Spatio-temporal power of the cortex

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Résumé

Cortical activity not only oscillates in time (e.g., alpha-band) but also displays monotonic phase shifts over space. During visual tasks, these traveling waves (TWs) have been described in visual cortex and related regions over a range of spatial scales, from columns in V1 to global cortex using MEG/EEG measures. The waves indicate a dominance of low *$spatial$* frequency components i.e., large-scale patterns of activity from millimetres to decimetres. In visual neuroscience, the method of differencing between experimental conditions and use of source localization techniques tend to emphasize local foci of activity, limited only by the measurements' spatial resolution. The implied spatial frequency spectrum peaks at higher frequencies.

Previous analyses of cortical activity have revealed an approximately $1/(f\hat{}m)$ spatial spectrum, where the positive exponent m varies depending on whether the observations are (a) at the cortical surface (e.g., ECoG) or (b) extra-cranial (e.g., EEG). Spectra may differ due to the spacing of electrodes-finer sampling in (a) giving smaller m and a higher cut-off for the minimum measurable spatial frequency. These measurement effects de-emphasize large-scale patterns. The volume conduction effects in (b) give larger m and emphasize large-scale patterns. In either case, the measured cortical activity is dominated by low spatial frequency components (hence $1/(f\hat{}m)$ within the measurable spectrum), more consistent with TW activity and less with foci of activation in real-time signal.

We sought to clarify the relation between observed TWs and focal activations by simultaneous measurement of spatio-temporal dynamics at two different spatial scales, i.e., depth (sEEG) and surface (ECoG) cortical contacts, while participants (n=9) performed a visual categorization task. Estimation of the spatial frequency spectrum in sEEG and ECoG is hampered by the shape of the cortex and contacts' spacing. The spatio-temporal dynamics for each set of contacts was decomposed into spatial and temporal modes using singular value decomposition. From these components we computed the spatial frequency spectra of the activity. sEEG and ECoG components with the lowest spatial frequencies accounted for more variance in the signal than high spatial frequency components. The quantified spectra are consistent with dominance of TWs over focal activations.

Mots-Clés: cortex, spectra, visual, traveling waves, sEEG, ECoG

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