A New Neurologic and Adaptive Capacity Scoring System for Evaluating Obstetric Medications in Full-term Newborns

Claudine Amiel-Tison, M.D.,* Genevieve Barrier, M.D.,† Sol M. Shnider, M.D.,‡ Gershon Levinson, M.D.,§ Samuel C. Hughes, M.D.,‖ Stephen J. Stefani, M.D.**

A variety of examinations are currently available for evaluating the neurobehavior of the newborn. These exams are often difficult and time-consuming to perform, require extensive training of the examiners, and produce results that may be difficult to interpret. The authors describe a new Neurologic and Adaptive Capacity Score (NACS) for full-term neonates and compare it with the Scanlon Early Neonatal Neurobehavioral Scale (ENNS), the most widely used test for evaluating effects of obstetric medication on the neonate. The NACS was designed as a screening test to detect central nervous system depression from drugs and also to differentiate these effects from those found after birth trauma and perinatal asphyxia. The NACS is based on 20 criteria, each of which is given a score of 0, 1, or 2. These criteria assess five general areas: 1) adaptive capacity; 2) passive tone; 3) active tone; 4) primary reflexes; and 5) alertness, crying, and motor activity (general observations). In contrast to the ENNS, the NACS places more emphasis on motor tone, avoids the use of noxious stimuli (pinprick, repeated Moro examinations), takes half the time to perform, and provides for any given baby a single number that immediately identifies a depressed or vigorous neonate. (Key words: Anesthesia: obstetric; Neurobehavior: neonatal.)

Some analgesics and anesthetics administered during labor have neonatal neurologic effects that range from profound to subtle and persist after birth. The persistence of these effects depends on placental transfer of the drugs, the neonate’s ability to metabolize and excrete these agents, and the response of the central nervous system to their presence. However, birth trauma, perinatal asphyxia, and neurologic disease also affect the neurologic status of the newborn, and these effects must be differentiated from those caused by drugs.

Severe neonatal depression or injury is readily apparent and easily detectable by standard neurologic examinations. However, mild depression or injury is not so readily observable in the newborn. Infants having high Apgar scores may have subtle neurologic signs of drug depression (e.g., mild hypotonia, mediocre primary reflex responses, absent or poor habituation to repeated stimuli).1 Perinatal asphyxia or mild birth trauma may result in subtle imbalances of extensor and flexor tone of the neck muscles or in hypotonia in the upper extremities.2-5 Therefore, several investigators have tried to create a neurologic exam having criteria sensitive enough to detect subtle neurologic problems in the neonate and to determine if these effects are drug-induced.2-8-9

The test most commonly used to detect the effects of obstetric medication is the Early Neonatal Neurobehavioral Scale (ENNS, described by Scanlon and co-workers).1 The Neonatal Behavioral Assessment Scale (NBAS, described by Brazelton6), a much more complicated and time-consuming exam, is also used, but far less frequently. We believe these examinations have several shortcomings, and we propose a new, alternative examination to detect drug effects in the neonate. The ENNS uses noxious or aversive stimuli (repeated pinprick and Moro maneuvers) that are unpleasant to perform and observe. Also, we believe it places too little emphasis on motor tone, which may limit its use in differentiating drug depression from perinatal asphyxia and birth trauma. In addition, the ENNS, like the NBAS, may be too complicated and time-consuming to perform to achieve widespread routine clinical use, and does not provide for any given baby a single number (like the Apgar Score) that can immediately identify a depressed or vigorous neonate. Therefore, we describe a new neurologic and adaptive capacity score (NACS) for full-term infants and compare it with the ENNS. By placing more emphasis on muscle tone (especially of the upper extremities and the neck extensors and flexors), our test should identify not only babies having drug depression, but also those with birth asphyxia or trauma.

Description of the NACS

Using 20 criteria, the NACS evaluates five general areas: adaptive capacity, passive tone, active tone, pri-
mary reflexes, and general neurologic status (fig. 1). Each
criterion is given a score of 0, 1, or 2, based on whether
the response to testing that criterion is absent or grossly
abnormal (0), mediocre or slightly abnormal (1), or nor-
mal (2). Therefore, the maximum possible score is 40.

