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The Relationship Between Maternal and Musical Auditory Stimulation and the Developmental Behavior of Premature Infants

Gail B. Malloy, RN, PhD

This paper is a report of a study to determine the relationship between planned auditory stimulation and the developmental behavior of premature infants.

The sample consisted of 127 infants of 183–230 days gestation, randomly assigned to 2 experimental groups and 1 control group. Group A was exposed to a taped recording of the mother's voice for 5 minutes 6 times a day at 2-hour intervals, beginning on the fifth day of life and continuing until the infants reached a weight of approximately 2,000 gm and were ready for discharge. Group B was exposed to a taped recording of Brahms' Lullaby in the same manner. Group C received no regimen of planned auditory stimulation.

It was hypothesized that the experimental groups would reach a higher level of development at hospital discharge and at 9 months postnatal age than would the control group, and further, that the maternal stimulation group would reach a higher level of development at 9 months than the musical stimulation group.

The groups were tested at home on the day following discharge, using selected scales of Rosenblith's modification of Graham's Behavioral Examination of the Neonate, and again at 9 months using the mental and motor components of the Bayley Scales of Infant Development.

The results were inconclusive. Infants in the experimental groups gained weight significantly faster in the hospital. This suggests an initial effect of the stimulation regimens. It was tentatively concluded that the Rosenblith test was not a valid measure of development for this sample since ages, arousal levels, and home environments differed considerably. Testing at 9 months indicated no significant differences among the groups in either mental or motor development, although the control group had higher mean scores in both measures.

A number of possible explanations are suggested. The enriched environment may have no lasting effect, it may affect behavior other than mental or motor development, or it may have effects not apparent at 9 months. Perhaps variables, such as sex, race, gestational age, home environment, and maternal-child interaction, mask or negate the effects of sensory enrichment. Finally, perhaps the effects of the regimens are altered by individual needs or preferences for intensity, or type of sensory stimulation, and the degree of active participation of the infant in seeking out or rejecting stimulation.

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This study was conducted to investigate the relationship between 2 types of planned and patterned auditory stimulation regimens, and the developmental behavior of premature infants at hospital discharge and at 9 months of age.

Several years ago I became intrigued with the studies of Katz and Segall who investigated, in premature infants, the relationship between planned maternal auditory stimulation and various aspects of behavior measured prior to hospital discharge [1, 2]. Many factors might affect infant development in home and community settings. A key question was whether the effects of stimulation would be lasting, despite the varied environments to which the infants were discharged. When Chapman began her study of auditory stimulation and gross motor activity in premature infants [3], I was able to study this question by following these infants after hospital discharge.

The study was based on the theory that human development is characterized by an interrelationship with the environment such that patterned, varied, and periodic sensory stimulation from the environment is essential for the achievement of maximum perceptual, cognitive, and sensorimotor development. The study was also based on the phenomenon of imprinting. This suggests that certain types of early experiences have far-reaching and stable effects on later development when they occur during a critical period [4]. It was postulated that the mother's voice might be imprinted on the developing organism and that this should enhance further development.

Many studies have indicated that sensory deprivation in the neonate results in a multitude of chemical, anatomical, functional, and behavioral deficits [5–11]. Conversely, both animal and human studies have demonstrated that sensory enrichment produces increased brain development, maturation, and adaptive behavior [1, 2, 12–16]. Studies of the imprinting phenomenon have suggested that there are critical or sensitive periods during early development, during which the presence of certain types of experiences are both anxiety reducing and necessary for species and parent identification [17–21].

The premature infant begins extrauterine life separated from the mother and in an environment which is notoriously monotonous in terms of sensory stimulation. It is generally agreed that all the senses of the newborn can be stimulated and that all the sensory nerves are capable of transmitting stimuli to the brain [22]. The neonatal brain is vulnerable at birth because it is developing rapidly. The sensory apparatus, although intact, is poorly utilized in the premature nursery. According to the studies cited above, environmental monotony at this time should have negative effects on development, while enrichment of the environment should stimulate the sensory apparatus to develop normally.

The following hypotheses were set forth: (a) premature infants who had received a regimen of maternal voice or musical stimulation will score higher on developmental tests at hospital discharge and at 9 months of age than will premature infants not so treated, and (b) those receiving maternal voice stimulation will score higher on developmental tests at 9 months than infants receiving musical stimulation.

