The Inquiry Into Prenatal Musical Experience: A Report of the Eastman Project 1980-1987

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Full Text: Headnote ABSTRACT: This paper describes early research and current trends in prenatal brain growth, development of the auditory system, and characteristics of the fetal environment including auditory stimuli. Questions which initiated the investigator's longitudinal study of pre and postnatal response to musical stimuli are discussed. The protocol for the research, nature of specific musical stimulus sources, pre and postnatal behavioral response, and implications for accelerated musical and speech development are discussed. A review of data collection procedures, and observations regarding infant cognitive, affective, and psychomotor development of the subjects involved in the study will be presented. Plans for continued observation of both control and experimental subjects are described. My interest in both the handicapped and the musically gifted young child dates from the early '60s, and forms the basis for this status report of a study of prenatal and postnatal response to musical stimuli initiated as a result of my association with the Japanese musician and educator, Shinichi Suzuki. You may recall that Suzuki's work has always included the handicapped as well as the average and talented children. It was Suzuki who speculated about the possibility that the unborn child was able to respond to recorded violin repertoire. Conversations with him during the research study "Project Super" I directed at the Eastman School of Music from 1966-1970, and subsequent consultation with audiologist Lawrence Dalzell of the University of Rochester Medical School, encouraged me to embark on the investigation of prenatal response to musical stimuli discussed in this paper (Shetler, 1985). It was after reading Dr. Thomas Verny's book The secret Life of the Unborn Child, (1981) and listening to a graduate student describe the movements her in utero child was making while she was playing the piano, that I began in earnest to investigate the phenomenon of in utero sensory response. The observation that the prenatal infant responds to external stimuli is not a recent one. In early oriental societies, in China and Japan, a child's age is reckoned to be one year at birth. Sir Thomas Browne, 17th century physician and philosopher wrote: Every man is some months older than he bethinks him, for we live, move, have being, and are subject to the elements and the malices of diseases, in that only world, the truest microcosm, the womb of our mother, (cited in MacFarlane, 1977, p. 5) Reviews of research by Sontag (1935), Sontag and Wallace (1935), Sontag and Newberry (1940), Forbes and Forbes (1927), Grimwade (1970), Grimwade, Walker, and Wood (1971), Sakabe (1969), Bench (1968), Read and Miller (1977), produced ample evidence that the issue of prenatal auditory response had been an increasingly important area for scientific investigation. In addition to the studies reported by obstetricians and other medical professionals, questions of in utero activity, including the fascinating issue of prenatal memory and learning have been explored by a growing number of psychologists since the 1940s. Most prominent and empirically based reports are those by MacFarlane (1977), Annis (1978), Ferreira (1960), Montagu (1962), Spelt (1948), Salk (1960,1962, 1966), Liley (1972), Wedenberg (1964, 1970), De Casper and Fifer (1980), Smotherman (1982), Eimas et al. (1980, 1982, 1984), and Panneton (1985). Among the questions that would interest a music psychologist-or an educational researcher-are those that focus first on the physiology and neuroanatomy of the fetus. Correlated issues that call for investigation are those that deal with the ontogeny of primate auditory and cortical systems as they impinge on memory and learning. 1. Can the fetal infant hear? 2. What does it hear, and how does it respond? 3. Does the prenatal infant respond differently to a variety of stimuli? 4. Is music a feasible stimulus source? 5. Is the fetal cortical response to auditory stimuli measurable? 6. How early in postnatal development does the infant respond to auditory stimulation? 7. Is it possible to detect specific differentiated behavioral response to musical stimuli in the postnatal infant that refer