Although the 20 items in the NACS can be performed in
any order, we have listed them in a sequence we believe
to be the easiest and most logical to follow (fig. 1). The
examiner determines the neonate’s best performance; if
the neonate scores 1 or 0 on an item, that item should be
retested later in the examination to confirm the low
score.

Assessment of Adaptive Capacity
(Items 1 Through 5)

The ability of the infant to respond to his environment
(adaptive capacity) is tested using five criteria composed
of reactions to sensory stimuli (light and sound) and ob-
servations of consolability when the baby is agitated. This
portion of the NACS requires a bell and flashlight.

The infant should be tested in a quiet environment,
preferably before he has been unwrapped or undressed,
to minimize distracting stimuli. If the infant is too sleepy
or fussy, the maximal response may not be elicited easily.
In such instances, the neurologic portion of the exami-
nation should be completed first and the adaptive re-
sponses retested afterward. This affords the infant the
opportunity to score optimally.

1. Response to Sound. Ring a bell sharply but briefly
(the “sound stimulus”) a few inches behind the infant’s
head in the midline. (We suggest a bell similar to the
one used in a standard Gesell Test.10) A “response” con-
ists of a startled reaction, blinking, and/or respiratory
changes. If there is no response to the first ring, gently
stimulate the infant and repeat the test to a total of three
times before giving a score of 0. Ring the bell three times
and use the greatest response to determine the score: 0
= no reaction; 1 = moderate reaction; and 2 = vigorous
reaction (a startled reaction and, possibly, searching for
the bell).

2. Habituation to Sound. After the previous response
has ended, repeat the sound stimulus (to a maximum of
12 times) while observing the nature of the infant’s re-
sponses. Note if the response is similar, diminished or
altered, or absent each time the bell is rung. Repeat the
stimulus until the response changes or ceases. If no modi-
fication of the response occurs, discontinue the test after
12 stimuli. A score of 0 = no decrease or change in
response; 1 = a decrease or change in response after the
seventh stimulus; and 2 = a decrease or change in re-
sponse before or at the sixth stimulus. (If the response
to sound received a score of 0, the habituation or response
decrement score would also be 0.)

3. Response to Light. Briefly shine a flashlight into
the infant’s eyes. A response consists of blinking, a star-
tled reaction, an eye-widening reflex, general motor ac-
tivity, and/or respiratory changes. If no response occurs,
gently stimulate the infant and repeat the test (to a max-
imum of three times) before giving a score of 0. A score
of 0 = no reaction; 1 = a sluggish or delayed reaction;
and 2 = brisk blinking or a startled reaction.

4. Habituation to Light. After the infant’s best re-
sponse has been observed, repeat the light stimuli to a
maximum of 12 and observe the sequential reactions. A
score of 0 = no decrease or change in response; 1 = a
decrease or change in response after the seventh stimulus;
and 2 = a decrease or change in response before or at
the sixth stimulus. (If the response to light has been
scored 0, the habituation score would also be 0.)

5. Consolability. Consolability is measured in an in-
fant who is actively fussing or crying for 15 s or more.
Crying usually occurs during the neurologic examina-
tion, especially during the Moro maneuver. Therefore,
the absence of crying or fussiness during the examination
would be distinctly abnormal and would be scored 0.
Consolability is first assessed with the infant lying on
even better, the prone position, and rocked. Consolability is demonstrated when the infant becomes quiet for at least 5 s. A score of 0 = inconsolability after 60 s, even when caressing, rocking, and finger sucking are used; 1 = difficult but obtainable consolability (using previously mentioned maneuvers); and 2 = easily obtainable consolability using the examiner’s voice and/or face or the previously mentioned maneuvers.

**NEUROLOGIC ASSESSMENT (ITEMS 6 THROUGH 20)**

This portion of the examination requires no equipment and can always be completed even if the infant is lethargic, irritable, or almost inconsolable. The only prerequisite is that the general condition of the infant allow testing in the upright position.

