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The Assessment of Preterm Infants' Behavior (APIB): Furthering the Understanding and Measurement of Neurodevelopmental Competence in Preterm and Full-Term Infants

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Abstract

The Assessment of Preterm Infants' Behavior (APIB) is a newborn neurobehavioral assessment appropriate for preterm, at risk, and full-term newborns, from birth to 1 month after expected due date. The APIB is based in ethological–evolutionary thought and focuses on the assessment of mutually interacting behavioral subsystems in simultaneous interaction with the environment. The subsystems of functioning assessed include the autonomic (respiration, digestion, color), motor (tone, movement, postures), state organization (range, robustness, transition patterns), attention (robustness, transitions), and self-regulation (effort, success) systems as well as the degree of facilitation required to support reorganization and subsystem balance. The environment is represented by a sequence of distal, proximal, tactile, and vestibular challenges, derived from the BNBAS. The APIB conceptualizes infant competence as the degree of differentiation of subsystem function and degree of modulation of subsystem balance at any stage in infant development. Infants are understood as actively seeking their next differentiation, while counting on good enough environments to assure progressing developmental competence. In the case of interference such as premature birth, the mismatch of expectation and actual experience causes misalignment, which may become developmentally costly. The assessment is a finely tuned dialogue between examiner and infant, which requires training, skill and self-knowledge. The APIB has well established inter-rater-reliability, concurrent and construct validity, and is clinically relevant for behavioral intervention and individually appropriate and supportive care.

Keywords

APIB; assessment; prematurity; newborn; neurobehavior; preterm infant; development

The Assessment of Preterm Infants' Behavior (APIB) [Als et al., 1982a, 1982b] is a widely used behavioral tool specifically designed to document the spectrum of full-term as well as preterm newborn infants' neurobehavioral functioning. It presents the infant with increasingly demanding environmental inputs in a graded sequence of distal and proximal stimuli. The APIB is based on a model of development that aims to document the degree of

differentiation and modulation of various behavioral subsystems, which stand in continuous intraorganism interaction and in continuous interaction with the environment. The subsystems include the autonomic, motor, state, attention/interaction, and self-regulation systems. Differentiation and modulation of behavior are considered the dominant parameters of an infant's individuality recognizable over time.

Historical Background

During the last two decades, the decrease in infant mortality and morbidity, even of the very smallest newborns, has been considerable. This decrease is a result of the remarkable improvements in newborn intensive care [Hack et al., 2002]. Simultaneously, with these improvements has come a surge of interest in the functional capabilities of early-born infants. Fetal infants were once thought to function mainly at a brain stem level. They have more recently been recognized as remarkably complex, reactive and active in eliciting social and sensory stimulation, while always attempting to regulate their own thresholds of reaction and response. Increasingly, clinicians and researchers are challenged to identify ways to assess such early born newborns in terms of current strengths, vulnerabilities, prognosis, and recommendations for support and care.

Newborn assessments traditionally derive from two schools of thought: a classical, neurological approach, derived from adult neurological status examination, and a behavioral, psychological approach based on psychological laboratory procedures for studying specifically human functions. These distinctions have at times led to artificial separation of aspects of newborn functioning. More recently, there have been efforts to combine neurological and behavioral assessment aspects into more comprehensive approaches, as indicated in this volume.

Assessing Newly Emerging Developmental Agenda

The model that underlies the APIB [Als et al., 1982a, 1982b] is anchored in human ethology. From early work with healthy full-term newborns examined with the Brazelton Neonatal Behavioral Assessment Scale [Brazelton, 1973] and from direct observation of newborns and their mothers, differentiation of the attention system emerges as the most salient, most rapidly changing, and apparently newest emerging agendum of the full-term newborn [Als, 1977]. Autonomic stability in terms of respiratory control, temperature regulation, and digestive tract functioning is relatively quickly re-stabilized after the birth process, as are smoothness of movements and adaptation of well-regulated balance between flexor and extensor posture [Casaer, 1979]. The same holds true for state organization in terms of range of states and transition patterns [Sander, 1980]. Most healthy full-term newborns readily achieve a robust, lusty cry and return to sleep relatively readily. The most challenging issue for newborns in the first several weeks after birth is the stabilization of alertness, as they move from sleep to crying and back to sleep again. Although in the 2-day-old full-term infant, alert periods may still be embedded in long stretches of sleep, by 2 and 3 weeks after birth the periods of alertness have become increasingly reliable, and by 6 weeks many infants are increasingly socially and cognitively interactive.

