Supporting material

S.1 Electrovascular model

Neural mass model The equations used to generate the electrical dynamics in the cortical unit are summarised below:

$$
\begin{aligned}
\tau_m \frac{dV_{IN}^T(t)}{dt} + V_{IN}^T(t) &= I_3^+(t) R_m^0 \\
\tau_m \frac{dV_{IN}^F(t)}{dt} + V_{IN}^F(t) &= I^+(t) R_m^0 \\
\tau_m \frac{d\nu_1(t)}{dt} + \nu_1(t) &= R_m^1 I_1^+(t) \\
\tau_m \frac{d\nu_2(t)}{dt} + \nu_2(t) &= R_m^2 I_2^+(t) \\
\tau_m \frac{d\nu_-(t)}{dt} + \nu_-(t) &= R_m I^-(t) \\
\tau_m \frac{dV_{PC}(t)}{dt} &= -(\alpha_0 + \sum_k \frac{1}{\beta_k}) V_{PC}(t) + \frac{\Omega(t)}{\prod_k \beta_k} + R_m I^-(t) \\
&+ \sum_k \left[\frac{R_m \nu_k(t)}{(R_i^k + R_e^k)} - \frac{\nu_-(t)}{\beta_k} \right] \qquad (1) \\
\tau_m \frac{d\Omega(t)}{dt} &= R_m \sum_k \frac{\beta_k (V_{PC}(t) - \nu_k(t))}{(R_i^k + R_e^k)} + V_{PC}(t) + \nu_-(t) - \Omega(t) \\
\tau_m \frac{d\rho(t)}{dt} &= -(\alpha_0 + \sum_k \frac{1}{\beta_k}) \rho(t) + \frac{\Theta(t)}{\prod_k \beta_k} \\
&+ \frac{R_e^2}{(R_i^2 + R_e^2)} (R_m I^-(t) + R_m^2 I_2^+(t)) \\
&+ \frac{[R_m^1 (\nu_-(t) + \nu_2(t)) + R_m(\nu_2(t) - \nu_1(t))] R_e^2}{\prod_k (R_i^k + R_e^k)} \\
\tau_m \frac{d\Theta(t)}{dt} &= \left[1 + R_m \sum_k \frac{1}{R_m^k} \right] \rho(t) - \Theta(t). \qquad (2)
\end{aligned}
$$

Balloon model Below is a summary of the Balloon model's equations:

$$
\begin{aligned}
\frac{ds(t)}{dt} &= z(t) - \frac{s(t)}{\tau_s} - \frac{f(t) - 1}{\tau_f} \\
\frac{df(t)}{dt} &= s(t) \\
\tau_0 \frac{d\nu(t)}{dt} &= f(t) - \nu(t)^{1/\alpha} \qquad (3) \\
\tau_0 \frac{dq(t)}{dt} &= \frac{f(t)}{E_0} [1 - (1 - E_0)^{1/f(t)}] - q(t) \nu(t)^{(1-\alpha)/\alpha}.
\end{aligned}
$$

Table 1. Electrical and vascular states

Electrical and vascular states			
Type	State	Symbol	Initial value
Electrical			
	Membrane potential at the soma of GABAergic IN (Transmission)	V_{IN}^{T}	0
	Membrane potential at the soma of GABAergic IN (Feedback)	V_{IN}^{F}	0
	Membrane potential at the soma of Layer V PC	V_{PC}	0
	Voltage difference	Ω	0
	Equivalent voltage source at the layer V PC basal dendrites	ν_1	0
	Equivalent voltage source at the layer V PC apical tuft dendrites	ν_2	0
	Equivalent voltage source at the soma of layer V PC	ν_-	0
	Extracellular voltage difference along the layer V PC apical tuft	ρ	0
	Voltage difference	Θ	0
	Time derivative of the input (extended Balloon approach)	r	0
	Input (extended Balloon approach)	z	z_0
Vascular			
	Flow-inducing signal	s	0
	CBF	f	1
	CBV	ν	1
	Concentration of dHb	q	1

Table 2. Fixed parameters: these parameters are not estimated from the data.