**Evaluation of Passive Tone (Items 6 through 9)**

6. Scarf Sign. “Scarf sign” means that the arm should encircle the neck like a scarf. Using the palm of the hand as a support, for the back and neck, place the infant in a semireclining position. Take the infant’s hand and gently pull the arm across the chest towards the opposite shoulder, continuing as far as possible (fig. 2). Observe the position of the elbow in relation to the umbilicus. Both arms should be tested successively. Three positions are scored: 0 = very ample movement—the arm encircles the neck without resistance; 1 = the elbow passes midline; and 2 = the elbow does not reach midline.

7. Recoil of Elbows. Recoil of elbows can be checked only when the infant is in a spontaneously flexed posture (fig. 3). Both sides are tested simultaneously. With the infant supine, fully extend the infant’s arms by pulling on the hand or lower forearm. Release the arms, observing how quickly they return to a position of flexion. A score of 0 = recoil absent or not able to be tested (i.e.,

![Fig. 2. Scarf sign. The elbow does not reach midline.](image)

![Fig. 3. Posture and recoil. The infant is in a spontaneously flexed posture. Forearms and lower limbs return briskly to a position of flexion when extended.](image)

![Fig. 4. Popliteal angle. The angle between the leg and the thigh is the popliteal angle.](image)
initial position is one of extension); 1 = recoil sluggish or weak; and 2 = brisk, reproducible recoil response.

8. Popliteal Angle. Keeping the infant's pelvis flat on the table, flex both thighs at the hip and fix the knees on each side of the abdomen. Then, simultaneously lift the lower segment of the legs and observe the angle between the leg and the thigh, the popliteal angle (fig. 4). A score of 0 = an angle of more than 110°; 1 = an angle of 91°-110°; and 2 = a right angle or less.

9. Recoil of Lower Limbs. When an infant is supine, the hips and knees are usually flexed (fig. 3). To test recoil of lower limbs, simultaneously extend both legs by pushing the knees downward and then releasing them. A score of 0 = recoil absent or not able to be tested (i.e., if initial position is in extension); 1 = recoil sluggish or weak; and 2 = brisk, reproducible recoil response.

Remarks on Testing Passive Tone

The examiner can evaluate passive tone by observing and manipulating the infant while he is quiet but not asleep. The resistance of an extremity to these manipulations is measured by noting the angle formed by the movement, or the amplitude of the movement or of a recoil. During these maneuvers, keep the infant's head in the midline position to avoid eliciting the asymmetric tonic reflex. The maneuvers must be performed slowly and gently and to the point of meeting resistance.

In case of an asymmetric response, score the best side, since the hypotonic side may be abnormal due to peripheral nerve injury.

In case of breech delivery, passive tone in the lower limbs will be modified temporarily by the intrauterine posture. The resulting apparent hypotonia of the lower limbs therefore will result in an abnormal popliteal angle and abnormal recoil of the lower extremities, effects that are unrelated to central nervous system dysfunction. Therefore, with breech presentation, these two criteria should not be tested. To complete the scoring of passive tone, the same scores as those obtained for scarf sign and recoil of elbows should be used. We believe that this is appropriate, since mild central nervous system dysfunction causes hypotonicity predominantly in the upper limbs. Thus, in the breech infant, if passive tone is normal in the upper limbs, one can assume it would also have been normal in the lower limbs had the baby been born in the vertex position.
Evaluation of Active Tone and Primary Reflexes (Items 10 through 17)

The quality of most primary reflexes depends on the quality of the active tone. Since poor primary reflexes signify more profound central nervous system depression than does poor tone, it is important to differentiate as much as possible between the two kinds of abnormalities.

