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AUTHOR Inselberg, Rachel; And Others
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ABSTRACT

This study sought to determine whether differences existed between infants from low socioeconomic status (SES) families and those from high SES families in the occipital rhythmic activity of the brain, as recorded in their electroencephalograms (EEGs), as well as in other developmental measures. Ten low SES white infants and 10 high SES white infants given EEGs at age 3, 6, and 12 months did not show differences in the occipital rhythmic activity, suggesting comparable neurological functioning between groups. Three measures of infant development were administered at varying intervals between 1 and 18 months. No significant differences between the 2 groups were found until age 12 months. At 12 months, the low SES infants scored lower than the high SES infants in personal-social and adaptive development and, at 18 months, they lagged behind the high SES infants in mental development and language comprehension. Observations of the infants' home environments found that the low SES group was exposed to more television and experienced less maternal responsivity than the high SES group. (Contains 18 references.) (MDM)

Occipital Rhythmic Activity and Other Developmental Measures of Infants from High and Low Socioeconomic Groups

Rachel Inselberg

Western Michigan University

Michael Sluss

Neurology and Rehabilitation Association

Arthur Feinberg

Bronson Methodist Hospital

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Running head: Occipital Rhythmic Activity in Infants

Rachel Inselberg, Ph.D.

Professor

Western Michigan University

Kalamazoo, MI 49008

(616) 381-8868

Abstract

Poverty group children are generally thought to receive less environmental stimulation and maternal attention. Yet, recent animal studies show positive changes in the brain resulting from enriched, stimulating environments. The primary objective was to determine whether differences existed in the occipital rhythmic activity of the brain and other developmental measures between 10 welfare group infants and 10 comparable higher socioeconomic group infants. Another objective was to determine differences between the groups' exposure to certain environmental stimuli. Electroencephalograms at ages three, six, and 12 months did not show differences in the occipital rhythmic activity, suggesting comparable neurologic functioning between the groups. Neither were differences found before 12 months of age in other measures. At 12 months, the poverty group infants scored lower in personal-social and adaptive development and, at 18 months, they lagged in mental development and language comprehension. They were exposed to more TV and experienced less maternal responsivity.

Occipital Rhythmic Activity
and Other Developmental Measures of
Infants from High and Low Socioeconomic Groups

It is commonly accepted, both in popular (Will, 1990) and professional literature (Berger, 1988) that children from poverty groups have less environmental stimulation and maternal attention than those from higher-income groups. Pressures in the poverty mother's life, such as single parenthood and lack of money, are among the reasons used to explain the situation. On the other hand, numerous ex post facto studies (Casler, 1961) have amply demonstrated motor, language, cognitive, as well as social and emotional deficits in young children who experienced lack of stimulation or maternal deprivation. More recently, studies on infant animals (Diamond, 1984; Renner & Rosenzweig, 1987) have shown that exposure to enriched environments and greater stimulation have resulted in changes in the brain, both structurally and chemically.

Among the more obvious neuroanatomical differences noted between animals reared in enriched environments and controls reared under impoverished conditions, were gross weight of the brain, weight and thickness of the cerebral cortex, as well as changes in the structure of individual neurons. Animals raised in enriched enviornments were placed in large cages with other animals of their kind and had toys and equipment to play with. In contrast, an animal raised under impoverished conditions was put in a small cage by itself without toys, and had only a tray for food and water dispenser. Nottebohm (Kiester, 1986) showed that cerebral cortices of birds grew each year as they learned new songs. Volknar and Greenough (1972) found that animals in enriched conditions showed consistently more higher-order dendritic branches than their littermates in impoverished conditions. The corpus callosum underlying the occipital cortex was also found to be thicker in enriched-experience animals than in animals with impoverished experiences (Szeligo & LeBlond, 1977).