The Social Environment of the Human Newborn

Parents are keen and sensitive in aiding their newborn infant in stabilizing alertness. Mothers will typically acknowledge even brief eye opening with delight, at which the infant may avert the gaze, yawn and sneeze, or fuss and cry, and thus resets the interactive intensity to a lower level. Infants who stay locked on the mother's face may gradually tense, spit up, hiccough, gag, or move their bowel, overall reacting at an autonomic visceral level. Or else they may extend and flail, squirm, and arch, using motor system shifts in resetting the intensity of interaction. Should an infant sustain alertness for substantial periods, with well-functioning subsystems, the mother may be the one to draw the baby close, nuzzle and kiss, stroke or pat the baby, and therefore reset the intensity of attention [Als, 1977; Grossman, 1978]. From the very beginning of extrauterine life, the newborn is launched onto the species-specific, interactive, collaborative, and communicative track, supported and affectively rewarded by the caregiver. Newborn interactive attention appears to be of high species value [Als and Duffy, 1982].

High-Risk Newborns' Capacity for Attention and Interaction

Infants born early and/or with fetal growth restriction often show great reluctance to come into alertness: they may demonstrate hypertonic, flexed, high guard arm positions with fistled hands, become pale, breathe rapidly and unsteadily, and show pained, drawn facial expressions [Als, Duffy, and McAnulty, 1990]. With slow, calm support, they may gradually open their eyes, whereas the hypertonic high-guard fistled defensive posture may shift abruptly into flaccidity and tuning out, the infant will pale further, and breathe slow and unsteady. The attention mustered will likely be glassy-eyed, strained, and barely focused, thus the cost to the autonomic and motor system regulation will be high. This pattern of relatively poor subsystem differentiation, in which all systems are drawn into generalized reaction, exemplifies the overall cost for even a small accomplishment, such as eye opening. Measurement of subsystem involvement in specific performances is considered important in understanding an infant's current competence on the developmental trajectory.

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APIB Objective: Assessing Infant Individuality and Competence

The main objective of the APIB is the assessment of infant individuality and competence, based on observation of the behavioral subsystems in interaction with each other and with the environment. The conceptual ingredients of the assessment of individuality and competence include determination of 1) the infant's current, newly emerging developmental agendum and the degree of its saliency; 2) the infant's current level of subsystem balance and smoothly integrated subsystem functioning independent of the new agendum; 3) the threshold of disorganization indicated in subsystem behaviors of defense and avoidance as the emerging developmental agendum is aimed for; 4) the degree of relative modulation and regulation of the various subsystems in accomplishing the new agendum; 5) the degree of differentiation and effectiveness in rebalancing the subsystems in the accomplishment of the agendum; 6) the degree of environmental structuring, support, and facilitation necessary to

bring about optimal implementation of the new agenda; and 7) the degree of environmental structuring, support, and facilitation necessary to bring about return to smooth, well-integrated, baseline functioning. This approach to the assessment of newborn competence is considered appropriate throughout the life span. At each stage of development, newly salient agenda are negotiated on the background and basis of previous levels of subsystem differentiation and modulation. Fig. 1 is a schematic attempt to visualize this conceptualization applied to the fetal and newborn stages [Als, 1982].

The four concentric cones represent, from the innermost going outward, the autonomic system, which assures the organism's baseline functioning. The motor system surrounds the autonomic system and unfolds from early embryonic stages with increasing differentiation of flexor-extensor postures, limb, and trunk movements. Around the motor system is a third cone, the state organizational system, which unfolds in distinct states of consciousness from a diffuse quasi-sleep to increasingly differentiated sleep, wake, and aroused levels of consciousness. Around and within the state system lies the gradually differentiating awake state. The awake state is increasingly elaborated and finely tuned through cognitive receptivity and activity to engage in the social and inanimate world. These systems are continuously interactive with one another; they influence and support one another or infringe on one another's relative stability. Each subsystem continuously strives for within-subsystem differentiation, which 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 evolved environment, expected for species-appropriate ontogenesis. The organism actively shapes and selects from this environment as the environment in turn constantly challenges the organism [Hunt, 1961; Piaget, 1963].

