eNeonatal Review
Jointly presented by the Johns Hopkins University School of Medicine and the Institute for Johns Hopkins Nursing
Supported by an educational grant from INO Therapeutics
JOHNS HOPKINS MEDICINE
JOHNS HOPKINS NURSING
The Institute for Johns Hopkins Nursing

FEBRUARY 2006 VOLUME 3, NUMBER 6

In this issue...

The acoustic environment of a traditional NICU is noisy and distracting, affecting parents and staff as well as infants. In this issue we review the current literature investigating:

- the possible role of exposure to NICU noise during periods of rapid brain development in attentional problems of early born children,
- some parameters of infant attention to auditory signals,
- the relationships between attention and distraction,
- studies of adult performance errors in noisy working conditions, and
- NICU noise measurement parameters and the means of reducing NICU noise.

This Issue

Guest Editors of the Month

Reviews and Commentary:
M. Kathleen Philbin, RN, PhD
Department of Pediatrics
University of Medicine and Dentistry of New Jersey
Robert Wood Johnson Medical School
Camden, NJ

Reviews:
Lincon Gray, PhD
College of Integrated Science and Technology
James Madison University
Harrisonburg, VA

Program Information

CE Info
Accreditation
Credit Designation
Target Audience
Learning Objectives
Faculty Disclosure
Disclaimer Statement
Internet CE Policy

Length of Activity
1.0 hour

Expiration Date
February 26, 2008

Next Issue
March 15, 2006

Complete Post Test
and Receive CME/CE Credit

Click here to ask our author a question.

For a limited time, get a free subscription to
EPOCRATES ESSENTIALS
for submitting a question.

Newsletter Archive
Our comprehensive library of accredited programs

Course Directors

Edward E, Lawson, M.D.
Professor

Department of Pediatrics Neonatology
The Johns Hopkins University
School of Medicine

Lawrence M. Nogee, M.D.
Associate Professor

Department of Pediatrics Neonatology
The Johns Hopkins University
School of Medicine

Christoph U. Lehmann, M.D.

Reviews:
Jane C. Hilton, PhD, CCC-SLP
College of Integrated Science and Technology
James Madison University
Harrisonburg, VA

Guest Faculty Disclosure:
M. Kathleen Philbin, RN, PhD
Faculty Disclosure: No relationship with commercial supporters.

Lincoln Gray, PhD
Faculty Disclosure: No relationship with commercial supporters.

Jane C. Hilton, PhD, CCC-SLP
Faculty Disclosure: No relationship with commercial supporters.

Unlabelled/Unapproved Uses:
No faculty member has indicated that their presentation will include information on off label products.

Learning Objectives

The Johns Hopkins University School of Medicine and The Institute for Johns Hopkins Nursing take responsibility for the content, quality, and scientific integrity of this CE activity.

At the conclusion of this activity, participants shouldbe able to:

• Identify key non-auditory problems for infants associated with the acoustic environment of the traditional NICU.

• Identify key non-auditory problems for adults (staff and parents) associated with the acoustic environment of the traditional NICU.

• Describe the sound parameters to be addressed when designing a quality improvement project for the acoustic environment of the NICU.

Assistant Professor

Department of Pediatrics,
Health Information
Science and Dermatology
The Johns Hopkins University
School of Medicine

Mary Terhaar, DNSc, RN
Assistant Professor

Undergraduate Instruction,
The Johns Hopkins University
School of Nursing

Robert J. Kopotic, MSN, RRT, FAARC
Director of Clinical Programs

Vital Signs Development Center
ConMed Corporation

Recommend to a Colleague

Commentary

This issue considers the effects of the acoustic environment of a traditional NICU on all of its inhabitants. This environment is the consequence of closely spaced infant beds and sound-generating adult activities (e.g., traffic, storage, workstations) intermingled in open rooms surfaced with hard, reflective materials.[1] A newly built NICU can be as noisy as a traditional one if its design and construction are not guided by a specific plan to achieve quiet. [2] While a quiet nursery need not be expensive, it does require informed and purposeful planning as well as the correct choice of materials and construction.

While some clinicians worry that the noise levels in a NICU contribute to the loss of infant hearing acuity, all NICU sound levels reported to date are far lower than the eight-hour OSHA limits of sustained 90 dBA implicated in hair cell damage. [3, 4] Nevertheless, there remain substantial arguments in favor of vigorous and sustained efforts to reduce NICU noise.

