Brain wave changes in adolescence signal reorganization of the brain

December 6 2006

Brain wave changes in adolescence are related to age, not sexual maturation, and may be associated with one of the brain's major reorganization projects: synaptic pruning, a new study finds.

The study, "The adolescent decline of NREM delta, an indicator of brain maturation, is linked to age and sex but not to pubertal stage," was undertaken by Irwin Feinberg, Lisa M. Higgins, Wong Yu Khaw and Ian G. Campbell, all of the University of California, Davis. The American Physiological Society published the study, which appears in the December issue of the *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*.

In childhood, the brain has many synapses -- small junctions between neurons that transmit signals. The more junctions there are, the more intense the brain activity. During adolescence, the brain reorganizes and eliminates many synaptic connections, a process known as synaptic pruning.

This pruning makes the brain's information processing more efficient and powerful while consuming less energy. Previous studies have found that there is a steep decline in sleep slow wave activity, the delta wave, during adolescence. The authors hypothesized that the decline is caused by age-programmed synaptic pruning.

Brain changes begin at age 11

This study followed two groups of children over the course of two years: 31 children were nine years old at the beginning of the study. Thirty-eight children were 12 years old.

The researchers used an in-home electroencephalograph (EEG) to record the children's brain activity during sleep. Measurements were taken at six-month intervals and analyzed by computer. The researchers also recorded sexual maturity and physical growth (height, weight and body mass index) at each interval.

They found delta wave intensity across the 9-11 age group was:

- unchanged
- the same for girls and boys

They found delta wave intensity across the 12-14 year group:

- declined by 25%
- was related to age but unrelated to physical growth and sexual maturation
- was related to gender, with lower intensity in girls than boys because girls begin the brain reorganization sooner
- was unrelated to the later bed times and reduction in total sleep time that occurs during adolescence

Changes related to age

Previous studies had shown a delta wave activity decline of 50% between ages 10 and 20, but it was unclear when the change began and whether there were gender differences, Feinberg said. This study shows that changes in delta wave activity during sleep begin at about 11 years of age and declines 25% by age 14.

The gender difference observed in delta intensity among the 12-14 year old children suggests that girls, on average, begin adolescent brain maturation at least one year earlier than boys. However, once they begin this maturational process, it proceeds at the same rate in both sexes. Also, previous research had not resolved whether these changes are related to sexual maturation. This study suggests the change in delta wave activity occurs with age, not sexual maturity.

"It may seem surprising that age is the (predominant) factor in the delta power density decline," the authors wrote. "However, many maturational events in the development of the nervous system proceed on a programmed schedule." It is still possible, however, that the unknown brain stimulus that initiates sexual maturation in adolescence also initiates the changes in the brain, but that the processes then proceed independently.

"Longitudinal sleep EEG measurement could also provide a new arena for clinical studies of subjects at high risk of schizophrenia and other neurodevelopmental disorders," the authors noted. The emergence of schizophrenia during adolescence and the dramatic change in delta wave activity during that time might both be related to synaptic pruning, Feinberg said. "It is possible that sleep EEG changes will prove a relatively direct indicator of synaptic pruning," the authors concluded

Source: American Physiological Society