Section I

Changing Paradigms

1

Transforming the Research Landscape

Barry M. Lester

COPYRIGHTED MATERIAL

In the history of science it has been said that major advances are not made by the steady accumulation of facts but by what Kuhn called scientific revolutions (Kuhn, 1962). Rather, the evolution of scientific theory comes from a set of changing intellectual circumstances and possibilities. An existing paradigm is stretched to its limits and can no longer explain the facts or take into account observed phenomena. As a result there is a crisis. Bold scientists create a revolution by challenging the assumptions of the existing paradigm. A new paradigm emerges and a paradigm shift occurs. The same information is seen in a completely different way. The classic example is the Copernican revolution; the shift from the view of the earth as the center of the universe to the view of sun as the center of the universe. T. Berry Brazelton put the baby at the center of the universe of the science of child development and revolutionized how we think about, understand, and study children.

There are many ways to describe the new lens through which we see and study children based on the scientific contributions of Brazelton. In this chapter, Brazelton's impact on the research landscape is organized into four themes: How we see the baby, how we see the parent–infant relationship, our models of how development unfolds, and research methods – the very conduct of research. But before we consider that, we need to appreciate history and understand the existing paradigms that Brazelton challenged.

The Zeitgeist

In the 1950s, there was already a revolution going on in the field of psychology, particularly, cognitive psychology. Scientists were questioning behaviorism, the Skinnerian, operant psychology paradigm, with the assumption that the mind is a "tabula rasa" or blank slate. As summarized by Pinker (Pinker, 2002), "The mind cannot be a blank slate because blank slates don't do anything." The field of cognitive psychology emerged and gave us the mind. (It did not give us the brain, or at least the study of the brain, that we think of in modern neuroscience; that came 35–40 years later). The goal of cognitive psychology was to describe the meanings that human beings created out of their encounters with the world, and to then explore the meaning-making processes that were involved (Bruner, 1990). But just as, if not more, important, psychology was no longer restricted to only observable behavior; it meant that the mind *interprets* experience. And it is not only the adult mind that interprets experience. Brazelton showed us that the ability to interpret experience is present at birth.

View of the Baby

The Neonatal Behavioral Assessment Scale (Brazelton, 1973), often referred to as the Brazelton scale, forever changed the way we see, think about, and understand babies. In the sense of a true Kuhnian revolution, the data, the facts that came to be known from research with the Brazelton scale, no longer fit the existing paradigm and we could no longer view the baby as a tabula rasa. There are literally hundreds of studies that have used the Brazelton scale to document the extraordinary behavioral repertoire of the newborn, the baby as part of an interactional process, and the baby with self-regulatory capacities.

One key contribution that came out of this work was the study of individual differences in newborn behavior. In *Infants and Mothers* (Brazelton, 1969), Brazelton described three different kinds of babies; "quiet," "active," and "middle of the road." These differences were described as "constitutional" and Brazelton pointed out that parents need to learn to adjust to these differences, thus opening the door to the idea that newborn infant behavior affects parenting. Numerous studies have documented individual differences at birth using the Brazelton scale in the U.S. and

many other cultures throughout the world. Cross-cultural comparisons show similarities and differences between the U.S. and other cultures suggesting both universal dimensions of newborn behavior as well as behaviors that are unique to particular cultures (Brazelton, 1969; Brazelton, Tryphonopoulou, & Lester, 1979). The fact that there are individual differences at birth also helped shatter the myth of the baby as a tabula rasa. But it did more than that because the research also showed that these individual differences shape the mother–infant interaction (Kaye, 1978). So the infant emerges as shaping his or her own development and this phenomenon can be observed all over the world (Loo, Ohgi, Howard, Tyler, & Hirose, 2005). Showing that these individual differences affect parenting – that they alter the caregiving environment – may very well have been the *coup de grâce* that brought about the paradigm shift.

