Infant Neuromotor Assessments: A Review and Preview of Selected Instruments

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The advancement of medical technology has produced an increased number of surviving neonates. Occupational therapists and physical therapists working in neonatal intensive care units and follow-up clinics are faced with the challenge of providing early assessment and treatment for this relatively new population of infants. The purpose of this article is to review selected infant motor evaluation instruments used by therapists and to preview those currently being developed. An overview of the historical background of infant neuromotor testing is provided, followed by a review of the Infant Neurological International Battery (Ellison, Horn, & Browning, 1985) and the Neonatal Neurobehavioral Examination (Morgan, Koch, Lee, & Aldag, 1988). Two infant motor tests currently being developed, the Chandler Movement Assessment of Infants Screening Test and the Miller Infant and Toddler Test (both of which, at the time of this writing, are unpublished) are described. Updated information on the psychometric properties and the clinical usefulness of these new infant neuromotor tests can assist therapists in selecting reliable and valid measures in their clinical practice.

Medical advances in neonatology have permitted more low-birth weight and high-risk premature infants to survive. This population of infants constitutes the highest risk group for motor dysfunction (Ellison, 1984). Occupational and physical therapists involved in early intervention services initiated in the neonatal intensive care unit are faced with the challenge of addressing the developmental needs of these infants.

To fully understand the intent as well as the strengths and limitations of an infant neuromotor assessment, pediatric therapists must critically evaluate the psychometric properties of that instrument. Adequate reliability, validity, and normative data are essential elements of an instrument for accurate identification of motor delays in infants. One must also consider the psychometric basis of an instrument when making accurate interpretations of test results. An increased need for standardized and psychometrically sound test instruments has emerged, not only in research, but also in clinical practice. The current emphasis on accountability and efficacy research in the fields of occupational therapy and physical therapy necessitates reliable and valid measurement tools. Several recently developed and soon-to-be-available evaluation tools attempt to meet this need.

The evolution of infant neuromotor test development has predominantly followed a chronological course, with each subsequent assessment adding to and expanding on previous works. Early infant neuromotor assessments have identified key characteristics and components of newborn infant behavior and motor development. However, many of these earlier assessments lack a sound psychometric basis. Normative data, in particular, are often limited in these earlier assessment instruments (Harris & Brady, 1986).

The purpose of the present paper is threefold:

1. To briefly review the historical background of infant neuromotor test development, with an emphasis on the contributions of some of the more traditional infant neuromotor assessments currently used in the fields of occupational therapy and physical therapy.
2. To review selected infant neuromotor assessment tools that have been published recently.
3. To provide a preview of infant motor tests currently in progress.

The reader is encouraged to consult references listed with regard to the test development process and the psychometric properties of test development, which are beyond the scope of this article but provide an important basis for the understanding of the use, interpretation, and limitations of standardized assessments (Harris & Brady, 1986; Miller, 1989).
Review of Infant Neuromotor Tests

The historical roots of infant neuromotor tests can be traced to the early pioneers of infant neuromotor test development in Germany and France. Peiper (1928) originally identified and documented various aspects of neuromotor behavior of newborn infants, although he did not develop a systematic neurological examination. Thomas (1949) and Thomas and Saint-Anne Dargassies (1952) continued with this work and evolved a detailed concept of different forms of muscle tone. They observed and defined active tone as associated with voluntary or spontaneous movement. Passive tone was defined as the capacity of muscles to be lengthened when joints are moved passively (extensibility) and the resistance of muscles when distal parts of the limb are freely swung or flapped (passivity). Thomas, Chesni, and Saint-Anne Dargassies (1960) went on to develop an evaluation that used various measures of muscle tone, including measures of consistency, extensibility, passivity, and tone of action.

Saint-Anne Dargassies (1954, 1966, 1972, 1977) developed an additional systematic examination of the newborn. She also described primitive reflexes and mapped out the maturational process of these neurological features. She identified the gestational age at which various reflexes and reactions first become apparent.

