Multimodal imaging of alpha rhythms: from local field potentials, EEG/MEG, fMRI to BCI

Lopes da Silva F.¹
Centre of Neuroscience, Swammerdam Institute for Life Sciences, University of Amsterdam.

There are several kinds of brain rhythmic activities within the alpha frequency range that have different distributions in the cortex (visual cortex, sensorimotor cortex (mu rhythm), auditory cortex (tau rhythm)) and functional connotations. A well established feature of the visual alpha is that its neuronal generators at the level of local field potentials (LFPs) constitute cortical dipolar fields centered on layer V-IV¹. In addition, recent findings in monkey² showed that alpha rhythms occurring in deep layers are associated with gamma-band activity in superficial cortical layers, and that alpha and gamma power are anti-correlated, displaying different dynamics in space and time associated with attention³.

Dipolar source localization based on scalp distributions of alpha and mu rhythmic activities reveals complementary information obtained from EEG and MEG recordings⁴; simultaneous recordings of EEG and fMRI puts in evidence typical correlations between alpha power modulation and BOLD signals, characteristic of the resting state⁵.

Both in the visual and in the sensorimotor modalities alpha /mu power⁶ and phase⁷ can modulate sensory perception demonstrating that alpha rhythms constitute oscillations of brain excitability expressed in “attention systems”, such that the threshold of sensory detection fluctuates over time along with the power and phase of these ongoing rhythmic activities. These findings support the notion that ongoing rhythmic oscillations within the alpha frequency range modulate attention and perception, and appear to operate as “traffic controllers” of the flow of neural information in thalamo-cortical systems. Thus it is not appropriate to say that alpha activity corresponds to an “idling state”; it rather corresponds to an active “gating” process⁸ that may be operational in controlling the focus of attention. This latter feature is particularly evident with respect to the phenomenon of event-related “(de)synchronization” of the sensorimotor mu rhythm, with characteristic spatial and dynamic properties⁹ associated with the intention to make, or to imagine a movement. Furthermore in this way it is possible to generate specific brain signals at will, with a high degree of accuracy⁹, that can be transformed into electrical messages acting on the environment by means of Brain Computer Interfaces (BCI).