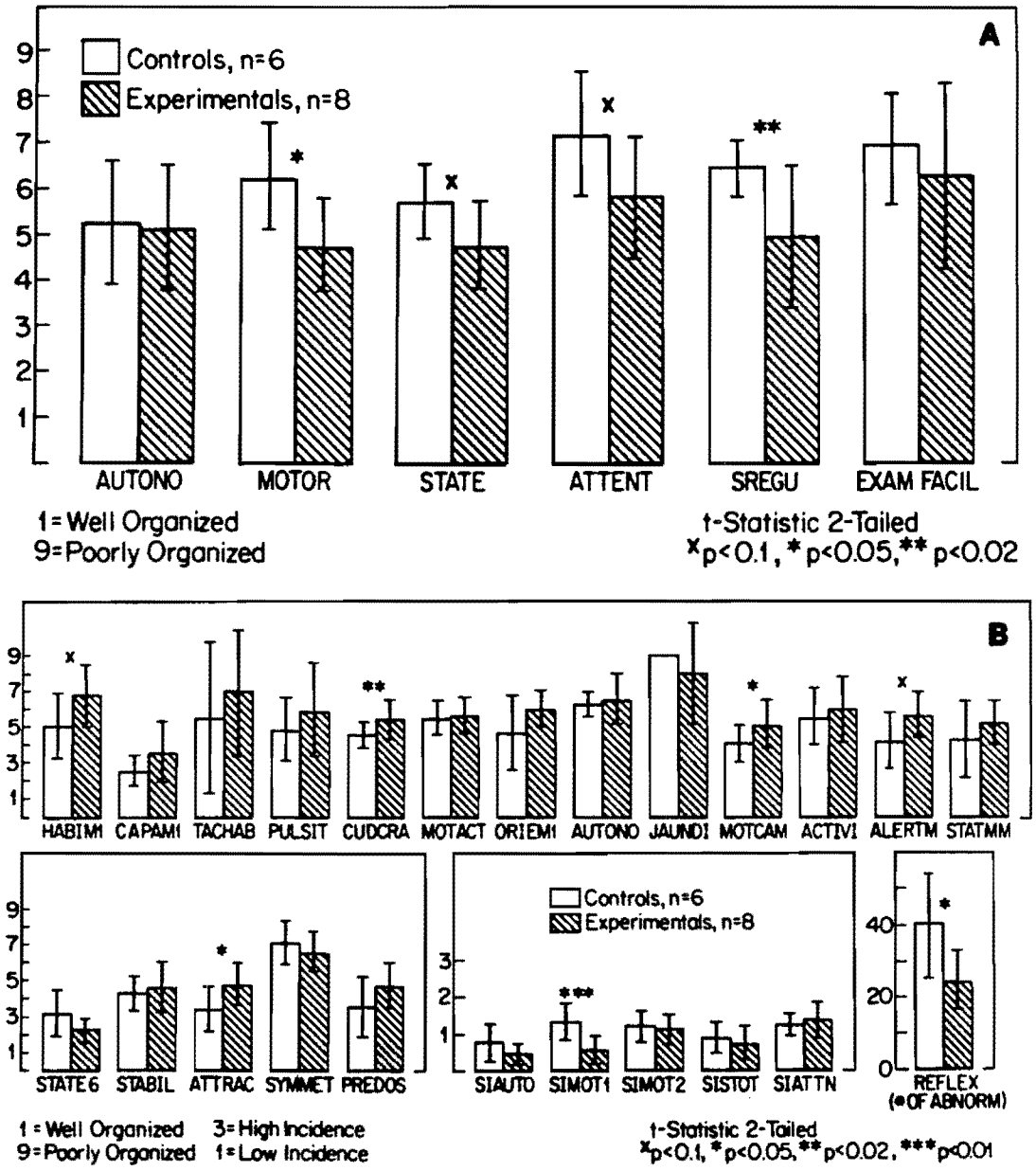


FIGURE 5. (A) APIB at 1-month post-EDC—systems scores, means, and standard deviations. (B) APIB at 1-month post-EDC—summary scores, means, and standard deviations.

