BORN TOO SOON

Cheated of feature by dissembling nature,
Deformed, unfinished, sent before my time
Into this breathing world, scarce half made up,
And that so lamely and unfashionable
That dogs bark at me as I halt by them....
Shakespeare
Richard III, Act I, Scene 1

Inconsistent sleep-wake states may be an indication of later medical or behavioral disorders in prematurely born children

BY ROBERT J. TROTTER

Long before Shakespeare's Richard III blamed his physical deformities on his premature birth, it was realized that being born prematurely can be associated with severe developmental problems. And long have ways been sought to avoid those problems. Research now suggests a method that might at least identify those premature infants most likely to encounter developmental problems.

The evolutionary process designed infants for survival after a 40-week gestation period, but about 7 percent of all infants are born three, four or more weeks ahead of schedule. Many of these infants will develop quite normally (Shakespeare exaggerated Richard's problems in a politically motivated attempt to vilify a previous administration), but many others will be handicapped. Premature infants, for instance, have a poorer chance of immediate survival than do full-term infants, and those that do survive tend to get infections and are subject to various respiratory difficulties. Feeding is another problem, especially for the smallest infants, who may lack the strength to suck at breast or bottle, and immature swallowing mechanisms may cause choking, gagging or breathing in of liquids.

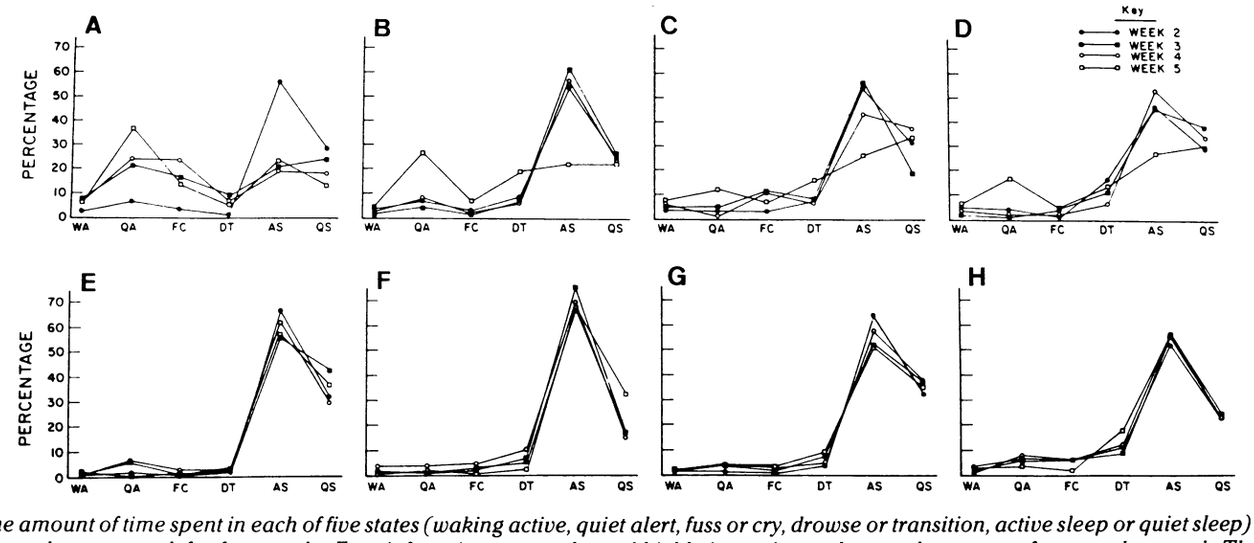
Intensive medical care saves the lives of many premature infants, but the problem goes beyond the first few weeks of life. Associated problems that are seen later in life include lower intelligence, learning difficulties, poor hearing and vision and physical awkwardness. The usual medical and behavioral assessment procedures can detect most existing problems, but because these procedures do not always predict which infants will have later difficulties, a major task for developmental psychology is to devise a method of identifying those premature infants who will need special care and intervention. Evelyn B. Thoman of the department of biobehavioral sciences at the University of Connecticut at Storrs has developed what may prove to be just such an assessment procedure. Her experimental data suggest that monitoring of sleep-wake states can be used to detect subtle central nervous system (CNS) dysfunctions and predict later developmental problems. She discussed her work earlier this year at the University of Vermont in Burlington during the annual meeting of the Vermont Conference on the Primary Prevention of Psychopathology.