The potential for long term deleterious effects of preterm infant exposure to NICU noise rests in third trimester mechanisms of sensory and brain development. [5] During this time the ear is fairly well developed and is fully capably of sending signals to the brain. The brain, however, is relatively less mature and relies on a narrow range of only moderately strong, biologically expected stimuli to attain its species-typical structure and function. [5] There is ample evidence that repeated atypical stimulation and response during brain development result in atypical brain and behavior function.[6, 7] Behavioral studies of preterm infants show that strong stimuli tend to cause disorganized responses in the physiologic, motor, and state-related systems. [8] These repeated, disorganized responses also constitute experience and make their own contribution to brain-behavior development. In a very real sense we are what we practice doing — particularly in early development.

Unfortunately, the acoustic stimuli of the traditional NICU are far stronger and very unlike those in the pregnant uterus. Many studies of animal behavior demonstrate that strong, biologically atypical experience in one sensory modality results in atypical sensory capacities in the same as well as other sensory modalities. [5] For example biologically atypical auditory experience late in the gestation of bobwhite quail results in an atypical inability to identify the mother hen by sight or sound. [9, 10, 11, 12] The 2003 study by Chang, et al (reviewed this issue) shows that exposure to low level noise similar to that of a NICU results in atypical brain activity maps in immature animals.

It is not known which aspects of NICU noise are responsible for which effects. The possibilities include the level (perceived as loudness), the frequencies (perceived as pitch), the onset/offset characteristics, the lack of rhythmicity, and the lack of diurnal cyclicity. Gray and Philbin's 2004 study of older children and adults (reviewed below) suggests that the lack of predictability of NICU sound and the consequent, repeated distraction of the infant listener merit investigation as agents of long term attentional problems.

Gray and Philbin's study complements other research showing that a continuum of unpredictable or distracting acoustic stimuli will result in failures of attention at some point for anyone: for example, studies of errors in the workplace suggest that the distraction masking of NICU noise likely contributes to errors in understanding and remembering information in speech, particularly for older adults. [13-16] Children diagnosed with attention deficit disorder, therefore, may not differ from their normal counterparts in the kind of distractibility they display, but in their lower threshold for it. There is ample evidence for a continuum of decreasing distractibility with age in childhood [17-20], and it seems fair therefore, to assume that an identical NICU environment is more distracting for infants than for adults. Given the dependence of the brain on experience, it may be worth considering whether the acoustic environment of the traditional NICU is an iatrogenic contributor to the attentional problems of early born children.

References:

1. Philbin MK. Planning the acoustic environment of a neonatal intensive care unit. Clin Perinatol 2004;31:331-352.
2. Evans JB, Philbin MK. Facility and operations planning for quiet hospital nurseries. J Perinatol. 2000;20(No. 8, Pt 2) S105-S112.
3. National Institutes of Health Consensus Report: Noise and hearing loss. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health; 1990.
4. Philbin MK. The influence of auditory experience on the behavior of preterm newborns. J Perinatol. 2000;20:S77-S87.
5. Lickliter R. Atypical perinatal sensory stimulation and early perceptual development: Insights from developmental psychobiology. J. Perinatol. 2000;20:S45-S54.
6. Lecanuet JP, Fifer WP, Krasnegor NA, Smotherman WP, editors. Fetal development: A psychobiological perspective. Hillsdals, NJ:Earlbaum; 1995.
7. Als H, Duffy FH, McAnulty GB, Rivkin MJ, Vajapeyam S, Mulkern RV, Warfield SK, Huppi PS, Butler SC, Conneman N, Fischer C, Eichenwald EC. Early experience alters brain function and structure. Pediatrics. 2004 Apr;113(4):846-57.
8. Als H, Butler S, Kosta S, McAnulty G. The Assessment of Preterm Infants' Behavior (APIB): furthering the understanding and measurement of neurodevelopmental competence in preterm and full-term infants. Ment Retard Dev Disabil Res Rev. 2005;11(1):94-102.
9. Lickliter R, Hellewell TB. Contextual determinants of auditory learning in bobwhite quail embryos and hatchlings. Dev Psychobiol. 1992;25:17-24.
10. Lickliter R, Lewkowitz DJ. Intersensory experience and early perceptual development: attenuated prenatal sensory stimulation affects postnatal auditory and visual responsiveness in bobwhite quail chicks. Dev Psychol. 1995;31:609-618.
11. Sleigh MJ, Columbus RF, Lickliter R. Type of prenatal sensory experience affects prenatal auditory learning in bobwhite quail. J Comp Psychol. 1996;110:233-242.
12. Sleigh MJ, Lickliter R. Augmented prenatal auditory stimulation alters postnatal perception, arousal, and survival in bobwhite quail chicks. Dev Psychobiol. 1997;30:201-212.
13. Pichora-FullerMK, Schneider BA, Daneman M. How young and old adults listen to and remember speech in noise. J Acoust Soc Am. 1995;97(1):593-608.
14. Tun PA. Fast noisy speech: age differences in processing rapid speech with background noise. Psychol Aging. 1998;13(3):424-34.
15. Tun PA, O'Kane G, Wingfield A. Distraction by competing speech in young and older adult listeners. Psychol Aging.

