Neurobehavioral Assessment of High-Risk Infants in the Neonatal Intensive Care Unit

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Neurobehavioral organization describes infants' abilities to organize themselves within their central nervous system maturation and environment. As part of infants' environment, caregivers can structure the environment to support infants' development. Care of the high-risk infant emphasizes support of infants' emerging neurobehavioral organization. This article describes the theoretical rationale of neurobehavioral organization, effects on the infant and family, and assessments available to the neonatal occupational therapist for use with high-risk infants. Information gained via neurobehavioral assessment can be used to engage parents in better understanding their infant's behaviors and interact at a level appropriate with their infant.

Synactive Theory of Development

The synactive theory of development (Als, 1982, 1986) describes infant behavior and development according to separate but interdependent subsystems. The theory includes a problem-solving matrix for treatment considerations. The subsystems of development are the autonomie-physiologic, motoric, state organizational, attentional-interactive, and self-regulatory (Als, 1982, 1986). The interplay of subsystems allows differentiation and modulation as the infant develops.

The autonomie-physiologic system refers to physiologic functioning and is the core of infant function (Lawhon & Melzar, 1988). The subsystem is observable in the infant's color, respiratory function, and visceral functions (i.e., digestion). The motoric subsystem includes muscle.

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tone, posture, quality of movement, and presence of reflexes. State organization relates to the infant’s regulation of levels of alertness. The levels can range from deep sleep to quiet, alert, and fussy states. State organization also includes clarity of state, how well-defined behavior states are, and ease of transition from one state to another. State modulation, also part of state organization, refers to the infant’s ability to adjust behavior state in response to internal and external stimuli. The attentional–

An infant has self-regulatory capacities that allow the maintenance of or return to smooth, balanced subsystem integration. Some examples of regulatory behavior include grasping to limit the movement of extremities, looking away to decrease the level of interaction, or becoming drowsy (changing behavior state) to avoid over-stimulation. An infant will move toward stimulation if appropriate. If stimulation is inappropriate in timing or intensity, an infant will move away from it (Als, Lester, & Brazelton, 1979).

Als (1982, 1986) has categorized infant behaviors as unstable or self-regulated. Instability is evident when an infant’s regulatory capacity is exceeded; the infant is stressed, and organization of subsystems becomes unstable. These cues of instability may be seen across subsystems of development (see Table 1).

Although each subsystem may be observed independently, they are interdependent. Immaturity or disorganization in one system will affect the others. The high-risk infant may not have sufficient subsystem maturity, especially of physiologic function, to maintain a balance of subsystems. Physiologic stability forms the basis on which the other systems develop. If an infant is not physiologically stable, the other systems will be compromised. For example, if an infant becomes apneic, the infant will show immaturity in the motor system by becoming limp, and in the state organization system by decreasing alertness (Lawhon & Melzar, 1988).

Competence is the degree of smoothness and modulation, regulation, and differentiation in the behaviorally observable subsystems of development (Als & Duffy, 1989). Als (1982) suggested a spiral diagram to illustrate the process of infant development and differentiation along the continued spiral of life. As each subsystem develops, it affects other subsystems. The integration of these subsystems supports the infant’s continued differentiation.

Implications of Neurobehavioral Organization for the Family

The birth of a high-risk infant has a profound effect on the family and on parent–infant relationship. Increased incidence of child abuse and divorce is noted in families with high-risk infants as compared with the general population (Macey, Harmon, & Easterbrooks, 1987). Parent–infant interaction is altered. Because high-risk infants often have difficulty engaging in the interaction that parents seek, parents may feel rebuffed or rejected. Gorski (1984) suggested that the effect of premature birth in parent–infant attachment is threefold. First, the stress level in the family is heightened by premature birth due to concerns about the infant’s and mother’s health, premature assumption of parental roles, disruption of the family, and possible financial worries. Second, parents may feel insignificant in the overwhelming technical environment of the NICU. Third, significant qualitative differences in parent–infant interactions have been identified between preterm and full-term infants. Parents and their high-risk infants have fewer reciprocal interactions and fewer interactions based on infant cues than with full-term infants (Gorski et al., 1979).

