The Neurobehavioral Assessment Scale as an Instrument for Early Long-Term Prognosis and Intervention in Major Disability in High-Risk Infants

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Evaluated the hypothesis that more effective prognosis is achieved by assessing the modifiability of infants’ reactions than by evaluating the presence or absence of normal/abnormal reactions. To evaluate this hypothesis the Neurobehavioral Assessment Scale (NAS) was developed. The NAS assesses the extent to which infants can change their responses in functional contexts. The NAS was administered to 102 high-risk infants repeatedly over the first 16 months of life. Analysis confirmed that the modifiability of performance was predictive of outcome significantly earlier in development than scoring the same items in terms of their normalcy or abnormality.

KEY WORDS: early diagnosis; cerebral palsy; long-term prognosis.

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A major goal of neurological assessment is the long-term prognosis of an infant recovering from a perinatal neurological insult (Parmalee & Michaelis, 1971). Current assessments are only partially successful in fulfilling this goal. False positive rates are high (Allen & Capute, 1988; Amiel Tison, 1988; Bierman-Van Eendenburg, Jurgens-Van Der Zee, & Olinga, 1982; Touwen, 1989) and specificity is low at later ages, except for significant problems (Astbury, Orgill, Bajuk, & Yu, 1990; Ford, Kitchen, Doyle, Rickards, & Kelly, 1990). Combining neurological assessments with instrumental techniques, such as ultrasound imaging, results in only marginal prognostic improvement (Hecox & Cone, 1981; Kitchen et al., 1990; Majnemer, Rosenblatt, & Riley, 1988; Stewart et al., 1988). Furthermore, diagnostic categories, such as spastic tetraplegia, which are based on the normalcy of tone or reflexes, provide little useful information for planning interventions that would improve the child’s functional and psychological status (Bottos, 1987).

Understandably the prognostic evaluation of the status of the infant’s central nervous system (CNS) is a daunting task. To us, several reasons account for this lack of success. We now know that the CNS is characterized by plasticity. However, plasticity is not simply internally controlled. Recovery from insult, as well as normal development, are reciprocally affected by environmental inputs (Changeaux, 1979; Changeaux, Courrege, & Danchin, 1973; Changeaux & Danchin, 1976; Changeaux & Mikoshiba, 1978; Duffy, Mower, Jensen, & Als, 1984; Floeter & Greenough, 1979; Goldman-Rakic, 1980; Goldman-Rakic & Lewis, 1978; Pysh & Weiss, 1979). That is, following insult, the residual capacities of the CNS must meet with an appropriate context for plasticity and adaptation to occur. Furthermore, the classic distinction between “neurological reflexes” on one hand and “behavioral” on the other no longer seems tenable (Tronick & Brazelton, 1975). An aphysiologic model (e.g., spinal preparations) may allow us to observe reflexes distinct from behavior, but this distinction cannot be maintained when observing an active functioning organism. Rather, motor performance must be viewed as the product of a diverse set of constraints including features of the CNS, physical forces, environmental supports and constraints, and quite importantly, the infant’s motivational state and functional goals (Anochin, Bernstein, & Solokov, 1973; Horak & Nashner, 1986; Roy, 1982; Turvey, Shaw, & Mace, 1978). From our perspective the extent of recovery and quality of the functional organization of movement is affected by the interplay of qualitatively different factors and constraints, yet few examinations are designed to evaluate these variables, especially psychological organismic qualities. Last, in part because of our inadequacies in understanding the appropriate unit of analysis (e.g., reflexes vs. behaviors and rate of change over time) many assessments utilize a large number of items that often produce a rather clouded clinical picture (Harris, 1987).

These issues have led us to develop a somewhat different perspective and
methodology for prognostic assessment. Tronick has argued that the newborn and young child is a goal-directed, motivated organism (Tronick, 1987). To accomplish functional goals, infants must simultaneously regulate an unknown but large number of internal and external processes and events. Internally regulated processes include physiologic states, CNS processes, and motivations, whereas external regulation requires processing environmental information and generating behavioral strategies adapted to the affordances (i.e., ecological opportunities) for action in the environment. But it is critical to note the distinction between internal and external breaks down when one considers the infant’s regulatory system. For the infant, internal and external processes reciprocally affect the other. For example, the infant’s physiologic states are affected by the caretaking he/she receives as are the infant’s behavioral states such as crying. Clearly, many of the infant’s regulatory systems incorporate the caretaker’s regulatory input as an integral part of their functional organization. Tronick characterized this incorporative feature as indicating that the infant’s regulatory system is inherently a dyadic system in which each partner’s behavior is guided by the behavior of the other.

