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The Electroencephalogram During Infancy and Childhood.

J. Roy Smith. (Introduced by Rustin McIntosh.)

From the Normal Child Development Study of the Department of Diseases of Children, Columbia University, and the Babies' Hospital, New York.

The study of the electroencephalogram in infancy and childhood has thus far received little attention from investigators. Of the existing data those of Lindsley[1] (*c.f.* also Berger,[2] Loomis, Harvey and Hobart,[3] Davis and Davis,[4] and Kreezer[5]) showing the nature of the frequency variation of the so-called "alpha waves" with age are the most complete. In the present study observations have been made which are in general corroboration of Lindsley's findings except for one minor difference. In addition data have been obtained which indicate the presence within a few days after birth of previously unreported rhythmic waves apparently different from the alpha waves and emanating from the motor region.

Observations were made upon 58 normal children ranging in age from one day to 17 years. The group included 13 infants and young children upon whom serial observations were made at intervals of 7 to 30 days over a period of several months. In order to record the alpha waves which in the adult are usually observed over the occipital lobes, standard electrode positions over this region (both electrodes on the midline, the anterior one just posterior to the lambda and the inter-electrode distance 3½ to 4½ cm.) were employed. Recording technique including amplifiers and ink-writing undulators was standard. Tracings were taken with the child lying at rest and in semi-darkness within a shielded chamber.

Under these conditions the potentials appearing during the first 2½ months are predominantly random and "base line" in appearance. During the second month irregular sequences of waves of alpha amplitude (50μv approximately) may be observed but it is not until the tenth or twelfth week that short series of rhythmic waves varying between 3 and 4 oscillations per second begin to appear. During this early period (tenth to fourteenth week) repeated measurements on the same infant show that these rhythmic waves are

[1] Lindsley, D. B., *Science*, 1936, **84**, 354.

[2] Berger, H., *Arch. f. Psychiat.*, 1932-33, **98**, 231.

[3] Loomis, A. L., Harvey, E. H., and Hobart, G., *J. Exp. Psychol.*, 1936, **29**, 249.

[4] Davis, H., and Davis, P. *Arch. Neurol. Psychiat.*, 1936, **36**, 1214.

[5] Kreezer, G., *Arch. Neurol. Psychiat.*, 1936, **36**, 1206.

quite variable, being well-defined one week and hardly noticeable the next. By the end of the fourth month, however, they are usually well-established and can be reproduced consistently. Thereafter they gradually increase in frequency and reach the adult level (approximately 9 oscillations per second) at about 8 years. This gradual increase in the frequency of the alpha waves over the period from the third month to the eighth year is in general agreement with Lindsley's observations. Our data, however, fail to show any acceleration beyond the adult average from the tenth to the twelfth years such as he has reported.

While no rhythmic activity is observed over the occipital region before the third or fourth month with the above described technique, simultaneous tracings obtained from electrode positions over other underlying cortical areas do show periodic waves long before this time. These waves appear only when the infant is asleep; they may be present within a few days after birth and may be of various rates and amplitudes. One example of this early rhythmic activity is given in Fig. 1, which shows tracings taken simultaneously from 3 separate areas on the scalp in a sleeping infant 12 days old. As shown in the figure, the upper tracing is taken from the occipital region. The electrodes for the middle tracings are over the motor

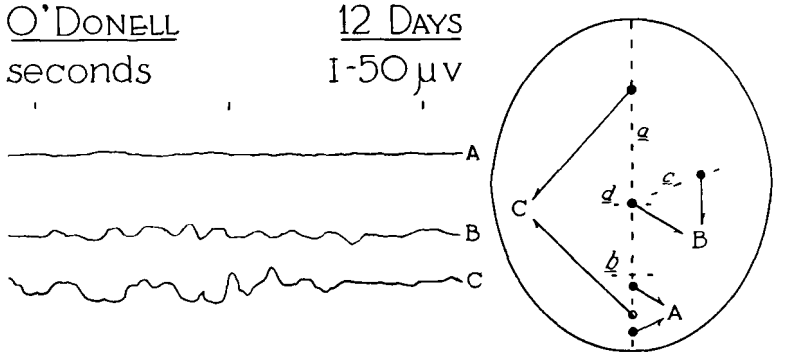

FIG. 1.

Brain potentials from sleeping infant 12 days old. The paired electrode positions are shown in approximate relation to underlying cortical structures in the schematic figure at the right. Upper tracing, leads A: occipital lobes over midline *a* posterior to parieto-occipital sulcus *b*; middle tracing, leads B: motor region approximately over central sulcus *c* with medial lead over superior Rolandic point *d*; lower tracing leads C: occipital to frontal over midline. Time interval is one second. All amplifiers equated at the gain indicated.

Note the presence of well-defined periodic waves at about 5 per second over the motor region and the absence of any rhythmic waves over the occipital area.

region, one being on the so-called "superior Rolandic point" and the other 4 cm. away at an angle of 70° with the midline, anterior to

this point and thus approximately over the central sulcus. The electrodes for the lower tracing include between them practically the entire cortex along the midline, one being over the mid-occipital region and the other just anterior to the anterior fontanelle. The 3 amplifiers are equated in gain. It is to be noted that while there is no semblance of any rhythmic activity over the occipital region, well-defined periodic waves at approximately 5 per second are present over the motor region. These latter waves as shown by the lower tracing are not quite so well-defined when the leads include the whole cortex between them. Repeated observations have shown that the essential conditions for the appearance of these waves during the first few weeks after birth are that one or both electrodes should be over the motor region or that the latter area should be included between the electrodes, and that the child should be asleep. Their probable origin in the motor region is thus indicated.

Waves at 4 to 5 per second similar to those already described have been observed as early as the first post-natal day. They do not appear to be the forerunner of the familiar 10 per second alpha waves but rather of large slow rhythmic waves at 4 to 5 per second which have regularly been observed in older children during states of drowsiness and light sleep and which also appear to originate in the motor region. It should be noted that Kreezer[5] has also reported large slow waves at 4 to 5 per second appearing over the motor area in mongoloid defectives with mental ages below 5 years.

Rhythmic waves at 8 per second, as well as faster, smaller oscillations varying from 12 to 15 per second have also been observed within a few days after birth. These latter waves also have their counterparts in comparable frequencies which have been observed repeatedly in older children during sleep. The faster, smaller waves particularly have been found by the writer to appear typically over the motor region and only during deep sleep. They probably correspond to the 14 per second waves reported by Loomis, Harvey and Hobart[3] as appearing during sleep in adults.