

The NICU Network Neurobehavioral Scale: A Comprehensive Instrument To Assess Substance-Exposed and High-Risk Infants

Edward Z. Tronick and Barry M. Lester

INTRODUCTION

This chapter summarizes the authors' work in the development of a comprehensive neurobehavioral instrument, the NICU (neonatal intensive care unit) Network Neurobehavioral Scale (NNS) (Lester and Tronick 1993). The NNS was designed to evaluate the neurobehavioral and neurological profiles, adaptation to stress, and withdrawal status of neonates exposed to illegal drugs in utero.

Work on this instrument grew out of research on newborn assessment and training for the Perinatal-20 project, a set of 20 National Institute on Drug Abuse (NIDA)-sponsored intervention studies of cocaine- and other substance-abusing mothers, and the specific requirements of research on the Maternal Lifestyles Study, a National Institute of Child Health and Human Development-sponsored multisite study of the development of cocaine-exposed infants from four NICUs. Investigators on these projects, as well as on several other projects related to prenatal cocaine exposure on which the authors are working, were confronted with a similar set of assessment problems that were unresolved by extant biobehavioral instruments.

These problems included a need for an instrument that would detect and describe the possibly unique neurobehavioral characteristics of infants exposed to cocaine and other substances in utero (Tronick et al., in press). Specialized instruments have already been developed for different populations of newborns: full-term healthy infants (Brazelton 1984; Tronick and Brazelton 1975, pp. 137-156), prematurely born infants (Als et al. 1982, pp. 85-132), infants with intrauterine growth retardation (IUGR) (Als et al. 1976), opiate-exposed infants (Finnegan 1986, pp. 122-146), cross-cultural samples (Dixon et al. 1982; Tronick and Winn 1992), and other groups (Tronick 1987). These instruments were developed because investigators found that, although these heterogeneous populations shared many neurobehavioral features, they also had unique neurobehavioral characteristics that are not adequately captured on existing measurement tools. Similarly, the specific instruments commonly

used to assess these populations might not adequately describe the neurobehavioral features of in utero drug-exposed infants. In the authors' experience, available instruments did not appear to be adequate to describe the neurobehavioral organization of cocaine-exposed infants (Beeghly and Tronick 1994).

A second problem was the need for a single instrument that would assess the neurobehavioral and neurological profiles, adaptation to stress, and the withdrawal status of the neonate. Such an instrument must meet standard criteria for reliability of administration, scoring, and validity, which are not necessarily characteristics of existing instruments.

INSTRUMENT SELECTION

To meet these needs, the authors first drew on extant instruments and then from state-of-the-art instruments that are well established and have been used extensively. The authors wanted the data from a new instrument to be comparable to the data generated by its parent instrument, insofar as the new instrument incorporated the approaches and techniques of its parent. The following core instruments were used: (1) Neonatal Behavioral Assessment Scale (NBAS) (Brazelton 1984), (2) Neurological Examination of the Full-Term Newborn Infant (Prechtl 1977), (3) Neurological Examination of the Maturity of Newborn Infants (Amiel-Tison 1968), (4) Neurobehavioral Assessment of the Preterm Infant (Korner and Thom 1990), and (5) the authors' scale for the Assessment of Preterm Infants' Behavior (APIB) (Als et al. 1982, pp. 85-132). These scales have different goals. The NBAS and APIB were developed to document the behavioral repertoire of the full-term and preterm infant, respectively. Prechtl and Amiel-Tison wanted to assess the neurological status of the newborn, whereas Korner and Thom wanted to evaluate the relative maturity of the infant. Because the authors and other researchers on the ongoing projects also wanted to document any withdrawal symptoms or stress associated with in utero cocaine exposure, Finnegan's (1986) Neonatal Abstinence Score was drawn on. The scales developed by Dubowitz and coworkers (1970) and Ballard and colleagues (1991) also provided guidance. Together, these instruments provide a detailed description of many characteristics that need to be assessed in in utero-exposed infants that is more comprehensive than that provided by any one instrument alone.

Second, it was necessary to limit the number of items because administering all the instruments individually would place a tremendous burden on the newborn and the examiner. The approach was to use the structure of a core examination, add items if necessary, and develop multiple, domain-specific

coding schemes. Fortunately, limiting the number of items administered was facilitated by the fact that many items in different assessments are similar, if not identical. In addition, many items that are scored in one scale (e.g., abnormal posture from the Prechtl examination [Prechtl 1977]) can be observed during the administration of another (e.g., the NBAS), although the item may not be formally elicited or scored during the administration of the other examination. Observation of these items often can be made without having to make significant changes in the scale being administered. Thus, it was possible to conceive of a “generic” examination that used many overlapping items from various extant scales and also permitted the elicitation, observation, and scoring of a wide range of features of the infant’s behavior.

