Periodicities in the electrical signals generated by the brain bear information about its perceptual and cognitive functions. Specifically, in processing speech signals Ghitza and Greenberg [1] observed that natural brain rhythms in the range of 3 - 10 Hz. are related to the syllabic structure of speech and may play a role in decoding the speech signal. Palva [2,3] notes that EEG activity in the gamma (20 - 80 Hz.) band is sensitive to the presence of speech signals and that cross-frequency phase synchrony is observed to be due to specific mental processes. Fee [4] points out the importance of sequence generation in vocalization and suggests that chains of neurons in specific brain regions are responsible for timing sequences of articulatory events.

There are three mathematical models with which I am familiar that are presently being offered to explain the empirical studies cited above. First is some work by Brown et al. [5] that shows how synchrony encodes information in the brain. Starting with the Hodgkin-Huxley [9] equations for a neuron, they model large ensembles of neurons as systems of coupled ODEs. Passing to the limit of an infinite number of neurons, this system becomes a diffusion equation (PDE) in which the density of neurons is represented by a probability distribution. This equation can be solved numerically showing how the system may be forced into and out of synchrony. The simulation results agree well with recordings made from neurons in the locus ceruleus. Thomas and Kaufman [6] show how non-linear dynamical systems can display stability far from equilibrium and that the traces in phase space can be related to sequential operations in neural networks. They show how the equilibria can be calculated from the forcing function and their stability determined from the eigenvalues of its Jacobian evaluated at the equilibrium points. Levinson [7] recounts many techniques for representing different levels of linguistic structure using stochastic models such as Hidden Markov models and stochastic grammars.

Both the experimental and theoretical investigations are powerful ways of exploring brain function in language processing and should be vigorously pursued. There is, however, an interesting alternative based on the notion of functional equivalence the underlying idea of which is that it is not necessary to understand the brain at the neuronal level in order to explain its function. We have been studying automatic language acquisition by autonomous anthropomorphic robots [8]. An important feature of this work is the presence of an integrated sensori-motor periphery without which the language faculty would not be possible. This work suggests that when we seek to discover temporal structure in brain signals associated with speech processing we should consider electrical signals originating in all sensory and motor areas of the cortex.