2002;17(3):453-67.

16. Tun PA, Wingfield A. One voice too many: adult age differences in language processing with different types of distracting sounds. J Gerontol B Psychol Sci Soc Sci. 1999;54(5):P317-27

17. Bargones J, Werner L. Adults listen selectively; infants do not. Psychonomic Sci. 1994;5:170-4.

18. Liebold L. Informational masking in infancy [PhD dissertation]. University of Washington, Seattle, WA: Speech and hearing sciences; 2004.

19. Werner LA, Boike K. Infants' sensitivity to broadband noise. J Acoust Soc Am. 2001;109(5 Pt 1):2103-11.

20. Wrightman FL, et al. Children's detection of pure-tone signals: informational masking with contralateral maskers. J Acoust Soc Am. 2003;113(6):3297-305.

Recommend eNeonatal Review to a Colleague

Ask a Question about this Newsletter

BIOLOGICALLY UNEXPECTED ACOUSTIC EXPERIENCE AFFECTS THE DEVELOPMENT OF CENTRAL HEARING

Chang E, Merzenich M.
Environmental noise retards auditory cortical development. Science. 2003;300:498-502.

(For non-journal subscribers, an additional fee may apply for full text articles)

Article Options
View journal abstract
View full article

The brain changes over the course of development and is, therefore, susceptible to alteration from typical structure and function with atypical experience. Illustrating this principle, Chang and Merzenich showed that even moderate levels of environmental noise affect the development of the auditory cortex resulting in an atypical brain activity map. During an early sensitive period, the auditory cortex changes to achieve a mature tonotopic organization in which each region represents a specific frequency. This maturation depends on favorable signal-to-noise ratios in the early acoustic environment.

To test the effects of noise on the development of a typical brain activity map, rat pups were reared in continuous, moderate noise that partially masked signal inputs. Chang and Merzenich used functional magnetic resonance imaging to show that the rats reared in noise had delayed maturation of normal patterns of cortical connectivity. These results implicate noise, even at moderate levels, as a risk factor for atypical brain development.

UNPREDICTABLE ACOUSTIC ENVIRONMENTS INTERFERE WITH ATTENTION IN CHILDREN

Stuart A.
Development of auditory temporal resolution in school-age children revealed by word recognition in continuous and interrupted noise. Ear Hear. 2005;26 (1):78-88.

Article Options
View journal abstract
View full article

Gray L, Philbin MK.
Effects of the neonatal intensive care unit on auditory attention and distraction. Clin Perinatol. 2004;31:243-260.

(For non-journal subscribers, an additional fee may apply for full text articles)

Article Options
View journal abstract
View full article

Studies of the behavioral responses of newborn preterm infants to acoustic stimuli are difficult to perform and rare in the literature. Possible general principles of hearing development, however, can be established with older infants and children. While most hearing is adult-like in infancy, some recent studies show that the abilities to discriminate a signal in noise and to resist distraction are not adult-like until late childhood or early adolescence.

Looking past infancy for clues about the effects of noise across the span of hearing development, Stuart replicated a commercially available word-recognition test (NU-CHIPS, Auditec, St. Louis) in the quiet and then in the presence of an unpredictable background sound. The unpredictable background sound was comprised of alternating periods of white noise bursts and silence in which both noise and silence had random durations between 5 and 95 milliseconds. Normal-hearing subjects varied in age from 6 years to adult. Without any background sound, children are able to perform this test by eight years of age. However, with a background stimulus children did not achieve adult levels of performance until eleven years of age. In discussing this result, the author notes that adults appear to use a strategy of attending to, discerning, and retaining parts of the words in the silent periods between the noise bursts; children, in contrast, were too distracted by the unpredictable background noise to make use of the parts of the signal that were available.

