Supplementary Materials part 1:

Quantitative model description

and parameter values

THE RELATIONSHIP BETWEEN OSCILLATIONS IN BRAIN REGIONS AND FUNCTIONAL CONNECTIVITY: A CRITICAL ANALYSIS WITH THE AID OF NEURAL MASS MODELS

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1). The equations of a single ROI are written below:

Pyramidal neurons

$$\frac{dy_p(t)}{dt} = x_p(t) \tag{1}$$

$$\frac{dx_p(t)}{dt} = G_e \omega_e z_p(t) \quad - 2\omega_e x_p(t) - \omega_e^2 y_p(t) \tag{2}$$

$$z_p(t) = \frac{2e_0}{1 + e^{-rv_p}} \tag{3}$$

$$v_p(t) = C_{pe} y_e(t) - C_{ps} y_s(t) \quad - C_{pf} y_f(t) \tag{4}$$

Excitatory interneurons

$$\frac{dy_e(t)}{dt} = x_e(t) \tag{5}$$

$$\frac{dx_e(t)}{dt} = G_e \omega_e \left(z_e(t) + \frac{u_p(t)}{C_{pe}} \right) \quad - 2\omega_e x_e(t) - \omega_e^2 y_e(t) \tag{6}$$

$$z_e(t) = \frac{2e_0}{1 + e^{-rv_e}} \tag{7}$$

$$v_e(t) = C_{ep} y_p(t) \tag{8}$$

Slow inhibitory interneurons

$$\frac{dy_s(t)}{dt} = x_s(t) \tag{9}$$

$$\frac{dx_s(t)}{dt} = G_s \omega_s z_s(t) \quad - 2\omega_s x_s(t) - \omega_s^2 y_s(t) \tag{10}$$

$$z_s(t) = \frac{2e_0}{1 + e^{-rv_s}} \tag{11}$$

$$v_s(t) = C_{sp} y_p(t) \tag{12}$$

Fast inhibitory interneurons

$$\frac{dy_f(t)}{dt} = x_f(t) \tag{13}$$

$$\frac{dx_f(t)}{dt} = G_f \omega_f z_f(t) \quad - 2\omega_f x_f(t) - \omega_f^2 y_f(t) \tag{14}$$

$$\frac{dy_l(t)}{dt} = x_l(t) \tag{15}$$

$$\frac{dx_l(t)}{dt} = G_e \omega_e u_f(t) \quad - 2\omega_e x_l(t) - \omega_e^2 y_l(t) \tag{16}$$

$$z_f(t) = \frac{2e_0}{1+e^{-rv_f}} \tag{17}$$

$$v_f(t) = C_{fp} y_p(t) - C_{fs} y_s(t) \quad - C_{ff} y_f(t) + y_l(t) \tag{18}$$

To simulate connectivity, we assumed that the average spike density of pyramidal neurons of the presynaptic area (z_p^k) affects the target region via a weight factor, W_j^{hk} (where $j = p$ or f, depending on whether the synapse targets pyramidal neurons or fast inhibitory interneurons) and a time delay, T. This is achieved by modifying the input quantities u_p^h and/or u_f^h of the target region.

Hence, we can write

$$u_j^h(t) = n_j^h(t) + \sum_k W_j^{hk} z_p^k(t-T) + I_j \qquad j = p, f \tag{19}$$

I_j represents the external input. In this work we assumed that only the input to the pyramidal populations is non null, while the input to the fast-inhibitory populations I_f = 0. $n_j(t)$ represents a Gaussian white noise (in the present work, if not explicitly modified, we used: mean value m_j = 0 and variance $\sigma_j^2 = 5/dt$,where dt is the integration step) superimposed on the external input. The sum in Eq. (19) is extended to all presynaptic regions k which affect the post synaptic region h. Table S1 reports the parameter values of the neural populations in the four different ROIs (set to obtain the four different rhythms), including the basal values for the inputs I_p to pyramidal populations; however note that the values of the inputs I_p are changed during the different trials (see text)

Table S1

Part I - Parameters assumed fixed for the four populations

Parameter	**value**	**meaning**
$\boldsymbol{e_0}$	2.5 Hz	Saturation of the sigmoid
$\boldsymbol{s_0}$	10 Hz	Center of the sigmoid
r	0.56 mV^{-1}	Slope of the sigmoid
T	10 ms	Delay
Ge	5.17 mV	Synaptic gain of excitatory
Gs	4.45 mV	Synaptic gain of inhibitory slow
Gf	57.1 mV	Synaptic gain of inhibitory fast

Part II – Parameters values used for the four populations

Parameter	$\boldsymbol{ROI_\theta}$	$\boldsymbol{ROI_\alpha}$	$\boldsymbol{ROI_\beta}$	$\boldsymbol{ROI_\gamma}$	**Meaning**
Cep	54	54	54	54	Internal Connectivity Constant
Cpe	54	54	54	54	“
Csp	54	54	54	54	“
Cps	67.5	450	67.5	67.5	“
Cfs	15	10	27	27	“
Cfp	27	35	54	108	“
Cpf	300	300	540	300	“
Cff	10	25	10	10	“
$\boldsymbol{\omega_e}$	75 s^{-1}	66 s^{-1}	68.5 s^{-1}	125 s^{-1}	Reciprocal of time constant of excitatory synapses
$\boldsymbol{\omega_s}$	30 s^{-1}	42 s^{-1}	30 s^{-1}	30 s^{-1}	Reciprocal of time constant of inhibitory slow synapses
$\boldsymbol{\omega_f}$	300 s^{-1}	300 s^{-1}	300 s^{-1}	400 s^{-1}	Reciprocal of time constant of inhibitory fast synapses
$\boldsymbol{I_p}$	400 s^{-1}	200 s^{-1}	400 s^{-1}	400 s^{-1}	External input to pyramidal neural population