MATERIALS AND METHODS

One hundred fifty infants from 3 metropolitan hospital premature units were enrolled in the study. They were between 27 and 33 weeks gestation, had no history of maternal diabetes, and no known congenital anomalies or major neurological or physiological problems at birth. All infants on pretesting had exhibited a gross response to sound. Using a table of random numbers, infants were randomly assigned to 3 groups: a maternal voice stimulation group, a musical stimulation group, and a control group.

Beginning on the fifth day of life, each infant in the maternal stimulation group was exposed to a taped recording of the mother's voice reading a prepared monologue for 5 minutes 6 times a day. Each infant in the musical stimulation group was exposed to a taped recording of Brahms' Lullaby in the same way. Infants in the control group received no planned auditory stimulation. The regimens were continued until the infant reached a weight of approximately 2,000 gm and was ready for discharge. All stimulation regimens were carried out by Chapman [3]. Since the investigator was not familiar with any of the infants or the groups to which they had been assigned, the behavioral testing was blind. When the infant was ready for discharge, an appointment was made to test the child at home on the day following discharge.

Graham's Behavioral Examination of the Neonate [23], as adapted by Rosenblith [24], was used to test infants at hospital discharge, as an extension of Katz' study [1], and to obtain baseline data. This test consists of four parts: (a) an assessment of auditory and visual function; (b) an irritability rating, which measures how sensitive the infant is to stimulation; (c) a muscle tension rating designed to measure deviations in the direction of increased flaccidity or increased rigidity; and (d) a general maturation scale, which includes a motor strength component and a tactile adaptive component [24]. In this latter part, the general distinction between low and high scoring responses is in terms of generalized mass movements versus more specific and stimulus-oriented responses.

The Bayley Scales of Infant Development [25] were used to measure mental and motor development 9 months after birth. This test is composed of a mental scale and a motor scale consisting of items arranged in order of difficulty. It is scored on the basis of the number of items passed and permits classification of an infant in terms of percentiles of expected achievement for given age up to 15 months [25]. The infants were tested at home by trained testers, including myself, with no knowledge of the experimental regimens.

The total sample utilized for the analysis of data was 127. The maternal stimulation group had 40 infants, the musical stimulation group had 44, and the control group had 43. Nineteen infants were lost to the study because they had moved out of state, and 4 infants were dropped from the study because of chronic illness or suspected abuse.

RESULTS

Data were analyzed to determine differences in a number of variables: age, sex, race, birth weight, gestational age, etc. One statistically significant difference was found. The musical stimulation group was younger at discharge than was the control group. The maternal stimulation group was also younger than the control group, although the difference did not reach significance. The hypotheses were then tested by analysis of variance and covariance techniques.

The first 3 hypotheses predicted that infants in the maternal and musical stimulation groups would score higher on the Rosenblith test at hospital discharge than infants in the control group.

No significant differences were found between the groups, however, and the scores indicated a rather mature population. The infants when tested were older than had been expected and their ages were varied. The testing situation in the home posed some unanticipated difficulties in that it was impossible to control the state of the infant, the hunger of the infant, and such environmental variables as heat, light, and noise. For these reasons the Rosenblith test was deemed inappropriate for this study and unable to provide valid data concerning the development of these infants. This, of course, is a major weakness of the study since there are no baseline data from which to proceed.

The last 3 hypotheses predicted that infants in the experimental groups would score higher in mental and motor development at 9 months of age than would the control group, and that the maternal stimulation group would score higher than the musical stimulation group. None of these hypotheses were supported. In fact, the control group had higher scores in both mental and motor development, although the differences did not reach statistical significance.

Nevertheless, some signs of an effect were present, since the experimental groups were discharged at an earlier age than the control group. The music group was 9.9 days younger on the average than the control group, and the mother's voice group was 6.2 days younger than the control group when the stimulation regimen ended [3]. Since the mean gestational age and the mean birth and discharge weights of the 3 groups did not differ significantly, it may be concluded that the experimental groups gained weight faster than the control group and were ready to go home at a younger age. These findings support other studies which document an initial, if temporary, weight gain as an effect of a stimulation regimen [16, 26].

SUMMARY

If the stimulation had no effect, then the question of why no significant differences were found at 9 months is moot. On the other hand, a treatment effect may have been present, but undetected because of inappropriate test measures.