Describing a conceptually similar principle of early distractibility by background sound, Gray and Philbin reviewed data showing that older children with ADHD (not necessarily NICU graduates) were more distracted by some background sounds than were control children. The key factor in this distraction was the predictability of the acoustic background. Children between the ages of 7 and 13 pressed one of two keys to indicate whether they thought a 500-Hz pure tone was present or not. In this study there was no difference in performance between children with ADHD (tested off medication) and control children under both very predictable listening conditions (where everyone could detect the signal) and very unpredictable conditions (where everyone was distracted). The very predictable condition was the quiet of a sound booth - essentially no acoustic distraction. The very unpredictable listening condition, called informational masking, consisted of 10 different random tones between 1000 and 2500 Hz alternating in the background on each trial.

The normal and ADHD children did differ in a moderately unpredictable condition called central masking. In this condition broad band noise was played in one randomly selected ear while the signal was presented in the opposite ear. While all children became distracted under sufficiently unpredictable conditions, the children with ADHD became distracted at an intermediate level of unpredictability that did not affect the normal control children. Based on reported studies of NICU noise characteristics, the authors speculated that similar conditions of intermediate predictability, which separate the vulnerable and control listeners, might be found in the acoustic environment of many NICUs.

In summary, these studies show that background noise can affect performance for everyone, particularly when the auditory system is developing. They also show that a mature ability to respond in noise is not present until adolescence. Further, children with ADHD were found to have delayed maturation in regard to attention in unpredictable listening environments. Because of the dependence of the developing brain on experience, the authors suggest that the noisy and unpredictable environment of a traditional NICU may contribute to attentional problems in premature infants.

UNPREDICTABLE ACOUSTIC ENVIRONMENTS INTERFERE WITH ATTENTION AND PERFORMANCE IN ADULTS

Thomas, KA, Martin, PA. (2000).
The acoustic environment of hospital nurseries NICU sound environment and the potential problems for caregivers. J Perinatol, 20, S93-S98

Article Options
View journal abstract
View full article

Gray L, Philbin MK.
Effects of the neonatal intensive care unit on auditory attention and distraction. Clin Perinatol. 2004;31:243-260.

Article Options
View journal abstract
View full article

Aucott S, Donohue PK, Atkins E, Allen MC
Neurodevelopmental care in the NICU. Mental Retardation and Developmental Disabilities Research Reviews, 2002;8:298-308.

Article Options
View journal abstract

The current, empirically based, peer-reviewed literature examining the potential effects of noise on adult attention and performance has been reviewed by several authors interested in the effects of hospital noise on staff and adult family members. Both Thomas & Martin and Gray & Philbin report consistent findings in the literature that adults in environments with persistent, distracting auditory stimuli experienced lapses in attention to tasks, increased anxiety, errors in remembering details, and mistakes in interpreting visual information, such as x-rays. Some of these studies were completed in laboratory settings with standardized tests and controlled background noise, while others were observational studies performed in real work environments. In their review of studies examining speech communication, these authors report that problems are found to be more pronounced for older adults (with good hearing), for those speaking a non-native language, and those listening to non-native speech.

Based on his 2001 review of the literature, Rossetti concluded that adults and infants may have difficulty establishing the synchronized, reciprocal patterns typical of early communication if the infant's interaction is repeatedly disturbed by anything including noisy backgrounds.[1] Similarly, Aucott's 2002 review of the literature on NICU care indicated that focused, undistracted parental involvement in daily activities was effective in fostering attachment and helped parents to better comprehend their child's situation. The trend in this literature, however, was that family involvement in the infant's daily care tended to be quite limited in NICUs.

The review by Thomas and Martin also reported compromised family intimacy and privacy in noisy NICU environments. These reviewers conclude that crowding (such as that found in traditional NICUs) may magnify discomfort beyond that inherent in the content of the conversation. Their review also suggested that lack of speech privacy interfered with the intimacy and calm thinking required for sound decision making.

References:

1.Rossetti, Louis M. (2001). Communication Intervention Birth to Three (2nd ed.). Singular Thomson Learning, Albany, NY.

