

Normative Neurobehavioral Performance of Healthy Infants on the Neonatal Intensive Care Unit Network Neurobehavioral Scale

Edward Z. Tronick, PhD*; Karen Olson, PhD*; Rebecca Rosenberg, BA‡; Lisa Bohne, MSS§; Jing Lu, PhD||; and Barry M. Lester, PhD||

ABSTRACT. Descriptive statistics for the Neonatal Intensive Care Unit Network Neurobehavioral Scale summary scores are provided for a sample of 125 full-term, healthy 1- to 2-day-old infants. The study sample is described, including demographic characteristics and infant and maternal medical characteristics. Descriptive statistics and percentiles are provided for the Neonatal Intensive Care Unit Network Neurobehavioral Scale summary scores. These tables can be used as quasinorms for comparison with other infants of this age. *Pediatrics* 2004;113:676–678; healthy, neurobehavior, newborn, NNNS, norms, preterm.

ABBREVIATIONS. NNNS, Neonatal Intensive Care Unit Network Neurobehavioral Scale; SD, standard deviation.

The aim of this report is to present descriptive and normative data on the Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNNS) for a sample of newborns who were selected for optimal-health status. In previous work, the NNNS has been used in studies of intrauterine exposure to cocaine,^{1,2} opiates^{2,3} (M. Coyle, MD, A. Ferguson, OTR/L, L. LaGasse, PhD, E. Liu, PhD, and B. Lester, PhD, unpublished data, 2000), and nicotine.⁴ Unexposed or control groups in these studies were selected to be comparable to exposed groups to allow for appropriate comparisons. As a consequence, infants in the control groups were from high-risk populations^{1,2} and may have been exposed to other drugs. In this report, we present data on a sample of newborn infants who were selected for optimal-health status. Although this choice limits the generalizability and representativeness of the sample, including infants with medical complications would skew norms toward poorer performance. Thus, the data reported on this selected sample can serve as a “gold standard” for infants with known characteristics against which infants with other medical complications or social risks can be evaluated.

From *Child Development Unit, Children’s Hospital, Department of Pediatrics, Harvard Medical School, Boston, Massachusetts; ‡Department of Psychology, Harvard University, Cambridge, Massachusetts; §Child Development Unit, Children’s Hospital, Boston, Massachusetts; and ||Brown Medical School, Infant Development Center, Women and Infants Hospital and Bradley Hospital, Providence, Rhode Island.

Received for publication Apr 28, 2003; accepted Oct 8, 2003.
Reprint requests to (E.Z.T.) Child Development Unit, 1295 Boylston St, Ste 320, Boston, MA 02215. E-mail: ed.tronick@tch.harvard.edu
PEDIATRICS (ISSN 0031 4005). Copyright © 2004 by the American Academy of Pediatrics.

Effectively, the data can be used in the way that standardized data such as the Bayley Scales of Infant Development–Second Edition are used.

The data reported include means, medians, ranges, standard deviations (SDs), and percentiles for the NNNS 13 summary scale scores. Tables of individual items can be obtained from the first author. These data were gathered as part of a larger project to standardize the NNNS.⁴

METHODS

Subjects

The sample consisted of 125 newborns. Of the 639 screened, 217 met criteria. Mothers of infants who met criteria were asked for their informed consent. Of the 217 mothers approached, 203 agreed to the study. Of these, 61 could not be examined for technical reasons (eg, went home, were nursing at the time of the examination). This left a sample of 142. Examinations were administered to these 142 newborns, but after additional examination of the medical records, 17 newborns were found not to have met selection criteria. This resulted in a final sample of 125 newborns. Neither the refusers nor the technical failures differed from the final sample of 125 on demographics or medical status.

