Intrinsic network properties govern the network response to repetitive Transcranial Magnetic Stimulation (rTMS) in a neuronal network model simulating the effects of rTMS

Since the underlying principles of the complex neuronal interaction in the brain are still far from being understood, network models are widely used to simulate neural activity. Classic neural network models based on binary neurons have limited dynamics and are not suitable to explain the highly chaotic behavior observed in measurement data. Yet, by adding the capability of summating the synaptic input over time, they offer chaotic dynamics in combination with computational efficiency [1]. Models of spiking neurons consider the number of spikes and their timing and range from detailed biophysical representations of neuronal activity [2] based on differential equations [3] to Integrate and Fire (IF) models. These networks exhibit rich dynamical properties [4] and account for results in the field of neuroscience.

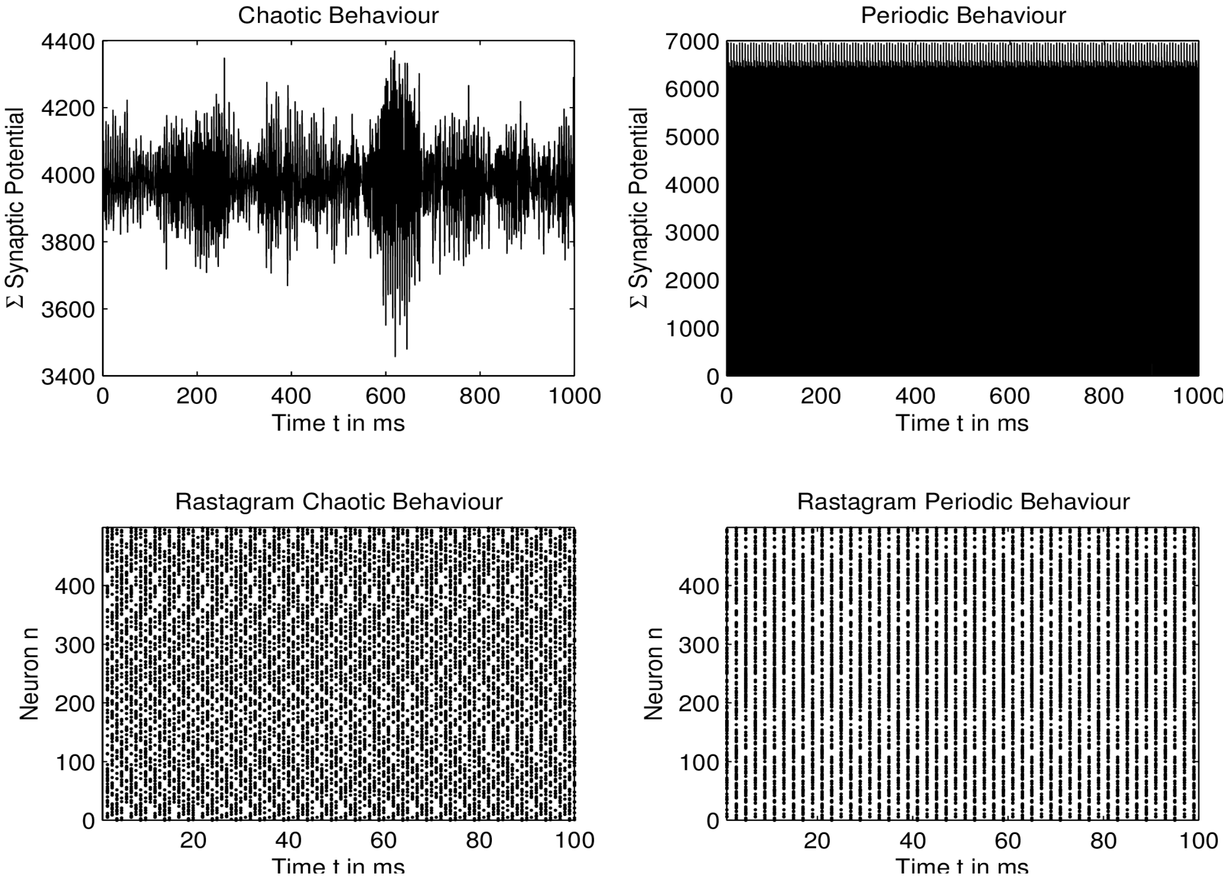
In spite of the vast number of models, there is still a gap between the theoretical findings and their mapping to neuropsychiatric and neurological disorders which are often characterized by an impaired resting state activity due to an altered connectivity. There is a need for models that account for the relation between local synaptic organization and transitions from normal to impaired neural activity.