10. Active Contraction of the Neck Flexors. Grasp the shoulders and pull the supine infant to the sitting position while noting the position of the head in relation to the trunk (fig. 5A). With the infant in this oblique position, just before the vertical position is reached, one can observe that the flexor muscles contract to raise the head. In the full-term infant, extensor and flexor tone is balanced (fig. 5B), and the head is maintained for about 3 to 5 s along the axis of the trunk before dropping forward (fig. 5C). A score of 0 is given in two instances: either active contraction of the neck flexors is absent (i.e., the head, which is pendulant at first, passively passes the midline of the axis and immediately drops forward), or if permanent hypertonicity of the neck extensors keeps the head backward or prevents the head from falling forward with gravity at the end of the maneuver. A score of 1 = mediocre contraction, e.g., head is maintained along the axis of the trunk, but only for 1 to 2 s; or contraction response is difficult to obtain or not reproducible. A score of 2 = a perfect response, i.e., the head is maintained along the axis of the trunk in the midline for a few seconds, and this response is reproducible.

11. Active Contraction of the Neck Extensors. With the infant in a sitting position and leaning forward with the head hanging down on the chest (fig. 5C), move the trunk backward and observe the reaction of the head. In this oblique position, just before the vertical position is reached, the neck extensors should respond by raising the head of the infant, and should be able to maintain this position for 3 to 5 s (fig. 5B). A score of 0 is given in two instances: active contraction of the neck extensors is absent (i.e., if the head, which is pendulant at first, passively passes the midline of the axis of the trunk and drops backward); or (an abnormal response) if the head is unable to hang on the chest at the beginning of the movement, being maintained strongly by the extensors. The head then passes backward too quickly, in such a way that the reaction appears too strong. A score of 1 = a mediocre response, in which the head is maintained along the axis of the trunk in the midline, but only for 1 to 2 s; or a response that is difficult to obtain or not reproducible. A score of 2 = a perfect response, one that is reproducible. The head is maintained along the axis of the trunk in the midline for a few seconds.

12. Palmar Grasp. Although this is primarily a reflex, palmar grasp is included with tests of active tone because it is a prerequisite to testing an infant’s response to traction (item 13). Failure to elicit a palmar grasp precludes the testing of traction as an indicator of active tone.
With the infant lying in the supine position, the arms are extended and the fists unclenched by the examiner. The examiner inserts his index fingers into the hands of the infant from the ulnar side and gently presses against the infant’s palms. This stimulation should produce flexion of the infant’s fingers onto the examiner’s index fingers (fig. 6). A score of 0 = no palmar grasp of the fingers; 1 = a mediocre response; and 2 = an easily obtainable response, one that is strong and reproducible.

13. Response to Traction. For this test, the baby’s hands should be dry. At the moment that a strong palmar grasp is obtained, the examiner should raise his index fingers approximately 12 inches (keeping his thumbs ready to hold the infant’s hands, if necessary). The normal term infant will respond actively by flexing his upper extremities and lifting himself from the table completely (fig. 7). The examiner should not grasp the infant’s hands and lift the baby, because this would be passively suspending the infant and would not evaluate active tone. A score of 0 = an absent response, with no active flexion of the upper extremities occurring; or a response not able to be tested because no palmar grasp can be elicited. A score of 1 = a mediocre response, in which the strength of the grasp allows only part of the body weight to be lifted before the palmar grasp is released; or in which the knees are not flexed when both feet are off the table. A score of 2 = an excellent response in which the infant lifts his body weight completely, both feet being off the table and the knees flexed. When the reaction is perfect, the head usually moves forward and the infant maintains an active semiflexed position for a few seconds.

14. Supporting Reaction. The infant is held in the standing position by the examiner, whose hand is on the infant’s anterior chest, and whose thumb and fingers are in the axillae (fig. 8). Observe if the infant’s legs actively straighten and the trunk muscles contract to support some of the body weight. Also observe if the soles of the feet are firmly on the table. If the infant’s feet are cold or overly sensitive because of blood sampling from the heel, this reaction might be difficult to obtain. A score of 0 = an absent response, i.e., no tendency to contract the extensor muscles of the legs and trunk, and the body...
weight is being supported entirely by the examiner; 1 = an incomplete and transitory contraction; and 2 = a strong contraction, in which the infant supports all his body weight and maintains this position for a few seconds.