A number of explanations for the lack of predicted findings are available. One is that the effect of stimulation may not be apparent at 9 months postnatal age. Several studies have suggested a "sleeper effect" of early stimulation. For example, it has been demonstrated in rats that different shock stimuli had significant effects on growth and survival. The effects, however, manifested themselves at different stages of development, ranging from increased mortality and decreased weight gain at 21 days to increased emotionality in adulthood [27]. It is commonly accepted in psychoanalytic theory that early events have effects that may not show themselves until later in life. Thus, it may well be that the effects of planned environmental enrichment may show themselves at a later time. Might these infants, for example, differ in development or behavior during stressful periods of their lives?

The theoretical rationale of this study suggested that early experiences during the first weeks of life have effects that are permanent. The issue of the timing and the parameters of critical and/or sensitive periods must be considered. Some evidence from animal studies suggests that short-term or incomplete deprivation may be reversible and may be compensated for by an appropriate later environment [7, 28, 29]. The limits of short-term and long-term deprivation, of subtotal deprivation, and of "appropriate" environment are unclear, however, and need to be clarified and defined.

As was mentioned before, although the difference in means did not reach significance, the control group consistently had higher developmental scores at 9 months. When the data were examined closely, it became apparent that several infants in the experimental groups had scores more than 3 standard deviations below the mean, and several infants in the control group had scores more than 3 standard deviations above the mean. The groups were not much different in development once these infants were eliminated from consideration. The question remains of why there should be more experimental infants doing very poorly and more control infants doing extraordinarily well.

It may be that a number of factors which, by themselves were not significant, have a cumulative effect. The control group, for example, was slightly older in gestational age and had a greater number of infants who were 30–31 weeks of gestation (60%), compared to the maternal (42%) and music (47%) groups. The control group also had more Black infants than the other groups. Bayley has found that these infants tend to score somewhat higher on the motor scale than white infants [25]. Replication of the study with these variables controlled, or the use of more sophisticated statistical techniques such as multiple regression, may help to unravel this.

Another possibility that must be considered is that nursery personnel, aware of the study, differed in their treatment of the experimental and control groups. If the control group received more attention from the staff, the amount of human contact might have been considerably different in the three groups. It is entirely conceivable that this might affect later development. Harlow, in his study of infant monkeys raised by an assortment of wire mother surrogates, concluded that "contact comfort is a variable of overwhelming importance in the development of affectional responses" [30]. Brody and Axelrod considered the time when the infant is able to fixate on a human face, especially when accompanied by the human voice, to be a major and sensitive period for socialization [17].

Another explanation stems from Piaget's moderate novelty principle [31, 32], which suggests that an enriched environment might expand the infant's experience, thereby affording him a broader basis for attention or curiosity. This theory, among others, views the infant as an active participant in an ongoing interaction with the environment. Escalona theorizes along the same lines that early behavior stems from an interaction of environmental and organismic factors and that each of these factors or groups of factors "is qualified and altered by all other coexisting intrinsic and extrinsic factors" [33]. Thus, the infant's behavior brings about a change in the environment which, in turn, brings about a change in the infant in an ongoing and everchanging pattern of interaction. It may be that the automatic turning on and off of the stimulation regimen in this study did not provide for active participation of the infant, and the stimulation, thus, became one more unsolicited environmental factor. One may wonder if the control infant learned to be more aggressive and demanding of his environment or whether the stimulation regimen soothed the neonate to the point where he had little reason to behave in such a way as to effect a reaction from the environment. Auditory stimulation "on demand" might be a fruitful area for further study.

Eysenck's theory of personality [34] suggests that the need for amount, intensity, and frequency of stimulation is biologically based and differs from individual to individual, depending upon the reaction of the autonomic and central nervous systems to stimulation. A typical extrovert will experience stimulation at a lower level than an introvert, the former having stimulus hunger, so to speak, and the latter having stimulus avoidance. Escalona [33], among others, used the term "perceptual sensitivity" to describe the degree to which an infant responds to sensory stimulation. She found that some infants respond more strongly to sensory stimulation in general than do other infants and that babies do show preferences for certain types of stimulation. She reported one study in which some infants were extraordinarily sensitive to stimulation, to the extent that even ordinary levels of stimulation were overwhelming to them. Birns found that 4- or 5-day-old term infants had consistent individual differences in the intensity of response to an external stimulus [35]. However, she found the type of response was generally the same regardless of the kind of stimulus used.