MEASURING SOUND IN THE NICU

Busch-Vishniac I, West J, Barnhill C, Hunter T, Orellana D, Chivukula R.
Noise levels in Johns Hopkins Hospital. J Acoust Soc Am. 2005;118:3629-3645.

Article Options
View journal abstract

Philbin MK, Gray L.
Changing Levels of Quiet in an Intensive Care Nursery. J. Perinatol. 2003;22:455-60.

Article Options
View journal abstract
View full article

Gray L, Philbin MK.
Measuring sound in hospital nurseries. J. Perinatol. 2000;20 Part 2:S1000 - S104

Article Options
View journal abstract
View full article

Hospitals are noisy and are getting noisier. In their 2005 report, Busch-Vishniac performed an extensive meta-analysis of hospital sound levels recorded over the last 45 years and found an increase on average of .38 dB per year for daytime levels and .42 dB per year for nighttime levels. Continuing at this rate, sound levels would double every 15 years. Although current literature on hospital sound levels is generally limited to overall noise levels, the authors note that a more thorough assessment should include the spectrum of frequencies and tonality (i.e., the particular frequencies that comprise the noise). Variance of sound levels over time could also be an important aspect of the acoustic environment and merits study.

In a 2000 report, Philbin and Gray investigated the complex work of bringing NICU noise under control. Serial sound dosimetry measurements were made at three epochs over a period of 12 years in the same NICU capturing sound levels across all hours of day and night and all days of the week. The relative effects of a staff education program in support of more quiet behavior and of moderate renovations of the physical space were measured. The outcome data were sound levels (L_ns) that were exceeded for various percentages of the time (L_{10}, L_{50}, L_{90}) and also the most noisy and most quiet audible events (L_{max} and L_{min}). The L_{90} (the level exceeded 90% of the time) can be thought of as the boundary of the most quiet 10th percentile, while L_{10} (the level exceeded 10 % of the time) can be thought of as the boundary of the most noisy 10th percentile.

For this quality improvement study a single aggregate sound level was not sufficient to identify the aspects of the acoustic environment that were affected by each intervention. The data revealed that the higher noise levels (L_{10} and L_{max}) were somewhat intractable, due (most probably) to the crowding and intermingling of adult activities and traffic within the infant bed areas. However, due to noise reduction efforts of the staff and administrators, the noise floor was lowered substantially into a range that supported infant sleep, avoided distraction of nascent attentional skills, permited discernment of the mother's voice against the background, and reduced acoustic distraction for staff.

Contrary to intuition, reducing the very loud noises - the noise ceiling - did not contribute substantially to lowering the noise floor. The noise floor is comprised of the constant background sounds produced by the heating, ventilation, and air-conditioning system (HVA-C), refrigerator condensers, etc. Speech communication, a major source of NICU noise, has to be louder than this floor in order to be audible. The noise floor is also comprised of the reverberating sounds of ongoing activity and machinery. The more quiet periods after the interventions showed an eight-fold lowering of the perceived loudness as compared to the nursery before interventions. This lowering was achieved by: 1) more quiet staff behavior, 2) reduced HVA-C noise following modifications in the duct work, 3) increased sound absorption from acoustic ceiling tiles with a noise reduction coefficient of .95, and 4) reduced noise generation at the floor with specialized carpet.

In a separate publication, Gray and Philbin (2000) offered some practical advice on measuring sounds in the nursery based on more than a decade of experience. They recommend first selecting a good quality sound level meter/dosimeter and learning how to use it correctly. They further noted that sound level meters/dosimeters appropriate for measuring hospital noise are not “point-and-shoot” tools, but specialized instruments designed for industry. Because neonatal clinicians typically have no training in the use of these instruments or the science of acoustics, the customer support capabilities of the manufacturer are important for assistance in understanding the software settings and for data collection and interpretation.

In the same report, Gray and Philbin also note that the objectives for measuring sound in the NICU are different than those in industry. Industrial hygienists are primarily interested in the noisiest events over an 8-hour workday because hearing protection for workers is required if specified criteria are reached. Further, industrial data can be averaged over an 8-hour workday, thereby allowing very loud but short noise exposures to be numerically diluted by more quiet periods during the shift. In a NICU, however, measurements summarized over an 8-hour period are not meaningful in terms of remediation, whereas those measured repeatedly over one hour across all hours of the week provide guidance in identifying both noise events and periods of quiet.