Illingworth (1958, 1960), a British physician, described methods for early diagnosis of cerebral palsy, although he did not develop a specific neuromotor assessment. He described methods of assessment of primitive reflexes and muscle tone, which included palpation of muscles, resistance to passive movement, examination of range of movement, shaking of the limbs, dropping of the lower extremity with the child supine, and elicitation of deep tendon reflexes and ankle clonus (Harris & Brady, 1986).

Paine and Oppe (1966) were the first American physicians to publish a comprehensive method for the neurological examination of infants. Their assessment included such neuromotor behaviors as muscle tone, primitive reflexes, and deep tendon reflexes as well as testing of the special senses, cranial nerves III through XII, abdominal reflexes, evaluation of speech and mental state, and assessment of sensation and autonomic function.

Prechtl and Beintema (1964) developed a standardized method for assessing the neurological status of infants. Their assessment tool, the Neurological Examination of the Full-term Newborn Infant (Prechtl, 1977; Prechtl & Beintema, 1964) was designed to measure nervous system integrity rather than developmental maturation for infants 38 to 42 weeks postconception. Their contribution to the area of infant motor assessment has been the systems approach of viewing the nervous system and the inclusion of a wide sampling of infant postures, movements, reflexes, reactions, and responses to stimuli. Another contribution from Prechtl and Beintema has been their conceptualization and application of optimality. The optimality concept involves criteria that indicate optimal measurements of maternal and fetal or infant characteristics, as follows: (a) age of the mother at the baby's birth, (b) number of previous deliveries, (c) maternal blood pressure (d) fetal heart rate, (e) condition of the placenta, and (f) duration of apnea before the onset of the first breath. Prechtl developed the optimal score to eliminate the need for classifying conditions as normal or abnormal. Prechtl also emphasized the importance of the infant's behavioral state during the evaluation.

Parmelee and Michealis (1971) devised an examination based on Prechtl and Beintema's (1964) approach, but attempted to produce an overall numerical scoring system and to define individual responses with the aid of diagrams. This method was never published in detail, although there has been a report on its application (Howard, Parmelee, Kopp, & Littman, 1976).

Brazelton (1973, 1984) examined the behavior of the newborn within the context of the infant-caregiver relationship. He developed the Neonatal Behavioral Assessment Scale as an empirical instrument for both research and clinical assessment purposes. This scale includes both motor and behavioral items and was intended for use on full-term (37 to 44 weeks gestation) infants. The Kansas Supplementary Items were subsequently designed to capture the characteristics of premature or fragile infants (Lancioni, Horowitz, & Sullivan, 1980a, 1980b) and consists of nine items added to the original Brazelton scale.

Capute, Accardo, Vining, Rubenstein, and Harryman (1978) developed the Primitive Reflex Profile, which consists nine primitive postural reflexes. Capute and his colleagues were among the first to collect normative data on the developmental sequence of reflexes.

Amiel-Tison and Grenier (1983) developed the Neurological Evaluation of the Newborn and the Infant as a result of Amiel-Tison's extensive experience in the neurological follow-up of infants (Amiel-Tison, 1968, 1973). The unique aspect of this assessment tool is that the assessment is intended to be used as a repeated measure to be administered monthly during the first year of life to document the course of the infant's development. This assessment was not normalized, but was an attempt to provide a systematic approach to neurological assessment. The emphasis on transient neurological findings has been an important contribution to the area of neuromotor testing.