Since 1972, Thoman and colleagues have been conducting a longitudinal study of full-term infants. Monitoring begins on the day after birth and continues through the first year of life. Intensive observations of behavioral states (asleep, awake, crying, etc.) made during the first five weeks of life have since proved to be useful in predicting later problems.

Sleep-wake states were closely monitored because they are assumed to be an expression of fundamental processes in the CNS and because deviations in sleep-wake patterns are known to be associated with neurological defects. Autistic children, for instance, show a delay in development of sleep patterns; retarded children have delayed development in patterns of eye movement during sleep; children with phenylketonuria or hypothyroidism show deviations in sleep patterns; infants with bilirubinemia have slower breathing during sleep; and infants with brain malformation and/or chromosomal abnormalities are poor sleepers.

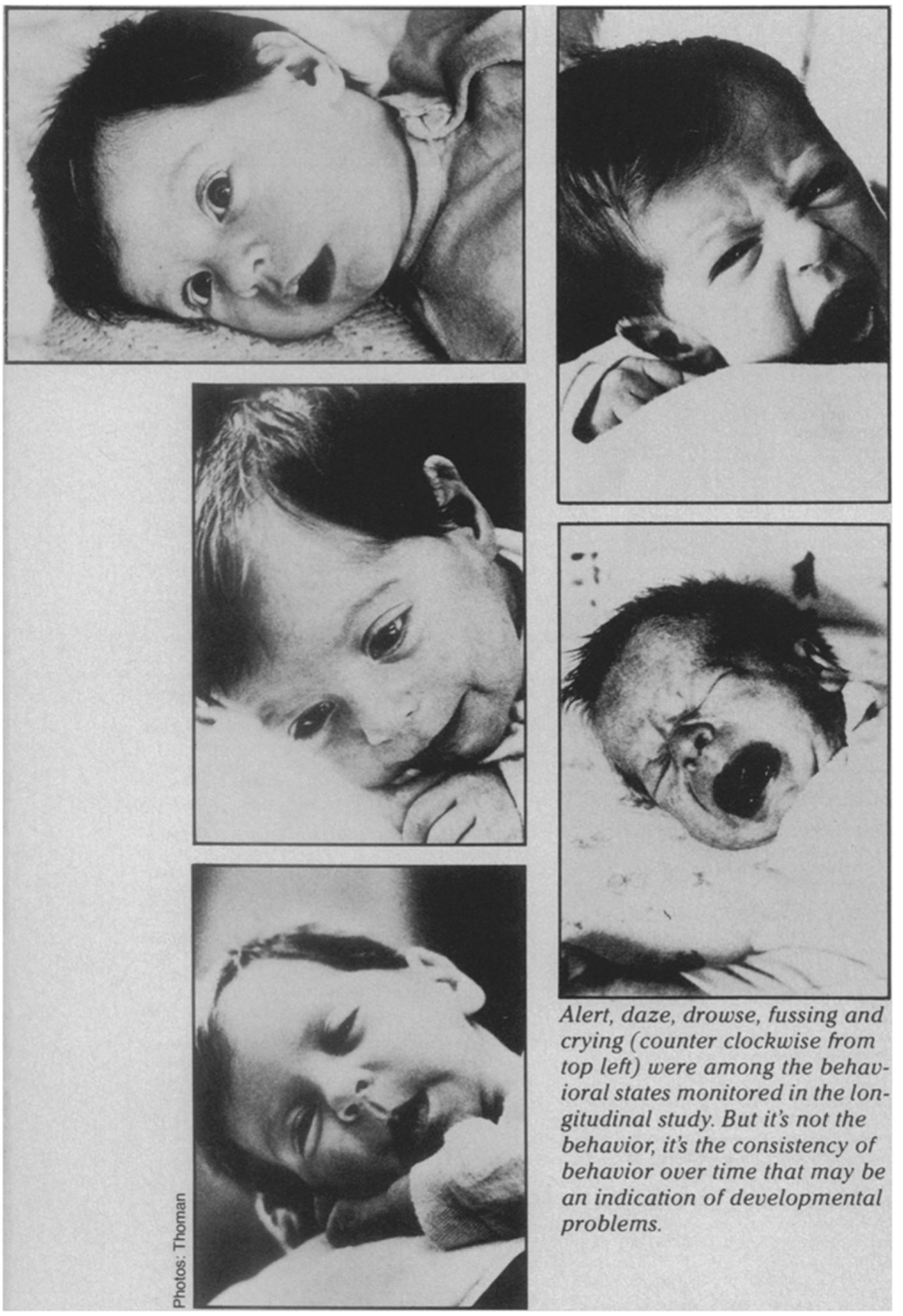
All of the infants in Thoman's study were apparently normal following delivery and during the first weeks of life, but some of them went on to have developmental problems at a later age, including sudden crib death. Thoman says, "We were able to identify behavioral patterns from *post hoc* analyses of social interaction and sleeping and waking states, including respiration and apnea [intermittent cessation of breathing], which were the prelude to those unfortunate developmental events."