variables presented, again 4, more than expected by chance, show significant differences between control and intervention group, favoring the intervention group. These include the ability to cuddle and to inhibit crawling motion when placed in supine (CUDCRA, $p<.02$), a motor capacity measure including the assessment of tone, motor maturity, and balance of postures (MOTCAM, $p<.05$), a measure of alertness (ALERTM, $p<.1$), and of overall behavioral organization and interactive

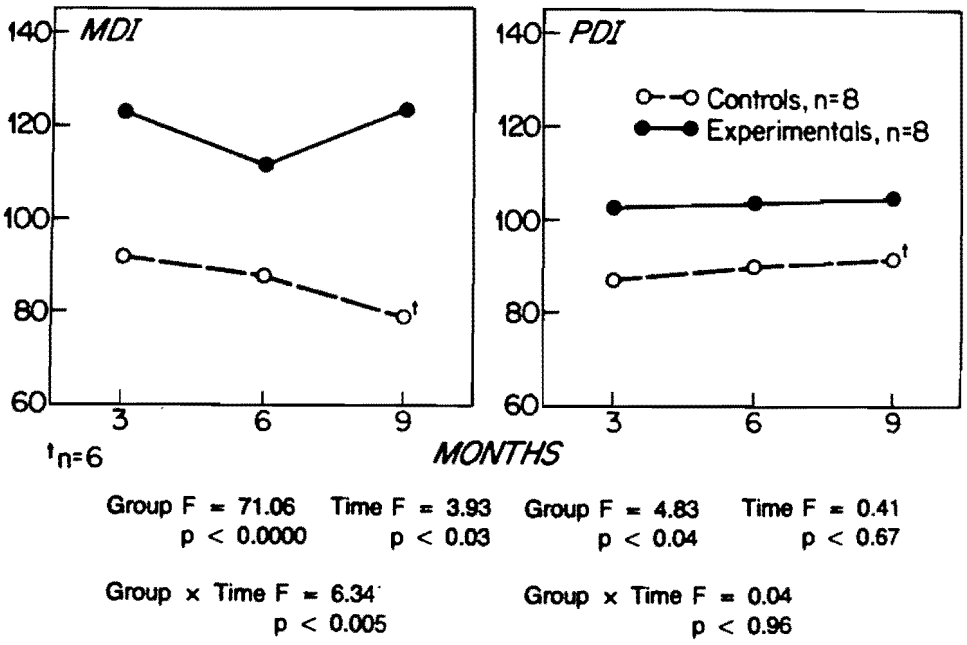


FIGURE 6. Bayley Scale Scores at 3, 6, and 9 months post-EDC—Mental Developmental Index (MDI) and Psychomotor Developmental Index (PDI).

attractiveness (ATTRAC, $p<.05$). Of the five body signal parameters measured, the intervention group shows a significantly lower incidence of motoric extension behaviors such as grimacing, arching, and so forth, considered indicators of stress (SIMOTO, $p<.02$). They also show a higher number of normal reflexes (REFLEX, $p<.05$). Thus, at 1-month post-expected due date, the intervention infants appear to be significantly more well organized along several dimensions of functioning than the control infants.

Bayley Scales of Infant Development: Three, Six, and Nine Months Post-EDC

Figure 6 shows the results of a repeated measures analysis of variance of the Mental Developmental Index (MDI) and the Psychomotor Developmental Index (PDI) of the Bayley Scales.[4] The MDI shows a highly significant group difference at all three age points favoring the experimental infants ($p<.00001$). The experimental infants show mean