Assessment of the Preterm Organism

Advances during the past 10 years in perinatal and neonatal medicine have resulted in significant increase in survival, especially of infants less than 28 weeks' gestation [Vohr et al., 2000]. Although these infants comprise only a small percentage of births, they add disproportionately to the mortality, morbidity, and cost of medical care and their long-term disabilities, including cerebral palsy (CP); learning, neurodevelopmental and school achievement deficits are disproportionately high [Peterson et al., 2000; U.S. Department of Health and Human Services Center for Disease Control, 1999; Wolke, 1999].

Fetal infants expect at least 13–16 more weeks of in utero development, with respiratory, cardiac, digestive, and temperature control aided by maternal blood flow and placental functioning. They expect total cutaneous somasthetic input from the amniotic fluid and kinesthetic input from the continuously reactive amniotic sac, which assures mutual extensor–flexor modulation for head, trunk and extremities [DiPietro et al, 1996]. Fetal infants expect maternal diurnal rhythms to entrain differentiating states of consciousness [Reppert and Rivkees, 1989] and muted inputs to ready primary senses of audition, olfaction, and gustation [Lickliter, 2000; Philbin, Lickliter, and Graven, 2000]. Preterm infants, rather than being inadequate or deficient full-terms, are well-equipped, competently adapted fetuses that function appropriately for their stage of development. The sudden passage to an environment poorly matched to their expectations triggers altered subsystem

functioning. Instead of the mother's womb, medical technology attempts to take care of respiratory, cardiac, digestive, and temperature control functions. In most neonatal intensive care units (NICUs), autonomic functioning is the primary focus, and the motor system, state organization, and sensory functioning are secondary concerns. When preterm infants reactivate their energy, it appears that they attempt to reestablish levels of developmental competence attained in the womb. It is important to ask how to assure these infants' smooth and balanced functioning now outside the womb. Realignment and emergence of next developmental agenda best occur on the background of well-integrated functioning to set development in a positive direction. This avoids reinforcement of costly maladaptive defense behaviors that all too readily spiral into vicious cycles of increasing distortion and disorganization [Anand and Scalzo, 2000], which in turn modify both brain structure and function [Als et al., 2003, 2004]. It is not surprising that many of these infants are later diagnosed with behavioral and neurological impairments.

Subsystems of Functioning Measured by the APIB

The conceptualization of development, which underlies the APIB, focuses on the way individual infants handle their experiences of the world around them, beyond assessing their specific skill repertoires [Als, 1982]. The infants' functioning is viewed as a model of continuous intraorganism subsystem interactions, which in turn occur in continuous interaction with the respective environments and thus has been termed "synactive." At each stage, various subsystems of functioning exist simultaneously while they mutually influence each other. Often functioning is truly interactive, at other times interactively supportive holding patterns provide a steady multisystem base for one of the system's current further differentiation. The systems addressed include autonomic, motor, state organization, attention, and interaction, as well as self-regulation and balance. A further parameter is the degree of environmental and caregiver/examiner facilitation required to bring about an infant's successful subsystem reorganization. Functioning of sub-systems is reliably observable without technical instrumentation.

The autonomic system is behaviorally observable in the patterns of respiration, color changes, tremulousness, and visceral signals, such as bowel movements, gagging, and hiccoughing. The motor system expresses itself in posture, tone, and movement patterns; state organization in the range of states from sleeping to awakening, and full arousal with crying, the degree of robustness and definition of each state, and the patterns of state to state transitions. The attention and interaction system, within the state continuum, is expressed in the ease of coming to an alert, attentive state, the robustness and definition of the alert state, and the utilization of the state in taking in cognitive and social emotional information from the environment, and in turn eliciting and modifying such inputs from the surrounding world. The regulatory system behaviorally expresses itself in the strategies utilized to maintain and/or regain a balanced, relatively stable and relaxed state of subsystem integration. If the infant fails to return to well-integrated subsystem balance, the infant is further assessed on the kind and amount of environmental facilitation required to aid the infant in returning to balance.

The APIB poses the following questions: How well differentiated and well modulated are the various subsystems of functioning in their mutual balance, given varying exogenous demands and endogenous developmental tasks? What are the thresholds of functioning beyond which smoothness and balance are threatened, self-regulation is stressed, and eventually behavior organization becomes so costly that eventually counterproductive maladaptations set in? Which subsystems are differentially vulnerable at what levels of environmental and endogenous demands? How severe is the kindling of other systems' imbalances by one system's current disorganization? What environmental modification will reinstate a more balanced and stably integrated level of functioning?