The Movement Assessment of Infants (which, at the time of this writing, was unpublished) was developed by physical therapists in response to a need for a neonatal intensive care unit follow-up evaluation tool. The test authors intended to develop an instrument that would reflect quality of motor performance with the use of a grading scale to quantify the degree and quality of response on specific test items. The Movement Assessment of Infants comprises four sections: (a) muscle tone, (b)
primitive reflexes, (c) automatic reactions, and (d) volitional movement. The authors have developed 4-month and 8-month profiles from data collected on 30 to 40 full-term, nondysfunctional infants in each of these age groups. High-risk points are calculated for performance at these age levels and are intended to reflect the infant’s risk for neurological impairment. Data are currently being collected on a group of nondysfunctional 6-month old infants for the development of a 6-month profile (M. W. Swanson, personal communication, July 2, 1991). The 4-month and 8-month profiles are available with purchase of the Movement Assessment of Infants manual (Chandler, Andrews, & Swanson, 1980). The strength of the Movement Assessment of Infants lies in its quantification of quality of infant movement. Chandler (personal communication, July 2, 1991) is developing the Chandler Movement Assessment of Infants Screening Test, a shorter version of the Movement Assessment of Infants for screening purposes (see a review of this test below).

The Neurological Assessment of the Preterm and Full-term Infant (Dubowitz & Dubowitz, 1981) is frequently used in infant neuromotor testing. The test items are grouped into four categories: (a) habituation, (b) movement and tone, (c) reflexes, and (d) neurobehavior. The strengths of this clinical tool are the brevity of time required for administration; the simplicity and organization of the scoring system, which is based on the use of illustrative diagrams; and the tool’s applicability for use with infants on respirators and infusion equipment.

Review of Recently Published Infant Neuromotor Assessments

The Infant Neurological International Battery (Ellison, Horn, & Browning, 1985) and the Neonatal Neurobehavioral Examination (Morgan, Koch, Lee, & Aldag, 1988) are two more recently published assessments. A formal manual is not available for either assessment, but the assessments are described in article form.

Infant Neurological International Battery

The purpose of this battery is to assess the neurological integrity of infants in neonatal intensive care unit follow-up programs. Ellison and Horn, both psychologists, and Browning, a pediatrician, developed this assessment to meet the following qualifications: (a) quantification and easy computer entry; (b) reliability across the age range of infancy; (c) sufficient reliability and validity for both clinical and research purposes; and (d) acceptability by clinicians for practical length of administration time, clarity of items, and simplicity of scoring. The authors reported that their goal is to make the Infant Neurological International Battery appropriate for 1-month-old to 18-month-old at-risk infants and toddlers.

Test content and scoring procedures. An item pool for the Infant Neurological International Battery was assembled through the selection of 32 items from the following assessments: (a) the Milani-Comparretti and Gidoni method (1967), (b) the French Angles method (Amiel-Tison & Grenier, 1983), (c) the Primitive Reflex Profile (Capute et al., 1978), and (d) Paine and Oppé’s (1966) method. These items were administered to 308 infants aged 3 months to 22 months. Some of these infants were assessed only once; others, twice; and still others, three times, totaling 365 assessments. A factor analysis was performed on these data to form a 20-item test battery. A factor analysis indicates the degree of interrelatedness of items and, therefore, forms the basis of the formulation of subsections, each of which measures a specific construct or factor. Four high-loading items were selected to measure each factor, thus forming a 20-item assessment with five mathematically independent factors. These factors were positively correlated, enabling the subscores to be summed to obtain a total score. The items selected for the Infant Neurological International Battery, on the basis of the above factors, were grouped into the categories of (a) spasticity, (b) vestibular function, (c) head and trunk control, (d) resting tone, and (e) description of the legs.

The authors of the Infant Neurological International Battery have developed a 1-page score sheet that uses illustrative drawings and brief descriptions of test items and responses. An additional sheet delineating scoring criteria is used along with the score sheet. The assessment is based on a 3-point scoring range, with a score of 5 indicating a normal response; 3, a mildly abnormal response; and 1, a markedly abnormal response. These scores are based on the amount of delay of the observed reaction from the infant’s current age level. A distinction between delayed and abnormal responses is not made on this assessment.