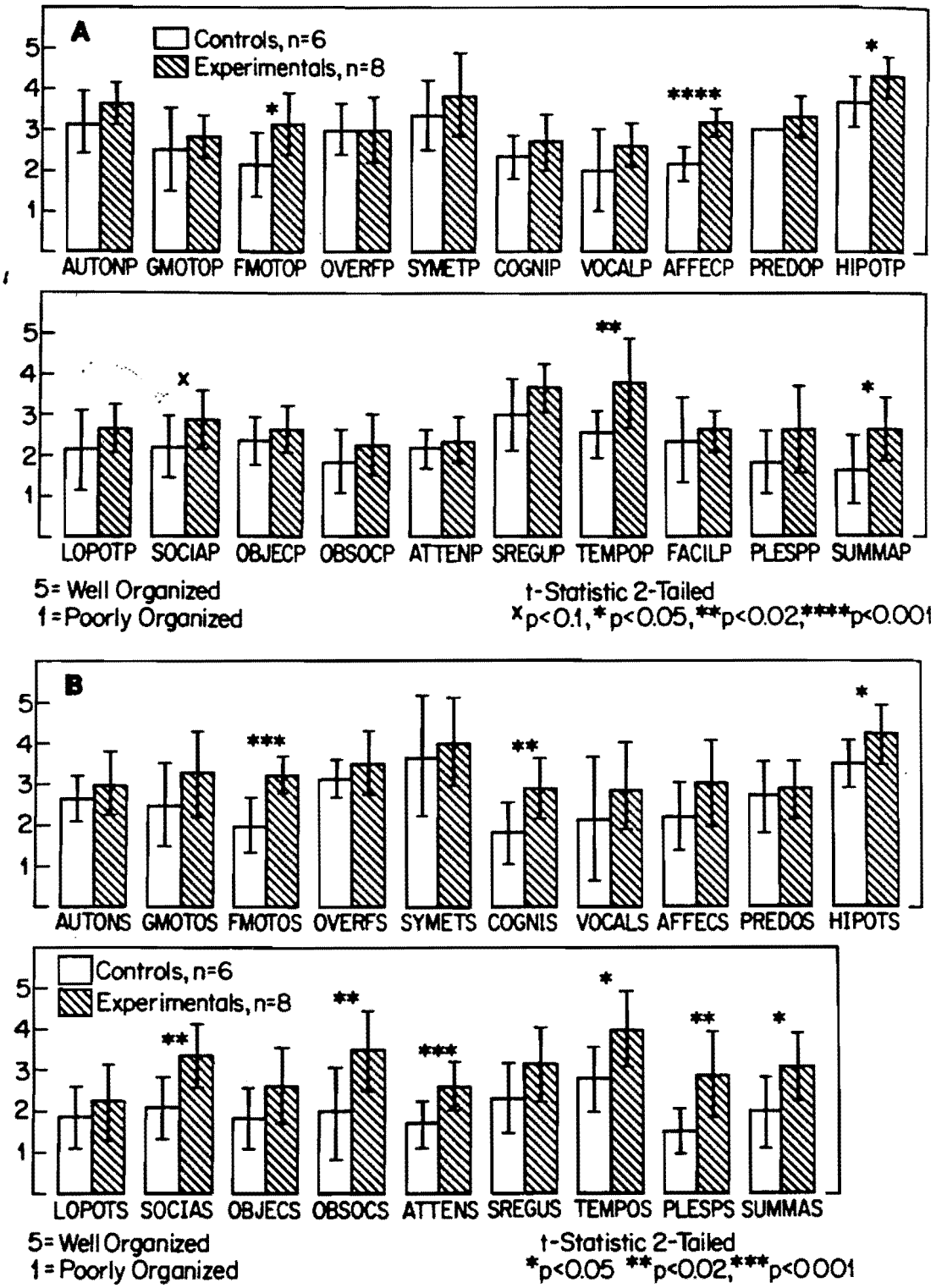
[4]One control infant was discharged from the NICU after 45 weeks. This infant was, therefore, not included in the 1-month post-EDC assessment described. One control infant died at 7 months post-EDC of SIDS by autopsy report and was lost to the 9-month study. Another control infant moved out of town at 8 months and was not studied at the 9-month data point.