Selection Criteria

Infants were selected to meet the following conditions: infants had to be full-term at delivery, have a gestational age of 38 weeks 0 days through 41 weeks 6 days, have a birth weight between the 10th and 90th percentiles, and have a score of 7 or higher on the 5-minute (or second) Apgar. In addition, infants had to be discharged from the hospital with the mother within 3 days of the infant’s birth (or 4 days for infants who were delivered by caesarean section). Both male and female infants were recruited. Infants with the following conditions were excluded: admission to the neonatal intensive care unit (NICU) for any reason, major malformations (eg, spina bifida), chromosome abnormalities (eg, trisomy 21, 18, 13), major sensory deficits (eg, blindness), neurologic syndromes or disorders (eg, neonatal white matter disorder, any intraventricular hemorrhage, hypoxic ischemic event, seizures), 1 of a multiple birth, surgical intervention, exposure to illegal substances, evidence of fetal alcohol syndrome or evidence of exposure to high levels of alcohol during gestation, any bilirubin treatment within 24 hours of examination (which effectively excluded infants with high bilirubin levels), or circumcision within 12 hours of examination. Infants were also excluded when their mother was not between 18 and 39 years of age and did not have >2 prenatal visits, had a condition or illness known to affect the fetus or newborn (eg, insulin dependence, hypothyroidism, chemotherapy treatment), was hospitalized during the pregnancy for a condition that might affect the infant (eg, infectious disease), was positive for human immunodeficiency virus or using medications for chronic conditions (eg, seizures, affective disorders), had an identified psychosis, or was mentally retarded. Mothers were recruited regardless of race/ethnicity.

Recruitment Procedure

Newborns were recruited on the well-child nurseries at Brigham and Women’s Hospital. All infants who met criteria were

TABLE 1. Demographic Characteristics

Variable	Value	N	%
Infant gender	Male	55	44.0
	Female	70	56.0
Mother's education	10–12 y	15	12.1
	High school/GED	8	6.5
	Some college	22	17.7
	Bachelor's degree	41	33.1
	Graduate degree	38	30.6
Mother's work status	Full-time	43	34.4
	Part-time	29	23.2
	No work	53	42.4
Mother's ethnicity	White	89	71.2
	Black	13	10.4
	Hispanic	23	18.4
Mother born in United States	Yes	95	76.0
	No	30	24.0
Father's education	10–12 y	13	11.1
	High school/GED	10	8.5
	Some college	13	11.1
	Bachelor's degree	36	30.8
	Graduate degree	45	38.5
Father's work status	Full-time	105	89.7
	No work	12	10.3
Father's ethnicity	White	80	72.1
	Black	13	11.7
	Hispanic	18	16.2
Father born in United States	Yes	89	72.4
	No	34	27.6
Mother's marital status	Single	29	25.0
	Married	87	75.0
Family income	<\$10 000	21	17.6
	\$10 000–\$25 000	6	5.0
	\$25 000–\$50 000	12	10.1
	\$50 000–\$75 000	15	12.6
	\$75 000–\$100 000	23	19.3
	>\$100 000	42	35.3
Insurance	HMO/private	96	78.7
	Medicaid/government	25	20.5
	Self/none	1	0.8

	N	Mean	SD	Minimum	Maximum
Mother's age	125	30.8	5.5	18.7	39.6
Father's age	117	33.5	6.0	19.4	51.7
No. of children* at home	125	2.0	0.9	1.0	7.0

HMO indicates health maintenance organization.

Not all N values equal 125 because of missing data.

* Children (under 18 years), including infants.

identified on the basis of nursing reports and review of the medical record. When >1 infant met criteria, the infants were ordered randomly. The parents of the first infant were approached and recruited. If the parents refused, then the next parents of an infant who met criteria were approached until a subject was recruited. Informed written consent was obtained from the parent(s).

Administration of the NNNS

The NNNS was administered according to the procedures specified in "The Neonatal Intensive Care Unit Network Neurobehavioral Scale Procedures" (earlier in this issue). Infants were brought

from the nursery or their mother's room in their bassinets and were wheeled to the examination room. The examination room was quiet, controlled for temperature (mean: 78.87; SD: 3.07) and light (mean: 6.03 lumens; SD: 1.02). The bassinet was used for the examination.