The Brazelton scale changed the field of temperament. Use of the term "temperament" had previously been reserved for older infants and children. With the advent of the Brazelton scale, temperament could now be described along the lines of individual differences in newborn behavior. The "quiet" baby became the child with "easy" temperament. Also, most temperament researchers claimed that temperament was biologically based. The fact that temperament could now be described in the newborn, before postnatal environmental factors come into play, gave strong support to the biological basis of temperament. In addition, temperament is thought of as what later becomes personality in the older child. So by extension, the newborn was seen as entering the world with a personality (Breitmayer & Ricciuti, 2006). A far cry from the tabula rasa!

Individual differences include strengths as well as weaknesses and one of the key features of the Brazelton scale is documenting behavioral strengths in the newborn. On the Hawaiian island of Kauai, Werner (Werner, 2005) was conducting a longitudinal study of development in infants born preterm. She found that temperament could be a protective factor, specifically Brazelton's "quiet baby," or the child with an easy temperament. Children were less affected by prematurity and environmental adversity if they had an easy temperament. This was one of the key findings that led to the development of the field of resilience and the idea that protective factors are "in" the baby, in fact, in the baby's behavior. One of the more intriguing questions in research with high-risk populations is how some children develop quite normally or do better than expected despite growing up in extremely adverse environments due to factors such as prenatal substance exposure, poverty, maltreatment, exposure to violence, and many others. The

Brazelton scale, especially with the ability to document behavioral strengths, suggested that at least for some children, resilience can be detected at birth so that the child's behavior attenuates the effects of adversity.

View of Infant–Parent Relationship

Not only did our view of the infant change but our view of the parent–infant relationship changed as well. Brazelton videotaped infants and their mothers during face-to-face interaction starting approximately when the infant was 3 months old (Brazelton, Koslowski, & Main, 1974). The paradigm includes both normal face-to-face interaction and the "still face" condition. In the normal interaction, mother and baby maintain a reciprocal interaction. In the still face condition (Tronick, 2007), the mother is unresponsive and this violation is disturbing to the baby, suggesting the importance to the baby of maintaining a reciprocal interaction. During mother–infant interaction, cycles of attention are thought to indicate social engagement while cycles of nonattention indicate disengagement (Tronick, Als, Adamson, Wise, & Brazelton, 1978). These videotapes were coded for infant behavior and maternal behavior and plotted over time. Brazelton described the component behaviors of cycles of interaction and interactional synchrony and that these cycles occurred 2–3 times/minute (Brazelton et al., 1974). In other words, each interactional cycle composed of infant behavior and mother's behavior lasted for 15–20 seconds. These data were analyzed using fast Fourier or spectral analysis which is a mathematical way of decomposing and quantifying cycles. The results showed statistically significant rhythms exactly where Brazelton predicted they would be; there were 15 sec cycles in the mother and 15 sec cycles in the baby (Lester, Hoffman, & Brazelton, 1985). This study included term and preterm infants and showed that the cycles were more coordinated in term than in preterm infants. That is, the correlation or coherence between infant cycles and maternal cycles, what we would think of as synchrony, was higher in the term infants. Also, analysis of the lead–lag relationship, or which cycle (infant or mother) leads the other, showed that in the term group the infant leads, whereas in the preterm group the mother leads. So, when the baby is faring well, by 3 months the reciprocal relationship has been negotiated such that the mother follows the baby's lead. But when the baby is fragile, the relationship is negotiated with the mother in the lead.

Like the Brazelton scale, the face-to-face/still face paradigm has also been used in other cultures. Again, there are important cultural differences. In Kenya, for example, the Gusii show some of the same patterns of reciprocal interactions as U.S. mothers (Brazelton, Dixon, Keefer, & Tronick, 1981), suggesting the universality of these early patterns of social interaction.