It is important to note that when the flexed posture is very strong in a full-term newborn, full extension of the legs may not occur during the first few days. Likewise, in breech deliveries, the standing position cannot always be achieved because of the previous abnormal position of the lower limbs. Therefore, if the trunk muscles contract visibly, a score of 2 can be given, even if the legs are not fully extended or if they have an abnormal posture during testing of this reaction.

15. Automatic Walking. When the supporting reaction is obtained, automatic walking occurs spontaneously (fig. 9), or can be facilitated by tilting the infant slightly backward or forward. A score of 0 = an absent response, i.e., no steps are taken; 1 = a mediocre response, in which a few steps are taken but not repeatedly; and 2 = a perfect, brisk, reproducible response. Note that walking usually can be obtained even if the infant’s lower extremities are not in full extension. If automatic walking cannot be demonstrated due to excessive flexion or abnormal posture of the lower extremities (as in breech deliveries), the placing reaction should be substituted as a primary reflex.

Placing Reaction. With the infant suspended in the upright position, the body is raised until the dorsum of the foot touches a protruding edge. Scoring is based on flexion, then extension, of the stimulated leg until placement of the ipsilateral foot on the edge is accomplished. A score of 0 = no response; 1 = weak flexion and extension with poor placement of ipsilateral foot; and 2 = a brisk, reproducible response.

16. Sucking. The examiner evaluates the sucking reflex by introducing a finger into the mouth and noting the strength and rhythmicity of sucking, and the synchrony of swallowing. A score of 0 = an absent response; 1 = a weak, discontinuous response that is asynchronous with swallowing; and 2 = a perfect, continuous rhythmic response that is synchronous with swallowing.

17. Moro Reflex. Holding both hands of the infant in abduction while keeping the back of his head on the bed, lift the infant’s shoulders a few centimeters off the bed (fig. 10A). At the point of maximum passive abduction release the hands briskly. The normal reflex is a brisk, active abduction of the arms at the shoulder, extension of the forearms at the elbow, and complete opening of the hands (fig. 10B), followed by adduction of the arms at the shoulder (an embrace) and flexion of the forearms at the elbow. In the normal newborn, crying almost always occurs. The embrace, or second part of the reflex, is not taken into account in the scoring. A score of 0 = an absent response; 1 = a weak or incomplete response, i.e., no crying or opening of the hands; and 2 = a perfect response (full extension, abduction of the arms, opening of the hands, and crying).

Because the Moro maneuver appears to be a frightening experience for the infant, if a spontaneous Moro response has been observed during the course of the evaluation, this reflex can be scored without actually performing the maneuver.

Remarks on Testing Active Tone and Primary Reflexes

The examiner studies active tone when the infant moves spontaneously in response to a given stimulus. The infant must be well enough to allow manipulation of the head and trunk. If the child is crying, postpone testing of the neck extensors until the child is consoled. A normal
crying infant has mild hypertonicity of the neck extensor, probably due to transitory elevation of intracranial pressure. Because the primary reflexes may also be transiently modified by excessive crying, testing of reflexes may also need to be postponed.

General Neurological Assessment
(Items 18 through 20)

18. Alertness. The judgment of alertness takes into account the predominant state of consciousness during the entire examination. A score of 0 = a comatose state, no response to stimuli; 1 = lethargy, with poor eye contact, short periods of attention, or sluggish response to stimulation; and 2 = a quiet alertness with eye contact, and immediate responsiveness to most stimuli.

Scoring of infant alertness corresponds to the evaluation of states of consciousness [sleep (S) or awake (A)] used in the Scanlon ENNS. A NACS score of 0 would be given to babies in sleep state S2 in which there is either no arousability or extremely poor arousability. A baby that is lethargic but able to be stimulated for the purposes of testing, would be given the score of 1, which would correspond to ENNS sleep state S1 or awake state A1. ENNS awake state A2, A3, and A4 infants would be vigorous through most of the testing and would receive a score of 2. Arousal of the infant for testing may bring him to an artificially high state of consciousness and may not be a measure of the predominant state.