Examiner Training and Reliability

Two research assistants were trained by 2 NNNS certified trainers. Both their administration and reliability of scoring were evaluated. Reliability was set to the criteria used on other neurobehavioral examinations of no more than two 2-point disagree-

TABLE 2. Infant and Mother Medical Characteristics

Variable	N	Mean	SD	Minimum	Maximum
Birth weight, g	125	3480.5	367.18	2374.0	4281.0
Birth length, cm	123	50.53	2.20	44.00	56.00
1-min Apgar	124	8.29	1.14	2.00	10.00
5-min Apgar	124	8.98	0.38	8.00	10.00
Gestational age, wk	125	39.70	0.84	38.00	41.57
Age at examination, h	125	29.88	11.79	12.08	56.47
Gravity	125	2.53	1.51	1.00	10.00
Parity	125	1.95	0.99	1.00	7.00

Not all N values equal 125 because of missing data.

TABLE 3. NNNS Scores

NNNS Scale	Descriptives					Percentiles						
	<i>N</i>	Mean	SD	Minimum	Maximum	5	10	25	50	75	90	95
Habituation	68	7.91	1.14	4.00	9.00	5.67	6.33	7.33	8.17	9.00	9.00	9.00
Attention*	66	5.30	1.04	2.75	7.57	3.71	4.00	4.50	5.27	6.00	6.60	7.00
Arousal*	125	4.16	0.81	2.17	5.86	2.50	3.17	3.71	4.17	4.67	5.14	5.43
Regulation*	97	5.00	0.82	3.10	6.50	3.30	3.67	4.50	5.08	5.67	6.00	6.13
Handling*	125	0.27	0.27	0.00	1.00	0.00	0.00	0.00	0.25	0.50	0.63	0.75
Quality of movement*	125	3.81	0.78	1.60	5.83	2.33	3.00	3.33	3.80	4.33	4.80	5.00
Excitability	125	4.23	2.10	0.00	9.00	1.00	1.00	3.00	4.00	6.00	7.00	8.00
Lethargy	125	6.32	3.24	0.00	12.00	1.00	2.00	3.00	7.00	9.00	10.00	11.00
Nonoptimal reflexes	125	4.32	1.73	0.00	9.00	2.00	2.00	3.00	4.00	5.00	6.00	7.00
Asymmetry	125	1.93	1.33	0.00	7.00	0.00	0.00	1.00	2.00	3.00	4.00	4.00
Hypertonicity	125	0.07	0.26	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Hypotonicity	125	0.55	0.76	0.00	3.00	0.00	0.00	0.00	0.00	1.00	2.00	2.00
Stress abstinence*	125	0.15	0.05	0.02	0.25	0.06	0.08	0.13	0.17	0.19	0.21	0.23

Not all *N* values equal 125 because of missing data.

* Scales that require a minimum number of items.

ments on items with ≥ 9 scale points, and for items with ≤ 5 scale points, agreement had to be exact with no more than 5 disagreements. At the end of training, reliability of scoring of each research assistant was evaluated by having each research assistant administer the NNNS with the NNNS trainer observing and then scoring the examination independently. Reliability was checked over the course of data collection by having the research assistants evaluated against the master trainer and also by having 1 research assistant administer the NNNS with the other research assistant observing and then scoring the examination independently. All examinations were observed and scored independently by a second, trained, and reliable research assistant. Disagreements were resolved in conference with the NNNS trainer. These procedures maintained a high level of quality control for this gold standard study.

Data Reduction

Means, SDs, range, median, mode, and 10th through 90th percentiles were calculated for the NNNS summary scores: habituation, attention, arousal, regulation, number of handling procedures, quality of movement, number of nonoptimal reflexes, number of asymmetric reflexes, hypertonicity, hypotonicity, and stress/abstinence, excitability, and lethargy (see Appendix 2 later in this issue).