When this dyadic perspective is applied to the neurobehavioral organization of the infant, it leads to a radical conclusion: Neurobehavioral action, like regulatory processes, is dyadically constructed. It is not simply an internally constructed “thing” that manifests itself in the external world. Take, for example, a 4-month-old infant with an abnormally strong asymmetric tonic neck reflex (ATNR). The classical neurological perspective argues for the evaluation of this ATNR’s deviation from normative standards (Amiel Tison & Grenier, 1985; Andre Thomas, Chesni, & Saint Anne Dargassies, 1955; O’Doherty, 1977; Prechtl, 1977; Prechtl & Beintema, 1964). It views the infant as generating preprogrammed reflexes/reactions on his/her own. To elicit these prepackaged responses the examiner behaves in a standardized fashion and must disregard functional and motivational factors. By contrast, from the dyadic perspective, the examiner must evaluate the extent to which the infant can overcome this “abnormality” in different contexts. The examiner assesses if the infant can move and realign his head to follow a toy or a face. The examiner is evaluating whether or not the infant is capable of adapting his/her behavior for a functional goal. The examiner makes a variety of adjustments and uses a number of different maneuvers to try and determine if a context can be created in collaboration with the infant in which the infant can achieve the goal. To the extent that the examiner and infant create environmental scaffolds that facilitate the infants “breaking out of the ATNR and looking at the object” then to that extent is the infant’s response coconstructed by the examiner in regulatory collaboration with the infant. Thus the critical feature that must be evaluated for successful prognosis and therapy is the ability of the infant to modify his/her performance (i.e., to change his/her functionally organized movement patterns) in interaction with socially adjusted
environmental demands and affordances, rather than simply the normalcy or abnormalcy of the behavioral reaction.

In this article we present a neurobehavioral procedure, the Neurobehavioral Assessment Scale (NAS), for evaluating the capacity of infants to adapt their behavior to environmental demands as a method for making long-term prognosis and as a method for planning early treatment of motor problems. We present a pilot study on a group of infants who experienced perinatal insults. These infants were examined repeatedly over the first 16 months of life with the NAS and a set of traditionally administered reflex items. The prognostic effectiveness was evaluated by comparing when, over the course of development, the items in each of the two assessments became associated with 5-year outcome, as well as the patterns or sequences of the modifiability of performance by normal infants and infants who had problems at 5 years.

METHODS

Subjects

The study population comprised 102 infants recruited from a total of 570 who were admitted to the Neonatal Intensive Care Unit (NICU) of Padua in 1 year. Of the original 570 infants, 184 (32%) died in the neonatal period; 102 complied with follow-up arrangements after discharge and were enrolled in this study. The remaining 284 infants were excluded. The main reason for exclusion was their failure to make the frequent visits required by the follow-up program. This group did not differ significantly from the study group with regard to birth weight, gestational age, sex, SES groupings, or perinatal pathologies (for $\chi^2, p > .05$). Conditions leading to the admission of the 102 study infants to the NICU, gestational age, and gender are presented in Table 1. Infants not followed did not differ significantly from the infants followed up (for $\chi^2, P > .5$). The 102 infants followed up were subdivided into two subgroups on the basis of gestational age: Group 1a had a gestational age of less than or equal to 33 weeks ($n = 41$); Group 1b had a gestational age greater than 33 weeks ($n = 61$).