scores between 110 and 124, the control infants between 91 and 78; the difference between the two groups ranged from 1½ to 2 standard deviations. Moreover, there is a significant time effect, with the control infants declining significantly over time ($p<.03$); and there is a significant group by time interaction effect with the experimental infants, showing a relative dip in performance at 6 months and improvement at 9 months, whereas the control infants steadily decline from 3 to 6 to 9 months to below 1 standard deviation below the mean ($p<.005$). The Psychomotor Developmental Index (PDI) shows a significant group effect, again favoring the experimental infants at all three age points ($p<.04$), yet the difference between the two groups is not as pronounced (slightly less than 1 standard deviation). There is no significant time nor group by time interaction effect as regards the PDI. Thus the intervention infants perform better at 3, 6, and 9 months post-EDC in terms of mental performance and motor performance.

Kangaroo Box Paradigm: Nine Months Post-EDC

Figure 7a shows the *t*-test results for the 20 parameters measured by videotape analysis involving the 6-minute play episode of parent and child focused on the kangaroo box. Six parameters show group differences favoring the intervention infants and ranging in significance level from .1 to .001. They involve fine motor fluidity and modulation (FMOTOP, $p<.05$),[5] degree of differentiation, range and appropriateness of affective functioning (AFFECP, $p<.001$), highest affective phase achieved in the course of the interaction (HIPOTP, $p<.05$), social interactive competence (SOCIAP, $p<.1$), modulation and speed of movement (TEMPOP, $p<.02$), and overall summary rating of performance (SUMMAP, $p<.05$). In the Still-Face Episode (see Figure 7b), in which the parent is instructed to no longer help and/or interact with the child in any way; 9 parameters out of 19 show significant differences, ranging in significance level from $<.05$ to $<.01$, and again favoring the experimental infants over the control infants. The parameters involve again fine motor modulation (FMOTOS, $p<.01$), apparent understanding of the task without the mother's help (COGNIS, $p<.02$), highest affective level achieved in the Still-Face Episode (HIPOS, $p<.05$), ability to elicit the parent by socially positive measures in order to resume play with the child (SOCIAS, $p<.01$), ability to combine object play with social elicitation (OBSOCS, $p<.01$), ability to stay engaged in the task and break it down into manageable components (ATTENS, $p<.01$),

[5]Acronyms for selected subtests of the Kangaroo Box Paradigm are briefly defined in the text. For a more complete description of this measure, see Als and Berger, 1979.


A
Controls, n=6
Experimentals, n=8
AUTONP GMOTOP FMOTOP OVERFP SYMETP COGNIP VOCALP AFFECP PREDOP HIPOTP
LOPOTP SOCIAP OBJECP OBSOCP ATTENP SREGUP TEMPOP FACILP PLESPP SUMMAP
5= Well Organized
1= Poorly Organized
t-Statistic 2-Tailed
xp<0.1,*p<0.05,**p<0.02,****p<0.001
B
AUTONS GMOTOS FMOTOS OVERFS SYMETS COGNIS VOCALS AFFECS PREDOS HIPOTS
Controls, n=6
Experimentals, n=8
LOPOTS SOCIAS OBJECS OBSOCS ATTENS SREGUS TEMPOS PLESPS SUMMAS
5= Well Organized
1= Poorly Organized
t-Statistic 2-Tailed
*p<0.05 **p<0.02,***p<0.001

modulation of speed of movement (TEMPOS, $p<.05$), the ability to show pleasure and pride in an accomplishment (PLESPS, $p<.01$), and the overall Summary Competence Rating (SUMMAS, $p<.05$). It is of interest that the control infants show poorer performance than the experimental infants on many more parameters when studied under increased stress, that is, the Still-Face Episode, when their parent no longer can be of assistance, than when they are helped by the parent. The results reinforce the importance of social context in facilitation of skill development and self-regulation of preterms.