Models of Development

Brazelton always had a questioning attitude toward science. His unwillingness to equate the scientific models of the day with eternal truths has led to revolutionary changes in our models of development, especially in terms of our understanding of the meaning of variability and change in behavior. Brazelton challenged prevailing views that significant amounts of variability in infant behavior, for example, on the Brazelton scale, were problematic. He argued, on the contrary, that for babies to stay the same on the scale would be problematic and potentially clinically worrisome. What others called error or "noise," he viewed as a critical part of the "signal." He urged the scientific community not to throw out the baby with the bathwater (Brazelton, 1990). Behavioral instability is part, in fact a critical part, of normal processes of developmental change. Infancy is a period of rapid development and while a "moving target" may be more difficult to study, the study of change is key to our understanding of development. Saving the bathwater has had a major impact on our models of child development because it meant rejecting simplistic "nature–nurture" models of development that were linear or additive. The idea that one could take different genotypes, add in the environment and sum up the child's development was replaced by models that incorporated change. From a psychometric or measurement point of view, this was nightmarish because it meant that traditional ways of partitioning the variance to estimate what was "error" and what was not were no longer viable. As a result there have been substantial advances in statistical models that include change such as nonlinear, growth, trajectory, and systems models.

Developmental models were constructed that were complex, multifaceted, and took a broad systems approach extending from factors proximal to the infant, such as the parent–infant interaction, to the far reaches of factors more distal to the infant such as community organizations, cultural values and the greater social fabric of society (Bronfenbrenner, 1979). Arguably the transactional model (Sameroff, 1982) became the most influential

of these and had at its core Brazelton's idea that development is the product of reciprocal interactions (transactions) in which infant behavior modifies parent behavior which in turn modifies infant behavior and that this is an ongoing dynamic process. Brazelton's work changed our fundamental understanding about how development unfolds and the very processes of development. *Touchpoints* (Brazelton, 1992) was a further advance. One of the remarkable features of *Touchpoints* is that it is both a book for parents on child rearing and a major theoretical advance in our understanding of child development. *Touchpoints* is based on the model that development is nonlinear and uneven. Psychological growth takes place in many directions at once. There are spurts in development but there are also regressions. Regressions are seen as not only normal, but necessary for normal development. There is order in the system. These spurts and regressions are predictable and *Touchpoints* is a blueprint that provides the schematic for these processes.

The Conduct of Research

It is, of course, tautological to say that a productive scientist influences research in his field but it is nonetheless interesting to see some of the ways in which Brazelton's work has changed the way we go about the business of research. The dynamics of newborn behavior, the infant's contribution to his or her own development, and processes of reciprocity in the infant–parent relationship have become major areas of research of their own. Even in studies not focusing on these areas, these issues still need to be accounted for or addressed in their research design. For example, studies of parenting need to include measurement of the mother–child interaction. Similarly, the bathwater of change including the normative nature of regression is both studied and serves as a platform to frame other research agendas and establish new areas of programmatic research.

Methodologically, the Brazelton scale and the face-to-face/still face paradigm have become industry standard tools in the field. These measures are based on direct observation and measurement of behavior in contrast to parent report. Using parents' reports of their infants' behavior to measure, for example, temperament or mother–infant interaction introduces bias and may not be as objective as measuring these behaviors directly. The advent of these tools contributed to methodological advances in measurement of infant behavior through direct observation.

The Brazelton scale, in addition to being a research instrument, is also used as an intervention to help parents get to know their babies (Kusaka, Ohgi, Gima, & Fujimoto, 2007). The scale has also been used with chimps in studies of cross-species comparisons of newborn behavior (Bard, Platzman, & Lester, 1992) and to study the molecular genetics of newborn behavior in chimps (Champoux et al., 2002). There have also been adaptations of the Brazelton Scale designed for special purposes such as the Assessment of Preterm Infant Behavior (Als, Lester, Tronick, & Brazelton, 1982), the NICU Network Neurobehavioral Scale (Lester, Tronick, & Brazelton, 2004) and a fetal neurobehavioral scale, the Fetal Neurobehavioral Assessment System (Salisbury, Fallone, & Lester, 2005). The NNNS was designed to expand the scope of behavior in the Brazelton scale for applicability to high-risk infants including substance exposed and preterm infants. The NNNS groups infants into discrete neurobehavioral profiles that reflect patterns of individual differences. In addition, the profiles have been shown to identify infants with medical problems, including brain damage, and infants that will go on to have cognitive and behavioral problems, including problems with school readiness (Liu et al., 2009). This could lead to the Brazelton scale goal of early identification and the development of interventions to prevent future deficits in children.