Clinicians contemplating or engaged in NICU noise-reduction projects are advised to consult Gray’s Properties of Sound (Gray, L. J Perinatol. 2000 V20:S6-S11), wherein the author notes that sound levels cannot be arithmetically averaged because the decibel (dB) metric is logarithmic (i.e., curved or non-linear). An average of several measurements in dBs underestimates actual sound levels and is a mathematically meaningless number. Characterization of noise levels can be given by distributions of L_{90s} (levels of quiet), L_{50s} (median noise levels), or L_{eqs} (integrated sound levels). Statistical significance in the difference between sound levels may be meaningless in terms of human sensitivity.Generally, a 2 dBA change is just barely noticeable for adults, and a 4 dBA change is just barely noticeable for infants. (Fay, R. Hearing in Vertebrates 1988 Hill-Fay Associates, Winetka IL) Additional information may be found in Recommended Permissible Noise Criteria for Newly Constructed or Renovated Hospital Nurseries (Philbin MK, Robertson AF, Hall III JW. J Perinatol. 1999;19(8 part 1):559-63.), in which the authors advise that quality improvement target levels be developed to achieve specific objectives, such as maintenance of infant sleep or preservation of speech intelligibility.

Complete Post Test and Receive CME/CE Credit

Recommend eNeonatal Review to a Colleague

Ask the Author

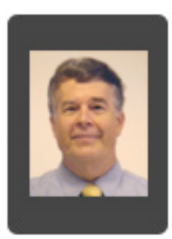
Ask a Question about this Newsletter

LAST MONTH’S Q & A February 2006 - Volume 3 - Issue 6

Last issue we reviewed the possible role of exposure to NICU noise during periods of rapid brain development, some parameters of infant attention to auditory signals, the relationships between attention and distraction, studies of adult performance errors in noisy working conditions, NICU noise measurement parameters and the means of reducing NICU noise.

Commentary & Reviews:

M. Kathleen Philbin, RN, PhD
Department of Pediatrics
University of Medicine and Dentistry of New Jersey
Robert Wood Johnson Medical School
Camden, NJ



Reviews:

Lincon Gray, PhD
College of Integrated Science and Technology
James Madison University
Harrisonburg, VA

Reviews:

Jane C. Hilton, PhD, CCC-SLP
College of Integrated Science and Technology
James Madison University
Harrisonburg, VA

We received the following questions from a few of our subscribers.

Q Regarding the effects of noise levels in the NICU, has there been any brain mapping done on neonates at any gestation? 2) On infants studied, has any post-discharge brain mapping been done for follow up and possible treatment and brain retraining, or do findings show damage beyond repair?

A Frank Duffy, Heidelise Als, Petra Huppi and their colleagues compared brain electrical activity (multi-channel EEG and fMRI) in preterm infants who received either traditional nursing care or individualized, developmentally supportive care via the NIDCAP method. Their studies show consistent differences between the two groups of infants in maps of neural activity at term gestational age (after discharge) as well as consistent differences in behavioral organization measured by a standard neurobehavioral assessment. Presumably these related differences in both behavior and brain activity are due to differences in sensory experience associated with the two types of care. Acoustic stimulation was not independently manipulated in these studies but was incorporated into either the global NIDCAP intervention or traditional NICU care. Some aspects of the atypical preterm brain mapping and behavioral functioning were found to persist into later ages (see Woodward et al., 2005). In particular, problems in paying attention appear to persist into the elementary school years at least.

The authors as well as most clinicians do not conceive of the preterm infant as "damaged", but as having a unique behavioral repertoire with some areas of strength and some areas that require consistent facilitation for best function. It is well known in the literature that preterm infants growing up with parents sensitive to their behavioral capacities function better on standardized tests throughout childhood compared to children growing up without these assets. Presumably, the infant brain retains aspects of the functioning seen at term gestational age while also remaining adaptable to conditions that support (or fail to support) increasing self-regulation and organization. This interplay of influences appears to affect each child uniquely.

Als H, Duffy FH, McAnulty GB, Rivkin MJ, Vajapeyam S, Mulkern RV, Warfield SK, Huppi PS, Butler SC, Conneman N, Fischer C, Eichenwald EC. Early experience alters brain function and structure. Pediatrics. 2004 Apr;113(4):846-57.