Fixed parameters				
Type	Symbol	Parameter	Dimension	Value
Electrical				
	c_m	Membrane capacitance	$\mu F/cm^2$	0.75
	τ_m	Membrane time constant	ms	30
	C_m^0	Effective membrane resistance: soma compartment (IN)	nF	6.81
	C_m	Effective membrane capacitance: soma compartment (PC)	nF	1.045
	R_m^0	Membrane resistance: soma compartment (IN)	$G\Omega$	4.082
	R_m	Membrane resistance: soma compartment (PC)	$G\Omega$	2.871
	R_m^1	Membrane resistance: basal compartment	$G\Omega$	0.222
	R_m^2	Membrane resistance: apical tuft compartment	$G\Omega$	0.667
	R_i^1	Membrane resistance: basal longitudinal (intracellular)	$G\Omega$	0.226
	R_e^1	Membrane resistance: basal longitudinal (extracellular)	$G\Omega$	0.272
	R_i^2	Membrane resistance: apical longitudinal (intracellular)	$G\Omega$	2.264
	R_e^2	Membrane resistance: apical longitudinal (extracellular)	$G\Omega$	2.716
	α_{PC}	Layer V PC synaptic factor	$pA(0 \sim 1.5)$	0.4
	γ_{IN}	GABAergic IN voltage-ampere relationships	mV^{-1}	5
	V_0^{IN}	GABAergic IN voltage-ampere relationships	mV	0.7
	β_1	Basal voltage divisor	no dim.	2.24
	β_2	Apical voltage divisor	no dim.	7.45
	α_0	Mixed coefficient	no dim.	7.32
Others				
	χ_{PC}	Layer V PC energetic factor	$nM(0 \sim 1)$	1.0
	χ_{IN}	GABAergic IN energetic factor	$nM(0 \sim 1)$	0.8
	ω_0	Low-pass filter: angular high cut frequency	Hz	$2\pi 8$
	δ	Low-pass filter: damping factor	no dim.	0.8
	A	Low-pass filter: gain	nM^{-1}	1.0
	ρ_{PC}	Layer V PC nonlinear function	no dim.	1.0
	ρ_{IN}	GABAergic IN nonlinear function	no dim.	1.0
	ω_{PC}	Layer V PC nonlinear function	$(nA)^2$	0.1091
	ω_{IN}	GABAergic IN nonlinear function	$(nA)^2$	0.0464

Table 3. Model comparison results. Log-evidence values for each model, session and subject (low-frequencies, high-frequencies and all-frequencies). 'Sum' is the sum of the log-evidences per session and 'Group' the sum of all subjects' sums. The values in bold correspond to the winning model for each session and subject. BF_{12} are the log-Bayes factors between the best (1) and second best (2) model for each session. The values x^{*} correspond to a posterior probability for the best model higher than 0.95. The values x^{**} correspond to a posterior probability higher than 0.99. $^{\diamond}$One of the subjects lacked the 4.0 and 7.5 Hz stimulus epochs and was therefore not included in 'low-frequency' analyses.

Log-evidences, F_x, Bayes Factors B_{xy} and 'mixture' model coefficient (synaptic) ω_{in}						
Subject	Session	F_{mix}	F_{in}	F_{out}	BF_{12}	ω_{in}
Low	frequencies$^{\diamond}$	(4 to 15 Hz)				
1	1	-57.27	-55.69	-56.82	1.13	0.72
	2	-37.27	-34.89	-44.58	2.38	0.80
	3	-59.23	-59.01	-58.21	0.80	0.60
	Sum	-153.77	**-149.59**	-159.61	4.18*	0.71
2	1	-39.54	-38.53	-42.25	1.01	0.66
	2	-41.30	-40.16	-45.85	1.14	0.65
	3	-34.21	-33.40	-37.69	0.81	0.67
	Sum	-115.05	**-112.09**	-125.79	3.00*	0.69
Group		-268.82	**-261.68**	-285.40	7.14**	0.69
High	frequencies	(12 to 30 Hz)				
1	1	-37.85	-80.68	-43.22	5.37**	0.60
	2	-32.59	-45.90	-35.21	2.62	0.40
	3	-47.59	-44.56	-87.01	3.03*	0.83
	Sum	**-118.03**	-171.14	-165.44	53.11**	0.61
2	1	-69.48	-69.92	-68.57	0.91	0.55
	2	-47.24	-55.77	-84.73	8.23**	0.48
	3	-59.41	-68.00	-57.21	2.20	0.46
	Sum	**-176.13**	-193.69	-210.51	17.56**	0.50
3	1	-31.91	-43.06	-34.27	2.36	0.46
	2	-38.51	-49.64	-40.64	2.13	0.41
	3	-29.60	-44.52	-31.27	1.67	0.43
	Sum	**-99.72**	-137.22	-106.18	6.46**	0.43
Group		**-393.88**	-502.05	-482.13	88.25**	0.51
All	frequencies	(4 to 30 Hz)				
1	1	-37.85	-80.68	-43.22	5.37**	0.60
	2	-32.59	-45.90	-35.21	2.62	0.40
	3	-47.59	-44.56	-87.01	3.30*	0.83
	Sum	**-118.03**	-171.14	-165.44	53.11**	0.61
2	1	-89.78	-90.93	-88.10	1.68	0.56
	2	-71.94	-71.42	-71.56	0.14	0.65
	3	-79.46	-91.57	-80.48	1.02	0.59
	Sum	-241.18	-253.92	**-240.14**	1.04	0.60
3	1	-49.41	-61.05	-52.21	2.80	0.49
	2	-54.19	-64.21	-59.13	4.94*	0.46
	3	-44.94	-46.84	-50.76	1.90	0.58
	Sum	**-148.54**	-172.12	-162.10	13.56**	0.51
Group		**-507.75**	-597.18	-567.68	59.93**	0.57