directly to prenatal stimulation with music? 8. To what extent is it possible to track the musical development of the young child in the first twenty-four months? 9. Do the available research finding support a hypothesis that prenatal learning takes place? 10. Do current musical development theories that prenatal auditory response to music stimuli into consideration? Following is a brief summary of the research results that bear on the foregoing questions. In each case, publication data and significant findings that relate to the questions are provided. 1. Peiper (1925) reported evidence existed that the fetus of five weeks responded with sudden movements to loud sounds originating outside the body of the mother. Sontag (1969) produced evidence that the fetus was responsive to a 120HZ vibratory stimulation and responded by muscular activity, cardioacceleration, in a patterned fashion. The prenatal infant in the second trimester possesses the physiological structure that permits hearing. (see Figure 1.) The infant responds differentially to frequencies of 20-12,000 HZ. Best response was reported to lower frequencies (200-4,000 HZ). 2. The environment for the fetus resembles the aquatic environment insofar as the physical nature of sound transmission to the ear. Rubel (1984) reports research by Saunders and his colleagues indicating conduction of sound to the external and middle ear follows principles of vestibular and cutaneous transmission of audio signals. 3. Cochlear function, basilar response and development of inner and outer hair cells permitting transmission to the eighth cranial nerve (the first to fully develop in the fetal brain) is present by the 5th to 7th month. Responsiveness is first to low frequencies and then to higher frequencies (Rubel, 1984). (See Figure 2.) 4. Animal research indicates imprinting of the maternal heartbeat in all primates. The human infant "memorizes" the sound among others originating in the gastrointestinal system of the mother.

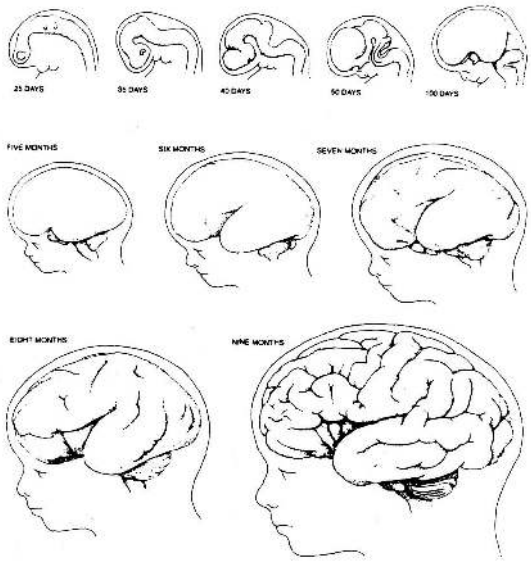

Figure 1
The human brain in its developmental sequence

The human brain shown in its developemtnal sequence starting at twenty-five days and progressing through birth. Early in our brain's development, the neural tube expands to form three prominent structures, the hindbrain, midbrain, and forebrain. As the cerebral hemispheres develop from the forebrain, the midbrain unites it with the hindbrain, which develops into the pons and medulla. (Restak, 1984, p. 43)

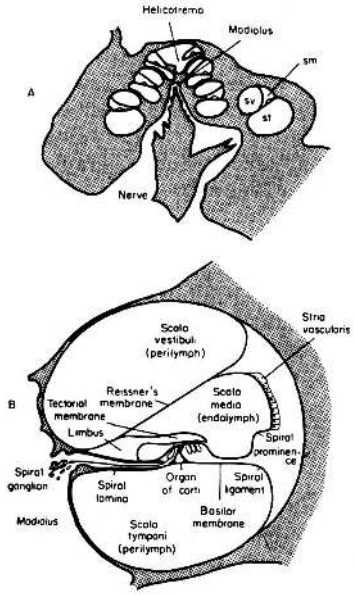

Figure 2
Cochlear structures in the prenatal infant

Cochlear structures involved in perception of musical signals present in the prenatal infant. The eighth cranial nerve is the first to become fully functional. (Pickles, 1982, p. 26)