Als H, Gilkerson L, Duffy FH, McAnulty GB, Buehler DM, Vandenberg K, Sweet N, Sell E, Parad RB, Ringer SA, Butler SC, Blickman JG, Jones KJ. A three-center, randomized, controlled trial of individualized developmental care for very low birth weight preterm infants: medical, neurodevelopmental, parenting, and caregiving effects. J Dev Behav Pediatr. 2003 Dec;24(6):399-408. Erratum in: J Dev Behav Pediatr. 2004 Jun;25(3):224-5.

Buehler DM, Als H, Duffy FH, McAnulty GB, Liederman J. Effectiveness of individualized developmental care for low-risk preterm infants: behavioral and electrophysiologic evidence. Pediatrics. 1995 Nov;96(5 Pt 1):923-32.

Woodward, L. J., Edgin, J. O., Thompson, D., & Inder, T. E. (2005). Object working memory deficits predicted by early brain injury and development in the preterm infant. Brain, 128(Pt 11), 2578-2587.

Q "White Noise" was discussed as a factor in this newsletter. One example given had to do with the HVAC system. I was curious if the High Frequency Ventilator could be considered "White Noise" as well? And what would the measured noise level be compared to the HVAC, since the Ventilator makes more noise?

A In technical terms, "white" noise has all sound frequencies at equal amplitudes. Unlike true white noise, HVAC systems produce broad band sounds with louder components in the low frequencies (more rumble) while oscillating ventilators produce broad band noise with louder components in the mid-range of frequencies where they can interfere with speech communication. It is possible that the worst effect of this noise for the infant is masking important acoustical signals such as the parent's voice. The actual sound level of a high-frequency ventilator depends on the machine, the settings, and the room in which it is used. Some companies offer sound shielding devices, but the effectiveness of these would need to be assessed at each hospital site. The annoyance of these machines for adults may have more to do with the rapid on-off nature of the sound (pop-pop-pop) than with the overall noise level (L50). It is not known whether the level of noise measured in the room and heard by adults accurately represents the effective level of noise at the infant's ear, as the sound could be conducted through the bones of the infant's head.

Q Our new NICU was specifically designed to reduce noise (we provide semi-private rooms — 2 beds in 1 room, with alarms outside the doors when caregivers are not present), but we had not previously considered a quality improvement assessment to determine if we have truly cut back on the noise level. Can you provide input re the best way to proceed?

A One would need accurate sound measurements from the old NICU in order to know whether noise levels have been reduced in the new unit. Assuming such archival sound measures are not available, you could compare the new NICU against the Recommended Permissible Noise Criteria offered by Philbin, Robertson, and Hall and adopted by the Committee to Recommend Standards for Newborn ICU Design and the AIA and many state regulatory agencies. The first step would be to obtain a good quality sound dosimeter and collect continuous 24-hour data over several weekdays and weekends as described in the Gray & Philbin and Philbin & Gray articles cited in the eNeonatal Review article.

Designing a successful QI program requires anticipating the problem(s) in a specific NICU. You could begin by measuring the levels in an unoccupied room with only a ventilator operating, and thus identify the noise floor. Comparing this noise floor with the measurements taken during typical operations would give the amount of improvement that could be achieved through staff behavior changes in a room with a ventilated baby. If the new NICU has hard surfaces (floors, walls, ceilings) it could be that normal activity generates appreciable noise (L10 and Lmax) above the background. Upgrading the ceiling tiles to a NRC .95 or better can lower considerably the levels generated by normal activity. If the noise floor (L90) appears high, the HVAC system may require modification. If you can hear street noise in the NICU the windows may require a better seal. An acoustical engineer can evaluate the HVAC system,windows, door mechanisms, etc. and recommended remediation.

White R.D / Committee to Recommend Standards for Newborn ICU Design. Recommended standards for newborn ICU design. J. Perinatol. 2003;23:(Sup.1):S1 - S21.

Philbin, M.K., Robertson, A. F., Hall, J.W., III. Recommended permissible noise criteria for occupied, newly constructed or renovated hospital nurseries. J. Perinatol. 1999;19:559-563.

Philbin, M.K. and Gray L. Changing levels of quiet in an intensive care nursery. J. Perinatol. 2002;22:455-460.

Gray, L., and Philbin, M.K. Measuring sound in hospital nurseries. J. Perinatol. 2000;20 Part 2:S1000 - S104.