In order to investigate the responsiveness of the resting state activity to external influences, such as medication or repetitive transcranial magnetic stimulation (rTMS), we use a time-summating binary network model for simulating the effect of synaptic layout and external influences, i.e. rTMS stimulation, on network activity with the following results:

(I) We observe two types of dynamics: a chaotic activity, and a seizure-like periodic activity [5] with large groups of neurons alternately firing together (Figure 1).

(II) A perturbation can convert periodic into chaotic activity or vice versa depending on the synaptic layout.

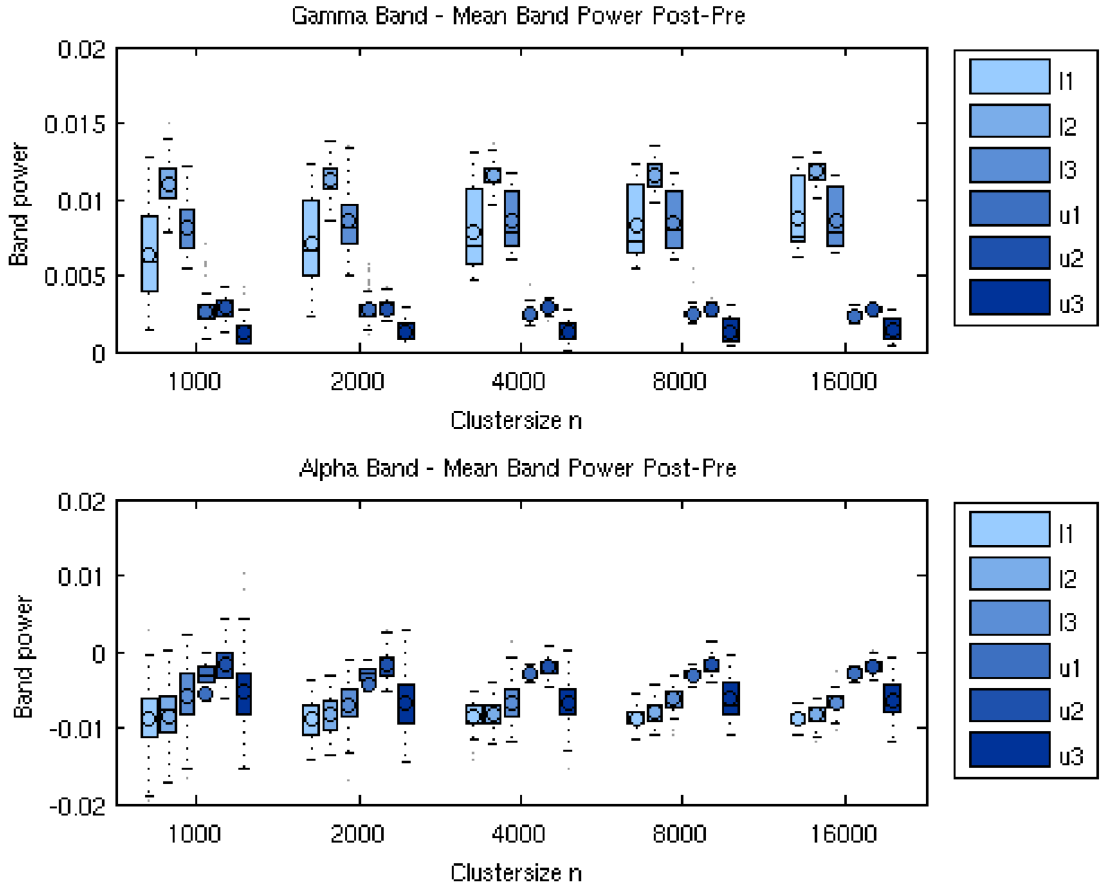
(III) We define a lower and upper parameter regime of the synaptic layout for which the chaotic



activity is altered by perturbation but not zero or periodic.

(IV) We calculate the mean band power of the EEG frequency bands using the network output and state a rising band power in the alpha and gamma band after perturbation in the lower regime, whereas in the upper regime, the band power is stable (see Figure 2).

In combination with our previous findings [6], it is further substantiated that the synaptic connectivity not only forms and maintains resting state activity but also affects the influence of rTMS application on resting state activity.



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