Assessments

The Neurobehavioral Assessment

The items making up the NAS and a brief description of their scoring are presented in the Appendix. (A complete manual for administration and scoring can be obtained from the authors.) What distinguishes the NAS from the traditional neurological examination is the manner in which the items are adminis-
Table I. Gestational Age, Perinatal Pathologies, and Sex and SES of Subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gestational Age (weeks)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 38</td>
<td>40</td>
<td>39.2</td>
</tr>
<tr>
<td>36–37</td>
<td>14</td>
<td>13.7</td>
</tr>
<tr>
<td>34–35</td>
<td>7</td>
<td>6.9</td>
</tr>
<tr>
<td>30–33</td>
<td>38</td>
<td>37.3</td>
</tr>
<tr>
<td>&lt; 30</td>
<td>3</td>
<td>2.9</td>
</tr>
<tr>
<td>Different perinatal pathologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retarded uterine growth (&lt;10%)</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>Neonatal asphyxia (Apgar &lt; 5 at 5 min)</td>
<td>12</td>
<td>11.8</td>
</tr>
<tr>
<td>Respiratory distress syndrome</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>Episodes of bradycardia</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Sepsis</td>
<td>11</td>
<td>10.8</td>
</tr>
<tr>
<td>Intracranial hemorrhage</td>
<td>12</td>
<td>11.8</td>
</tr>
<tr>
<td>Convulsions</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>Acidosis (pH &lt; 7.15)</td>
<td>12</td>
<td>12.7</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>3</td>
<td>2.9</td>
</tr>
<tr>
<td>Perinatal surgical procedures</td>
<td>11</td>
<td>9.8</td>
</tr>
<tr>
<td>Sex and SES characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>60</td>
<td>58.8</td>
</tr>
<tr>
<td>F</td>
<td>42</td>
<td>41.2</td>
</tr>
<tr>
<td>SES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>8</td>
<td>7.8</td>
</tr>
<tr>
<td>II</td>
<td>32</td>
<td>31.4</td>
</tr>
<tr>
<td>III</td>
<td>40</td>
<td>39.2</td>
</tr>
<tr>
<td>IV</td>
<td>20</td>
<td>19.6</td>
</tr>
<tr>
<td>V</td>
<td>2</td>
<td>2.0</td>
</tr>
</tbody>
</table>

tered, evaluated, and scored. Each item may be administered several times and the examiner attempts to elicit the infant’s best performance through various maneuvers. Each item is scored on a 5-point scale that rates the quality of the response as well as the adaptability/modifiability of the infant’s performance over the course of the examination. For example, Behavioral State Control is scored as follows:

1. The infant shows a prompt reaction to the more disturbing maneuvers. Although he will eventually reach a crying state, he is able to self-quiet or be comforted by minimal examiner intervention (face or voice) and achieve an alert state.

2. Crying or agitation is marked only during distressing phases; consolation is very quickly achieved with a minor examiner intervention, such as restraining one or both arms.

3. Even in the moderately distressing examination phases, the infant shows poor behavioral state organization. The infant has difficulty emerging from a
state of sleep or apathy, or is extremely irritable. Consolation or emergence from these states requires prolonged examiner intervention, such as holding and cuddling the infant.

4. The infant cries or does not respond during the entire examination; he shows no behavioral state modifications. Consolation or emergence are achieved only after he has been held by the examiner, cuddled, wrapped in a blanket, and rocked.

5. The infant shows a noncontrollable alteration in his behavioral states. Consolation is not achieved, even following prolonged attempts by the examiner.

Each score indexes the quality of the infant's performance and the responsiveness of the infant to the maneuvers performed by the examiner. These administration and scoring features are unique features of the NAS. The examiner does not just carry out standard maneuvers to obtain responses (reflexes) that are judged normal or abnormal according to a standard criterion. On the contrary, the examiner plays an active role, modifying his/her behavior in order to elicit the infant's "best performance" (Brazelton, 1984). In this way the NAS tests the modifiability of the infant's performance in response to changes of environmental inputs (i.e., affordances including the examiner's scaffolding behavior). This procedure permits the examiner to test the effectiveness of his/her maneuvers in modifying the infant's performance.

For purposes of this research, the comparison of the relative prognostic effectiveness of the NAS and a standard neurological approach, Items 5 (Moro/startle reflex), 6 (ATNR), 10 (grasp reflex), and 11 (positive supporting reaction) were also administered and scored according to traditional neurological criteria (i.e., scores of 1 to 4 were given on the basis of response degree; 1 (absent), 2 (weak), 3 (sustained), 4 (very strong)). Although these four items do not constitute a full neurological examination, they are key components of most pediatric neurological examinations and are sufficiently representative of the standard approach for the purposes of this paper.