Description of the APIB

The APIB attempts to systematically identify infants' relative standing in terms of differentiation and modulation of behavioral subsystems [Als et al., 1982a, 1982b]. The APIB is widely used, both clinically and in research studies. The instrument is appropriate for preterm infants, other high-risk, as well as healthy full-term infants. It is a substantial refinement and extension of the Brazelton Neonatal Behavioral Assessment Scale (BNBAS or NBAS) [Brazelton, 1973] in that it provides an integrated subsystem profile, and identifies current levels of smooth, well balanced functioning during varying developmental demands.

APIB Scoring System

The APIB uses the maneuvers of the BNBAS as graded sequences or packages of increasingly vigorous environmental inputs. It moves from distal stimulation presented during sleep, to mild tactile, to medium tactile paired with vestibular, and eventually to high tactile paired with vestibular stimulation. The social interaction/attention package is administered at any time in the course of the examination, when the infant's behavioral organization indicates availability for this sequence. It receives priority in the examiner's attempts to facilitate the infant's organization. The APIB yields six main system variables (the arithmetic means of the 81 scores of the 6 sets of system scores; see Fig. 2) and 26 additional variables, constructed by a priori rules from the additional 204 sub-scores.

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The six system scores (Physiology, Motor, State, Attention/Interaction, Regulatory, Examiner Facilitation) range from 1 to 9. Low scores (1–3) denote degrees of well-modulated and well organized behavioral regulation, reflective of optimal thresholds of

disorganization and stress, whereas high scores (7–9) denote easily disorganized, poorly modulated behavioral regulation, reflecting low to very-low thresholds of disorganization and stress. The examination consists of six item packages: (1) Sleep/Distal Stimuli; (2) Uncover and Supine Positioning; (3) Low Tactile Stimuli; (4) Medium Tactile and Vestibular Stimuli; (5) High Tactile and Vestibular Stimuli; and (6) Attention/Interaction. For packages 1 to 5, three separate status scores (Baseline, Response, and Post) are assigned for four of the systems (autonomic, motor, state, and self-regulation). For package 6, one overall system score of Examiner Facilitation is assigned. The attention/interaction system is only scored in package 6.

The three scores identified per package by system represent one score for the level of functioning in the respective system before stimulus onset (Baseline, B); one score for the cumulative performance during the response(s) to the set of maneuvers grouped within a package (Response, R); and one score for the system functioning after the items within a package and prior to the initiation of facilitation (Post, P). The 3 scores B, R, and P depict a detailed nuanced profile per package and by system of the infant's current differentiation and modulation of functioning in respect to increasing demands from the environment and examiner. Well-functioning infants between 10 and 30 days corrected age (age based on due date) respond in the 1–3 range, poorly functioning infants score in the 7–9 range [Duffy, Als, and McNulty, 2003].

The systems sheet of the assessment permits one to determine which tasks an infant handles with ease, maintaining well-regulated, balanced functioning of all subsystems, which tasks begin to stress an infant and surpass the balance and modulation of various subsystems yet may be managed with examiner facilitation, and which tasks are clearly inappropriate for an infant. In this way, developmentally appropriate goals and supportive facilitation may be established which are neither overtaxing nor underchallenging for the individual infant.

Aside from the system scores, the APIB provides detailed information on each of the tasks presented, summarized by a priori rules into the 26 mutually exclusive additional variables [Als, 1987]. The APIB scales document behavioral functioning with particular attention to reliable body language in expressing the thresholds from well to poorly regulated functioning. Additionally, a catalog of specific regulation behaviors proves helpful in characterizing the infants' preferred expressions. These are classified into signals of stress and of stability and may be grouped further into autonomic/visceral, motor, and state-regulation signals. The underlying conceptualization emphasizes defense against stimulation that is inappropriately timed or inappropriate in intensity and duration; and approach to stimulation that is properly timed and of appropriate intensity and duration [Denny-Brown, 1962]. The formulation of this dual antagonist integration of avoidance and approach is helpful in identifying an infant's current thresholds of balanced, well modulated functioning. In turn, it facilitates the individualization of caregiving and interaction. Fig. 3 shows two infants at 34 weeks' postmenstrual age in social interaction: on the left an infant with overly wide-eyed stressed facial expression, on the right a well-integrated, robust, and animated infant. The difference of modulation and differentiation is readily apparent.