Complete Post Test and Receive CME/CE Credit

Recommend eNeonatal Review to a Colleague

Accreditation · **back to top**

Physicians & Nurses

This activity has been planned and implemented in accordance with the Essential Areas and policies of the Accreditation Council for Continuing Medical Education through the joint sponsorship of The Johns Hopkins University School of Medicine and The Institute for Johns Hopkins Nursing. The Johns Hopkins University School of Medicine is accredited by the ACCME to provide continuing medical education for physicians.

Respiratory Therapists

Respiratory Therapists should click here to confirm that AMA PRA category 1 credit is accepted toward fulfillment of RT

Credit Designations · **back to top**

Physicians

The Johns Hopkins University School of Medicine designates this educational activity for a maximum of 1.0 *AMA PRA Category 1 Credit(s)*™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Nurses

The Institute for Johns Hopkins Nursing designates each newsletter that ispart of this educational activity for a maximum of 1.0* contact hours. TheInstitute for Johns Hopkins Nursing is accredited as a provider ofcontinuing nursing education by the American Nurses Credentialing Center'sCommission on Accreditation.

*Note: Newsletters with a Volume 1 or 2 designation offer a maximum of 0.5 credits/contact hours. Newsletters with a Volume 3 designation offer a maximum of 1.0 category credits/contact hours per newsletter

Respiratory Therapists

Respiratory Therapists should click here to confirm that your state will accept the CE Credits gained through this program.

Target Audience · **back to top**

This activity has been developed for Neonatologists, NICU Nurses and Respiratory Therapists working with Neonatal patients. There are no fees or prerequisites for this activity.

Learning Objectives · **back to top**

The Johns Hopkins University School of Medicine and The Institute for Johns Hopkins Nursing take responsibility for the content, quality, and scientific integrity of this CE activity. At the conclusion of this activity, participants should be able to:

• Identify key non-auditory problems for infants associated with the acoustic environment of the traditional NICU.

• Identify key non-auditory problems for adults (staff and parents) associated with the acoustic environment of the traditional NICU.

• Describe the sound parameters to be addressed when designing a quality improvement project for the acoustic environment of the NICU.

Faculty Disclosure Policy Affecting CE Activities · **back to top**

As providers accredited by the Accreditation Council for Continuing Medical Education and American Nursing Credentialing Center, it is the policy of The Johns Hopkins University School of Medicine and The Institute of Johns Hopkins Nursing to require the disclosure of the existence of any significant financial interest or any other relationship a faculty member or a provider has with the manufacturer(s) of any commercial product(s) discussed in an education presentation. The presenting faculty reported the following:

• Dr. Nogee has indicated a financial relationship of grant/research support with Forest Laboratories and has received an honorarium from Forest Laboratories.

• Dr. Lawson has indicated a financial relationship of grant/research support from the NIH. He also receives financial/material support from Nature Publishing Group as the Editor of the Journal of Perinatology.

• Dr. Lehmann has indicated a financial relationship with Eclipsys Corporation.

All other faculty have indicated that they have not received financial support for consultation, research, or evaluation, nor have financial interests relevant to this e-Newsletter.

Unlabelled/Unapproved Uses · **back to top**

The following faculty members have disclosed that their presentationwill reference unlabeled/unapproved use of drugs or products.

Maureen M. Gilmore, MD
Has indicated that the presentation includes information on Darbepoetin used for anemia of prematurity.

Disclaimer Statement · **back to top**

The opinions and recommendations expressed by faculty and other experts whose input is included in this program are their own. This enduring material is produced for educational purposes only. Use of Johns Hopkins University School of Medicine name implies review of educational format design and approach. Please review the complete prescribing information of specific drugs or combination of drugs, including indications, contraindications, warnings and adverse effects before administering pharmacologic therapy to patients.

Internet CE Policy · **back to top**

The Offices of Continuing Education (CE) at The Johns Hopkins University School of Medicine and The Institute for Johns Hopkins Nursing are committed to protect the privacy of its members and customers. The Johns Hopkins University maintains its Internet site as an information resource and service for physicians, other health professionals and the public.

The Johns Hopkins University School of Medicine and The Institute For Johns Hopkins Nursing will keep your personal and credit information confidential when you participate in a CE Internet based program. Your information will never be given to anyone outside The Johns Hopkins University program. CE collects only the information necessary to provide you with the service you request.