Procedures

One—Sixteen Months. For this research, infants were examined during the newborn period in the nursery and after discharge in a pediatric outpatient examining room. Each infant was first administered the NAS followed by the four traditionally administered and scored neurological items. The entire sequence of items was carried out at the following ages: 0–1, 2–3, 4–5, 6–7, 9–10, 12–13, and 15–16 months. Following standard practices (Brazelton, 1984) all four members of the examination team were trained and reached interobserver agreement for each item scored with the first author (trainer) of greater than 90%. This level of reliability was maintained over the course of the study.
Sixty-Month Assessment. An outcome assessment was performed in the 5th year of life. The age of 5 years was selected in order to formulate a full diagnosis of the different subtypes of cerebral palsy (CP) (Bobath & Bobath, 1975). The evaluation was carried out by a team composed of a pediatrician, a child neuro-psychiatrist, a child physiatrist, a psychologist, an ophthomologist, an otolaryngologist. The assessment entailed a standard pediatric examination, a neurological assessment, and an evaluation of mental function. The neurological examination consisted of an assessment of muscle tone, motor pattern, sensory intactness, and gait (or other form of locomotion) according to the criteria suggested by Boccardi and Lissoni (1984). The children's neurological status was expressed in term of normality, minimal brain disorder, or cerebral palsy. The diagnosis of minimal brain disorder was based on the criteria suggested by the Gillbergs (C. Gillberg, 1985; I. C. Gillberg & Gillberg, 1983; I. C. Gillberg, Gillberg, & Rasmussen, 1983) whereas the diagnosis of cerebral palsy was based on the criteria suggested by Bobath and Bobath (1975). The evaluation of mental functioning was done with semi-structured interviews with parents, observation of the child and mother-infant relationship, and the L-M form of the Termann-Merril IQ test standardized for the Italian population (Bozzo & Mansueto Zecca, 1968).

RESULTS

In the index group of 102 infants, 78 (76.5%) showed a normal neuromotor and psychological outcome at final assessment; 14 (13.7%) had minor difficulties (e.g., clumsy motor control and spatial organization), labeled Minimal Brain Dysfunction, following I. C. Gillberg and Gillberg (1983); and 10 (9.8%) had cerebral palsy (with or without mental retardation).

Given the repeated administration of the two assessments into the 2nd year of life (i.e., until 16 months) it should be the case that if either of the examinations have any prognostic validity, by 16 months of age most items on both examinations would show an association to 5-year outcome. This finding would not be very informative. Given this, our approach to the analysis of the data was as follows: The hypothesis evaluated was that the items on the NAS would show significant relations to 5-year outcome earlier and more consistently than the traditional neurological items in the 16-month assessment period. For instance, we assume that some of the neurobehavioral items at 4 months would be significantly related to 5-year outcome, whereas neurological items would be related only at a later age.

To evaluate this comparative temporal prognostic hypothesis the scores on each item of the two examinations at each assessment age (1–16 months) were evaluated for their association to the neurological status of the infants at age 5.
Table II. Assessment Ages at Which Different Items Became Significantly (p < .01) Associated with Outcome

<table>
<thead>
<tr>
<th>Neurobehavioral Assessment Scale items</th>
<th>Months</th>
<th>0–1</th>
<th>2–3</th>
<th>4–5</th>
<th>6–7</th>
<th>9–10</th>
<th>12–13</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Autonomic system control</td>
<td></td>
<td>.01</td>
<td>.01</td>
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<td>.01</td>
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<td>.01</td>
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<tr>
<td>2. Behavioral state system control</td>
<td></td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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<tr>
<td>3. Motor activity control</td>
<td></td>
<td>.01</td>
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<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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<tr>
<td>4. Visual auditory orientation</td>
<td></td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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<td>.01</td>
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<tr>
<td>5. Moro/startle reaction</td>
<td></td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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<tr>
<td>6. ATNR</td>
<td></td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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<tr>
<td>7. Head-righting reactions prone position</td>
<td></td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
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</tr>
<tr>
<td>8. Head-righting reactions during pull-to-sit</td>
<td></td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td></td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>9. Body-righting reactions</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>10. Grasp reflex</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td></td>
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<tr>
<td>11. Positive supporting reactions</td>
<td></td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td></td>
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<tr>
<td>Traditional assessment items</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td></td>
<td>.01</td>
<td></td>
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<tr>
<td>12. Moro reflex</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td>.01</td>
<td></td>
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<tr>
<td>13. ATNR</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td>.01</td>
<td></td>
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<tr>
<td>14. Grasp reflex</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>.01</td>
<td></td>
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<tr>
<td>15. Positive supporting</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
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</tbody>
</table>

years using a chi-square test. Although, both corrected and uncorrected ages were considered in the statistical analysis, we found no substantive differences in the results, and only report the findings for corrected age. We considered only two possible neurological diagnosis at outcome: normal and abnormal (only major sequelae, cerebral palsy).