Murphy's longitudinal study of children suggests a positive correlation between the ability of normal term infants to protest or to terminate unwanted stimulation and their coping abilities in later life [36].

These theories and studies are rather disquieting in terms of the present study, with its findings of higher scores in the control group and more very low scores in the experimental groups. The implication must certainly be considered that some premature infants might need more stimulation and some might do quite well with even a barren environment. The kind of stimulation that is appropriate for a given infant must also be considered.

The study raised far more questions than it answered. The first, and perhaps simplest, is how will these infants develop over time? Will a difference in social, emotional, and cognitive development become evident as they grow older? I hope to study these children again when they are 6 years old, and perhaps again later, in an effort to answer this question.

Still another fruitful area for study stems from the finding that the musical stimulation group gained weight faster than the maternal stimulation group. This difference was not significant and, therefore, the better weight gain of the music group over the maternal group may be explained by chance. However, it is interesting to speculate whether the patterning of an orchestral musical arrangement is more varied than that of a mother's voice reading a prepared monograph and has more of an effect. It is also possible that infants do hear people talking in the nursery and that music represents an experience of "moderate novelty" in the Piagetian sense [32]. The addition of musical stimulation to whatever voice stimulation is present in the nursery may also have a cumulative effect described by Brackbill [37], in which 2 types of stimulation are better than 1, 3 better than 2, and so on. The investigation of the effects of a variety of patterns and combination of sensory stimulation seems warranted.

Enrichment of the auditory environment of the premature infant is but one variable in a complex web of interrelated factors, both prenatal and postnatal. These may affect each child differently depending upon his individual history and internal and external milieu. The relative contributions these variables make to development must be considered further in determining the effectiveness of sensory enrichment.

DISCUSSION

Dr. Neal: First I would like to speak to using only one test and testing only at 9 months of age. We've used the Bayley Scales [25], and I have other measures which I am following on infants through their 30-month testing. Apparently, at least in my sample of 20 infants, the infant who has a shorter gestational age has a different pattern of motor and mental development. The pattern may not be significantly different, but it does not follow that of the full-term infant as far

as we are able to determine. So I think that one testing alone, although it is done in the home where the baby is relaxed, etc., does not tell you much. Hunt at Berkeley does Bayley testing at home and states babies catch up and are good babies [38]. I wondered about some of her data because my infants or children who are being followed through our Central Evaluation Clinic and who have extensive testing of all kinds at about 40 months are showing differences, particularly in language and speech. So I question how much one test can tell you at 9 months.

Dr. Malloy: Interestingly enough one of the things that I found, though I was not looking for it, was that gaps existed between mental and motor development. This, according to Bayley, should have raised everyone's index of suspicion [25]. Nothing seemed to be wrong with these babies. This was on the whole a good group of babies, and they scored quite high on mental and motor tests. They were about 1 month behind themselves chronologically, and about 1 month ahead of themselves in terms of their prematurity. The differences in mental and motor development seem to be that those who were doing exceptionally well in the mental development seemed to be doing an average kind of thing with the motor development. It was not that an infant was very low, but there was a big gap, and one explanation was that prematures would probably develop in a sort of erratic fashion.

Dr. Neal: I think we need more longitudinal studies to really follow through to see what they are like. Some of these children will do well on the Denver Developmental Screening Test given in the ambulatory clinic, but when they go through the evaluation clinic, they have real problems with their language and speech. Because this was identified, they are in special schools. So I think you should be really guarded about what you say about results with the Bayley at 9 months. Your treatment may be more effective than you think. I'd follow your infants until they are 7 years of age, although following infants longitudinally is an expensive venture. We are fortunate that the State of Maryland is funding the longitudinal follow-up of the infants we study.

Dr. Barnard: Apparently you did not correct for gestational age when figuring out the Bayley scores.

Dr. Malloy: Yes, I did. In fact I used a variety of ages to attempt to find out what was going on.

Dr. Barnard: Did you record it as chronological age?

Dr. Malloy: No. The scores were adjusted for prematurity, and the scores used for analysis were those adjusted for prematurity.

Dr. Barnard: Had you thought about doing any testing in terms of language, expressive or receptive?

Dr. Malloy: At 9 months of age?