Recent findings also suggest neurochemical changes as a response to differential experience. Ferchmin, Eterovic, and Caputto (1970) found that rats in enriched conditions had more cortical RNA than their littermates under impoverished conditions. Uphouse (1978) also reported increases in the capacity of cortical chromatin to support RNA synthesis in rats experiencing enriched conditions. Since the primary function of RNA is the manufacture of proteins, an increase in RNA in the cells of the cerebral cortex indicates increased production of proteins in subjects experiencing enriched conditions. These findings attain further significance when viewed in relation to the evidence that protein synthesis is involved in the brain's reaction to experience, as in long-term memory formation (Rosenzweig & Bennett, 1984).

In total, there is strong evidence, particularly from animal studies, demonstrating positive changes in the brain, as a result of enriched, stimulating environments. However, there is still a scarcity of human studies. One study (Robertson, Jan & Wong, 1986.) revealed that in case of cortical impairment among human children, the alpha rhythm was absent. In a recent study (Bell & Fox, 1992) on the relationship between frontal brain electrical activity and cognitive development during infancy, the authors claimed that before their study was published, there was only one study (Hagne, 1972) which examined the correspondence between changes in cognitive development below the age of 12 months and the EEG. Hagne (1972) computed a ratio score of two frequency bands (1.5-3.5 Hz/3.5-7.5 Hz) and found that infants scoring high on the Griffiths Scale of Mental Development also had more power in the high frequency band.

Bell and Fox (1992) who studied 14 healthy, caucasian infants born to middle- and upper-middle class parents, examined the relationship between changes in brain electrical activity and the development of the ability to successfully perform such cognitive tasks as the A-not-B task, with delay and object retrival, which are attributed to frontal lobe functioning. They found that infants tolerating long delays at 12 months exhibited changes in the power of brain electrical activity and an increase in anterior-posterior coherence. Also, the group tolerating long delays had greater power in the left occipital level. Infants who showed rapid mastery in object retrieval did not differ on frontal EEG development from those exhibiting normal developmental progression in object retrieval.

The primary objective of the present study was to determine whether differences existed between infants from poverty group families (low SES) and those from a higher socioeconomic group (high SES) in the occipital rhythmic activity of the brain, as recorded in their electroencephalograms (EEGs), as well as in other developmental measures. Before the age of approximately three months, there are usually no organized rhythms in the posterior region of the cortex. The onset of rhythmic activity at around three months is thought to reflect the progress from a sub-cortical to a cortical level of functioning (Woodruff, 1978). Since parts of the cerebral cortex are associated with intellectual functioning, such as learning and memory (Mader, 1990), it would be significant to determine differences, if any, between high and low SES infants in the onset as well as the frequency of organized rhythmic activity, as there have been no studies comparing the EEGs of high and low SES infants. It would also of interest to compare the two groups with respect to other developmental measures, such as standardized mental and psychomotor tests, and to interpret the results of these tests in relation to the EEGs.

Another objective of the study was to determine differences, if any, in the extent to which low and high SES infants were exposed to certain environmental stimulation. As indicated in the literature review, positive changes in the brain result from enriched, stimulating environments.

Method

Subjects

One of the co-authors, a pediatrician, invited mothers who qualified for the study to participate along with their newly born infants. All infants had to be full term, having normal delivery with at least a 5-minute Apgar score of 8, and were either first, second, or third born. The low SES mothers had to be on welfare, with a maximum education of 12 years. The high SES mothers had to have a Bachelor's degree and were not to be on welfare. All mothers had to be between the ages of 18 and 34 years at the time of the infant's birth.

All high SES mothers and 83 percent of the low SES mothers who were invited to participate consented to do so. Only white mothers and their infants were included in the analysis of data, since the rejection rate (90 percent) among black mothers was far too high. A total of 10 high SES mothers and 10 low SES mothers participated.

In Table 1, the characteristics of the mothers are summarized. The low SES mothers were, on the average, in their early twenties, while the high SES mothers were in their early thirties. The low SES mothers had 6.4 less years of schooling and all, except for one, were single and unmarried. Ninety percent of the high SES mothers were back to work either full-time or part-time within 6 months of their infants' birth. The children of the employed mothers were cared for in either a family or regular day care, except for one who had a baby sitter at home.