Figure 7c shows the 12 parent parameters in play, the parent's ability to maintain the still face (PSTILF), and the parent's ability to reengage the infant during the reunion episode (REPLAY). Only 1 parent parameter shows a significant group difference, namely Degree of Parent's Facilitation of Play (DPFACL, $p<.05$), indicating that control and experimental infants' parents are overall equally adept and invested in making the play successful and enjoyable to the infant, yet the intervention parents may be more sensitive to the specific needs of their

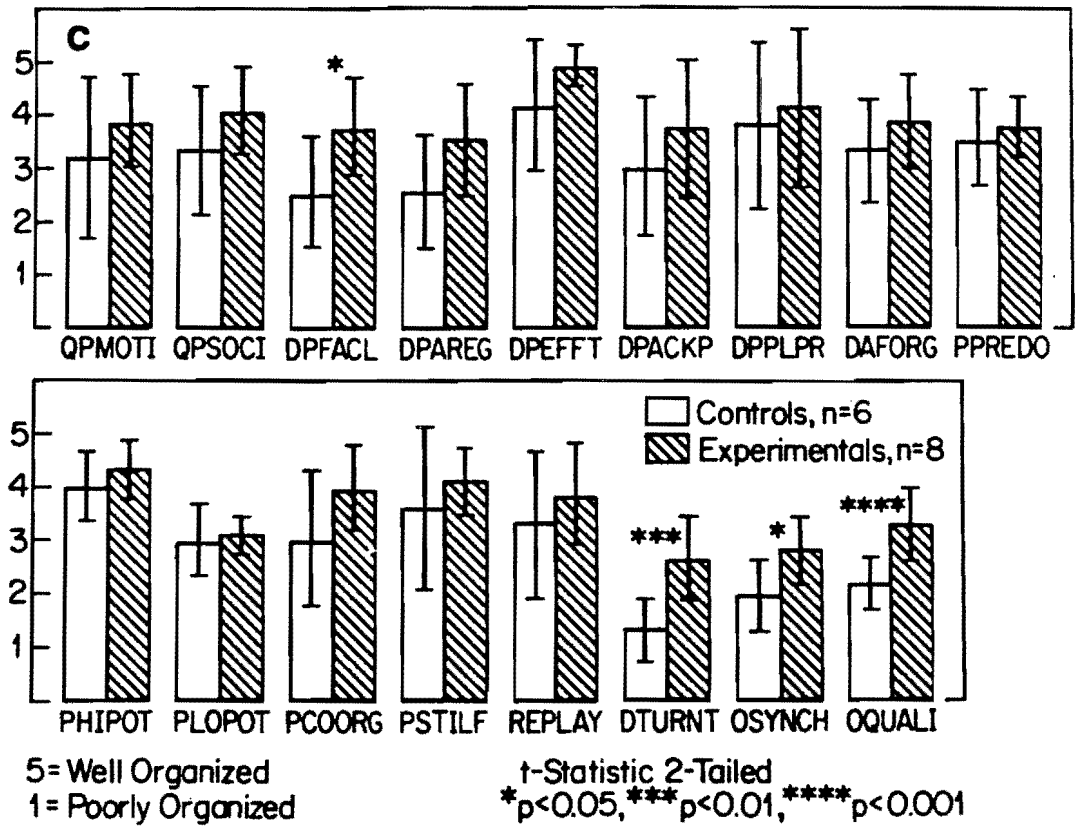


FIGURE 7. (A) Kangaroo Box Paradigm at 9 months post-EDC: Play Episode. (B) Kangaroo Box Paradigm at 9 months post-EDC: Still-Face Episode. (C) Kangaroo Box Paradigm at 9 months post-EDC: Parent and Interaction Parameters.

babies, although this may be a chance finding. The last three parameters graphed involve interaction parameters, and all three show significant group differences. The parameters measured are Degree of Turn-Taking Ability (DTURNT, $p<.01$), Degree of Overall Synchrony of the Interaction (OSYNCH, $p<.05$), and Overall Quality of the Interaction (OQUALI, $p<.001$). Again, the experimental parent–infant pairs show the better scores in free play at 9 months. The experimental infants appear, again, significantly more well organized, well differentiated, and well modulated than the intervention infants. These results support the hypothesis that the synactive formulation of development provides a specific framework for the design of appropriate social and sensory contexts for the high-risk preterm infant in the NICU, from which the infant profits significantly not only medically but also developmentally.