As mentioned earlier in this chapter, the cognitive revolution gave us the mind but not the brain. The Brazelton revolution gave us the baby and, once we knew what the baby could do, it only made sense to try and figure out how. Where do these individual differences come from? Why does one baby have one set of behaviors and another baby have a different set of behaviors – at birth? How does the baby know what behaviors to use to change the caregiving environment? Brazelton always argued that these behaviors and behavioral systems are not random and simply reinforced by the environment. They have a purpose. They have adaptive value. How does this work?

The answer may lie in modern neuroscience. These are exciting times as we have probably learned more about the brain in the past 20 years than in all of recorded history, including fetal programming. Fetal programming is based on developmental plasticity, which enables the organism to change (i.e. reprogram) structure and function in response to environmental cues. These are evolved mechanisms that monitor the environment to adjust set points of brain circuits. The adaptive significance is that plasticity enables a range of phenotypes to develop from a single genotype depending on environmental influences. Developmental plasticity sets the template or "programs" the fetus

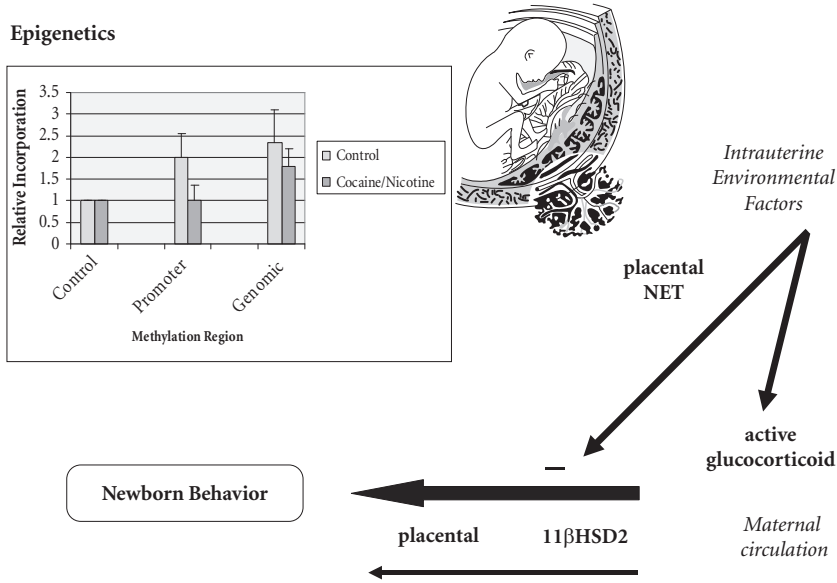

Figure 1.1 Factors in the intrauterine environment can affect genes in the placenta that determine fetal exposure to the stress hormone cortisol which, in turn, affects the behavior of the newborn
Source: Adapted from Lester & Padbury (2009).

for postnatal adaptation to the environment. The fetus "reads" characteristics of its environment and prepares to adapt to the external environment. Most of the work on fetal programming has been directed toward studying adult chronic disease. Observations that low birthweight was related to the later development of cardiovascular disease and metabolic disorders (Barker & Fall, 1993) led to the concept of the "fetal origins" of adult disease. The idea is that fetal metabolic pathways are reprogrammed in response to undernutrition but, in a postnatal environment with adequate nutrition, this becomes maladaptive and leads to the adult development of chronic disease.

The fetal origins of adult disease invite speculation about the possibility of the fetal origins of behavioral outcomes. It is understood that undernutrition is but a proxy for specific processes that may involve, for example, the neuroendocrine system. Figure 1.1, adapted from Lester and Padbury, shows a model in which factors in the intrauterine environment can affect genes in the placenta that determine fetal exposure to the stress hormone cortisol which, in turn, affects the behavior of the newborn (Lester &

Padbury, 2009). A wide range of factors, not only undernutrition but factors such as maternal depression, drugs, etc., act as intrauterine stressors that signal the fetus to prepare for a different postnatal environment than the one for which it was originally programmed. In this case, the HPA axis is reprogrammed by altering set points in the brain regions, especially the hippocampus, amygdala, and prefrontal cortex, resulting in a wider range of newborn behavior that gives the infant more opportunities to adapt to potential adversity in the postnatal environment.