The synaptic model of development outlines infant behavioral cues (Als, 1982, 1986). Infant cues can guide the parent’s attempts to modify interaction with his or her infant, allowing the parent’s behavior to become contingent on the infant’s behavior (Als, 1986). This mutual regulation of interactions becomes a key factor in the infant’s future development (Tronick, 1989). The infant regulates the behavior of a parent by a variety of behavioral cues or signals. These cues are then read by the parent to further facilitate the infant’s efforts toward goal-directed activities (Tronick, 1989). Subsystem stability is maintained or regained through self-regulatory coping behaviors of the infant (Als, 1982, 1986; Tronick, 1989).

When parents learn to read their infant’s cues and to understand the reciprocal nature of interactions and techniques that support infant neurobehavioral organization, the interactive fit between parent and infant improves (Als, 1986; Tronick, 1989). Parents who understand the behavior and cues of their infants are able to interact with them more effectively.

The overall goal of intervention with families is to improve interactions between parents and their infant. Hedlund (1989) suggested a program that includes sensitizing parents to infant behaviors and helping parents become aware of and modify interactional styles according to infant cues. Bennett’s (1988) review of early intervention studies revealed that the most positive results were in studies that included parent–infant interaction as a focus of intervention and as measure of the success. The focus on parent–infant interaction addresses many of the profound effects high-risk infants have on the parent–infant relationship and was pivotal to the success of the program.

Implications of Neurobehavioral Assessment for Occupational Therapy

Many pediatric occupational therapists work in NICUs...
The occupational therapist's ability to handle high-risk infants' limited tolerance of handling and interaction can impact the infant's overall development. The Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973, 1984) and the Assessment of Preterm Infant Behavior (APIB) (Als, Lester, Tronick, & Brazelton, 1982b) are designed to gradually introduce increasingly complex sensory inputs and to monitor infant responses. Occupational therapy education includes an in-depth study of sensory system development as well as activity analysis according to sensory systems involved. The occupational therapist's ability to carefully grade sensory input with high-risk infants contributes to accuracy of the assessment.

Another factor to consider during assessment is the handling inherent in some assessments is stressful for high-risk infants, the occupational therapist must consider the purpose of the assessment. Handling that appears innocuous can cause physiologic instability in the high-risk infant (AOTA, 1993). The deleterious effects of handling that is too intense or mistimed are well documented. Sweeney (1986) found that the process of a routine neurological assessment can stress the premature infant, as indicated by statistically significant increases in heart rates. Field (1990) measured negative physiologic changes of decreased growth hormone and increased cortisol after administration of the NBAS on healthy premature infants at 36 weeks’ gestation.

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Table 1
Signs of Instability and Stability in Preterm Infants

<table>
<thead>
<tr>
<th>Autonomic System</th>
<th>Motoric Stress Signals</th>
<th>State-Related Stress Signals</th>
<th>Attention/Interaction Stress Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth respirations</td>
<td>Flaccidity (“low” tone)</td>
<td>Diffuse sleep states</td>
<td>Gaze aversion</td>
</tr>
<tr>
<td>Good, stable color</td>
<td>trunk</td>
<td>whimpering</td>
<td>Abrupt state changes</td>
</tr>
<tr>
<td>Stable digestion</td>
<td>extremities</td>
<td>grimacing</td>
<td>&quot;Tuning out&quot;</td>
</tr>
<tr>
<td>Absence of stress signs</td>
<td>facial (“gape” face)</td>
<td>irregular respirations</td>
<td>Staring</td>
</tr>
</tbody>
</table>


and follow-up clinics for high-risk infants. Their role is to foster optimal development of the infant, including neurobehavioral organization, sensory and motor processes, and daily life activities (American Occupational Therapy Association [AOTA], 1993). During assessment of these infants, before treatment, neonatal occupational therapists must consider a number of factors.