Dr. Barnard: Yes.

Dr. Malloy: No, we just used the Bayley mental and motor development scales.

Dr. Barnard: It would be my clue that probably in this particular study that might be where you would find some differences.

Dr. Malloy: Well, some items on the infant behavior record do approach this.

Dr. Barnard: Did you use the behavioral record?

Dr. Malloy: I have the data from it. It was not analyzed because at that time there was no way of adjusting the scores for age. So it became a rather difficult thing to look at, and besides it was a very subjective measurement.

Ms. Brown: Having reviewed your study and Dr. Rice's study, I would like to emphasize the need to assess mother-infant interaction along with behavioral indices of the infant. It may not be the infant stimulation, per se, which produces changes in the infant's behavior, but rather the infant stimulation may be contributing to the mother-infant interaction, which in turn affects infant behavioral development. If one could establish baseline data on the mother-infant interaction prior to the infant's hospital discharge, one could then assess the interaction over time and its relationship to the infant's behavioral indices.

The poor developmental outcome of your experimental group could have been the result of the infant's earlier discharge from the hospital, which may have increased the anxiety level of the parents. A full-term infant develops diurnal sleeping patterns at 5 weeks and reaches a peak in his intensity of crying at 6–8 weeks of life. In comparison, the parent of a preterm infant, discharged at 36 weeks conceptual age, must endure an additional 4 weeks of the infant's disorganized schedule. I often wonder what we are doing to "God's built-in system" for the tolerance of parents to crying and sleep-wake disturbances when we discharge the infant at 36 weeks conceptual age. We need early supportive intervention to deal with these increased concerns of the parents of the preterm infant.

Dr. Malloy: When I went in to see these babies 1 day postdischarge, I almost invariably found a state of utter crisis. I did a great deal of crisis intervention in those 2½ years when I saw those babies the first time. The crisis level was so high one must wonder how the parents survive those first few days with anything left of them, let alone any sort of interaction going between the mother and the father and the child.

Dr. Rice: Did you see anything that looked significant in terms of specific test items on the Bayley?

Dr. Malloy: I examined the Bayley item by item to see if I could ferret out some answers. The only thing that really surprised me was that the control group did much better on the infant behavior record in fine and gross motor development. The control group was the group that was doing better. This was not analyzed statistically, but was clear just looking at the raw data. The control group was more sophisticated than the experimental groups. Other than that, the scores on individual items were similar.

Dr. Anderson: I liked your point regarding the need for more continuous longitudinal assessment. I have 2 comments in that regard. One concerns an article by Bower [39]. Bower presents data showing that certain abilities already present in the young infant temporarily drop out as cortical control for these abilities begins to take over. So you may have been testing at just this time. The second point is related and involves the idea of transitional periods which are well recognized in developmental theory. One basic principle is that a transitional period, during which behavior is quite disorganized, precedes qualitative change. Reorganization takes place during the transitional period, and then consolidation occurs at a higher level of performance, ie, a new stage. This principle operates at macro and micro levels. According to this principle, your experimental group may have been moving into cortical control of the tested abilities, while the control group was still functioning at the subcortical level. Thus, the experimental groups could have been developmentally ahead of the control group, even though the experimental groups achieved lower scores on the Bayley at 9 months. This is one reason why development needs to be measured at periodic intervals.

Dr. Gluck: I wanted to ask whether you control for something that very few people think about, although it would best be part of their armamentarium of thinking. Did you control for maternal history; what kind of diseases the mother may have had, or other conditions; or what the placenta looked like?

Dr. Chapman: Two maternal conditions known to affect activity were used to exclude subjects from the sample. One was diabetes because activity is related to infant body fat. The other was maternal heroin addiction because infants of heroin-addicted mothers are known to be hyperactive.