Cutoff scores based on the total score are indicated for infants less than 4 month of age, 4 to 8 months of age, and 8 months of age or more. Three categories of degree of normality and abnormality (i.e., normal, transient, and normal) are indicated by these cutoff scores. The category of abnormality is scored based on the examiner’s professional judgment of the infant’s responses into one of the following categories: spastic tetraparesis/dyskinesia, spastic hemiparesis, spastic diplegia, and hypotonia. Therefore, each infant is scored in two ways—by degree of neurological abnormality or normality and by category of abnormality. Because a fair amount of subjectivity is required to score the Infant Neurological International Battery, especially in the category of abnormality, it is important that examiners have adequate experience working with this population. The amount of training required of the examiner, however, is not specified by the test authors.

Norms. In the initial normative database, 308 graduates of the neonatal intensive care unit were used. Some
age ranges were well represented (e.g., 95 infants at age 6 months, 63 infants at age 15 months), whereas other age ranges were poorly represented (e.g., 1 infant at age 3 months, 1 infant at age 4 months, 2 infants at age 19 months, 1 infant at age 20 months). The test authors discussed the need to fill these gaps and to include a well-baby sample. On the scoring protocol of the Infant Neurological International Battery, it appears that the test authors have used some of the norms established for the instruments from which the test items were taken (Amiel-Tison & Grenier, 1983; Capute et al., 1978; Milani-Comparetti & Gidoni, 1967; Paine & Oppe, 1966).

**Reliability.** An unpublished study by Castro, Sanchez, and Landinez (1987) showed a test–retest reliability coefficient of .97 and an interrater reliability coefficient of .95. In the study, seven evaluators assessed 65 infants. Ellison and colleagues (1985) reported that further interrater reliability studies comparing physician-to-physician, physical therapist-to-physical therapist, and physical therapist-to-physician scores are in progress.

**Validity.** The authors used factor analysis in the development of the test, thereby assuring internal validity of the assessment. Ellison (personal communication, August 3, 1990) reported collaboration in three longitudinal predictive validity studies on the Milani-Comparetti method (Milani-Comparetti & Gidoni, 1967). The Milani-Comparetti scores for infants are being compared to neurological examination scores for children aged 7 years. Ellison believes these results may lend support to the predictive validity of the Infant Neurological International Battery, as several items on this battery were taken from the Milani-Comparetti assessment. The details and results of these studies are not yet available.

**Summary.** The Infant Neurological International Battery has been developed to meet the need for a psychometrically sound infant assessment tool. The instrument’s strengths lie in the brevity of administration and scoring time. The normative database, consisting of graduates of the neonatal intensive care units, includes infants with neurological abnormality as well as infants who are neurologically normal. The high degree of internal consistency between factors and items provides a strong psychometric base for the content of the test instrument. The authors reported that the limited number of items in the assessment was a compromise between measuring everything and establishing a workable scale that accurately reflects the various aspects of neurological integrity. Examiners may want to supplement additional developmental testing with the Infant Neurological International Battery, which is primarily intended to provide an indicator of neurological integrity and not motor milestones.

The limitations of this assessment instrument include sparsely represented normative data at several age levels, the exclusion of a well-baby sample from the normative database, limited predictive and concurrent validity data, and the extensive amount of experience required of the examiner to adequately score and interpret the test results. The lack of distinction between abnormal and delayed responses in scoring may also limit the ability of the assessment to detect differences in quality of responses.

**Neonatal Neurobehavioral Examination**

The purpose of the Neonatal Neurobehavioral Examination (Morgan et al., 1988) was to provide an instrument that offers a concise numerical system necessary for quantitative analysis and standardization. The theoretical construct on which this assessment tool is based comes from the work of Thomas and colleagues (1960), who demonstrated that distinct changes in active tone, passive tone, and primitive reflexes occur at three specific gestational age ranges. The Neonatal Neurobehavioral Examination was designed to describe various aspects of neurobehavioral fitness at different conceptional ages (i.e., gestational plus chronological age) and to provide a quantitative rather than qualitative assessment of neonatal neurobehavioral status. This assessment is intended for use with infants 32 to 42 weeks conceptional age.