APIB Test Procedures, Training, and Inter-Rater Reliability

The examination of a preterm infant may take up to an hour, depending on the periods of reorganization appropriate for the infant. Scoring by a skilled examiner takes between 30 and 45 min. Writing the clinical assessment report may take up to 3 h, depending on the complexity of medical history, developmental issues, and recommendations. APIB assessment is by no means a quick, easily learned screening test. It more closely resembles the careful, detailed neuropsychological assessment of integrative function of the older child.

Requirements for an appropriate examination setting include a separate testing room free of interfering variables, extraneous sound, light, conflicting space requirements, and unpredictable interruptions. The examining room should be comfortably furnished with a chair appropriate to sit in a relaxed manner, with feet well supported. The examiner's lap should be stably inclined to approximately 45–60 degrees, arms should move freely, and opportunity to recline to a close to horizontal position is important. The room should have one light source with dimmer capacity, at eye level with the seated examiner, wall oxygen, and portable or permanently installed vital sign monitoring equipment, as well as an accessible sink. The room should be comfortably warm. All care materials required during the examination should be prepared in advance (clean linen, prewarmed blankets, infant clothing and hat, diapers, washcloths and baby wipes, hand disinfectant, pacifiers, portable basin with warm water, and waste receptacle with a quiet lid closure). The room needs to be spacious enough to accommodate an incubator, the examiner's chair, and the maneuvering of equipment with ease. Furthermore, chair(s) for the parent(s) and staff should be available, as well as a cushioned surface for the examiner's clipboard and APIB “toys.” These include the standard BNBAS materials (flashlight, red rattle, bell, and red ball, available through the Brazelton Center web site) and a Happy Apple (Fisher Price, East Aurora, NY), which is a red shiny, plastic apple with a black and white face on one side, a blank surface on the other, and a soft melodic chime activated by gentle movement. All materials should be easily accessible.

By definition all infants are appropriate for examination since all infants express themselves in their current behavior.

The examiner should wear soft-soled quiet shoes. Bold patterns and colors and large jewelry should be avoided. Fingernails should be short and clean. All fragrances should be eliminated. Room and examiner should be well prepared before bringing the infant to examination room.

The examination is best performed 1 hour prior to an infant's next expected awakening and/or feeding, for the more immature infant, closer to the next feeding. The infant should be asleep at the beginning of the examination to observe system functioning at rest and assess response to distal stimuli (light, sound) during sleep as well as transition from sleep to higher states of arousal in the course of sensory inputs. The infant's face should be shielded during transport to prevent light fluctuations. Once in the quiet room, an infant may require up to half an hour to settle into restful sleep. Comparable arrangements should be made for examinations in home, research, or clinic settings.

The use of the APIB requires extensive background and training in the understanding and interaction with preterm and full-term newborns to identify and modulate their integrative capacities and to know when examination is appropriate. Advanced level professionals are appropriate users, assuming that they have acquired extensive experience in standardized infant testing and command sufficient medical and clinical knowledge of fetal, preterm, and full-term new-borns, infants, and child development and parent development in normal and high-risk situations. The continuous identification of the thresholds of balance and stress is a key feature of the APIB examination. Typically the process requires approximately 8 to 10 months preparatory study and training, depending on background and time available for practice. Preparation includes mastering the required background readings, and shadowing an experienced NICU nurse and neonatologist in their daily work in the NICU, caring for preterm infants, as well as establishing rapport and access with a full-term well-baby nursery. This experience will identify areas where further study is needed. Training in the Brazelton scale and NIDCAP (Newborn Individualized Developmental Care and Assessment Program) [Als, 1986, rev. 2002] training are excellent preparatory skills and are highly recommended. APIB training is available from two national training centers in the United States upon individual application and a preliminary screening and acceptance process. Reliability with the trainer needs to be achieved before the assessment may be safely and appropriately used. In the course of the practice, which typically is a 1-year process from formal introductory and demonstration training to reliability, the trainee is expected to acquire specific knowledge regarding the basic neurological functioning of the newborn, master the assessment and appropriate interpretation of the reflex repertoire and foremost become astute in the facilitation of the behavioral regulation of the infant in the course of the specific questions posed in the course of the assessment. While interacting with the infant in a co-regulatory, well-specified, and reliable fashion, assessors are required to remain aware of and modify their own behavioral influence on the infant, as well as, registering the infant's response patterns. The instrument requires relationship based assessment skills.