(Table 1 about here)

The characteristics of the infants are presented in Table 2. The low SES children had a significantly shorter gestation period and were lighter at birth; however, there was no difference in weight between the two groups at 12 months. They were also similar in their Apgar scores.

(Table 2 about here)

Procedure

The EEG was run on each of the infants at the ages of three, six, and 12 months at a local hospital. Surface electrodes were attached in the usual manner. The EEG was a continuous 30 minute recording during the waking state, with no sedation given to the subjects. Two electrode montages were used. The first montage was the standard transverse and longitudinal bipolar infant montage utilizing 12 channels for EEG data as well as an additional channel for 01-02. Two additional channels were used for monitoring eye movement and another for EMG/EKG monitoring. The second montage utilized ipsilateral ear reference channels for nine surface electrodes as well as bipolar channels defined as 01-02, Fpl-01, and Fp2-02. The first montage was run for 10 minutes, the second montage for the second 10 minutes and the first montage again for the final 10 minutes. During each 10 minute segment, the EEG technician noted three eye opening - eye closing episodes. If these did not occur spontaneously, they were brought about by the technician. While the EEG was run, the mothers held their infants, talked to or read to them and showed them pictures and toys that produced sounds.

The EEG was interpreted "blind" as to age, gender and SES by a neurologist. Three determinations of the occipital rhythmic activity were made during each 10 minute segment of the EEG, with the final score being the average of nine determinations. In order to obtain a measure of the reliability of the neurologist's EEG readings, an electroencephalographer was also asked to read the EEGs of the infants at 12 months of age. The two sets of EEG readings were correlated, with a resulting Pearson product moment correlation coefficient of .91, $p < 0.01$.

Additionally, the families were observed, and the children were administered various tests "blind" at different times by a testing specialist. The Battelle Developmental Inventory (Harrison, 1991) was administered at one month and also at 12 months. It assessed five domains: Personal-social, adaptive, motor, communication, and cognitive. The derived score reported in the present study is the deviation quotient.

The Bayley Scales of Infant Development, specifically the mental and motor scales, were administered at three, six, and eighteen months. The mental developmental index and the psychomotor developmental index were the scores obtained. Birth to Three, a screening test of learning and language development, was used to assess language comprehension and language expression. The test was administered at 18 months. The deviation quotient is the score reported in the study.

Since the Bayley Scales of Infant Development are standardized tests, frequently used in child development studies, we felt that a measure of their reliability for the present study was not necessary. However, the Battelle Developmental Inventory and Birth to Three were also administered, as a form of replication. While these developmental tests are not identical, if all showed similar trends and did not contradict each other, confidence would be placed on the findings.

HOME or the Home Observation for the Measurement of the Environment (Caldwell & Bradley, 1978) was the instrument used in observing the families when the infants were 12 months of age. It consisted of 45 items grouped in six subscales: Emotional and verbal responsiveness of the mother, avoidance of restriction and punishment, organization of the physical environment, the provision of appropriate play materials, maternal involvement with the child, and opportunities for variety in daily stimulation. Each item was answerable by either yes or no, corresponding to the presence or absence of a characteristic.

The HOME Scales were administered by two individuals, namely, the psychometrician mentioned above, as well as a child development specialist. The percent agreement in their ratings was 90.

The mothers were also observed during six visits to determine whether they watched television with their infants at the time of the visits. Additionally, the mothers were asked when the infants were 12 months of age how often they had the television on during the day.

T-tests and Fisher's exact test were used to test for significance of differences between the two groups.

