speed of light to the speed of sound in a gas at a temperature T and consisting of particles of mass m.

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BRAIN POTENTIALS IN CHILDREN AND ADULTS

AN attempt has been made to compare the spontaneous electrical activity of the brain in normal adult subjects with that in children from infancy to adulthood. Using a standardized procedure,[1] both in the placement of the electrodes and in the conduct of the experiments, brain potentials were recorded from 54 adults (40 men and 14 women) ranging in age from 18 to 64, and from more than 100 children of from 1 month to 16 years of age. Significant differences in the frequency and pattern of the potential oscillations were observed, but the frequency variations of the so-called alpha waves in relation to age is the main purpose of this report.

Records were obtained from over the occipital areas of the brain, while the subjects were relaxed and at rest in a dark and relatively sound-proof room, which was electrically shielded. The position of the electrodes was determined by actual measurement with respect to certain anatomical landmarks. A comparison of these measurements with x-rays of the skulls which are available for all children and with the brain and x-rays of the skulls of child and adult cadavers has indicated that the electrodes were usually just posterior to the parieto-occipital fossa.

Wide differences in frequency of the waves were observed between the records of children and adults. Table I gives the average and range of frequency for each age group. The frequency of the large rhythmic waves of the adult records ranged from 8 to 12 per second as has generally been reported by others, without significant age differences. The average frequency for the men was 10.2 per second, whereas that for the women was 11 per second.

TABLE I

No. of subjects	Age	Average frequency	Range
1	1 mo.		
2	2 mos.		
7	3 "		
1	4 "	3.8	3.5– 4.0
2	5 "	4.6	4.0– 5.0
4	6 "	4.7	4.0– 5.5
2	7 "	4.8	4.5– 5.0
1	9 "	4.8	4.5– 5.0
1	13 "	5.5	5.0– 6.0
1	18 "	5.8	5.0– 6.5
8	2 yr.	6.3	5.0– 8.0
3	3 "	8.3	7.0– 9.5
14	4 "	8.3	7.0–12.0
5	5 "	8.1	6.5– 9.5
10	6 "	8.8	7.5–10.0
5	7 "	9.0	7.0–11.0
3	8 "	10.3	9.0–12.5
4	9 "	9.4	8.5–11.0
4	10 "	11.2	9.0–14.0
13	11 "	10.8	8.5–13.0
10	12 "	10.9	8.5–13.0
7	13 "	10.3	9.0–11.0
1	14 "	10.5	9.5–11.0
2	15 "	10.3	9.5–12.0
54	adults	10.4	8.0–12.0

The records obtained from children of 1 and 2 months of age showed occasional waves of the magnitude of alpha waves but of irregular size and shape and never in rhythmic sequence. The records from 7 babies of 3 months of age were essentially similar and showed mainly gross and irregular variations of potential, with often a complete absence of electrical activity except for the small oscillations (presumably beta waves) at frequencies ranging from 25 to 40 per second. In a few of the records from 3 of the 3-months-old children there were occasional evidences of waves of rhythmic character, that is, a series of 3 or 4 waves in rhythmic sequence occurring at a frequency of 3 to 4 per second. It appears that this occasional rhythmic activity is the forerunner of the clear and more persistent rhythms which have been observed in the records of these same children when examined at intervals of 1 to 3 months later.

Table I shows the gradual increase in the frequency of the waves with age from 4 months of age upward until the adult frequency level is reached at about 8 to 10 years of age. From 10 to 12 years of age the frequency is higher than that of the adult average.

These observations lead us to conclude that rhythmic (alpha) waves first become manifest between the age of 3 and 6 months, and probably in most infants at or shortly after 3 months of age. In view of the fact that children begin to perceive objects and follow them across the visual field at about this same time, it appears that the onset of the rhythmic waves may be associated with the development of functional activity in certain parts of the visual area from over which our records were obtained.

No satisfactory explanation has yet been found for the beginning of the rhythmic waves around 3 months of age or for the increase in frequency of the waves with age in children, but the consistent and somewhat uniform upward trend of the frequency until the adult level is reached at 8 to 10 years of age suggests a developmental process of some sort. Whether myelinization of projection fibers or some other growth process is concerned can not be hazarded. The rise in frequency in children from 10 to 12 years of age to a value above the average for the adult group appears to be significant and may be related to some of the many physiological changes which are believed to occur at this age.

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[1] Apparatus, procedure and additional results will be discussed in detail elsewhere.