Reliability in the use of the APIB requires skill and experience in examination of infants from as young as 28 weeks, for whom only portions of the assessment may be appropriate, to healthy full-term newborns and one month old infants, by which age the APIB typically should be supplemented with other assessments such as the Bayley Scales of Infant Development [Bayley, 1993]. Examination of an infant with the APIB in the presence of parents requires special skill, security and maturity and is inappropriate for the learner and novice user. Key indices of insecure users are sleepiness and/or excessive crying of most infants examined, and/or parents who wish to interrupt the examiner to wake up or console their infant, or are otherwise uncomfortable with the examination. Infants and parents are the best projective test for examiners in gauging their skill level. There is no correct behavior and no failure in the APIB, all behavior is valid and adds to the understanding of the infant. By definition all infants are appropriate for examination since all infants express themselves in their current behavior.

The APIB is one of the few examinations in which “missing data” represents important information and enters into the scoring of the test because it indicates where the infant's thresholds of organization currently lie. Once the relationship-based nature of this

assessment is mastered, the skills developed extend well beyond the use of the APIB to a better understanding of infants and appreciation of the effect of care and environment on infant functioning and development.

APIB training materials, aside from the “toys” described earlier, consist of a set of background readings, an annually updated program guide for self preparation and training steps, published APIB manual with accompanying introductory chapter, a guide to the scoring of the APIB and one specifically for state system scoring, an APIB variable reduction key for data preparation prior to analysis, and a reliability criteria sheet. Furthermore, the trainee receives two sets of score sheets for use. A videotape, available with score sheet, demonstrates the pace and flow of an examination in adjustment to the infant's cues and signals.

The APIB is an advanced level test, which will be successful in the hands of skilled infant professionals. It is inappropriate for use by research assistants and professionals with insufficient specialization and interpersonal interactive clinical skill, by those under time pressure and with limited resources to create appropriate examination settings. The financial cost involved in the use of the APIB is mainly the cost of training. Regularly scheduled re-reliability sessions with the trainer are necessary for reliable research and clinical use. Only with regular use will the clinician and researcher grow in the use of this complex interactive assessment. Inter-rater reliability between a trainer and examiner, as well as between two examiners, trained to reliability, is readily established when appropriate preparation and training conditions are met.

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Significance and Meaning of APIB Results

Of all currently existing neurobehavioral newborn assessments, the APIB has the most solid theoretical foundation and the best evidence of wide-ranging scientific value. The APIB shows highly significant detection of cross-sectionally assessed developmental differences between medically low-risk infants at varying gestational ages at birth (34, 37, and 40 weeks) [Mouradian, Als, and Coster, 2000], thus providing significant implications for clinical care and support. Significant longitudinal developmental changes were identified in a study of healthy full-term and preterm infants assessed at 40 and 44 weeks' postmenstrual age; thus demonstrating high test-retest reliability of the APIB [Als, Duffy, and McAnulty, 1988b]. A study by Sell [Sell, Figueredo, and Wilcox, 1995] identified by confirmatory analysis, six stable constructs within the APIB, based on a population of 145 preterm infants with varying medical backgrounds, all assessed at 39 weeks' postmenstrual age. The model was highly acceptable (Bentler-Bonett normed fit index 0.994; non-normed fit index 0.999; comparative fit index 0.999) and indicative of high construct validity. The authors concluded that in contrast to most other newborn neurobehavioral assessments available, the APIB measures not only task performance but also quality of performance. The APIB also showed consistently high sensitivity in identifying neurobehavioral differences associated with gestational ages at birth [Als et al., 1988b; Duffy, Als, and McAnulty, 1990]; as well as with documentation of the effects of individualized behavioral intervention (NIDCAP) in the

NICU [Als, 1986; Als et al., 1994, 2003, 2004; Buehler et al., 1995; Fleisher et al., 1995]. No such sensitivity has been identified for any of the other newborn behavioral assessments available.