All data were analyzed by the CROSSTABS chi-square subprogram of the Statistical Package for the Social Sciences (Hill & Nie, 1979). To reduce the risk of a Type I error, we lowered the alpha level to $p < .01$. This approach reveals the point in time (i.e., the infant’s age) when a particular item shows an association to 5-year outcome. Our expectation was that items on the NAS would evidence an association to outcome at earlier ages than the traditional neurological items.

The age at which each item became statistically significant associated with outcome is reported in Table II. Five items from the NAS (autonomic subsystem, behavioral states subsystem, motor subsystem control, orientation, and positive supporting reaction) were significantly associated to 5 year outcome from the initial assessment onwards. The Moro/startle, ATNR, and head-righting reactions from the NAS were significantly associated with outcome by the 2-
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3-month assessment. The grasp reflex and body-righting reaction became significantly associated with outcome by the fourth assessment (6–7 months). Indeed, by the fourth assessment all the items of the NAS were significantly associated with outcome. In striking contrast, for the standard neurological items only the Moro reflex at 6 months is associated with outcome. The ATNR was associated with outcome at the fifth assessment (9 months), the grasp reflex at the sixth assessment (12 months), and the positive supporting reaction was still not significant at the eighth assessment (16 months) (see Table II).

To summarize, the NAS of these infants with its emphasis on the modifiability of the infant’s performance in an interactive context detects dysfunction earlier and is a more effective prognosticator than are standard neurological items. Indeed, a Fisher Exact Text indicated that the overall difference in the number of items related to outcome was significantly different \((p < .05)\) between the NAS and the neurological items by the second assessment. It is also noteworthy that the scores for the neurological items of the neurological examination were not differentially distributed among the cases of severe and moderate forms of paralysis until the 9-month assessment.

Clinical evaluation of the changes in performance for each of the pathological cases, as well as the normal cases revealed several noteworthy characteristics. First, for the children who were normal at outcome, none had a score of 5 on any of the items related to outcome after the fourth assessment. Most important, when they did receive a score of 5 for an item, their performance always improved at the next assessment. This change in scores over time is strong attribution to the critical importance of modifiability in performance. Second, in infants with moderate forms of paralysis (hemiplegia and diplegia) the initial deficit in autonomic, behavioral state, motor control, and orientation resolved early. Only in one case of hemiplegia (an infant who initially showed total body involvement), and one case of diplegia did an infant have a score of 5 in these items after the first assessment. In these cases, the deficit in Moro/startle, ATNR, head in prone, head in pull-to-sit control also disappeared early; no score of 5 was recorded in these infants from the third assessment (4 months, corrected age) onwards. On the other hand, poor modification scores (scores of 5 until the 16-month assessment) were found for their grasp and positive supporting reaction on both sides in the diplegics and on one side in the hemiplegics.

Third, in infants with the most severe forms of cerebral palsy (dyskinetic syndromes and spastic tetraplegia) the scores of 5 in the first four items (autonomic, behavioral state, etc.) were unchanged through the first two assessments. The scores of 5 all related to head control items (i.e., Moro/startle, ATNR, head-righting reaction in prone and in pull-to-sit), were unchanged until the 9-month assessment. The scores of 5 in these items were not differentially distributed among the cases of severe and moderate forms of paralysis until the 9-month assessment.

Tables of these results are not included but are available from the first author.
assessment in all cases, with one exception. This infant was affected by a less severe form of dyskinetic syndrome. Scores of 5 on positive supporting reaction and grasp were found for this infant through the 16-month assessment.

**DISCUSSION**

These findings support the hypothesis that more effective long-term prognosis is achieved by evaluating the modifiability of reactions (i.e., the infant’s capacity for adapting neurobehavioral responses in interaction with socially organized environmental demands and affordances) rather than by evaluating the presence or absence of normal/abnormal reflexes and reactions. Functionally organized and motivated movement patterns correlated more strongly and at a younger age with neuromotor outcome than reflex performance. Traditionally administered reflexes and reactions became associated with outcome only late and no homogenous discriminatory pattern was found in relation to severity of outcome. These results suggest that we may be able formulate a prognosis at an early age based on the quality and modifiability of the infant’s performance in a socially scaffolded context.

