ABSTRACTS

AN IMPROVED METHOD FOR EEG ANALYSIS AND COMPUTER-AIDED SLEEP SCORING

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In recent years several methods have been suggested for automatic EEG analysis as a basis for computerized sleep scoring (1,2). Most have used either power spectral analysis by the Fast Fourier Transform (FFT), or period-amplitude analysis (PAA). PAA has the advantage of being able to assess independently any changes in the number of waves, their period length or frequency and their amplitude. FFT gives results only in terms of total power at particular frequencies. However, none of the existing methods, whether using FFT or PAA, gives results which are related in a simple, quantitative way to existing definitions of sleep stages. We have developed an improved PAA method which overcomes these problems by using on-line computer analysis with our own hardware and software. It provides simple, condensed graphical summaries of the sleep EEG, related directly to sleep stages.

The EEG signal, digitized at 250 samples per sec, is analysed on-line for each 20-sec epoch of recording. Intervals between consecutive zero-crossings (half-periods) are measured in millisecs and each half-peak amplitude in microvolts. The unique feature of this method lies in how this information is further processed and displayed. Vertical lines representing each 20 sec of data are displayed continuously on a screen and then printed in colour every 90 mins during recording. Each line is divided into coloured segments, the lengths of which represent the percentages of epoch time taken up by waves in various period windows, equivalent to the following frequencies, but with the delta-wave segment further subdivided into amplitude categories (peak-to-peak).

Percent Time Segment	Frequency(Hz)	Amplitude
Beta	16.0 - 32.0	All
Sigma	12.0 - 15.9	All
Alpha	8.0 - 11.9	All
Theta-A	5.0 - 7.9	All
Theta-D	3.1 - 4.9	All
Delta-L	0.5 - 3.0	< 40 microvolts
Delta-M	0.5 - 3.0	40 - 75 microvolts
Delta-H	0.5 - 3.0	> 75 microvolts
Sub-Delta	< 0.5	All

Several of these parameters have not been used previously. Theta waves are subdivided according to their frequency into Theta-A, which behave like low-frequency alpha-waves, and Theta-D which behave more like high frequency delta-waves during sleep. The percent time taken up by Delta-H waves (amplitude greater than 75 microvolts) gives an objective measurement which relates directly to the usual, visually scored sleep stages, especially for NREM. The cut-off between St 2 and St 3 is 20% and between St 3 and St 4 is 50%. Other new parameters, made possible by our method, are the percent time of low or medium amplitude delta-waves (Delta-L or Delta-M). These help distinguish St 1 and REM from NREM and wakefulness. Sub-Delta waves are mainly artefacts.

The raw EEG is also passed through a high-pass filter (>5Hz) to remove delta-waves and is then digitized in parallel with the main EEG channel. Separate PAA is carried out on this filtered EEG to detect and count spindles by a method similar to that of Gondek et al (3). The mean amplitude of all waves with frequencies greater than 8Hz is also calculated and displayed graphically.

These methods form part of an integrated 48-channel digital recording and analysis system which deals with two patients simultaneously. This was manufactured by Compumedics Pty Ltd in Melbourne, Australia. In addition to the EEG analysis and spindle count for each epoch this system summarizes graphically (and stores numerically in a spreadsheet) the number of REMS, the mean EMG (submental) amplitude, number of snoring noises, leg movements, sleeping position, mean or minimum SaO2, and presence of apneas determined from nasal and oral airflow and respiratory movements. Taking all this information into account a night's results of polysomnography can be scored in terms of sleep stages in a few minutes with little reference to the raw data which can, nevertheless, be displayed in epochs from the hard disc and printed as required.

(1) Penzel T, Peter JH, et al. Computerized continuous sleep stage classification in patients with sleep apnea: a new EEG monitoring method in diagnosis and therapy. Sleep Research 1988, 17:346
(2) Feinberg I, March JD et al. Period and amplitude analysis of 0.5 - 3 c/sec activity in NREM sleep of young adults. Electroenceph. Clin. Neurophysiol 1978, 44: 202-213
(3) Gondek A, Smith JR, et al. A specific Σ-spindle detector. Psychophysiology 1972,9(1):141