Because high-risk infants have a lower threshold for sensory input, it is critical to carefully grade input to minimize potential stress to infants (Als et al., 1986; Vergara, 1992). The Neonatal Behavioral Assessment Scale (NBAS) (Brazelton, 1973, 1984) and the Assessment of Preterm Infant Behavior (APIB) (Als, Lester, Tronick, & Brazelton, 1982b) are designed to gradually introduce increasingly complex sensory inputs and to monitor infant responses. Occupational therapy education includes an in-depth study of sensory system development as well as activity analysis according to sensory systems involved. The occupational therapist’s ability to carefully grade sensory input with high-risk infants contributes to accuracy of the assessment.
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Another factor important to assessment is its purpose, which should be well defined. Information obtained from the assessment is used to make recommendations about modification of the environment and caregiving to minimize the infant's stress (Vergara & Angley, 1992). Developmentally supportive care plans for routine caregiving can be generated after assessment of neurobehavioral organization (Tribott & Stein, 1992). Awareness of infants' thresholds for instability and recognition of their self-regulatory strategies enable all caregivers to modify handling and support the infant's development. The benefits of parent involvement and understanding infant behaviors call for their presence and participation in the assessment process. Parents' understanding of infant cues and effective ways to interact with their infant can be facilitated by the neonatal occupational therapist.

Components of Neurobehavioral Assessment

Assessments have been developed to address infants' neurobehavioral organization (Als, Lester, Tronick, & Brazelton, 1982a; Brazelton, 1984; Hedlund & Tatarka, 1991). Appropriate assessment gives the clinician baseline information about the infant and measures change and progress. This allows emphasis on early intervention and amelioration of potential problems.

The infant must be viewed in the context of the physical and the social environment (Als 1982, 1986). The full-term newborn is capable of social interaction at birth. In the first month, an infant's attention changes dramatically, providing the infant more opportunities for interaction. In comparison, the high-risk infant carries on social interaction with the chance of instability of his or her subsystem organization (Als, 1986).

In neurobehavioral assessment, the role of the examiner is greater than in traditional developmental assessments. Most developmental assessments, such as the Bayley Scales of Infant Development (Bayley, 1969), focus on the skills of the infant, and the examiner determines whether skills are present, absent, or emerging. During neurobehavioral assessment, the examiner is part of the infant's social environment and interaction between the infant and examiner is part of the assessment. The examiner is responsible for eliciting optimal behavior of the infant and determining how much structure and facilitation the infant requires throughout assessment (Brazelton, 1984; Hedlund & Tatarka, 1991).

The physical environment of high-risk infants contains potentially negative influences (Brazelton, 1984; Hedlund & Tatarka, 1991). The NICU includes lights, sounds, visual stimuli, and increased activity. Hedlund and Tatarka (1991) provided recommendations about the environment during neurobehavioral assessment. They recommend that "all elements within the environment should have the potential for graded intensity" (1991, p. 47). The optimal environment has overhead and indirect lighting, ambient temperature, and minimal extraneous noise and activity. Caregivers and examiners should avoid wearing bright colors and high-contrast designs that may overstimulate infants with low sensory thresholds. By minimizing extraneous and unnecessary input from the environment, the occupational therapist enhances the infant's ability to organize self and attend to the environment.

Careful systematic observations are a critical component of any infant assessment and may provide more information than a hands-on assessment. Using the systematic framework to structure these observations, the occupational therapist obtains information about the infant's neurobehavioral organization. One needs to consider behavioral observations in the context of the infant's activity. For example, when an infant extends a leg, it may be part of a startle response to being moved quickly, or it may be an effort to limit the movement by finding a boundary. The leg extension may be part of whole body squirming in the infant who has difficulty with modulating of flexion-extension.

The clinician should be cautious of interpreting specific isolated observations or behaviors. Ongoing or repeated observations provide cues to patterns and more accurately reflect infant competence.

Neurobehavioral Assessments

Some assessments of neurobehavioral organization require that the user be certified in their administration; others do not. Those requiring no certification are briefly mentioned due to space considerations. Four of the assessments requiring certification are discussed in depth.

Assessments that may be used without certification include the Neonatal Neurobehavioral Evaluation (NNE) (Morgan, Koch, Lee, & Aldag, 1988) and the Neurological Assessment of the Preterm and Fullterm Infant (NAPFI) (Dubowitz & Dubowitz, 1981). The NNE is used to establish quantifiable indicators of the infant's neurobehavioral maturation over time. Behavioral components examined are responsiveness, temperament, and equilbrium or the "ability to return to emotional baseline" (Morgan et al., 1988, p. 1553). The NAPFI is applicable for infants soon after birth and is designed for sequential use. Habitation, movement and tone, reflexes, and neurobehavioral responses are examined. Partial administration is allowed for the ill infant.