Specifically, what appears most predictive of an unfavorable prognosis is that the infant obtains a score of 5 in one or more items and the infant does not modify his score in a subsequent evaluation after an 8-week period. The importance of the modification of the infant’s performance at the next assessment before formulating a prognosis must be stressed. The infants with severe cases of CP (dyskinetic and tetraplegia) did not modify their scores of 5 on the subsequent assessment or the next assessment. The infants with moderate forms of CP (hemiplegics and diplegics) did not modify Body Righting, Grasp, and Positive Supporting Reaction items for at least two subsequent assessments, even after the 6-month assessment. On the other hand, infants who were later free of pathologies, even when they evidenced poor performance, invariably modified that poor performance on the next assessment. Thus, as found by Brazelton (1984) with the neonate, repeated evaluation of the infant’s behavior to specify a pattern of recovery, here defined in terms of the adaptability of reactions, is more effective in determining outcome than a single assessment.

The NAS also may serve several purposes beyond prognosis. First, the finding of the relation between homogeneous patterns of functional performance with different diagnostic categories at outcome may prove to be useful for the recognition of different syndromes or at least different levels of severity at an early age. Second, the examiner’s awareness of which maneuvers were effective or ineffective in modifying the infant’s performance can serve as the basis for a therapeutic plan. Last, the assessment provides parents with the opportunity to achieve a better understanding of their at-risk infant. Assessing and reassessing
the infant in search of infant's functional competencies, rather than incompetencies, allows the parents to learn and appreciate their infant and to observe the performances that may be obtained during daily handling. We believe that use of the NAS (i.e., assessment in a socially supported functional context) is more likely to provide parents with the knowledge they need to more effectively interact with their child than are other forms of assessment.

In conclusion, the NAS evaluates the modifiability of the infant's functional motor performance in response to socially modified environmental inputs. The procedure is based on the view that single motor performances are not in and of themselves pathological or prognostic. Rather, that the modifiability and adaptability of an infant's neurobehavioral actions are more likely to be prognostic because these characteristics are an expression of the presence of the central nervous system’s potential for a nonpathological outcome. Since this assessment model is still experimental our results are preliminary, but they appear to support the validity of this approach. Particular limitations of the study are the heterogeneity of the sample and a lack of evaluation of the infant’s home environments. Nonetheless, of particular relevance for pediatric psychology is the importance of evaluating the functional capacities of the infant and young child. This functional perspective is critical in an environment that emphasizes and focuses on correction of a disorder rather than functional status. Interventions built on functional evaluations can be more adequately tuned to the daily needs and psychological functioning of the child. Additionally, the use of a comparative temporally based approach to the evaluation of prognostic instruments is an approach that pediatric psychologists can bring to research designs that often emphasize static one-shot designs.

APPENDIX

Items Making up the Neurobehavioral Assessment Scale

The Neurobehavioral Assessment Scale (NAS) is intended to test the modifiability of an infant's performance in response to activities specific to the newborn or young infant. The NAS can be used for neurobehavioral examination over the first months of life (0–18 months). Its underlying principles can be applied at any age. Note that each score indexes the quality of the infant's performance and the responsiveness of the infant to the maneuvers performed by the examiner. The examiner does not just carry out standard maneuvers to obtain responses (reflexes) which are judged normal or abnormal according to a standard criterion. The examiner plays an active role modifying his/her behavior in order to elicit the infant's "best performance." In this way the NAS tests the modifiability of the infant's performance in response to changes of environmen-
tal inputs (i.e., affordances and the examiner's scaffolding behavior). This procedure permits the examiner to test the effectiveness of his/her maneuvers in modifying the infant's performance. Below the 11 neurobehavioral areas assessed are illustrated with the descriptions of the extreme scores.

1. **Autonomic System Control.** A score of 1 is assigned when the infant shows good autonomic control during the entire examination. No change in skin color or respiratory rate is observed. By contrast, a score of 5 is given when the infant is never able to control his autonomic subsystem, not even following prolonged examiner attempts to console him/her.

