Chapter 17
The Relationship between Sleep Apnea and Cognitive Functioning

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ABSTRACT
The brain is the most complicated and least studied area of Neuroscience. In recent times, it has been one of the fastest growing areas of study in the Medical Sciences. This is mostly due to computers and computational techniques that have emerged in the last 10-15 years. Cognitive Neuropsychology aims to understand how the structure and function of the brain relates to psychological processes. It places emphasis on studying the cognitive effects of brain injury or neurological illness with a view to inferring models of normal cognitive functioning. We investigate the relationship between sleep apnea and learning disorders. Sleep apnea is a neural disorder, where individuals find it difficult to sleep because they stop breathing. We want to see if patients with learning disabilities should be treated for sleep apnea.

BACKGROUND
Sleep Apnea
We have a number of different datasets of EEG data of children collected concerning both the reactions to different stimuli and from sleep apnea studies. These data have been completely de-identified and will be used throughout this project. Generally, EEG data are collected using a Geodesic Sensor Net. (Johnson et al., 2001; Tucker, 1993) This is a system that allows the mapping of brain activity data using a cap containing 128 electrodes. The cap is placed on the subject’s head. This system makes it much easier to collect brain activity data from children since previously, collecting these type of data required electrodes to be placed on a person’s head one-at-a-time using applicator gel. Most children will not sit still for this type of research. The Geodesic Sensor Net allows all of the electrodes to be placed on a child’s head at once and collection of data is much faster than using the old EEG or electro-encephalogram method. Data are recorded at fixed time intervals, usually measured in seconds.
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For example, in the data analyzed for any one child, an entire collection of 250 data points can be recorded in under 20 minutes.

Figure 1 represents the positioning of the electrodes for a 128 channel Geodesic Sensor Net.

The electrodes that appear vertically in the center of the chart, running from top to bottom, divide the other electrodes into left and right sections. For statistical analyses, all electrode readings from the left side of the brain can be averaged to one value as can all values from the right side of the brain. The brain positioning of all electrodes is shown in Table 1.

The EEG data, then, have hundreds, sometimes, thousands of data points recorded in sequence from each of the net sensors. There may be just a handful of subjects in a study, with each subject having these multiple recordings of data. The methods used to model the data must be able to accommodate the type of data collected.

For each electrode, then, we have a sequence $X_{i1}, X_{i2}, \ldots, X_{in}$ representing the first to the last timed reading (assuming a total of $n$ readings). The value $i$ represents the specific electrode. This sequence is not a random sample since it is clear that $X_{it}$ is related to $X_{i,t+1}$. It is also questionable whether we can assume stationarity, meaning that $X_{it}$ and $X_{i,t+1}$ have the same probability distribution. For the purposes of this study, we will make such an assumption. Moreover, if $i$ and $j$ are in
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