EEG PHASE LOCKING DURING COGNITIVE PROCESSING

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The physiological mechanisms at cellular levels underlying EEG are outlined. A single conceptual framework in which to view EEG, ERP, MEG, fMRI and PET is proposed. Neocortical dynamics and behavior/cognition are viewed in the context of *cell assemblies* (or neural networks) embedded within *synaptic action fields*. These so-called synaptic action fields are simply the numbers of active synapses per unit volume, independent of their functions. The introduction of such *fields* to neuroscience has two complementary motivations: 1) To provide a direct link between synaptic or action potential activity and scalp potentials 2) To suggest the importance of top-down interactions between the synaptic fields and network activity, analogous to top-down cultural influences on social networks. Complex dynamical systems are typically characterized by both top-down and bottom-up interactions, called *circular causality* in the field of *Synergetics*, for example. A similar picture is proposed for neocortex in which the so-called localized functional regions obtained with fMRI and PET are viewed as *hubs* in the various networks.

Brains apparently operate at various intermediate dynamic states between the extremes of *global coherence* (widespread neural masses acting together) and *functional localization* (regional tissue acting independently). Differences in this local-global "balance" are associated with different cognitive or behavioral states. In this context, several similar measures of neocortical dynamics are discussed, *covariance*, *coherence*, *phase synchronization* and *bicoherence*.

Every *cognitive brain state* may be identified with some combination of dynamic measures, the *dynamic brain state*, including the above measures of local versus global dominance. For example, the coherence or covariance between every electrode pair (2016) in a 64-channel recording might be used to define *dynamic brain state*. With the covariance measure, normally applied to transient ERP's as in the work of Alan Gevins and colleagues, spatial covariance patterns are obtained at different latencies from the stimulus. With the coherence measure, applicable to spontaneous EEG or steady-state evoked potentials as in the works of Petsche, Thatcher, Silberstein, Pfurtscheller, Lopes da Silva, Schack, Nunez and others, spatial coherence patterns are obtained in specific frequency bands.

Any such analyses of *spatial patterns* are limited by the distortions of volume conduction and reference electrode. *High-resolution EEG* provides estimates of dura surface potential independently of assumptions about the nature of brain sources. The accuracy of high-resolution EEG is discussed briefly. High-resolution EEG data showing various measures of phase locking in the theta and upper alpha bands during mental calculations is presented in the context of the proposed conceptual framework