Dr. Gluck: Several years ago we began studying the maturational patterns of infants based on the objective measure of lung maturation. We compared these patterns with the evaluations by Dubowitz and associates [40] and Amiel-Tison [41]. Dr. Jeffrey Gould, who was then a fellow, and I became very interested in the findings that some babies were neurologically way in advance of their gestational ages. We were able to relate these to specific conditions in the mother,

fetus, and particularly in the placenta. Where chronic hypoxia had occurred in utero, it nearly always was associated with organ acceleration. The most impressive stimulus came from the retroplacental bleeder, also known as the chronic abruptio placentae. Other conditions included hypertensive syndromes; severe toxemia, not just terminal preeclampsia; sickle cell disease; some of the narcotics-addicted babies; diabetes mellitus D,F,R; and placental insufficiencies and infarctions. These conditions all stimulated accelerated maturation of lung, ie, maturation prior to 33 weeks gestation, some as early as 28–29 weeks. Neurologically many of these babies were way in advance, the most impressive being the chronic retroplacental bleeders where infants of 28–29 weeks gestation by external examination would test out without question neurologically to be 35–36 weeks. On ventral suspension, for example, they could bring their heads and arms and legs up, and if one lifted them up by the shoulders, they brought their heads upright, a feat for 36 weeks gestation.

The old embryologic chestnut is simply not true, that the fetal brain continues along its normal developmental schedule even though other fetal growth and development is compromised. One can stimulate the nervous system like any other fetal system, but this brings up a very intriguing thought. We talk about the gestational age or about the baby appropriate for gestational age, but seldom does one think about them *functionally*. Studies do not control for the functional status. Prematurely born infants who are well, who do not have the respiratory distress syndrome, for example, may well be abnormal prematures with accelerated pulmonary and neurologic maturation. Thus one may not have true comparable groups at all, and controls may have little value. A true premature infant, for example, will have the respiratory distress syndrome. I think it is going to be terribly important to start checking for this. The article by Dr. Gould and me [42] looked at 25 of these babies in great detail and about this whole problem in general. These phenomena had been very well documented and confirmed by Dr. Amiel-Tison [41], as well as several other workers who also looked for accelerated neurologic maturation of babies. There is, however, another unhappy side to this. At first glance, acceleration of central nervous system and pulmonary maturation seems advantageous. The baby's lungs mature early, and the brain seems to mature a little quicker, or at least neurologic function is accelerated and responds to a highly undesirable intrauterine milieu. But it turns out to be a real two-edged sword because these babies have just as much apnea and just as many digestive problems, plus all the other problems of the premature. They proved that there are *no* advantages to being born early. But babies like these certainly can confuse control studies if the investigator does not appreciate the fact that certain diseases in the mother, fetus, and placenta may make an enormous difference in how a baby functions. These infants are not necessarily comparable to premature infants of like age.

This phenomenon can be seen even with parabiotic identical twins, where one twin bleeds into the other. The baby who bleeds will be advanced compared to the one who is the recipient of the blood. The recipient will have RDS, and the donor will not. The donor will have advanced neurologic function, and the recipient will not. Yet both are in the same womb. Thus, it is necessary to throw another factor into our thinking. What is the functional age of the baby compared to gestational age? Most of all, it is necessary to learn to look at the placenta. Unfortunately very few physicians know how. At our institution we are almost fanatics about this. Transports of sick infants include the placenta as well. At the University of California, San Diego, we think one cannot understand a baby fully unless one knows what that placenta looks like. This is a key determiner. Eventually fetal growth maturation comes down to the effectiveness of oxygen transport across the placenta.

Ms. Maurer: Dr. Gluck, are you saying that based on the theory of brain sparing, those babies exposed to chronic or prolonged stress in utero will be more mature because they must accelerate their maturation to withstand this particular environment?

Dr. Gluck: I suppose if one were to consider mechanisms, the most appealing one suggests that possibly glucocorticosteroids are elaborated earlier and the same phospholipids that are seen in the lung are also seen in the brain. We can identify very objectively the phenomenon of pulmonary surfactant in the amniotic fluid. In accelerated pregnancy, the phosphatidyl glycerol component of surfactant appears very early. This component never appears prior to 36 weeks in a normal pregnancy, but may appear as early as 28 weeks in some of these severely stressed babies. However, the same phospholipids are in the brain. They invest the neurons especially. Studies on animals cause us to worry about whether the number of brain cells in babies from these stressed pregnancies are equal to the number in uncomplicated pregnancies because of known bad effects of corticosteroids. Steroids accelerate maturation at the expense of growth by inhibiting DNA synthesis, specifically an enzyme called thymidine kinase, which is responsible for DNA synthesis. The whole pattern of these high-stress pregnancies teleologically may be to try to get the baby ready to be born in order to escape a hostile environment, so to speak. However, in the long run this may not do all that well for the baby who may have certain auditory-visual coordination defects such as dyslexia. In the short-term when one sees them in the nurseries one may be completely fooled by such a baby. They will have every "ill" of the premature, including apnea, bradycardia, and digestive and nutritional problems. And there aren't really any good long-term studies yet on these babies. They had never been identified before. We are now into our fifth and sixth years of looking at some of these infants and following them along, and I really am unprepared until they are well into school to have any absolute thoughts about them.