The NBAS was chosen as the core examination: It incorporates behavioral, neurological, and stress measures and is the widely used benchmark in the field. The NBAS had been used as the core examination for the APIB, and the authors had experience in adapting it for studies of other populations (e.g., infants with IUGR [Als et al. 1976]) and cross-cultural samples (Dixon et al. 1982). Moreover, many of its items were drawn from the other scales. (For example, the concept and scoring of behavioral state by the NBAS are based on Prechtl’s [1977] work.) The authors valued its concept of eliciting best performance, flexibility, and semistructured administration.

SCORING REFINEMENTS

Once the NBAS had been selected as the core examination, several tasks remained. The first was to add items that were not part of the NBAS (e.g., items assessing withdrawal and behavioral, neurological, and stress measures). The second was to develop scoring systems for different domains of assessment—neurological status, stress, and withdrawal. These domain-specific scoring systems were based on items that were elicited and observed during the administration of the examination (e.g., a separate neurological score based on all infant reflexes and postures and a stress scale based on observation of the infant’s stress signs). For some domain-specific scoring systems, the scoring was based on added items; in other cases, some items were used and scored for more than one domain of functioning. For example, tremors are scored in the motor maturity items of the NBAS as an item for both the stress and neurological scales. Scoring of these multiple-domain items is often different for each scale because of differences in focus among the scales. (For example, tremors are related to state in the NBAS but not in the stress scale.) This multiple coding of items is burdensome for the examiner, but it allows for maximal use of the information generated during the administration

of the examination. The third task was to add scores to items to describe either hypothesized features of drug-exposed infants or characteristics suggested by research that were not captured by the original scoring system. This approach was based on work with the NBAS in cross-cultural studies in which scores were added to specific items to capture a heretofore undescribed characteristic (e.g., the additional score on the standard NBAS motor maturity scale developed by Tronick and colleagues [Dixon et al. 1982; Keefer et al. 1982] to describe the unique balance and strength of motor behavior among Gusii infants of Kenya). An advantage of this approach is that the original scoring remains intact, and scores still can be compared across studies. The prevalence of the additional score specifies a unique feature of the population. For example, several scores were added to the habituation scales from the NBAS to capture the lack of response observed in exposed infants.

ADMINISTRATION PROCEDURES

It first was decided that the examination would be administered in a semistructured manner. In an unstructured examination, different examiners may conduct the examination differently and elicit different behavioral qualities in the infant, whose scores can be affected by these stylistic differences, reflecting an examiner-infant interaction rather than the infant's performance when faced with a standard challenge. However, the solution is not a rigidly standard examination because an inflexible examination does not elicit the infant's best performance. The authors' solution was to define and limit when items could be administered based on the infant's state. Second, we decided to have a relatively invariant sequence. However, required deviations from the standard sequence are scored. Variations on the sequence thus become data rather than errors among examiners.

CONCLUSIONS

These are the major features of the NNNS. It is designed to provide a comprehensive examination of normal full-term infants, preterm infants, and especially infants at risk because of prenatal substance exposure. Infants must be medically stable, and although a precise lower gestational age limit cannot be set, the examination is appropriate for infants as young as 34 weeks. The upper limit may be 44 weeks, but it may prove to be useful with older infants who were or are medically compromised. The scale's reliability has been demonstrated, and its concurrent and predictive validity is being evaluated in the Maternal Lifestyles Study

with 1,000 infants (also see Napiorkowski et al., in press). A complete manual, film, and training are available from the authors.