Certification is required for use of the assessments discussed below and listed in Table 2. This list is not all-inclusive. Benefits of completing certification include improved reliability in administration and interpretation of results and thorough understanding of the components of each assessment. The assessments are not specific to
The trainee practices use of the assessment in the work. Certification is similar. The trainee is expected to list assessment centers for readers wanting further.

One way in which the clinician can complete advanced study.

For the four assessments discussed, the process of certification is similar. The trainee is expected to have a strong knowledge base of normal and abnormal development, particularly infant development, neonatology, and NICU routines and procedures. The trainee should be comfortable with handling infants. The trainee learns about the specified test via workshop, independent study, and observation of trainers using the assessment. The trainee practices use of the assessment in the work setting before completing required reliability in assessment administration and scoring, and summary and development of appropriate recommendations. The Appendix lists assessment centers for readers wanting further information on certification.

Neonatal Behavioral Assessment Scale

The NBAS (Brazelton, 1973, 1984) is designed to assess behavioral capabilities of full-term healthy infants from 36 to 44 weeks’ gestation. It was initially developed as a clinical teaching tool for use with parents and is also now frequently used as an outcome measure in research (Worobey & Brazelton, 1990).

Infant behaviors are viewed within the context of a dynamic relationship with the caregiver. The type and amount of facilitation needed to elicit the infant’s best performance is a reflection of the infant’s organizational capacities. Infant states of consciousness and examiner flexibility are pivotal to the exam. Emphasis is on the examiner’s ability to vary procedures in response to infant cues and movement through the various behavior states. Supplemental items described below provide additional information regarding high-risk infants. Nugent (1985) published a volume addressing use of the NBAS with families. This volume is a useful teaching tool due to its consistent emphasis on keen observation skills, the role of the infant–caregiver dyad, and control of environmental factors.

The NBAS consists of 28 behavioral items scored on a 9-point scale and 18 elicited responses scored on a 4-point scale. Behavior of the 3-day-old infant is considered the mean, although the tool is used for a wide range of neonates with varied perinatal histories. The Kansas Supplemental Items, designed for use with high-risk infants, include quality of alertness, responsiveness, cost of attention, examiner persistence, general irritability, regulatory capacity, state regulation, balance of motor tone, and reinforcement value of the infant’s behavior state (Brazelton, 1984).

Clusters of behaviors have been established and are used in a clinical description of infant behavior. The clusters include habituation, orientation, motor performance, range of state, regulation of state, autonomic regulation, and reflexes. Optimal scoring of the NBAS varies with deliberate avoidance of one total summary score in favor of behavioral clusters.

Assessment of Preterm Infant Behavior

The APIB (Als et al., 1982b) is an extension and refinement of the NBAS for use with premature infants. It is a complex assessment designed to provide an integrated subsystem profile of the infant, identifying current level of function in the face of varying environmental demands. The subsystems, as outlined by the synactive theory of...
development, are referenced throughout the assessment. Through observation of an infant's communicative behaviors, the examiner determines the infant's threshold for sensory input and margins for stimulus overload. The examiner identifies tasks the infant handles well, tasks the infant can handle given environmental supports, and tasks that are beyond the infant's capabilities (Als, 1986).

An infant must have physiologic stability to tolerate most of the test maneuvers. A systematic sequence of increasingly demanding environmental inputs, termed packages, is administered. While increasingly complex stimuli are introduced, infant responses are closely monitored (Als, 1986). The social interactive package is given at any time during the assessment process when the infant indicates availability and readiness. The examiner is able to assess the infant's threshold from organization to disorganization (Als & Duffy, 1989).

**Naturalistic Observations of Newborn Behavior (NONB)**

The NONB (Als, 1984) was developed after the APIB, with the same conceptualizations, for use with infants who cannot tolerate the systematic handling and manipulation of the APIB. Information about an infant's thresholds of instability and self-regulatory efforts is obtained via systematic observations (Als, 1984) that provide the basis for specific recommendations of modifications to the infant's physical environment and direct caregiving. Specific aids to support an infant's self-regulatory behaviors, promotion of infant developmental progress, and differentiation of subsystem function are recommended (Als et al., 1986).