Results

The mean cycles per second of the occipital rhythmic activity recorded by the EEGs of the infants are shown in Table 3. At age three months, the low SES infants had greater rhythmic activity, with the difference between the two groups approaching significance. At age six and 12 months, no significant differences between the two groups were noted. (Table 3 about here)

In Table 4, the mean deviation quotients of the two groups of infants on the Battelle Developmental Inventory are presented. No differences were noted in any of the domains between the groups at one month of age. However, at 12 months some significant differences had emerged, with the high SES infants having significantly higher means on the personal-social and adaptive domains, as well as the total deviation quotient. (Table 4 about here)

The mean mental and psychomotor developmental indices obtained using the Bayley Scales of Infant Development are summarized in Table 5. No differences between the two groups were found at three or six months of age. On the other hand, by 18 months, the high SES infants were significantly higher in mental developmental index.

(Table 5 about here)

The difference between the two groups in psychomotor developmental index was approaching significance, with the high SES children scoring higher. It should also be noted that the low SES infants' mental and psychomotor developmental indices decreased from age three months through 18 months.

Using the test of learning and language development, Birth to Three, at 18 months, the mean deviation quotient of the high SES infants in language expression was 107.9, while the corresponding score of the low SES infants was 95.1, with the mean difference approaching significance ($\underline{t}$ (18) = 1.87, $\underline{p} < .10$). In language comprehension, the respective mean deviation scores of the high and low SES infants were 123.7 and 105.9, the difference being significant, $\underline{t}$ (18) = 2.26, $\underline{p} < .03$.

As indicated previously, one of the present objectives was to determine the extent of exposure of the infants to certain environmental stimulation. During all six visitations of mothers and their infants, 90% of the low SES mothers were observed to watch TV with their infants while the corresponding percentage for the high SES mothers was 10 ($\underline{p}$

<.003, Fisher's exact two-tailed test). Also, according to the mothers, the mean number of hours per day that the TV was on in the low SES homes was 9.5, compared to 3.3 in the high SES homes (t (18) = 5.14, $p < .001$).

The data on the observations of the mother-child pairs, using HOME, are presented in Table 6. The high SES mothers were observed to manifest both emotional and social responsiveness, as well as be involved with their child to a highly significantly greater degree than were the low SES mothers. The high SES mothers also avoided restriction and punishment to a slightly greater extent. Significantly more suitable play materials and variety in daily stimulation were observed in the high SES homes. No significant difference was found in the organization of the physical environment.

(Table 6 about here)

Discussion

An implicit hypothesis of the study was that differences would be found in the occipital rhythmic activity between the two groups of infants, with the high SES infants having greater mean activity. Contrary to expectation, no significant differences were obtained between the two groups. In fact, greater activity was recorded for the low SES group at 3 months with the difference approaching significance.

It would seem, therefore, that the lack of difference in EEG development between the two groups suggests that the two groups had comparable physiologic brain functioning at least during their first year of life.

The occipital rhythmic activity reflects the activity in the visual region of the brain. It is, therefore, possible that the low SES infants experienced sufficient visual stimulation from television, compensating for lower levels of stimulation in other areas. Just as with observations of EEG development, no significant differences were identified between the two groups in various developmental domains, namely, personal-social, adaptive, motor, communication and cognitive, before the age of 12 months. However, by 12 or 18 months, certain differences had emerged. The low SES infants scored lower in personal-social and adaptive development at 12 months while they were found to lag in mental development and language comprehension at 18 months.

Ausubel (1958), has suggested that there is a minimum degree of individualized care, personal attention, and social stimulation from a familiar person or persons which is sufficient to promote in an infant a sense of security and adequate development progress, at least before the infant starts developing explicit intelligence. At around 12 to 24 months when the infant is learning a language, a more active role on the part of the caregiver in teaching the child becomes necessary. This is supported by Golden's and Birns' (1983), conclusions from past studies that differences between low and high SES children on language and cognitive measures generally emerge between 18 and 24 months and not sooner.

Since no differences were found between the two groups in EEG development, suggesting comparable physiologic brain functioning, the subsequent developmental differences were apparently due to other external factors. Thus, when the low SES infants were observed at 12 months, their mothers manifested less responsivity and involvement. The low SES infants also had fewer developmentally appropriate toys and less daily stimulation.