**Test content and scoring procedures.** The authors of the Neonatal Neurobehavioral Examination selected items from existing assessments (Brazelton, 1984; Dubowitz & Dubowitz, 1981; Thomas et al., 1960) that they believed would reflect changes in neurobehavioral function with increasing maturation. They also designed several additional test items to form a 27-item test battery. The 27 items were organized into three sections, each with nine items, representing different aspects of neurobehavioral status, specifically, tone and motor patterns, primitive reflexes, and behavioral responses. The behavioral responses section consists of three subsections: (a) responsiveness, (b) temperament, and (c) equilibration (i.e., the ability to return to an emotional baseline).

A 3-point scoring system was developed for each item. The authors explained that a 4- or 5-point system was rejected because they thought that it would result in more subtle differences in the performance choices and produce greater scoring indecision than would a 3-point scale. In the tone and motor patterns and primitive reflexes sections, a score of 3 reflects responses expected of a full-term infant (37 to 42 weeks gestational age), a 2 reflects responses expected at 32 to 36 weeks gestational age, and a 1 reflects responses expected at less than 32 weeks gestational age. Exaggerated responses that are generally considered to be signs of neurological injury are included in a separate column and are given a score of 1. The behavioral responses section deviates slightly from the scoring procedure used in the other sections and is based on a modified version of the scoring system of the Neonatal Behavioral Assessment Scale (Brazelton, 1984).
A scale of 1 to 3 represents performance, from consistent deficient responses (1) to consistent optimal performance (3). A section score based on the three subsection scores is calculated for this section.

The Neonatal Neurobehavioral Examination score sheet contains drawings and capsule instructions and is organized into four general columns based on the 1 to 3 scoring criteria and an abnormal response section. The test authors reported that the Neonatal Neurobehavioral Examination can be administered and scored in 15 minutes. The examiner training required to administer the Neonatal Neurobehavioral Examination is not specified by the test authors.

**Norms.** The initial normative study involved testing two groups of infants. The first group consisted of 54 full-term infants who met the inclusion criteria. This group was tested at 48 hours of age. The second group of infants consisted of 298 randomly selected high-risk infants who were examined as they approached conceptional term (37 to 42 weeks conceptional age) or at discharge (some infants were transferred back to their referring hospitals and were tested before discharge), whichever occurred first. Inclusion criteria for the high-risk group were the presence of at least one of the following conditions: (a) birth weight less than 1,500 g, (b) respiratory difficulty requiring mechanical ventilation, and (c) any neurological complication. Otherwise healthy preterm infants were not included in the normative study.

Mean and standard deviation scores are reported for both groups of infants. The high-risk infant group scores fell into three distinct conceptional age clusters: (a) 33 weeks of age or less, (b) 34 to 36 weeks of age, and (c) 37 weeks of age or more. The infants were divided into three groups by severity of illness, according to the amount of ventilator support they required (i.e., less than 2 days, 2 to 7 days, or greater than 7 days).

Generally, there was limited variability in the full-term infant responses, except for the behavioral response section. The preterm infant group analysis indicated that there were no significant interactions for age group or severity of illness and section or total score, as determined by four two-way analyses of variance for each measure. For the conceptional age groups, however, highly significant differences were found for each of the four measures. For each measure, t tests were conducted by conceptional age group. Significant differences ($p < .001$) were found between all three age groups for each measure. A Pearson correlation matrix also showed that the correlation of conceptional age with each of the four test measures was significant. Correlations among the three sectional scores (tone and motor patterns, primitive reflexes, and behavioral responses) varied from .498 to .630, indicating a modest amount of overlap between the scores. This analysis indicates that each section does not completely measure a separate construct and that a degree of overlap of constructs is evident. This would be expected, as it is difficult to isolate these measures from each other.