The infant is observed before, during, and after caregiving. Each observation requires a minimum of 50 min. Infant behaviors and measures of physiologic function (heart rate, respiratory rate, oxygen saturation) are systematically charted in 2-min increments. Information regarding observations is summarized and recommendations regarding infant care are generated (Als et al., 1986).

The infant is observed for up to 5 min during a brief social interaction, caregiving, or developmental task such as presentation of a toy. The occurrence of behaviors is noted. Behaviors are classified according to subsystems: autonomic-visceral cues, motor responses, behavior state, and attentional-interactional cues. One hundred fifteen behaviors are defined and identified as approach, self-regulatory, or unstable behaviors. The interpretation of behaviors varies and is dependent on the context. Rather than categorization of behaviors, a continuum of responses is a more accurate model. Clear explanation to the caregivers interacting with the infant reassures them that they are not being evaluated during the observation, thus their discomfort is minimized. Guidelines are then developed with the parents, identifying strategies that support self-regulatory behavior, encourage attention and interaction, and minimize unstable behaviors of the infant, thus strengthening the quality of the parent-infant interactions. Although IBA scoring is based on a brief observation, the approach to understanding behaviors with the synactive model is beneficial throughout intervention.

**Comparison of Assessments Requiring Certification**

Commonalities exist between the four assessments discussed. They may be viewed on a continuum of age and physiologic stability. Because handling is not a part of the NONB, minimal physiologic stability is required for its administration. Emerging physiologic stability is needed for administration of the APIB, because handling is inherent in this assessment. Greater physiologic stability is required when using the NBAS and the IBA. The NONB and the APIB are designed for use with premature infants. As the infant approaches full-term gestational age, the NBAS may be more appropriate. The IBA is designed for use with infants from birth to 6 months of age and can also be incorporated within the administration of other assessments.

Figure 1 summarizes the continuum with regard to gestational age, physiologic stability, and appropriate neurobehavioral assessment. This figure illustrates generalizations about each assessment. Careful consideration of individual circumstances is essential when assessing an infant.

**Conclusion**

Neurobehavioral organization encompasses central nervous system function and maturation as the infant interacts with parents, other caregivers, and the environment. Als' (1982, 1986) synactive theory of development provides the theoretical basis for examining neurobehavioral organization of high-risk infants.

By assessing neurobehavioral organization, one becomes sensitive to the complex dynamics of infant behavior, physiologic status, and infant attempts at self-regulatory strategies. Current assessments of neurobehavioral organization allow the clinician to measure change and
maturation in high-risk infants and to identify and explain infant behavior. The clinician can design developmentally based care plans based on the information gained from neurobehavioral assessments.

The assessment integrates the examiner into the infants' social environment. The examiner modifies handling, facilitates infants' neurobehavioral organization, and supports infants' physiologic stability throughout assessment and intervention. Careful observations are crucial as the clinician considers the interplay of subsystems and the subtle adjustments in infant behavior that may signal distress or instability.

Collaboration with parents is a critical component of care for high-risk infants. The framework of neurobehavioral organization supports inclusion of parents by providing information about infant behaviors and ways to modify interactions to match the infant's needs.

The long-term effects of focus on neurobehavioral organization by NICU caregivers are not known and are an issue for further research. The short-term effects are well documented. When care of high-risk infants is focused on improving neurobehavioral organization, results are decreased severity of medical problems, shorter hospitalization, improved developmental outcome, and enhanced parent–infant interaction.

Appendix

Further Training Information

Assessment of Preterm Infant Behavior (APIB)

Enders Pediatric Research Laboratories
The Children's Hospital
320 Longwood Avenue
Boston, MA 02115

Brazelton Neonatal Assessment Training Center
J. Kevin Nugent, PhD
300 Longwood Avenue
Boston, MA 02115

Infant Behavioral Assessment
Rodd Hedlund, MSc, Mary Tatarka, MS, PR
Child Development and Mental Retardation Unit
WJ-10 University of Washington
Seattle, WA 98195

Figure 1. Continuum of gestational age, physiologic stability, and neurobehavioral assessment.

References


512
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