5. In a pioneering study, Spelt (1948) reported conditioning the fetal infant to an external auditory stimulus during the final two months of gestation. This included extinction, recovery, and retention of the response as well as significant agreement with records of fetal movement and maternal reports of fetal movement. 6. The imprinting (longterm memory, autonomic SR driven) of the mother's normal heartbeat, and the implications for normal health of the fetus, were investigated extensively by Salk (1960), 1962, 1966). He observed that rhythm in all societies from the primitive drum beat to the patterns heard in the symphonies of Mozart and Beethoven bear "startling similarity to the rhythm of the human heart." The perinatal infant responds to the adult heartbeat rhythm with less anxiety and more stable sleep habits. Salk suggests in a later study that this phenomenon lends credence to the idea that later learning is enhanced by the imprinted-or learned-response. He further states "For this reason we must explore further the elements of prenatal sensory experience in the human. Perhaps conditions . . . may alter the sensory and intellectual thresholds . . . resulting in variations in intellectual capacity or in emotional stability." (Salk, 1966, p. 302) (see Figure 3.) 7. The early anecdotal reports by mothers that the fetal infant responded to external musical sounds is referred to in a number of articles. A.W. Liley (1972) reports early data on FHR (fetal heart rate) response to both pure and complex tones. Likewise, Wedenberg (1970) observes that the fetus is "listening all the time after the 24th week." (Karolinska Institute, Wedenberg et al. (1985). 8. Grimwade (1970) and Grimwade et al. (1971) report direct differentiation of FHR to a wide variety of frequency stimuli. In addition, differentiation of response to sine tones and percussive sounds is reported. Sakabe, Arayama and Suzuki (1969) report AER (auditory evoked response) in the fetal brain. Thus, it appears that the stimulus is transmitted to the brain, and it can be concluded that it is perceived and stored in memory. 9. Investigations of fetal well-being by Read and Miller (1977), Bench (1968), Grimwade (1970) and Scibetta (1971) using auditory response data further support the observation that the prenatal infant "hears" and responds to a wide variety of external sound sources. It is not possible at this point in research

history to conclude that longterm memory for specific rhythmic and tonal patterns is detectable. One of the central objectives of the present study focuses on that issue. It is hypothesized that only by longitudinal tracking of postnatal developmental response can it be determined that prenatal stimulation may enhance prenatal learning.

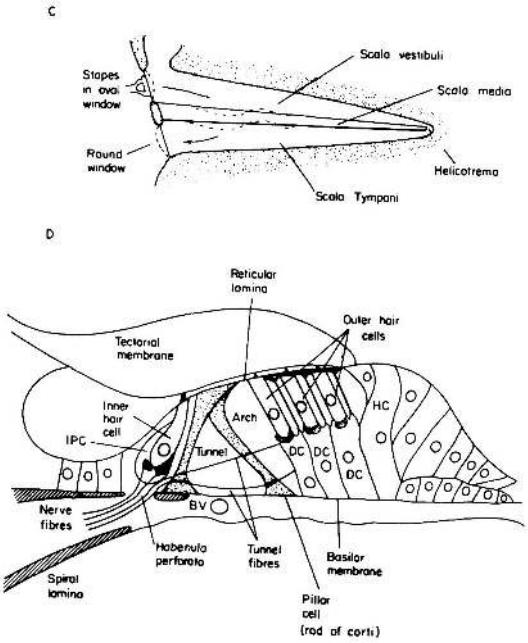

Figure 3

C. The path of vibrations in the cochlea.
D. A cross section of the organ of Corti as it appear in the basal turn. (From Pickles, 1982, p. 27)

In his recent book The Infant Mind, Richard Restak (1986) speculates that memory in the "wide sense" is achieved, before birth at full term. He reviews the work of Hamburger and Harrison who learned that during normal fetal development about 50 percent of cortical neurons die off. Those surviving cells continue to develop connections and to differentiate for years after the baby is born. Very little is known about this amazing process of neuronal organization. (Restak, pp. 50-57) Current research efforts by De Casper, Eimas, Trehub, Aslin et al. (1983) in the area of speech perception may have much to offer us in our search for answers to the important questions of differentiation of response in infants. Rene Van deCarr (1985) has suggested that prenatal infants are in a "prenatal university." He programs in utero infants with music, poetry, mother's and father's reading The Cat in the Hat. He and his parents report dramatic developmental differences between first and second children, and between siblings when only one child experienced systematic stimulation. (1986) THE EASTMAN PILOT STUDY: 1980-1987 It was after reading the intriguing anecdotal reports that had appeared in Verny's 1981 book, and reviewing the available published research findings, that we decided to investigate the phenomenon of in utero auditory response to musical stimuli in a more scientifically controlled fashion. Although medical researchers had used tones and clicks as stimuli, only one report indicated the identification of what we would regard as "real music," recorded excerpts of instrumental selections or orchestral works, as stimuli to be administered in any systematic design. That work came to my attention shortly after I started my research project at the Eastman School.