Epigenetic mechanisms are thought to be responsible for this reprogramming. Epigenetic effects occur when there are chemical changes around the DNA that change gene expression but the structure of the DNA, i.e. the DNA sequence or code, stays intact. In DNA methylation, the most studied epigenetic process, in which a methyl group is attached to the gene thereby inhibiting gene activity, is also known as gene silencing. Empirical findings shown in Figure 1.1 (see insert in Figure 1.1) indicate that the placental gene that prevents the fetus from being exposed to excessive levels of cortisol (11β-HSD-2) is methylated or silenced when a mother uses cocaine or smokes cigarettes during pregnancy. In other words, intrauterine stress silences this gene and the fetus is exposed to higher levels of cortisol. A pathological model would interpret this as a deficit in the baby. But if we have learned anything from the Brazelton revolution it is that this could also be a strength or have adaptive value. The purpose of these epigenetic changes is to enable the baby to have a broadened newborn behavioral repertoire designed to be responsive to the kind of postnatal caregiving environment that will maximize the baby's recovery and optimize normal development. Once again, the key is how we interpret variability. Following McEwen (McEwen, 1998), behavior belongs to the class of allostatic systems in which the ability to achieve stability through change is vital for survival. What we call disorganized in one environment may be beneficial in another environment. For example, studies among boys growing up in poverty and crime show that those that do best are behaviorally inhibited and more fearful. In some environments, such as a hostile environment, fear is adaptive. This is one reason why babies are not the same in all cultures. They need to come equipped with behavior suited to the environment in which they are born. Epigenetics may well play a role in the individual differences in newborn behavior that have been documented with the Brazelton scale, including other cultures.

In addition to these prenatal effects, these same mechanisms may also be operative in the postnatal environment. Research with rodents has shown

that maternal licking and grooming behavior results in epigenetic changes in rat pups, lowering levels of stress hormones and altering behavior that continues into adulthood and is transmitted to future generations (Meaney & Szyf, 2005). We may eventually come to learn that epigenetic mechanisms are involved in infant mother face-to-face interaction. To those who may cringe and interpret this as a reductionist approach, note that epigenetics is a true gene–environment interaction consistent with Brazelton's original idea that individual differences in newborn behavior are constitutional but are then modified through interaction with the postnatal environment. These constitutional differences are adaptations, the product of biologically embedded monitoring or cue reading in the prenatal environment.

Babies are not born to fail. The Brazelton model that focuses on strengths and how babies adapt will enable us to understand normal as well as atypical development and how children grow up normally in the face of adversity and become resilient. And to think that so many of Brazelton's contributions, and the subsequent paradigm shift of a whole field, sprang from his early observations that some babies were easier than others (Brazelton, 1969).

Thanks to Brazelton, the baby has come of age and the research landscape has been transformed.

References and further reading

Als, H., Lester, B., Tronick, E., & Brazelton, T. (1982). *Manual for the assessment of preterm infants' behavior (APIB)*. New York: Plenum.

Bard, K., Platzman, K., & Lester, B. (1992). Orientation to social and nonsocial stimuli in neonatal chimpanzees and humans. *Infant Behavior and Development, 15*(1), 43–56.

Barker, D. J., & Fall, C. H. (1993). Fetal and infant origins of cardiovascular disease. *Archives of Disease in Childhood, 68*(6), 797–799.

Brazelton, T. B. (1969). *Infants and mothers: Differences in development*. New York: Dell.

Brazelton, T. B. (1973). *Neonatal behavior assessment scale*. Philadelphia: Lippincott.