Dr. Malloy: I would just like to comment on your original question, and that was that these babies were assigned randomly and there were about 40 or 50 variables that were examined in terms of differences between the groups.

Dr. Gluck: What I am suggesting is that they should never be assigned randomly. Once you know that a group of infants like these exist, then they should be ruled out on the basis of their accelerations because that creates a whole different order of things.

Dr. Fleming: I would like to raise 3 issues. The first is why are we stimulating the babies? I think sometimes we ought to try to determine the purpose for stimulation. Is it to help babies to catch up, is it to maintain them, or is it to prevent regression? I base my question on the last note of Dr. Malloy's paper, because some of the things that disturb her also disturb me. Consequently, we need to try to determine why we are stimulating.

The second issue deals with the quality of life of the mother. We seem to have gotten away from the idea that the high-risk mother produces a high-risk infant, and I think we need to keep that idea in mind. I do think the quality of life of the mother is certainly an indicator as to what the infant's life is likely to be when he begins existence out of the uterus. He has been developing for 9 months, and we seem to assume that he only started the day before his birth. I know you were not assuming that, but I think we need to consider the quality of life of the mother as a factor.

The third issue concerns the possibility of taking the concept of critical periods and broadening it a little, in terms of the readiness state of the infant. This might help us to determine when the infant ought to be stimulated and when he should not. I do believe we ought to consider individualizing stimulation and not routinely think that all babies ought to be stimulated the same way.

Dr. Porges: We've talked about intervention and stimulation, made the assumption that intervention was good, and then felt tremendous disappointment when the intervention did not show any effect. I'm really wondering why you would expect effects from such slight intervention. Even the animal studies, upon which I think most of you are basing your intervention research, don't show very large changes. And the effects that are found are primarily a function of a deprivation control group, not an enriched group. Even when experimenters use deprivation control groups and start showing differences in cortical development, the cortical changes are in very, very specific areas, and it is very difficult to relate those cortical changes to behavioral function. So if you are not getting these effects, I don't see what the real concern is. There might be another way of viewing stimulation intervention, ie, to make the nursing environment a little more comfortable for people who work there, as well as for the parents when they interact with their child, rather than talking about long-term effects and cortical development. So in a sense one could be more functional in the rationale for doing this.

Dr. Malloy: I think that one of the assumptions made in many of these studies was that the control group was indeed a deprived group in the sense of not receiving any patterned stimulation.

Dr. Porges: I did not see any real control group that was deprived. Even in the isolette, we said it might be a case of overstimulation or poor quality stimulation. You have to blindfold the infant for long periods of time. When you have blind infants, you find out the compensatory sensory systems exist, so what might be deprivation on one sensory level may in fact emphasize receptor development in another system. The systems are very plastic.

Ms. Maurer: Perhaps your controls should be babies who are being treated for hyperbilirubinemia under the bilirubin lights, who have blindfolds on, and who, except for feeding, are maintained under continuous light therapy.

ADDENDUM, JANUARY 1979

During the past several years, researchers have continued the search for short-term developmental effects of various experimental stimulation programs in premature infants [43–48]. Korner and associates found that 10 infants who were placed on gently rocking waterbeds had fewer episodes of apnea than a control group [43]. Kramer and Pierpont placed infants on waterbeds, rocked them, and played a recording of a heartbeat and a woman's voice during the rocking period [44]. At the end of the regimen, the 11 infants in the experimental group had a better weight gain and increased head circumference, but no difference in neurologic or behavior tests, as compared with 9 control infants. Tactile stimulation was found to be significantly related to weight gain, and to fewer but larger feedings in one study [48]; in another study [47], no difference in weight gain was noted, but the stimulated infants performed somewhat better on the Brazelton Neonatal Assessment Scales. Miller noted no significant effects on sucking during a regimen of auditory stimulation [45], and Palmqvist found no significant differences in weight gain in 92 full-term infants exposed to a recording of a heartbeat and 83 who were not so exposed [46].