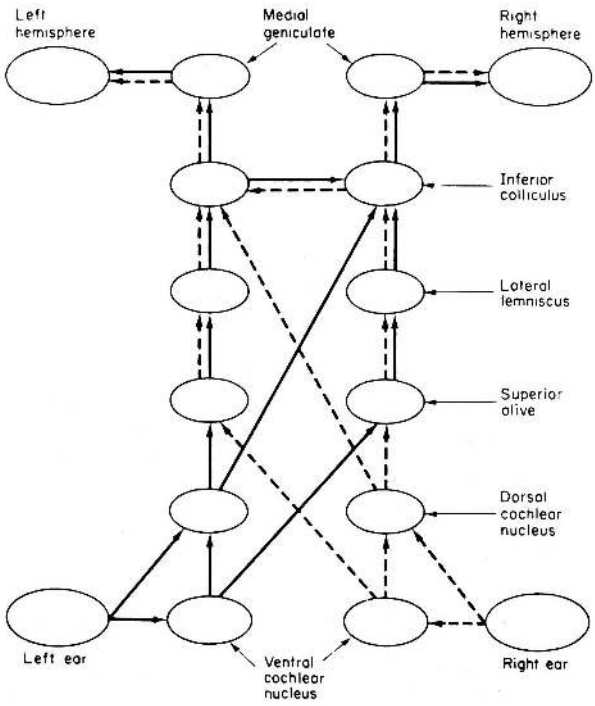

Figure 4

A schematic illustration of the most important pathways from the ear to the auditory cortex. (From Moore, 1982, p. 36)

Although his research had been cited in other publications, it was the brief report in Science Digest (February 1984) on the work of Dr. Clifford Olds of England that referred to the use of recorded music sources employed in the same prenatal environmental placement on the mother's abdomen I was beginning to use. Further, Olds reported his tracking, or developmental observation of the infant for some time following the perinatal period, another factor that one interested in learning could not disregard. Since 1981, and those lonely, early beginnings, I have been contacted by many doctors, mothers-to-be, and young parents who have forwarded anecdotal reports of in utero response to external music stimuli of a wide variety. At this point, however, it is my perception that no other formal studies of the sort I will describe are underway. There are many valid reasons one might cite in not choosing to investigate the issues of prenatal response to musical stimuli-or the even more tenuous issue of prenatal learning. 1. In spite of the findings reported by Eimas (1978) and De Casper (1980), among others, musical signals are very different in physical energy content than those of normal adult speech. It is this difference in acoustic complex wave forms, on the other hand, that renders some types of musical patterns (both tonal and rhythmic) ideally suited for research involving fetal response, and even the potential for in utero learning. 2. Until we have documented specific measurements of differential post-natal developmental behavior due to the treatment variable (musical stimuli), it is not appropriate to report anything but a tentative cause-effect relationship. It is this critical factor in the design of my studies that I hope will produce data that will generate a protocol for others to replicate. 3. Many unsubstantiated reports have been published by musicians and psychologists that border on the bizarre, resulting in negative reaction from professionals in the field. Beginning with one mother and prenatal infant in 1981,1 established a protocol for exploring the phenomenon in a pilot study that continues to the present. Following are some of the most critical factors, or controls, I have exercised, and some observations on my findings: 1. The mother is a volunteer. She usually contacts me as a result of reading about the study in a paper or magazine, or discussing our work with one who has been a