Brazelton, T. B. (1990). Saving the bathwater. *Child Development, 61*(6), 1661–1671.

Brazelton, T. B. (1992). *Touchpoints: The essential reference: Your child's emotional and behavioral development*. Cambridge, MA: DaCapo Lifelong Books.

Brazelton, T. B., Dixon, S., Keefer, C., & Tronick, E. (1981). *Culture and early interactions*. Hillsdale, NJ: Erlbaum.

Brazelton, T. B., Koslowski, B., & Main, M. (1974). *The origins of reciprocity: The early mother–infant interaction*. New York: John Wiley.

Brazelton, T. B., Tryphonopoulou, Y., & Lester, B. M. (1979). A comparative study of the behavior of Greek neonates. *Pediatrics, 63*(2), 279–285.

Breitmayer, B. J., & Ricciuti, H. N. (2006). The effect of neonatal temperament of caregiver behavior in the newborn nursery. *Infant Mental Health Journal, 9*(2), 158–172.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.

Champoux, M., Bennett, A., Shannon, C., Higley, J. D., Lesch, K. P., & Suomi, S. J. (2002). Serotonin transporter gene polymorphism, differential early rearing, and behavior in rhesus monkey neonates. *Molecular Psychiatry, 7*(10), 1058–1063.

Kaye, K. (1978). Discriminating among normal infants by multivariate analysis of Brazelton scores: Lumping and smoothing. *Monographs of the Society for Research in Child Development, 43*(5–6), 60–80.

Kuhn, T. S. (1962). *The structure of scientific revolutions* (3rd ed.). Chicago: University of Chicago Press.

Kusaka, R., Ohgi, S., Gima, H., & Fujimoto, T. (2007). Short-term effects of the neonatal behavioral assessment scale-based intervention for infants with developmental disabilities. *Journal of Physical Therapy Science, 19*, 1–8.

Lester, B. M., Hoffman, J., & Brazelton, T. B. (1985). The rhythmic structure of mother–infant interaction in term and preterm infants. *Child Development, 56*(1), 15–27.

Lester, B. M., & Padbury, J. F. (2009). Third pathophysiology of prenatal cocaine exposure. *Developmental Neuroscience, 31*(1–2), 23–35.

Lester, B. M., & Tronick, E. Z. (2004). Neonatal Intensive Care Unit Network Neurobehavioral Scale. Supplement to *Pediatrics, 113* (3 Pt 2), 634–640.

Liu, J., Bann, C., Lester, B., Tronick, E., Das, A., LaGasse, L., Bauer, C., Shankaran, S., & Bada, H. (2009). Neonatal neurobehavior predicts medical and behavioral outcome. *Pediatrics*, *125*(1), 183–184.

Loo, K. K., Ohgi, S., Howard, J., Tyler, R., & Hirose, T. (2005). Neurobehaviors of Japanese newborns in relation to the characteristics of early mother–infant interaction. *Journal of Genetic Psychology, 166*(3), 264–279.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine, 338*(3), 171–179.

Meaney, M. J., & Szyf, M. (2005). Maternal care as a model for experience-dependent chromatin plasticity? *Trends in Neuroscience, 28*(9), 456–463.

Pinker, S. (2002). *The blank slate: The modern denial of human nature*. New York: Viking Penguin.

Salisbury, A. L., Fallone, M. D., & Lester, B. (2005). Neurobehavioral assessment from fetus to infant: the NICU Network Neurobehavioral Scale and the Fetal

Neurobehavior Coding Scale. *Mental Retardation and Developmental Disabilities Research Reviews, 11*(1), 14–20.

Sameroff, A. (1982). *In the beginning: Readings on infancy*. New York: Columbia University.

Tronick, E. (2007). *The neurobehavioral and social-emotional development of infants and children*. New York, NY: W. W. Norton.

Tronick, E. Z., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child Psychiatry, 17*, 1–13.

Werner, E. (2005). Resilience and recovery: Findings from the Kauai longitudinal study. *Research, Policy and Practice in Children's Mental Health, 19*(1), 11–14.