Spinoffs of the study have since affected overall caregiving in the NICU, especially the care of the long-term hospitalized, chronically ill newborns with severe lung disease who typically suffer from extreme hypersensitivity to stimulation often accompanied by increasingly distorted motor system development with shoulder retraction, head and trunkal arching and extension, poor trunkal tone, and increased leg extensor tone (Als, 1986). Position of flexor tone and calm relaxation together with structuring of a developmentally supportive environment in order to maximally facilitate normal socioemotional, cognitive, and motor development in the face of chronic severe illness and prolonged hospitalization is the goal. Humanization of the hospital environment with the integration of the infant's care by his or her own parents, affording space, privacy, and the ongoing opportunity for increasing developmental differentiation is aimed for. The context provided by caregivers in general and the parents, in particular, reinforces and supports the preterm infant in his or her ongoing confrontation of an otherwise stressful environment.

A training course in the observation of the behavioral signals of the infant and in the individualized caregiving based on these behaviors is available.[6]

SUMMARY

The preterm infant is a product of our advances in neonatal medical technology. Now that survival even of very early born and very small infants is increasingly assured, our attention can shift to the quality of

[6]For information regarding the individually scheduled training course, write to H. Als, Enders Research Building, Room M-29, The Children's Hospital, Boston, Massachusetts 02115.

this survival. The brain of the immature fetal infant is the critical organ that orchestrates and influences all aspects of development. The protection and support of the immature yet rapidly differentiating brain in our NICU environments has to become a foremost priority for all those giving care to the infant. The synactive model of development outlines access avenues for the observation of that brain's function via the behavior displayed by the infant. Autonomic, motoric, state organizational, attentional, and self-regulatory capacities of the infant can be observed productively in order to identify succinctly and specifically where an individual infant's thresholds to stress and ability for self-maintenance and increasing self-regulation and self-differentiation lie. Stress is always a necessary concomitant of all development. In order to take the next step to differentiation, previously integrated and synchronized connections have to be opened up which necessitates the disorganization and dyssynchronization of subsystems in their interplay. When the newly in-reach agendum becomes gradually mastered, that is, stress diminishes, then the subsystems realign and support each other again, now at a higher level of more differentiated functioning. If stress is too massive, more differentiated new alignment of subsystems is not possible; then a maladaptive, costly realignment occurs at a more rigid, canalized level of functioning, forcing the infant over time to practice and fall back onto maladaptive strategies and precluding flexible differentiation. The synactive framework of development provides an approach for the caregiver to identify on an individual basis for each child the opportunities currently available with the infant in the quest to support optimal differentiation and modulation without overtaxing and overstressing the child. Respect for the child's behavioral communications as meaningful will engender in the caregiver confidence in the child and her or his own ability to jointly negotiate the next step in the developmental process.

The social context that evolved over thousands of generations of human phylogenesis in surprisingly fine-tuned specificity provides the good-enough environment for the normal full-term nervous system to unfold initially intrauterinely, then extrauterinely, adequate to assure the continuation of human evolution. With the advances in medical technology, that is, material culture, even the very immature nervous system can exist and survive outside the womb. However, the social context of the traditional special care nursery brings with it less than adequate support for that immature nervous system, leading to maladaptations, disability, and even at times death. Is the human mind and emotional makeup good enough to pair instrumentation and technology with appropriately tailored social context in order to support adequately the threatened immature nervous system? In the NICU, detailed observation

of the behavior of the fetus displaced from the womb as it reacts to the onslaught of sensory experiences is necessary. Such observation provides the opportunity to estimate and infer how appropriate social context can be provided sufficiently to support that highly sensitive and highly vulnerable being's developmental progression. We are evolved as adults to be attuned biologically to the full term, just as the full term is evolved to be attuned to us, a mutual developmental fueling system established and tuned over time. We have to become differently conscious of our reaction to and interaction with the displaced fetus we are confronting *ex utero*. In this challenge lies our opportunity.

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