19. Crying. The quality of the cry is evaluated. Normal babies usually cry at some point during the examination. Additional mild tactile stimulation may be necessary to elicit crying. A score of 0 = no crying; 1 = abnormal crying (i.e., high-pitched, weak, monotonous, moaning, or discontinuous crying; crying that results in cyanosis or vasomotor changes, or that is difficult to elicit); and 2 = crying that is normal in quality and quantity.

20. Motor Activity. Spontaneous motor activity is best evaluated by inspecting the infant while he lies undisturbed. The speed, intensity, and amount of movement vary a great deal in the normal infant, and only the most obvious alterations should be considered abnormal. A score of 0 = no motor activity, e.g., the infant lies motionless (even when strongly stimulated), or has excessive motor activity with permanent motor agitation, incessant tremors, or bursts of clonic movements; 1 = diminished or excessive motor activity with intermittent jitteriness; and 2 = motor activity that is normal in quantity and harmonious in quality.

Comparison of the Scanlon ENNS and NACS

Sixty-one infants were examined 15 min after vaginal delivery with the NACS, and at two and 24 hours after birth with both the NACS and the ENNS. Mothers had received a variety of obstetric medication, including narcotics, pudendal block, local infiltration, and inhalational analgesia.

Each examination was scored simultaneously and independently by two observers who were unaware of the analgesic management. These observers were either anesthesiologists or staff research associates trained to perform their examinations by Amiel-Tison (NACS) or Scanlon (ENNS), or persons trained by these pediatricians. Throughout the study, different observers were selected; and the 15-min, 2-, and 24-hour examinations on each infant rarely were performed by the same two observers. The choice of which of the two tests to administer first was random. The 15-min examination was performed in the delivery room, the two-hour examination in the well-baby nursery, and the 24-hour examination at the mother’s bedside.

Interobserver Reliability

The 61 babies underwent 183 NACS and 122 ENNS exams. This produced 3,660 joint observations for the NACS exam and 2,074 joint observations of the ENNS. The interobserver reliability was 92.8 per cent for the NACS and 88 per cent for the ENNS.

Duration of Examination

Time required to perform the examination was significantly less for the NACS examination, the average (±SE) length of time being 4.36 ± 0.1 min compared with 7.2 ± 0.1 min for the ENNS (P < 0.01, Student t test).

Correlation of Results of the NACS and the ENNS Exams

Using the NACS, we have chosen a score of 35 or greater to describe a neurologically vigorous neonate. The ENNS has no overall summary score. In using the ENNS to compare the effects of obstetrical medication, each item in the ENNS score has been arbitrarily defined by various investigators as “poor” or “good”. We compared our scoring system with the ENNS in the following way. For each item tested, a “good” ENNS score was assigned a value of 1 and a “poor” score a value of 0. An infant performing optimally in each ENNS test item would score 15 points (table 1). We chose a score of 12 or greater on the ENNS to indicate a baby with good neurobehavorial status. Of the examinations in which infants scored high on the NACS, 92 per cent scored equally well with the ENNS. Since both tests do evaluate many identical variables (such as tone, primary reflexes, and response decrement), and since each test was per-
**Table 1. Early Neonatal Neurobehavioral Scale (ENNS)**

<table>
<thead>
<tr>
<th>Test Items</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Response to pinprick</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Habituation no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Pull to sitting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Arm recoil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Truncal tone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. General body tone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Rooting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Sucking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Moro response</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Habituation no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Habituation to light in eyes no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Response to sound</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Habituation no.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Placing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Alertness</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREDOMINANT STATE</th>
<th>General assessment</th>
<th>A</th>
<th>B</th>
<th>N</th>
<th>St†</th>
</tr>
</thead>
<tbody>
<tr>
<td>LABILITY OF STATE</td>
<td>(circle)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reasons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† A = abnormal; B = borderline; N = normal; and S = superior.

formed on a given baby only minutes apart, it is not surprising that we found a good correlation between the results of the NACS exam and the ENNS.