subject in the study. Many are musical, or come from a family history that indicates higher education. 2. Mothers, and fathers-or both parents-make an initial appointment to discuss the project and their potential involvement. The importance of record keeping, consistent use of the music selected, and follow-up visits is stressed. Only two of over thirty who considered joining the study did not choose to participate. Of course, I have not been able to accept many who wanted to join. 3. After the first interview and discussion of music matters, we select a "stimulative" piece and a "sedative" work. The selection process involves instruction on time for use of the music, position of the mother, record keeping, and the general medical history of the mother-to-be. Visits during pregnancy are usually once every four to six weeks. 4. During the in utero stimulation period, music is "programmed" to the infant by means of high fidelity stereophonic earphones, removed from the headpiece frame, placed directly on the abdominal skin without any clothing or obstruction. Although the stimulus may be recorded in stereo, the signal amplified to about 90 dB, is monophonic. The listening period-or in utero stimulation time-is between five and 10 minutes, no longer. Some mothers use one stimulus in the morning hours and the other in the evening. The reason for using two contrasting musical selections is that we are interested in differences in motor response that might occur. Measurement of fetal cardio acceleration and AER (audio evoked response) have not been reported when these widely contrasting types of music have been used except for those reported by Olds (1984, 1985) in two informal monographs. In my studies, by the way, 10 of the 30 subjects have reported differences in response to the two types of music: a. The infant tended to respond with more sharp, rapid or agitated movement to the stimulative selection, and b. With more "rolling" or soft, muted motor movement to the slower of "sedative" selection. This supports the speculation made by Olds (1984, 1985) that tempo-the temporal variation-may be the earliest and most primitive musical response possible. It may be a predictor of personality and, eventually, of competent speech acquisition as well. Studies recently reported by Gagnon and his associates at the St. Joseph Hospital in London, Ontario indicated that external sounds of 110 dB at the skin surface are attenuated 40 to 50 dB in the uterus. Thus, there would appear to be no damage to the fetal hearing system. It should be noted that the 90 to 110 dB levels are peaks. 5. My first appointment with the mother and new baby is always within the first 4 to 6 weeks. At this first visit a routine is established that continues, with minor variations, until the present. The appointments-or clinical observation periods are designed to be very low in stress to the mother and child. The same office, a small seminar room in the music department, is always used. Music is presented by means of records or tapes played on highquality equipment and stereo speakers, or by real instruments and toy-like music sources. No more than one additional observer is in the room. Sessions are audio or video tape recorded. I take brief observational notes for the subject's cumulative folder. The sessions normally last about 25 to 35 minutes. A major music behavior I am trying to assess is that of vocal production (singing or cooing) in addition to early babbling or speech acquisition. The research on infant vocal behavior is rather new and the corpus very small. I refer here to those studies that attempt to measure the singing, or presinging behavior of the infant before 24 months (Fox, 1982). It is quite possible that the infant of less than 12 months can match pitch and echo intervals as well as rhythmic patterns. At present, in light of the small sample of mothers and infants participating in the study, and with many environmental variable uncontrolled, I am not suggesting that prenatal musical stimulation has a promotive, or direct cause-effect impact on behavior of the infant between one and twenty-four months. It is the period after this-that of 24-60 months-that interests me even more. It appears that after the child attains spoken language and the cognitive skills that support language, he or she "remembers" much more than one might have imagined. I am just beginning to learn about this most intriguing phenomenonin my studies of cognition and memory. One of the findings I have reported in brief articles and interviews about the study, is the early development of highly organized and remarkably articulate speech of those children who have been exposed to prenatal music stimulation. Note: Following is a brief description of color video recordings of four subject clinical sessions. All children received prenatal musical stimulation I. Female 27 months The child sings the popular Christmas song "Rudolf, the Red Nosed Reindeer" from beginning to end. The song is thirty-two measures long.

