

# Supplementary Material

## 1 MODEL EQUATIONS AND PARAMETERS

The asymptotic function for the calcium conductance  $m_{\infty}$  is given by

$$m_{\infty}(v) = \frac{1}{2} \left( 1 + \tanh\left( (v - v_A)/v_B \right) \right).$$
 (S1)

The voltage and potassium nullclines,  $v_{\infty}(v)$  and  $w_{\infty}(v)$ , are

$$v_{\infty}(v) = \frac{-g_l(v - v_l) - g_{ca}m_{\infty}(v)(v - v_{ca}) + I - \bar{g}s(v - v_s)}{g_k(v - v_k)},$$
(S2)

$$w_{\infty}(v) = \frac{1}{2} \left( 1 + \tanh\left( (v - v_C) / v_D \right) \right).$$
(S3)

Model parameters were adapted from Bose and Booth (2011) and are given in table S1:

Table S1.	Default	parameters	for	coupled	Morris-Lecar	model
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Parameter	value		
$g_{ m L}$	$0.15 \text{ mS/cm}^2$		
$g_{\mathrm{Ca}}$	$0.3 \text{ mS/cm}^2$		
$q_{\rm K}$	$0.6 \text{ mS/cm}^2$		
$v_{\mathrm{L}}$	-50  mV		
$v_{Ca}$	100  mV		
$v_{\rm K}$	-70  mV		
$v_A$	1  mV		
$v_B$	14.5  mV		
$v_C$	4  mV		
$v_D$	15  mV		
Ι	$3.8 \ \mu A/cm^2$		
$ au_w$	100  ms		
$ au_a$	1000  ms		
$ au_b$	100  ms		
$ au_{\kappa}$	100  ms		
$v_{ heta}$	0  mV		
$v_s$	-80  mV		
T	376 ms		
$T_a$	49 ms		
$T_s$	327  ms		
$g^{\star}$	$0.0068 \text{ mS/cm}^2$		
$g_{bif}$	$0.0038 \text{ mS/cm}^2$		
$ar{g}_s$	$0.584 \text{ mS/cm}^2$		
$\lambda := \exp(-T_a/\tau_b)$	0.612		
$\rho := \exp(-T_s/\tau_a)$	0.721		

### 2 COMPUTING BIFURCATION DIAGRAM NUMERICALLY

The bifurcation diagram of stable n : n solutions of the two-cell network in fig. 3 is obtained numerically as follows: We initialise the coupling strength at parameter values associated with one type of n : n solution, that is we choose the values  $\bar{g} = 0.35, 0.4, 0.5, 0.52, 0.56$  for the 1 : 1, 2 : 2,3 : 3, 4 : 4, and 5 : 5 solutions respectively. For each  $\bar{g}$  the system is then numerically integrated sufficiently long for any transients to fully subside. We then identify one period of the solution by finding the first return of the depression variable  $d_1$ . That is, we choose some value  $d_k$  at a spike time  $t_k$ , and by iterating from spike to spike find some subsequent value  $d_{k+1}$  at spike time such that  $|d_{k+1} - d_k| < \epsilon$ . If a periodic solution of type n : n is found in such way,  $\bar{g}$  is step-wise increased/decreased, and the above algorithm is repeated. Otherwise, the set of all previously found solutions and the corresponding values  $\bar{g}$  are returned.

### 3 NUMERICAL VALIDATION OF CONSTANT ISI ASSUMPTION

To study the effect of the synaptic time constant  $\tau_{\kappa}$  on consecutive ISIs of the active cell we consider a single cell that is inhibited by an exponentially decaying synaptic conductance g:

$$\dot{v} = f(v, w) - g(v - v_s),\tag{S4}$$

$$\dot{w} = h(v, w),\tag{S5}$$

$$\dot{g} = -g/\tau_{\kappa},\tag{S6}$$

where functions f and h come from eqs. (3) and (4). We assume that the cell is released and fires its first spike at time t = 0. We therefore initialise v at the firing threshold  $v_{\theta}$ , w at its nullcline, and the g at the release conductance  $g^*$ , respectively:

$$v(0) = v_{\theta},\tag{S7}$$

$$w(0) = v(0),$$
 (S8)

$$g(0) = g^{\star}.\tag{S9}$$

We vary  $\tau_{\kappa}$  and integrate the system numerically to record consecutive ISIs.

Figure S1 shows the curves for the first  $(ISI_1)$ , second  $(ISI_2)$ , and third  $(ISI_3)$  inter-spike-intervals for values  $\tau_{\kappa} \in (0, 800]$ . These results suggest that for  $\tau_{\kappa} \leq 100$  we have  $ISI_i \approx T$ , that is, inhibition g decays sufficiently fast for its effect on the spiking period to be negligible. For  $\tau_{\kappa} > 100$  the first  $ISI_1$  becomes increasingly longer with  $\tau_{\kappa}$ , moreover the effect of the inhibition propagates to the subsequent  $ISI_2$  and  $ISI_3$ , suggesting that for a too slow synaptic time constant the assumption  $ISI \approx T$  is not suitable.

#### REFERENCES

Bose A, Booth V. Co-existent activity patterns in inhibitory neuronal networks with short-term synaptic depression. Journal of Theoretical Biology 272 (2011) 42–54. doi:10.1016/j.jtbi.2010.12.001.



Figure S1. Numerically computed values of the first  $(ISI_1)$ , second  $(ISI_2)$ , and third  $(ISI_3)$  interspike-intervals as a function of  $\tau_{\kappa} \in (0, 800]$ .