While animal studies have shown that environmental enrichment and stimulation result in greater brain size or bring about changes in brain structure as well as chemistry, such findings have not been demonstrated in human infants. Ex post facto studies on the effects of varying levels of environmental stimulation on brain size, as revealed by computed tomography or magnetic resonance imaging, may yield indirect results. Also, comparative postmortem studies may clarify the role of environmental stimulation in human brain development.

Table 1

Characteristics of Mothers

Characteristic	High SES n=10	Low SES n=10
Mean years of age	31.4	22.7
Mean years of education	17.4	11.0
Percent married	100.0	10.0
Percent single and unmarried	0	90.0
Percent receiving welfare	0	100.0
Employment status in percent		
Full time within six months of infant's birth	50.0	0
Part time within six months of infant's birth	40.0	0
Percent unemployed	10.0	100.0
Mean number of children	1.3	1.4
Percent with telephone	100.0	50.0
Mean number of rooms in home	7.2	3.7

Table 2

Mean Characteristics of Infants

Characteristic	High SES n=10	Low SES n=10	t
Gestation period in weeks	40.1	38.7	2.66*
Apgar score			
One-minute	8.1	8.3	0.85
Five-minute	8.8	8.9	0.45
Birth weight in kilograms	3.55	3.18	2.28*
Twelfth-month weight in kilograms	9.39	10.03	1.31

*$p < .05$, two-tailed.

Table 3

Frequency of Occipital Rhythmic Activity (Mean Cycles/Second) at Various Ages

Time	High SES n=10	Low SES n=10	*t*
Three months	4.37	4.72	1.75*
Six months	5.36	5.60	0.94
Twelve months	6.75	6.79	0.18

*$p < .10$, two-tailed.

Table 4

Infants' Mean Deviation Quotient on the Battelle Developmental Inventory at One Month and Twelve Months of Age

Domain	High SES n=10	Low SES n=10	*t*
One Month			
Personal - social	86.5	89.8	1.44
Adaptive	92.8	92.5	0.14
Motor	87.0	89.0	0.70
Communication	102.1	103.7	0.41
Cognitive	108.9	106.6	0.70
TOTAL	92.9	93.4	0.24
Twelve Months			
Personal - social	99.4	84.7	2.79†
Adaptive	92.5	85.9	2.07*
Motor	91.1	85.3	1.61
Communication	102.2	92.7	1.35
Cognitive	100.7	93.9	1.08
TOTAL	94.7	81.9	2.46**

$^{*}p < .05$. $^{**}p < 02$. $^{\dagger}p < .01$, two-tailed.

Table 5

Infants' Mean Developmental Indices on the Bayley Scales of Infant Development at Various Ages

Index	High SES n=10	Low SES n=10	*t*
Three Months			
Mental Development	130.3	124.0	0.75
Psychomotor Development	126.1	128.6	0.33
Six Months			
Mental Development	125.0	117.8	1.19
Psychomotor Development	122.7	116.6	0.92
Eighteen Months			
Mental Development	134.2	115.4	3.49**
Psychomotor Development	127.2	113.2	1.72*

*$p < .10$. **$p < .003$, two-tailed.

Table 6

HOME Observation of Mother-Child Pairs

Subscale	Mean High SES n=10	Mean Low SES n=10	t
Maternal Emotional and Social Responsivity	9.90	6.70	5.45**
Restriction/Punishment Avoidance	7.20	6.60	1.80*
Organization of Physical Environment	5.60	5.10	1.55
Provision of Suitable Play Materials	8.54	6.40	6.73**
Maternal Involvement With Child	5.50	4.10	4.33**
Variety in Daily Stimulation	4.73	2.70	5.77**
TOTAL	41.47	31.60	10.71**

*$p < .10$. **$p < .001$, two-tailed.

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