**Comparative Characteristics of Three Neonatal Behavioral Scores**

Brazelton\(^{8,12}\) introduced the Neonatal Behavioral Assessment Scale (NBAS), which consists of 47 individual tests. Twenty-seven tests evaluate behavior, and 20 tests evaluate elicited or provoked responses. To demonstrate a range of subtle differences between different groups of babies, a nine-point scale is used to score the behavioral portion and a three-point scale to score the elicited responses. It was not Brazelton’s intention to provide a summary or total score that could define optimality, since some items were scored optimal at mid-point and others at the high point. Therefore, based on the 47 test items, a total score that defines optimality is not obtainable. Testing and scoring of the NBAS require approximately 45 min by an experienced examiner, and this test rarely is used to assess the effects of obstetric medication in the first 24 hours after birth.

The Scanlon ENNS (table 1) evolved from the work of Prechtl, Beintema, and Brazelton.\(^{6-8}\) The ENNS consists of 15 individual observations for muscle tone, primary reflexes, and decrement response to stimulation; 11 observations on states of consciousness; and one general assessment of the infant’s neurobehavioral status. State of consciousness is recorded before each individual test is performed. Four separate response decrements are tested, two of which (repeat pinprick and repeat Moro maneuver) Brazelton characterizes as strongly aversive.

Compared with the Brazelton NBAS, the ENNS puts increased emphasis on tone and takes less time to administer, requiring 6 to 10 min. During the course of the examination, no attempt is made to arouse the infant through means other than the tests themselves. In contrast to the NBAS, maximal responses are not aggressively sought, and the examiner usually uses a specific order of testing that does not individualize or allow sensitivity to the optimal method of testing a given infant.

The ENNS has been used primarily to examine neurobehavioral changes associated with the use of anesthetic drugs. In fact, the test was designed to be performed 2 to 8 hours after birth, times that correspond to the neonatal half-life of commonly used amide local anesthetics. Neurobehavioral changes are manifested primarily as decreased tone or diminished response decrement in an otherwise alert infant. We believe that the ENNS puts too little emphasis on neonatal tone and is not designed to distinguish tone differences in extensor and flexor muscles of the neck or differences in tone between upper and lower parts of the body. As will be discussed below, we believe that these differentiations are important in diagnosing abnormalities that are due to birth trauma rather than drug depression. The ENNS also uses strongly aversive stimuli that are a potential source of
tension when the newborn is tested in the presence of the mother.

The NACS developed by Amiel-Tison, Barrier, and Shnider embodies some portions of the Brazelton NBAS, the Scanlon ENNS, and the Amiel-Tison neurological examination.\textsuperscript{2,13} All criteria were chosen from those used in standard neurologic and clinical behavioral testing. We specifically chose items that have been demonstrated to be affected by obstetric medication, perinatal asphyxia, or birth trauma. We also selected specific items that were easy to perform, required no complicated equipment, were not aversive or noxious to the neonate (or mother), were quickly observable and simple to score, and possessed a high interobserver reliability. As passive and active muscle tone and reflexes depend on the postconceptional age,\textsuperscript{3} both exams are designed only for full-term newborns, i.e., those having a gestation of more than 37 weeks.

Since abnormalities in tone predominate among the effects of birth trauma, perinatal asphyxia, and neurologic disease, and since such abnormalities can also result from administration of drugs or anesthetics, we used eight separate tests for tone. Four tests of passive tone emphasize the upper and lower extremities equally and allow detection of hypotonia that may be unilateral or confined to the upper part of the body (as seen in mild birth trauma or perinatal asphyxia). The same is true for the tests of active tone. Additionally, the tests of active tone are more refined, which allows detection of abnormally high tone in neck extensors (as occurs in intracranial hypertension). Generalized mediocre tone responses probably indicate a more global depression and are frequently associated with drugs and anesthetics.\textsuperscript{1,14,15}