RESULTS

Demographic data on the mothers and fathers of the infants are shown in Table 1. The data indicate that the sample is at low social and demographic risk.

Medical data on the infants and mothers are shown in Table 2. The data demonstrate that the infants and mothers were at low medical risk. Table 3 presents the data on the NNNS summary scores. These scores indicate the NNNS performance levels of a sample of ~1-day-old (mean age of testing was 30 hours) healthy infants.

DISCUSSION

The data presented are for a sample of infants who were selected for clinically optimal health status. Using these data, clinicians will be able to assess the neurobehavioral performance of an infant in their care and compare the infant’s performance against the NNNS data and to integrate this information with their clinical experience. Researchers will be able to evaluate the performance of infants who have specific medical conditions or are receiving specific treatments.

ACKNOWLEDGMENTS

This research was supported by a grant from the National Institute of Child Health and Human Development, Standardization of the NRN–Neurobehavioral Scale (1R01 1RD 37138 to Dr Tronick).

We acknowledge the invaluable assistance of Jennifer Strickland and Joan Riley. We thank Drs Steven A. Ringer, Eric Eichenwald, and Constance Keefer; nurse managers Ellen Sharpe and Miriam Trainer; the nursing staff of the 8th and 9th floor well-child nurseries for assistance and advice; and of course the parents and their infants.

REFERENCES

1. Napiorkowski B, Lester BM, et al. Effects of in utero substance exposure on infant neurobehavior. *Pediatrics*. 1996;98:71–75
2. Lester BM, Tronick EZ, LaGasse LL, et al. The Maternal Lifestyle Study (MLS): effects of substance exposure during pregnancy on neurodevelopmental outcome in 1-month-old infants. *Pediatrics*. 2002;110:1182–1192
3. Johnson RE, Jones HE, Jasinski DR, et al. Buprenorphine treatment of pregnant opioid-dependent women: maternal and neonatal outcomes. *Drug Alcohol Depend*. 2001;63:97–103
4. Law KL, Stroud LR, LaGasse LL, Niaura R, Liu J, Lester BM. Smoking during pregnancy and newborn neurobehavior. *Pediatrics*. 2003;111:1318–1323

Normative Neurobehavioral Performance of Healthy Infants on the Neonatal Intensive Care Unit Network Neurobehavioral Scale

Edward Z. Tronick, Karen Olson, Rebecca Rosenberg, Lisa Bohne, Jing Lu and Barry M. Lester

Pediatrics 2004;113;676

Updated Information & Services	including high resolution figures, can be found at: http://pediatrics.aappublications.org/content/113/Supplement_2/676
References	This article cites 4 articles, 3 of which you can access for free at: http://pediatrics.aappublications.org/content/113/Supplement_2/676#BIBL
Subspecialty Collections	This article, along with others on similar topics, appears in the following collection(s): Developmental/Behavioral Pediatrics http://www.aappublications.org/cgi/collection/development:behavioral_issues_sub Fetus/Newborn Infant http://www.aappublications.org/cgi/collection/fetus:newborn_infant_sub Neonatology http://www.aappublications.org/cgi/collection/neonatology_sub Neurology http://www.aappublications.org/cgi/collection/neurology_sub
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://www.aappublications.org/site/misc/Permissions.xhtml
Reprints	Information about ordering reprints can be found online: http://www.aappublications.org/site/misc/reprints.xhtml

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®



PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Normative Neurobehavioral Performance of Healthy Infants on the Neonatal Intensive Care Unit Network Neurobehavioral Scale

Edward Z. Tronick, Karen Olson, Rebecca Rosenberg, Lisa Bohne, Jing Lu and Barry M. Lester

Pediatrics 2004;113;676

The online version of this article, along with updated information and services, is located on the World Wide Web at:

http://pediatrics.aappublications.org/content/113/Supplement_2/676

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2004 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