2. **Behavioral State Control.** A score of 1 is assigned when the infant shows a prompt reaction to the more disturbing maneuvers. Although he will eventually reach a crying state, he is able to self-quiet or be comforted by minimal examiner intervention (face or voice) and achieves an alert state. By contrast, a score of 5 is given when the infant shows a noncontrollable alteration in his behavioral states. Consolation is not achieved, even following prolonged examiner attempts.

3. **Motor Activity Control.** A score of 1 is given when startles, tremors and clonus are practically absent throughout the entire examination, or if present, do not influence the infant's performances and thus do not alter behavioral, autonomic and orientation responses. Motor activity is fluent and active for most of the exam. By contrast, a score of 5 is given when control is never reached.

4. **Visual and Auditory Orientation (Interactive/Attention Subsystem).** A score of 1 is assigned when the infant orients towards the examiner's face and voice for over 30 seconds, while head and trunk are supported by the examiner. The infant is able to follow with eyes and head horizontally over an arc of 180°. By contrast, a score of 5 is given when the infant never succeeds in orienting.

5. **Moro/Startle Reaction.** Typically thought of solely in reflexive terms it is often unrecognized that when the startle reaction is overactive, the infant cannot achieve a good head control. Consequently, this item is scored on the basis of the infant's capacity to control the influence of Moro/startle and then lift his head to follow a stimulus in a vertical position (sitting position helped by the examiner). A score of 1 is given when the infant is able to gain head control and follow an object for more than 30 seconds. Moro/startle reaction will be evident only infrequently in the sitting position, but does not interfere with performance. By contrast, a score of 5 is given when this performance is never achieved. Moro/startle reactions are always evident and stereotyped.

6. **Asymmetric Tonic Neck Reflex (ATNR).** This item is scored on the basis of the infant's capacity to align and realign his head in a supine position in order to follow a stimulus. A score of 1 is given when the infant follows over a horizontal arc of not less than 180°. The ATNR is evident only intermittently but does not interfere with performance. By contrast, a score of 5 is assigned when the
7. **Head Righting Reactions in a Prone Position.** This item is scored according to the duration the infant is able to keep his head raised in order to follow an object or a face. A score of 1 is given when the time for following is greater than 30 seconds. By contrast, a score of 5 is given when the performance is never accomplished.

8. **Head-Righting Reactions During “Pull-to-Sit” Maneuver.** The score for this item is based on the infant’s ability to control his head during the pull-to-sit. A score of 1 is given when the head is held in a straight line with the trunk. By contrast, a score of 5 is given when the head flops completely.

9. **Body-Righting Reactions in Prone Position.** This item addresses the infant’s ability to extend his head and the upper part of his trunk and bear weight on his forearms in order to follow a stimulus; this ensures the possibility of shifting weight to one side and thus freeing one hand for manipulation. The score is based on the length of time the infant extends his head and the upper part of his trunk and supports his weight. A score of 1 is given when the duration is greater than 30 seconds. By contrast, a score of 5 is given when the performance is never achieved.

10. **Grasp Reflex.** This item is scored on the basis of the infant’s capacity to bring his hands to the midline in a supine position; scores from 1 to 4 depend on the number of facilitations needed to accomplish this performance (e.g., gentle caressing of the dorsal surface may facilitate hand opening when the hands are clenched). A score of 1 is given when the infant is able to open his hands and bring them to the midline with smooth, well-directed movements, isolated finger movements, without facilitation. The grasp reflex is evident only intermittently but does not interfere with the performance. By contrast, a score of 5 is given when the performance is never achieved; the grasp reflex is always evident and stereotyped or the movement of the upper limbs is so poor that no functional activity can be performed.

11. **Positive Supporting Reaction.** This item is scored on the basis of the infant’s capacity to interrupt the typical pattern of this reaction (i.e., simultaneous extension of hip and knee associated with plantiflexion of the ankle joint) and its reversal (simultaneous flexion of hip and knee associated with dorsiflexion of the ankle joint) showing isolated hip, knee, ankle movements. A score of 1 is given when the infant is actively kicking and shows isolated hip, knee, and ankle movements throughout the examination. Simultaneous hip, knee, and ankle extension and flexion are evident only intermittently but they do not interfere with isolated movements. By contrast, a score of 5 is given if active kicking is absent or occurs only and exclusively as part of a total extension or total flexion pattern, while isolated movements are never observed.
REFERENCES


