Matters arising

Spectral Analysis of Tremor

Sir: A major pitfall in spectral analysis of limb tremors is one in which classical Fourier methods are applied directly to a stochastic time series. Generally, amplitude histograms calculated for small-amplitude hand tremor records are nearly Gaussian. (For consideration of the stochastic nature of hand tremor, see J Randall, *J Appl Physiol* 1973;**34**:390-5). Fourier methods fail when applied to such a time series. The basic reason for this failure is that this method is based on the assumption of fixed amplitudes, frequencies, and phases. According to Jenkins and Watts (*Spectral Analysis and its applications*, Holden Day, 1968, Ch. 6), "the estimator of the spectrum obtained from consideration of Fourier analysis, namely the sample spectrum, has the unfortunate property that its variance does not decrease as the length of the time series increases." However, ". . . a stationary stochastic process is simply described by its autocovariance function . . ." An equivalent description of the autocovariance function is provided by its power spectrum. A recent report by Findley et al (*J Neurol Neurosurg and Psychiatry* 1981;**44**:534-46) illustrates the application of Fourier analysis directly to digitised hand tremor records. Certain of their spectra of hand tremor records obtained from normal subjects display several bands, while a single prominent band is generally found by autocovariance and power spectral analysis of small-displacement hand tremor records. However, certain of the spectral bands found by Findley *et al* may not be real, since Jenkins and Watts indicate that sample spectra may display erratic behavior when Fourier analysis is applied directly to a stochastic time series.

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GRESTY REPLIES

Sir: Dr Robert Stiles kindly sent me a copy of his letter to the Editor concerning the appropriate conditions for application of Fourier analysis to small amplitude hand tremor records and its possible misapplication to normal hand tremor in a recent article by Findley *et al.* The comments contained in this letter highlight important considerations and we would welcome an opportunity to clarify matters.

Firstly, we would agree that in many (but not all) normal subjects, hand tremor has an approximately Gaussian amplitude histogram reflecting a stochastic process and that analysis of such records requires care. On this point we assure Dr Stiles that either by computation of the spectrum from the autocovariance function or by application of a suitably structured Fourier transform (Hewlett Packard Users Guide 05420 p 5-9. "Random line shape") multiple spectral bands are found in some normal subjects. Of greater importance is the question "what do they mean?" to which the answer is "not very much", at least in frequency terms. The spectrum of a random signal is in a sense only useful for indicating the energy distribution. Such a signal does not derive from a generator which is putting out deterministic signals with a stationary frequency content. This was our point in contrasting the spectrum of a normal hand tremor with the spectrum of the tremor following a period of isometric contraction. The normal spectrum indicates that the movement of the hand is attributable to a random series of events with little or no frequency structure. By contrast, following a period of tension a distinct dominant frequency band emerges. This does not represent random events but could be related to rhythmical EMG activity.

We would raise a general objection to lumping all normal tremor, that is to say "asymptomatic tremor" as being homogenous. Normal subjects show individual patterns of tremor, some have distinct rhythmical patterns of sinusoidal oscillations, others being of apparently random wave forms. The tremor mechanisms may be common to all but parameters are set differently and the technique of analysis must be tailored to the individual.

MA GRESTY