**Reliability.** An interrater agreement analysis was conducted on paired examinations of 20 full-term infants. Interrater agreement was 88% on individual item scores and 95% on section scores. Interrater agreement was not conducted on the high-risk infant population. Test–retest reliability was not reported.

**Validity.** The results of the initial normative study provide support for content and construct validity. The actual performance of the full-term and preterm infants coincided with the theoretical construct on which the design of the assessment tool is based. The distinct patterns of distribution for the high-risk scores differentiated three significantly distinct conceptional age clusters. These clusters approximated the design of the 3-point scoring system, theoretically representing performance at these conceptional age clusters. This provides evidence of construct validity, as the results indicate that the Neonatal Neurobehavioral Examination does appear to reflect gestational maturation at a given conceptional age. The authors also reported that the high-risk infant data indicate that the scores appear to depend primarily on the conceptional age at the time of the examination; gestational age at birth and severity of illness did not appear to be major contributing factors to the Neonatal Neurobehavioral Examination score.

Lee, Morgan, and Ling (1989) conducted a predictive validity study of the Neonatal Neurobehavioral Examination on 100 infants. The infants were tested at 37 to 41 weeks gestational age and, as a follow-up, were administered the Peabody Developmental Motor Scale (Folio & Pewell, 1983) at 6 and 18 months corrected age. Pearson correlation coefficients between the Neonatal Neurobehavioral Examination and Peabody Developmental Motor Scale scores ranged from .003 to .169, indicating virtually no correlation between the Neonatal Neurobehavioral Examination scores and later Peabody Developmental Motor Scale scores. Multiple regression analysis was then performed on various subgroups of the infants based on specific neonatal factors, such as gestational age, birth weight, asphyxia, and type of delivery. The regression analysis indicated moderate predictive ability for various subtests of the Neonatal Neurological Examination with Peabody Developmental Motor Scale scores on specific subgroups of children. The level of predictability ranged from 50% to 80% in the subgroups of birth weight (less than 1,500 g), gestational age (greater than 36 weeks), and presence of asphyxia. It should be noted, however, that in most subgroups of infants, predictive validity was limited.

**Summary.** Although the Neonatal Neurobehavioral Examination is in the initial stages of test development, the instrument addresses a need identified in the areas of neonatology in the measurement and quantification of neuromotor development in a systematic and empirically
based manner. The major contribution is the beginning development of normative data on medically fragile preterm infants and the documentation of maturational changes that occur during the preterm period at various conceptional ages.

The results of the Neonatal Neurobehavioral Examination assessments must be interpreted within the context of the instrument's limitations, which include a limited normative sample. A randomly assigned and more representative sample of full-term infants is needed. Although the high-risk infant group comprised a relatively large sample size, a discrepancy in sample size is noted in the conceptional age groups used in the normative data collection (i.e., less than 34 weeks of age, \( n = 21 \); 34 to 36 weeks of age, \( n = 138 \); greater than 36 weeks of age, \( n = 139 \)). The high-risk group should also be expanded to include healthy preterm infants. It is also important that the normative sample be represented adequately on such demographic variables as race, sex, socioeconomic status, geographic region, and maternal and paternal factors. Information on these variables was not reported in the normative study.

Interrater agreement was conducted only on the full-term infant group and should include the high-risk group also. Each infant was tested twice within the same hour by two independent examiners. Test—retest reliability has not been established and therefore confounds the interrater reliability calculations. The interrater reliability should be conducted with two examiners scoring the same performance. Test—retest reliability should also be established for both the full-term and high-risk infant populations.

Preview of Infant Assessment Tools in Progress

Chandler Movement Assessment of Infants Screening Test

This screening tool was copyrighted in 1983 and revised in 1988. Final publication awaits completion of the normative process and determination of reliability and validity (L. S. Chandler, personal communication, July 2, 1991). The Chandler Movement Assessment of Infants Screening Test was constructed for screening infants for movement disorders along a continuum from normal-to-delayed motor milestones to abnormal movement patterns. The emphasis of the Chandler Movement Assessment of Infants Screening Test is to identify children who have movement patterns that interfere with the acquisition of normal movement. The screening test is not intended to be diagnostic, but rather, to indicate when further assessment is needed and to identify children who are at risk for movement problems (Chandler, 1986). The Chandler Movement Assessment of Infants Screening Test is intended as a screening tool for the general infant population for children 2 through 12 months of age.