REFERENCES

- Als, H.; Lester, B.M.; Tronick, E.Z.; and Brazelton, T.B. Towards a research instrument for the assessment of preterm infants' behavior (A.P.I.B.). In: Fitzgerald, H.E.; Lester, B.M.; and Yogman, M.W., eds. *Theory and Research in Behavioral Pediatrics*. Vol. 1. New York: Plenum, 1982.
- Als, H.; Tronick, E.; Adamson, L.; and Brazelton, T.B. The behavior of the full-term yet underweight newborn infant. *Dev Med Child Neurol* 1:590-602, 1976.
- Amiel-Tison, C. Neurological evaluation of the maturity of newborn infants. *Arch Dis Child* 43:89-93, 1968.
- Ballard, J.L.; Khoury, J.C.; Wedig, K.; Wang, L.; Eilers-Walsman, B.L.; and Lipp, R. The new Ballard score, expanded to include extremely premature infants. *J Pediatr* 119:417-423, 1991.
- Beeghly, M., and Tronick, E. Effects of prenatal exposure to cocaine in early infancy: Toxic effects on the dyadic regulatory infant-caregiver system. *Infant Ment Health J* 15:281-286, 1994.
- Brazelton, T.B. *Neonatal Behavioral Assessment Scale*. 2d ed. Clinics in Developmental Medicine. No. 88. London: Spastics International Medical Publications; Philadelphia: Lippincott, 1984.
- Dixon, S.; Keefer, C.; Tronick, E.; and Brazelton, T.B. Perinatal circumstances and newborn outcome among the Gusii of Kenya: Assessment of risk. *Infant Behav Dev* 5:11-32, 1982.
- Dubowitz, L.M.; Dubowitz, V.; and Goldberg, C. Clinical assessment of gestational age in the newborn infant. *J Pediatr* 77(1):1-10, 1970.
- Finnegan, L.P. Neonatal abstinence syndrome: Assessment and pharmacotherapy. In: Rubaltelli, F.F., and Granati, B., eds. *Neonatal Therapy: An Update*. New York: Excerpta Medica, 1986.
- Keefer, C.H.; Tronick, E.; Dixon, S.; and Brazelton, T.B. Specific differences in motor performance between Gusii and American newborns and a modification of the Neonatal Behavioral Assessment Scale. *Child Dev* 53(3):754-759, 1982.
- Korner, A.F., and Thom, V.A. *Neurobehavioral Assessment of the Preterm Infant*. New York: The Psychological Corporation, 1990.
- Lester, B.M., and Tronick, E.Z. "The NICU Network Neurobehavioral Scale." National Institute of Child Health and Human Development contract N01-HD-2-3159. Unpublished manuscript, Brown University School of Medicine, 1993.

- Napiorkowski, B.; Lester, B.M.; Frier, C.; Brunner, B.A.; Dietz, B.A.; Nadra, M.S.; and Oh, W. Effects of in utero substance exposure on infant neurobehavior. *Pediatrics*, in press.
- Prechtl, H.F.R. *The Neurological Examination of the Full Term Newborn Infant*. 2d ed. *Clinics in Developmental Medicine*. No. 63. London: Spastics International Medical Publications with Heinemann; Philadelphia: Lippincott, 1977.
- Tronick, E. The Neonatal Behavioral Assessment Scale as a biomarker of the effects of environmental agents on the newborn. *Environ Health Perspect* 74:185-189, 1987.
- Tronick, E., and Brazelton, T.B. Clinical uses of the Brazelton Neonatal Assessment. In: Friedlander, B.Z., ed. *The Exceptional Child*. Vol. 3. New York: Bruner/Mazel, 1975.
- Tronick, E., and Winn, S.A. The neurobehavioral organization of Efe (pygmy) infants. *J Behav Dev Pediatr* 13(6):421-424, 1992.
- Tronick, E.Z.; Frank, D.A.; Cabral, H.; Mirochnick, M.; and Zuckerman, B. Late dose response effects of prenatal cocaine exposure on newborn neurobehavioral performance. *Pediatrics*, in press.

ACKNOWLEDGMENTS

Work on this project was supported by NIDA grants R01-DA-06532 to Deborah Frank, R01-DA-06882 to Edward Z. Tronick, and N01-HD-2-3159 to Barry M. Lester. The authors also acknowledge the observational and practical contributions of T. Berry Brazelton, Zach Boukydis, and Kevin Nugent to the development of the NNNS and the conceptual and editorial work of Marjorie Beeghly on the manuscript.

AUTHORS

Edward Z. Tronick, Ph.D.
Chief
Child Development Unit
Children's Hospital
Associate Professor of Pediatrics
Harvard Medical School
300 Longwood Avenue
Boston, MA 02115
(617) 355-6948 (Tel)
(617) 859-7215 (Fax)
tronick@a1.tch.harvard.edu (Internet)

Barry M. Lester, Ph.D.
Professor of Pediatrics
Department of Pediatrics
Women and Infants' Hospital
Brown University School of Medicine
101 Dudley Street
Providence, RI 02905
(401) 453-7640 (Tel)
(401) 453-7646 (Fax)
barry_lester@brown.edu (Internet)

[Click here to go to page 205](#)