It contains intervals of an octave, chromatic intervals, key changes. Her parents cue her twice. Noted are speech clarity, gestures and expressive dynamics. II. Male 46 months (This is the oldest subject in the study.) Mother is a singer and teacher. He had not been to a clinical session for over two months. He listens to recorded synthesized sounds, identifies them and displays creative, innovative response; excellent articulation and expressive verbalization. (These recorded sounds are heard only during clinical sessions.) He plays a small xylophone, imitates tonal patterns, dynamic contrast replicated. He wants to compose (improvise) his own songs. He imitates rhythmic patterns played by his mother on a small wood drum. He interchanges right and left hand, discriminates like and different patterns. He also plays the instruments in a toy drum (Fisher Price). Although he sees these instruments only every 2 or 3 months, he remembers the names of the instruments and plays each of them correctly. He plays the kazoo, sings the "ABC Song" and plays the piano with his mother. III. Female 30 months This Chinese child is being raised by her grandmother as well as her natural mother who is a singer and teacher. She sings in two registers, a loud low register and a soft high register. She sings over fourteen songs by memory. During this video sequence she sings 'This Old Man," "Twinkle, Twinkle Little Star," and "Rain, Rain Go Away." She replicates triadic and intervalic patterns that are played on an instrument or sung to her. She responds to synthesized sound by creating gestures and is very attentive to the novel auditory stimulus. She also plays the xylophone, the drums, the kazoo, and an electronic instrument-the Projectone. This was the first time she had been exposed to the Projectone. She "played" a song and experimented with sounds of short and long duration. This girl may be gifted. She exhibits remarkable attention and motor integration. IV. Female 21 months This is a first child, with one younger sibling. She is with a day care center most of the day. The mother was a music teacher who took a year's leave. I had not seen her in the clinical sessions for 69 days. (The audio stimuli are regarded as novel for most normal children if they are not exposed to them at least every three weeks. The girl sings "Jesus Loves the Little Children" in the correct key with no melodic or rhythmic errors. She sings 12 songs by memory. She played the Fischer-Price drum toys, xylophone, wood drum and kazoo. She also plays the piano with independent fingering. Often she will sing while playing. This child has excellent verbal articulation. She verbalizes in complete sentences. You may wonder why I have not systematically employed the same music for the longitudinal, or tracking, observations that was used in pre-natal sessions. I did that with my first three subjects-and for the first two or three visits. The infant responded with instant motor movement, fixed gaze at the source of the music, and in one case, by reaching out to the sound source. A decision was made to use another selection, and to introduce a novel series of synthesized musical sounds, in order to assess the infant's ability to transfer or generalize the response behavior to many types of music appropriately. Not surprising, subjects tended to respond to almost all musical selections of the same type in a generalized way. I am still investigating the stimulus value of comparable music selections among the more critical variables in this phase of the study. In addition, I am now recording a series of short melodic patterns for use in future study. Finally, I want to emphasize a most important point-even a tentative conclusion-of the studies now underway. This is a pilot experiment. It utilizes music in the sense that humans, not animals, recognize it as an esthetic object and a man made artifact. Because of the unique characteristics of the stimulus and its cultural significance, and because of the host of environmental variables that pour in on the postnatal infant beginning with the moment of birth, we are reluctant to advance the hypothesis that musical stimulation of the in utero infant will have significant behavioral effects on development. However, the data we have collected, and the tentative conclusions reported, encourage us to continue the research and to urge interested professionals who share our curiosity to join us. As I indicated in my article written for the Music Educators Journal in 1984, who knows when life begins, and who can state when musical life of the child is first experienced? I hope our research will help provide at least some of the answers to those questions. Since the first formal presentations of this study in the summer of 1986,1 have added three subjects-one who had 16 weeks of systematic stimulation, and two who will appear next month, or in September. We hope to be able to add ultrascan videos to the data now available. As the technology improves, and as others become involved in