In addition to sudden crib death and apnea, the data were used to identify several other problems. Inconsistency in sleep-wake states over several weeks was found in the case of one infant who became severely retarded at one year of age, in one who developed aplastic anemia and in one who was later diagnosed as severely hyperactive.



Thoman et al.

The amount of time spent in each of five states (waking active, quiet alert, fuss or cry, drowse or transition, active sleep or quiet sleep) is charted once a week for four weeks. Four infants in top row showed highly inconsistent sleep-wake patterns from week to week. They later had serious developmental problems. Bottom row shows consistent patterns of normal infants.



Photos: Thoman

Alert, daze, drowse, fussing and crying (counter clockwise from top left) were among the behavioral states monitored in the longitudinal study. But it's not the behavior, it's the consistency of behavior over time that may be an indication of developmental problems.

The association between behavioral states and later problems was made "postdictively," years after the problems occurred. In other words, the researchers knew the medical outcomes of the children before they went back and looked at the original data for clues to those outcomes. The predictive value of the behavioral state data was demonstrated when Victor H. Denenberg, also of the University of Connecticut at Storrs, evaluated the data on behavioral states without knowledge of the outcomes of the infants. He correctly identified which infants developed problems.

The most obvious characteristic of the infants that went on to have problems was extreme variability in measures of sleep-wake states over successive weeks (see graphs). "Taking this into account," explains Thoman, "and the common knowledge that instability is of general concern clinically, we became interested in the possibility of using stability as an indication of functional status." Thoman and co-workers have since developed what they call a State Stability Index that could "prove useful in assessing the functional status of premature infants."

Thoman's assessment system calls for one day of observation of the premature infant on four successive weeks while the infant is still in the hospital (but after it has become stabilized) and an additional four weekly observations after the infant has been discharged or is at full-term gestational age. For each week a profile, or set of scores, is obtained based on the percent of time spent in each of five behavioral states when the infant is alone. The scores from the first four weeks are then compared with those of the second set of observations. An increase in stability, says Thoman, is an indication of improving functional status on the part of the infant. A decrease in stability from one age to the next would be a clear indication of the need for intervention.

This assessment over time is a major difference between Thoman's and other assessment procedures that evaluate an infant one time and say "this is the baby's condition." "We assess developmental change," explains Thoman. And this is necessary in order to understand how the infant is functioning with regard to its environment. An infant may appear to have become stabilized while in the hospital, for instance, but get worse (or better) once it gets home.

If an infant's stability index does suggest a worsening condition, intervention is called for. At the very least, says Thoman, the infant's physician can be notified and the child can be kept under closer observation than usually would be necessary. In two cases, for instance, the physicians were warned and the infants were put on apnea monitors that give a warning when breathing stops for more than 20 seconds — and both infants did experience prolonged apnea. In another case, a prematurely born infant that had been considered normal was diagnosed as having meningitis soon after displaying an abnormal state stability index.

At first, State Stability Indexes were determined by many hours of direct observation, but there is an easier way, says Thoman. A pressure-sensitive mattress in the infant's crib now is used to record respiration and motor movements. Experience has shown that the infant's movements can be used to determine reliably sleep-wake states, and a miniature recorder makes it possible to collect 24 hours of data on a single cassette. In addition, a computer program is being developed to analyze the signals from the pressure sensor. This procedure, says Thoman, will make it possible "to collect an enormous amount of data on each infant's behavioral states not only without the necessity of direct observation, but without the necessity for physical intervention to obtain the recordings. Nothing has to be attached to the baby for this purpose, as the recording from the sensor-mattress proceeds continuously throughout an observation day."

Thoman's State Stability Index is still experimental, but she and her colleagues feel they have enough data to begin a demonstration program. "We don't want to claim things that we can't prove," she says, "but we do feel that we are now ready to show it." Funding for a demonstration project has been requested from the Public Health Service and from a private organization. If the usefulness of the State Stability Index is proved, Thoman hopes to put together a package (procedures and equipment) that can be used to assess premature infants in hospitals throughout the country. □