Duffy et al. demonstrated strong concurrent validity between APIB and EEG measures both in sleep and awake state, in 148 healthy preterm and fullterm newborns studied at 42 weeks postmenstrual age [Duffy et al., 1990]. Als et al. identified such concurrent EEG effects in differentiation of control and experimental groups; both high risk as well as low risk preterm infants; at 42 weeks postmenstrual age; as did Buehler et al., who furthermore documented concurrent EEG effects in comparison to a full-term group [Als et al., 1994, 2004; Buehler et al., 1995]. The recent study by Als et al. showed differentially vulnerable frontal lobe function behaviorally and electrophysiologically in control, when compared with experimental preterm infants [Als et al., 2004]. The behavioral and electrophysiological differences point to the adequacy of functioning for preterm infants in comparison with full-term infants and for preterm control in comparison with preterm intervention group infants. This was found by topographic mapping and independently by unrestricted cortical coherence measures. Furthermore, correlations between APIB and frontal brain electrical activity measures were consistently high [Duffy et al., 2003; Als et al., 2004].

Hüppi et al. reported the first use of the APIB in association with magnetic resonance imaging (MRI) in comparing at-term, low-risk preterms and healthy-term infants [Hüppi et al., 1996]. She reported preterm reduction in myelination and gray–white matter differentiation as well as 6 of 6 poorer APIB system scores. In addition, at-term infants displayed poorer MRI-based neurostructural and poorer APIB neurofunctional measures in fetal growth restricted compared with appropriately grown preterms [Zimine et al., 2002]. Als et al. reported high canonical correlation coefficients between APIB and EEG coherence measures as well as between APIB and MRI diffusion tensor imaging measures [Als et al., 2004]. Furthermore, this same study reported high discrimination power of control versus intervention infants by the APIB factors. Duffy et al. reported high correlation of APIB with EEG coherence factors on a study of 312 preterm and full-term infants all assessed at 42 weeks' postmenstrual age [Duffy et al., 2003]. In total, these studies attest to the high concurrent validity of APIB, EEG, and MRI measures.

The usefulness of the APIB in classifying infants on the basis of the six APIB system scores was demonstrated in a study of 98 preterm and full-term infants assessed at 42 weeks' postmenstrual age [Als, Duffy, and McAnulty, 1988a]. Split half replicability was at 89.8%, indicating significant stability of three clusters. Cluster-1 included mostly full-term infants yet also three of the earliest-born <32 weeks' gestation babies; the middle cluster-2 was made up of approximately equal numbers of infants born at <32 weeks (10), between 32 and 37 weeks (12), and between 37 and 41 weeks (12); in cluster-3 the majority of infants were born at <32 weeks, yet there were also three medically healthy full-term infants whose poor behavioral functioning was unexpected given their medical history. This presents the first successful grouping of infants by neurobehavioral functioning. The relationship of the behavioral clusters to EEG topographic mapping of these same infants showed that all 29 of the possible 29 maps indicated significant differences between the APIB groups [Duffy et al., 1990]. Again, the EEG factor that best differentiated the APIB clusters was a frontal lobe

factor. These studies taken together indicate that the APIB is a neurobehavioral newborn measure which taps neurophysiological brain function and to some extent underlying neurostructural fiber tracts.

The revised Brazelton Scales has added key APIB concepts such as regulation, cost, and degree of facilitation, quality of attention, and other responses, as qualifiers, which are intended to extend the usefulness of the Brazelton scale to high risk populations [Brazelton and Nugent, 1995]. A recent study with the BNBAS showed that inclusion of the “quantifiers” aided in prediction of the degree of developmental disability at age 5 for low birthweight and preterm infants from newborn measures [Ohgi, 2003].

The APIB also has been used in support of parents to enhance understanding of their preterm infant's vulnerability and sensitivity. The Vermont Mother Infant Transaction Program (MITP) used the three basic subsystems of the APIB, autonomic, motor, and state systems, as sequential foci of weekly intervention sessions predischARGE from the NICU, followed with a home visit focused on attention and overall integrative regulation [Rauh et al., 1990; Achenbach, et al., 1993]. This program was remarkably successful and illustrated increasing performance advantage for the intervention group children. This suggested that the earlier the intervention; which enhances confidence of a mother; the better the potentiation for later change. Parker et al., used the APIB to demonstrate to young mothers; from impoverished inner city families; the strengths and vulnerabilities of their very preterm infants' during their NICU stay [Parker, et al., 1992; Als et al., 2004]. Their intervention group showed significantly improved mental developmental indices in the first year, and the mothers felt more confident in parenting their infants.