In order not to over-emphasize the relative importance of reflex activity, only four primary reflexes were chosen. The general assessment, including quality of cry, motor activity, and alertness (or predominant state of consciousness), is easily observable throughout the exam. The adaptive capacity portion of the exam was designed to avoid strongly aversive stimulation (i.e., pinprick) and includes decrement responses to light and sound, both of which have been found to be significantly affected by drugs.\textsuperscript{16-18} While decrement response to pinprick has been found to be significantly affected by drugs in a few studies,\textsuperscript{1,14,15} we believe that advantages of the information derived from this one test are more than negated by the noxious nature of the exam. We have observed repeatedly that pinprick testing in the presence of the mother can provoke considerable maternal emotions, jeopardize rapport, and potentially compromise the quality of the exam.

As in the NBAS, the NACS examiner brings the infant to the optimal state of responsiveness prior to testing. The examiner is free to change the order of testing depending on the infant's state of consciousness. The best possible responses can be obtained more easily, because individual items (adaptive or neurologic) may be retested to the satisfaction of the examiner, thus giving the infant every opportunity to score optimally. This is unlike the ENNS, which confines the examiner to a particular test sequence.

The NACS exam gives a total score that evolves from the sum of the scores on each individual test. This is possible since poor performance and optimal performance are scored progressively to reflect this range of responses (as in the Apgar score). The total score can be viewed as a measure of neonatal neurologic status within a given population of infants. We have arbitrarily chosen the scores 35 to 40 to indicate neurologically vigorous neonates. We believe scores of 34 or below are low enough to detect babies with possible problems, yet not so low as to mislead us into mislabeling an inordinate number of vigorous babies as depressed. Future experience with large numbers of infants may require alterations in these numbers. A very high score may be reassuring, and a low score a cause for concern. However, close examination of low scores within a particular group of items (i.e., tone or adaptive capacity) may be of much greater importance than the total score. For instance, although an infant might have a relatively high total score, e.g., 35, all five points might have been lost in one specific category, such as tone or adaptive capacity. Thus, this grouping of test items allows easier identification of various patterns of response, and subsequent examinations may focus on items for which scoring was not optimal.

The NACS test is rapid and reproducible. The neurologic portion of the exam requires no equipment and can be performed in 60 to 90 s by an experienced examiner in the delivery room. The adaptive portion of the exam requires closer observation and skill in testing decrement responses and is thus more time-consuming.

Summary and Conclusions

The American Academy of Pediatrics Committee on Drugs has recommended that, during labor, drugs be used that have the least effect on the neonate, as determined by neurobehavioral testing.\textsuperscript{19} In addition, the current Food and Drug Administration guidelines for clinical investigation of general and local anesthetics recommend neonatal neurobehavioral studies for drugs under consideration for use in obstetric patients.\textsuperscript{20,21} Therefore, a test of neonatal neurobehavioral performance that is quick, easy to perform and score, with high interobserver reliability is highly desirable. Also, such a test should be able to differentiate between the infant who has drug-induced depression and one whose depres-
sion results from asphyxia, birth trauma, or neurologic disease. The NACS examination was devised for this specific purpose.

We suggest that the NACS be performed in the delivery room approximately 15 min after birth; that is, after the routine neonatal care, and that it be repeated at two hours when the baby is settled in the nursery. If abnormalities are present, the examination should be repeated at 24 hours. Abnormalities present beyond this point will require more extensive evaluation.

We believe it is not reasonable to assume that the NACS system will predict the late outcome of infants who have only slight deviations from normal responses. In most instances slight deviations such as "mildly excessive motor activity" or "weak" tone, scoring 1, will disappear by the end of the first week and are usually not detectable by the end of the fourth day.22-24 In these cases, the outcome is excellent.25 When abnormalities persist to day 7, particularly abnormalities of primary reflexes or consciousness, long-term follow-up is necessary.25,26 The evaluation of further testing beyond this period is not within the scope of this report. The definition of slight deviations from normal in the first hours of life and correlating these deviations with perinatal events are the aims of the NACS.

References