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# Dynamic causal modeling of cortico-cortical evoked potentials

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## Résumé

Epilepsy surgery procedures may use focal intracortical electrical stimulation using depth electrodes. These local stimulations propagate through white matter fibers to generate cortico-cortical evoked responses (CCEP) at distant sites.

In this study, we aimed at developing a biophysical modeling approach allowing to precisely estimate CCEPs features. Using dynamic causal modeling, a CCEP was considered as the activity generated by a transient stimulus entering the stimulated region, which in turn was directly connected to the recording region. Both regions were modeled with a neural mass model. The neuronal parameters of the model were estimated from the first CCEP component, occurring before 80 ms, using Bayesian model inversion. This methodology was applied to 301 epileptic patients from the F-TRACT database, providing a total of 9229 bipolar stimulations (90460 CCEPs). We focused the group analysis on the estimation of the axonal conduction delays between cortical regions and the local synaptic (excitatory and inhibitory) time constants. The cortical mapping of these neuronal parameters was obtained at the group level using anatomical-based averaging procedures, based on the *Lausanne2008* (130 parcels) and the *HCP-MMP1* (360 parcels) parcellation schemes.

Considering the group of patients older than 15 years old, we found that the cortico-cortical axonal conduction delays between parcels were globally very short (median=2.9ms) and only 16% (resp. 4%) were larger than 10ms (resp. 20ms). This was associated to a median velocity of 13 m/s. Synaptic dynamics were found faster in the sensorimotor and latero-temporal regions, compared to other parcels. For the group of patients younger than 15 years old, both neuronal delays were found significantly larger.

To our knowledge, this study is the first to propose an in vivo and local estimation of axonal conduction and synaptic delays across the whole human cortex, based on electrophysiological recordings. Importantly, these results will be available to the scientific community as part of the F-TRACT atlas ([ftract.eu](http://ftract.eu)).

**Mots-Clés:** Cortico, cortical evoked potential, direct electrical stimulation, dynamic causal modeling, axonal conduction delay, synaptic delay

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