A further application of the APIB is found in the Assessment of Behavioral Systems' Organization scales, an instrument for scoring the behavioral subsystems of the APIB based on naturalistic observation of the infant in the course of a caregiving intervention as performed in the NIDCAP framework. This is useful for the formal assessment of infants who are too immature and/or too ill to be examined interactively [Als, 1991]. Neu and associates successfully demonstrated the sensitivity of the Assessment of Behavioral Systems' Organization scales in two observational studies, one of different weighing techniques for NICU infants, the other of two transfer methods of infants from the incubator onto the mother's chest for skin-to-skin kangaroo-care. Such clinical applications are promising in expanding use of the APIB [Neu and Browne, 1997; Neu, Browne, and Vojir, 2000].

Cautions and Limitations

The APIB as an assessment instrument is as effective as the skill, experience, and background of the person who uses this complex assessment. The APIB represents the analog of an interview with a tiny and often immature and fragile infant. The interview requires a skillful assessor to expertly read and simultaneously regulate the infant to reliably bring out the infant's best performance as well as to hold an accurate picture in mind of the interview's flow and detail. Thus, the interviewer will then score accurately in paying attention to the separateness and simultaneity of subsystem interplay in concert with the

questions asked. The examiner needs significant understanding of infant development, astute observational skills, high self-awareness and reflection, as well as personal integrity and maturity to support the infant fully and to bring out the infant, instead of shaping the infant's behavior to the examiner's preconceived notion. This requires practice; broad familiarity with infants of varying ages, histories and degrees of fragility; as well as varying patterns of disability, risk, and wellbeing. The APIB is designed to identify and capture the individuality of an infant in the interplay of strengths and competencies with vulnerabilities and at times disability. This is a tall order for today's examiners and practitioners, who typically are pressed for time clinically and in their research work. The APIB is the appropriate assessment if the examiner is appropriate, if there is deep respect and acceptance of each infant's individuality, and if all behavior is acceptable and important. The length and expense of training involved and the depth of immersion required to understand infant development are prerequisites for using the APIB and, as such, are key factors in considering the choice of this instrument for a particular purpose. The APIB assessment requires a full investment in training and use. It is mastered with extensive practice and experience and it continues to enrich and teach the examiner.

Strengths and Benefits

The APIB affords an in-depth conceptual framework of development. It emphasizes subsystem interaction and continuous environmental interplay. The APIB is a dynamic transformational neurobehavioral assessment that goes beyond skill assessment to the assessment of differentiation and modulation of functioning. It shows good inter-rater reliability, internal consistency, good concurrent validity, and discrimination ability among even only subtly different study populations. Its clinical uses are diverse and it provides an excellent transactional vehicle for inquiry into infants' current organizational strengths and vulnerabilities. The APIB in essence constitutes a graded behavioral interview with the infant, which provides significant insight into the infant's current strengths and vulnerabilities, maintenance strategies for competent functioning, and insight into an infant's developmental goals and agenda at the particular time and stage in development. The APIB is highly recommended to the serious student of infant neuro-organization and dynamic environment infant transaction. It represents a tool of key importance in the understanding of the infant's effect on the environment and in turn, the environment's effect on the infant.

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Fig. 1.

Model of synaptic organization of behavioral development. In Als, H (1982). Toward a synactive theory of development: Promise for the assessment of infant individuality. *Infant Mental Health J* 3(4), 229-243.

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ASSESSMENT OF PRETERM INFANT BEHAVIOR (APIB)

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		HEIGHT		HEAD CIRCUMFERENCE		PONDERAL INDEX	
_____ LBS _____ OZS _____ GMS		_____ INCHES _____ CM		_____ INCHES _____ CM			
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			MOTOR			STATE			ATTN/INTERACT			REGULATORY			EXAM FACIL
		B	R	P	B	R	P	B	R	P	B	R	P	B	R	P	
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:

Fig. 2.

Assessment of Preterm Infant Behavior (APIB) score sheet (H. Als, M. Lester, E.Z. Tronick, and T.B. Brazelton, 1982a; H. Als, B.M. Lester, E.Z. Tronick, and T.B. Brazelton, 1982b).

Fig. 3. Alerting during social interaction. Left, stressed and hyperalert. Right, animated and engaged. (Photo provided by Alexandra Dor-Ner and Christine Fischer)[Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]