The variations in types of stimulation, assessment tools, sample selection and methodologies, and the very small sample sizes in most of these studies make generalizations difficult, if not impossible. There does seem to be a trend toward an initial benefit to the stimulated infants, a finding which this investigator's study supported.

A growing number of investigators have argued that the effects of early environment are not as irreversible as had been hypothesized, if environmental conditions improve. Many of the early studies of the effects of deprivation on animals made no attempt to reverse that deprivation or to provide any rehabilitation.

Mitchell et al found that kittens had significant recovery from the effects of unilateral eye closure when they were forced to use the deprived eye [49]. Chamove [50] and Novak and Harlow [51] studied monkeys from several types of isolated rearing conditions and found that they could learn to be social with appropriate rehabilitative measures. Kagan studied a group of Guatemalan children whose culture decreed that they spend their first year wrapped tightly in clothing; confined to the inside of a small, barren, dim, windowless hut; and exposed to minimum interaction with adults [52, 53]. At a year old, these infants, whose environment and experience were so severely limited, were quiet, somber, passive and withdrawn, and their cognitive development was 3–12 months below American infants matched for age and sex. At about a year, when the children became more mobile, they were permitted to leave the huts and were exposed to and became part of the full and varied life of the village. Kagan found that when tested for a variety of cognitive abilities at 5–12 years of age, the children performed as well as American middle class children. It seems, therefore, that these children have caught up, despite their early sensory deprivation, at least in intellectual abilities. Of course, one has no way of knowing how these children might have developed without the early deprivation, ie, whether they might have had the potential for cognitive abilities superior to what they have achieved. The question of whether the early deprivation affected characteristics other than intellect also remains unanswered. Nevertheless, these studies, among others, point out that infants may be far more resilient than has been believed and raise many questions about the permanence of many effects of early experience, especially when more optimal environmental conditions are provided.

Denenberg is also among those who have taken a more holistic stand in the design and interpretation of infant stimulation studies [54]. Rather than attempting to uncover a cause-and-effect relationship between one set of variables, he has suggested that studies need to be designed that would measure how several variables interact over time and how the interactions might "result in patterns of experience during early development that yield performance differences in later life" [54]. This view also supports Escalona's model of the interaction between environment and organism [33], one of the theoretical bases for this writer's suggestion earlier in this paper that auditory stimulation "on demand" be studied. Papoušek's studies of normal neonates and older children have led him to believe that environmental events can be categorized so that infants' adaptive responses are predictable [55]. He concluded that changes which were contingent upon the infants' own activity elicited the most intensive orienting reactions, and that these were highly resistant to habituation.

The recent literature reviewed supports many of the observations and conclusions of this study. Investigations of long-term consequences of environmental enrichment and studies of the interactions of a variety of environmental and organismic variables continue to be urgently needed.

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The Congenitally Methadone-Addicted Infant

Juanita W. Fleming, RN, PhD, and Pearl Rosser, MD

A review of research concerning the effects of methadone on infants born to mothers who received the drug during their pregnanc is presented. The goal was to provide a base for establishing that tl infant born of a heroin-addicted mother who is in a methadone maintenance program needs the help of health professionals to develop to maximum potential.

Factors which should be considered in studying infants born to methadone maintained mothers are delineated. Tools for predicting later development as an area of study are discussed. The sense of inadequacy and low self-esteem of the parents, particularly the mother, is presented as an area in need of study. Theoretical considerations are discussed. The literature review indicates the effect of methadone on the overall development of the infant is debatab However, evidence is mounting that infants born to heroin-addicte mothers receiving methadone maintenance treatment are high-risk Consequently, health professionals are alerted to the importance c providing appropriate stimulation during sensitive periods of infan readiness.

The goal of this paper is to provide a base for establishing that the in of a heroin-addicted mother who is in a methadone maintenance progra the help of health professionals to develop to maximum potential. The operates on the premise that neurological integrity, environmental integ maturational development are interrelated. Consequently, the maturatic velopment of infants born of methadone maintained mothers is threate cause the neurological and environmental integrity of these infants is th

The increase in heroin addiction among women suggests the magnitu problem. It is suspected that between 100,000 and 200,000 opiate addi in this country. Of this number 16.5% or more are thought to be wome man reported that within a decade the number of births to addicted mo from 1 in 164 to 1 in 40 [1].