research of the type being initiated by Brent Logan, I continue to follow my subjects and record their musical and cognitive development. References REFERENCES Adam, G. (1980). Perception, Consciousness, Memory: Reflections of a Biologist (translated by K. Takacsi-Nagy) New York, Plenum Press. Annis, L. (1978). The child before birth. Ithaca, NY: Cornell University Press. Araki, S. (1972). Studies on the sound of response of fetus and newborn infants. Journal of the Japanese Gynecological Society, 24, 267-275. Arayama, T. (1970). Intrauterine fetal reaction to acoustic stimuli. Journal of Otolaryngology of Japan, 73, 1885-1907. Argal, S., Rosen M. and Sokol, R. (1975). Fetal response to sound. (Special issue). Contemporary Obstetrics and Gynecology, 5. Aslin, R. N., Pisoni, D., &Jusczyk, P. (1984). Auditory development and speech perception in infancy. In P. Mussen (Ed.) Carmichael's Manual of Child Psychology, 4th ed. Vol. 2: Infancy and the Biology of Development. M. M. Haith and J. J. Campos (vol. 2 Eds.), (pp. 574-614). New York: Wiley &Sons. Bench, J. (1968) Sound transmission to the human fetus through the maternal abdominal wall. Journal of Genetic Psychology, 113, 85-87. Boddy, J. (1983) Information processing and functional systems in the brain. In A. Gale &J. A. Edwards (Eds.), Physiological Correlates of Human Behavior (pp. 69-71). New York: Academic Press. Marilyn Fergeson (Ed.) (1985). Breaking the Code of Musicality [Special issue]. Brain Mind Bulletin, 10 (4/5). Braun, S. (1985). Music in the womb (A report on Dr. Shetler's study) University of Rochester Research Review, Winter, p. 14. Brierley, J. (1985). The growing brain: Childhood's crucial years. Windsor, England: NFER. Bucheimer, A. (1986) Memory-Preverbal and Verbal in Pre- and perinatal psychology: an introduction. New York, Human Sciences Press pp. 52-61. Chapman, J. (1975). The relation between auditory stimulation of short gestation infants and their gross motor limb activity. Dissertation Abstracts International, 36, 4B-1654. (University Microfilms No. 75-21, 138) Chusid, J., &McDonald, J. (1967). Correlative neuroanatomy and functional neurology. Los Altos, CA: Lange Medical Publications. DeCasper, A. J., &Fifer, W. P. (1980). [News note]. Science, 208, 1174 Eccles, J., &Robinson, D. (1984). The wonder of being human: Our brain and our mind. New York: Free Press Ehrenwald, J. (1984). Anatomy of genius: Split brains and global minds. New York: Human Sciences Press. Eimas, P. D. (1978). Developmental aspects of speech perception. In R. Held, H. Leibowitz, &H. L. Teuber (Eds.). Handbook of sensory physiology: Perception (Vol 8). Berlin: Springer. Eimas. P. D., Siqueland, E. R., Juszyk, P., &Vigerito, J. (1971). Speech perception in infants. Science, 171, 303-306. Eimas, P. D. (1985). The equivalence of cues in the perception of speech by infants. Infant behavior and development, 4, 395-399. Eisenberg, R. B., and Marmarou, A. (1981) Behavioral reactions of newborns to speechlike sounds and their implications for developmental studies. Infant mental health journal 2, 129-138. Fernald, A., &Simon, T. (1984). Expanded intonation contours in mothers' speech to newborns. Developmental psychology, 20, 104-113. Fernald, A. (1984). The perceptual and affective salience of mothers' speech to infants. In L. Feagers, C. Garvey, &R. Golinkoff (Eds.) The origins and growth of communication (pp. 5-29). Norwood, New Jersey: Ablex. Fernald, A. (1985). Four-month-old infants prefer to listen to motherese. Infant behavior and development. 8, 181-195. Ferreira, A. (1968). Prenatal environment, Springfield, Illinois: Charles C. Thomas. Field, Tiffany (1980). Supplemental stimulation of preterm neonates. Early Human Development 4: 301-314 (Biomedical Press, Elsevier/North-Holland). Forbes, H. S., &Forbes, H. B. (1927). Fetal sense reaction: hearing. Journal of Comparative Psychology, 7, 353-355. Fox, Donna Brink (1982). The pitch range and contour of infant vocalization. Dissertation Abstracts Internationa1 43, 8A-506. (University Microfilms No. 83-00, 247) Fox, N. &Davidson, R. (1984). Hemispheric substrates of affect: a developmental model, in The Psychology of affective development, ed. Nathan A. Fox and Richard J. Davidson. Hillsdale, N. J. Erlbaum Press. Friiz, D. (1985). A prenatal approach to maximizing human potential: The work of Igor Charkovsky. second International Congress on Pre- and Perinatal Psychology, San Diego, California, July 1985. Gagnon, R., Patrick, J., and West R. (1986) Stimulation of human fetuses with sound and vibration, American journal of obstetrics and gynecology, 155, No. 4. 848-851. Gardner, H. (1981). Do babies sing a universal song? Psychology Today, 14, 70-76. Gifted children monthly 6, No. 7 (August, 1985). Mothers nurture future maestros, 4. Grimwade, J. C. (1970). Response of the human fetus to sensory stimulation. Australian and New Zealand Journal of Obstetrics

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