Test content and scoring procedures: The four sections of the Movement Assessment of Infants—tone, primitive reflexes, automatic reactions, and volitional movement (Chandler et al., 1980)—have been retained, but the number of items have been reduced from 65 to 37. Behavioral state and autonomic nervous system stability are two new items that have been added. Most of the items are scored from observation of spontaneous movement. Each item is criterion referenced and is in the process of being normalized at each month of age.

The Chandler Movement Assessment of Infants Screening Test has a 3-point rating scale, with a 1 representing the most mature/normal movement pattern, a 2 representing a developing movement pattern, and a 3 representing the least mature/abnormal movement pattern. For each item, risk points are based on age and on 90% of the normative sample who passed the scoring criteria. The score sheet is organized along a time line from 2 to 12 months of age. Any score falling behind the age line is a risk score, indicating that the child is at risk for delayed motor development or development of abnormal patterns. Chandler (1986) emphasized that children with 3 or more high-risk points should be comprehensively evaluated by a physical or occupational therapist.

The Chandler Movement Assessment of Infants Screening Test is designed for use by pediatricians, nurses, physical therapists, occupational therapists, early childhood educators, and licensed day-care specialists. The screening can be administered in 10 to 15 minutes. Current training on the assessment involves a 4-hour lecture and a half-day practicum, followed by testing or observation of testing on 4 infants. Interrater reliability is calculated on these 4 infants. The format of future training on the Chandler Movement Assessment of Infants Screening Test will be determined by the test author's analysis of interrater reliability data collected during past training (L. S. Chandler, personal communication, July 2, 1991).

Norms: The norms for the Chandler Movement Assessment of Infants Screening Test are being established on normal infants aged 2 to 12 months. On the basis of the initial normative data, Chandler (1986) suggested that 5 to 6 months may be the appropriate age for screening movement, as opposed to 4 months, because a greater number of motor skills are clearly present at that time.

Reliability: Chandler (personal communication, July 2, 1991) reported that preliminary test—retest and interrater reliability have been collected and are currently being analyzed.

Validity: Chandler (1986) discussed the need for prospective studies to establish the predictive validity of the risk scores. Validity studies are in progress.

Summary: The Chandler Movement Assessment of Infants Screening Test promises to be an important tool in the area of motor screening of infants. The strengths of
this screening tool lie in the brevity of time required for administration, the applicability for use by a variety of professionals who are in contact with the general infant population, and the empirical basis from which the tool has evolved. This assessment helps fill a gap in infant screening in that it provides a systematic method for professionals working in early intervention to identify infants who should be referred for a comprehensive motor assessment.

**Miller Infant and Toddler Test**

The Miller Infant and Toddler Test (which, at the time of this writing, has not yet been published) has recently been divided into two separate test instruments, the Motor Assessment and the Infant and Toddler Screening for Everybaby (L. J. Miller, personal communication, July 11, 1991). The Motor Assessment is a working name for the instrument. A final name has not yet been chosen. The Infant and Toddler Screening for Everybaby is a screening tool comprising cognitive, language, motor, self-care, and behavior domains. The following review includes only the Motor Assessment portion of the Miller Infant and Toddler Test.

The Motor Assessment is currently undergoing construction and is in its third research edition since first constructed in 1987 (L. J. Miller, personal communication, July 29, 1991). Miller is currently seeking funding for national standardization of the Motor Assessment.

The purpose of the Motor Assessment is to assess motor function through examination of the quality of movement in infants and toddlers. The focus of this instrument is to evaluate the child's inherent motoric repertoire and overall capacity for movement rather than the child's isolated motor skills. In this assessment, the parent completes all positioning of the child and is the only adult to interact directly. The examiner's role is to observe and record scores. The Motor Assessment is based on the theoretical hypothesis that certain combinations of motor behaviors will differentiate normal and at-risk children at specific ages. Its focus is on the child's ability to move between positions and to plan new motor actions rather than attain specific motor milestones. The instrument is based on neurodevelopmental treatment and sensory integrative theoretical frameworks and is intended to evaluate motor skills in the following four domains: (a) neurological foundations, (b) stability, (c) mobility, and (d) motor organization. The Motor Assessment is intended for use with children birth through 42 months of age.

**Test content and scoring procedures.** A play-based naturalistic observation is used to measure the quality of movement in the following areas: (a) transitions between positions, (b) frequency of movement, (c) ability to combine individual motor acts into a complex motor event, (d) presence of abnormal movement patterns, (e) ability to play or move easily while maintaining a stable position, and (f) ability to complete age-appropriate motor organization tasks. During the observational portion of the assessment, the child is placed by the parent in various positions and observed for a specified time. The sequence of movement patterns are sequentially recorded by the examiner, who circles the first six positions that the child assumes in the order of occurrence. In addition to the observational portion of the test, Miller has also included an evoked responses section in which the parent or the examiner stimulates the child to perform a specific motor activity designed to measure motor planning abilities appropriate for the child's age. These items include such activities as climbing in and out of a cardboard box, stepping over a string, and pushing a toy car. The assessment can be administered in 20 to 30 minutes, depending on the child's age and the examiner's experience.

**Norms.** Three pilot versions of the Motor Assessment have been administered to over 600 children. When funding is obtained, Miller plans to have 100 boys and girls representing each of the 10 age levels in the normative sample (L. J. Miller, personal communication, July 29, 1991). The age levels are divided into 3-month blocks in the first year, 4-month blocks in the second year, and 6-month blocks thereafter.

**Reliability.** Test–retest and interrater reliability studies of the pilot editions yielded coefficients greater than .90 (Miller, personal communication, July 11, 1991).

**Validity.** Content validity has been addressed in the test development process. Concurrent validity studies are planned with the use of the Motor Assessment, Bayley Motor Scales (Bayley, 1969), Battelle Developmental Inventory (Newborg, Strock, & Wnek, 1984), and Peabody Developmental Motor Scale (Folio & Fewell, 1983). Predictive validity studies are also planned.

**Current status.** Miller, in collaboration with faculty and students from Columbia University, New York, and Temple University, Philadelphia, is currently completing the following five projects in the test construction process: (a) refining the item pool, (b) using a timed analysis of movement behaviors to determine the optimal time interval for observation and recording of the infant's movement, (c) analyzing factors in the environment that affect performance on items assessing dysfunction in praxis, (d) assessing reliability of examiners in recording observed behaviors, and (e) examining the child's responsiveness with the parent versus an examiner as the primary person who interacts with the child.

**Summary.** The Motor Assessment offers an innovative approach to the testing of infants and toddlers and is unique in its attempt to assess quality of movement through observation of transitional movements. Parental involvement in the testing process is another unique feature of this instrument. The Motor Assessment promises
to have strong psychometric properties, which will enhance its use in research and clinical settings.

Summary

Infant assessment has become a vital component in the provision of early intervention for infants at risk. The early pioneers of test development have paved the way for newer assessments. With improved psychometric properties, such as reliability, validity, standardized test procedures, and adequate normative data, these newer assessment tools provide more reliable and valid measures for both clinical and research purposes. The field of infant assessment is a rapidly expanding and exciting one.

These assessments are urgently needed in this era of expanding populations of drug-exposed, premature, and other high-risk infants. It is important that therapists critically evaluate clinical assessment tools in terms of their psychometric properties in order to select valid and reliable measures and to accurately interpret infants' neuromotor behavior and development.

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