Appendix: Equations for Computational Models

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1 General Notes

Units of maximal conductances and currents for all equations below are in $\frac{mS}{cm^2}$ and $\frac{\mu A}{cm^2}$, respectively, based on the original formulation of [Hodgkin and Huxley]. Capacitance C_m for all cells was $1\frac{\mu F}{cm^2}$. Thalamic circuitry is based on [Destexhe et al., a], [Destexhe et al., b], and [Ching et al.] and is identical to [Soplata et al.]. Cortical circuitry is based on a from-scratch implementation of [Compte et al.] and [Benita et al.]. Thalamocortical and corticothalamic synaptic equations were derived from the same AMPAergic synapse as in [Soplata et al.], while inter-region synaptic conductance values are discussed in the Discussion and Methods section. Occasionally, multiplication dots will be used ($\cdot$) to help legibility. All simulations were run for at least 15 seconds of simulation time and solved using Euler integration, with a time resolution (dt) of 0.01 ms.

2 (PYdr) Cortical Pyramidal Dendritic Cell Compartment Equations

2.1 Voltage / Membrane Potential

$$\dot{V}_{PYdr} = \frac{1}{C_m}(I_{app} - I_{HVA} - I_{K(Ca)} - I_{K(Na)} + \\ -I_{NaP} - I_{AR} - I_{COM} - I_{syn})$$

$$I_{app} = 0.1\frac{\mu A}{cm^2}$$

2.2 (HVA) High-Voltage-Activated Ca Channel

$$I_{HVA} = \bar{g}_{HVA} m_\infty^2 (V - E_{HVA})$$

Parameters and Functions:

$\bar{g}_{HVA} = 0.43\frac{mS}{cm^2}$

$E_{HVA} = 120mV$

$m_\infty = 1/(1 + exp(\frac{-(V+20)}{9}))$

2.3 (K(Ca)) Slow Calcium-activated K Channel

$$I_{K(Ca)} = \bar{g}_{K(Ca)} \frac{[Ca_i]}{[Ca_i] + K_D}(V - E_{K(Ca)})$$

Parameters:

$\bar{g}_{K(Ca)} = 0.57\frac{mS}{cm^2}$

$E_{K(Ca)} = -100mV$

$K_D = 30\mu M$

$\alpha_{Ca} = 0.005 \cdot 1000\frac{\mu M}{\mu A \cdot ms}$

$A_{DR} = 0.00035cm^2$

$[Ca_i]_{initial} = 0.001\mu M$

State Variable Equations: $[Ca_i]$

$$\dot{[Ca_i]} = max(-\alpha_{Ca} \cdot A_{DR} \cdot I_{HVA}, 0) - [Ca_i]$$

2.4 (K(Na) Na-activated K Channel

See the section "Non-synaptic Connection Equations".

2.5 (NaP) Persistent Na Channel

$$I_{NaP} = \bar{g}_{NaP} m_\infty^3 (V - E_{NaP})$$

Parameters and Functions:

$\bar{g}_{NaP} = 0.0686\frac{mS}{cm^2}$

$E_{NaP} = 55mV$

$m_\infty = 1/(1 + exp(\frac{-(V+55.7)}{7.7}))$

2.6 (AR) Inwardly Rectifying K Channel

$$I_{AR} = \bar{g}_{AR} h_\infty (V - E_{AR})$$

Parameters and Functions:

$\bar{g}_{AR} = 0.0257\frac{mS}{cm^2}$

$E_{AR} = -100mV$

$h_\infty = 1/(1 + exp(\frac{V+75}{4}))$

3 (PYso) Cortical Pyramidal Axosomatic Cell Compartment Equations

3.1 Voltage / Membrane Potential

$$\dot{V}_{PYso} = \frac{1}{C_m}(-I_{Na} - I_K - I_A - I_{KS} + \\ -I_{Leak} - I_{COM} - I_{syn})$$

3.2 (Na) Na Channel

$$I_{Na} = \bar{g}_{Na} m_\infty^3 h (V - E_{Na})$$

Parameters:

$\bar{g}_{Na} = 50 \frac{mS}{cm^2}$

$E_{Na} = 55mV$

$\phi = 4$

State Variable Equations: m, h

$m_\infty = \frac{\alpha_m}{\alpha_m + \beta_m}$

$\alpha_m = \frac{0.1(V+33)}{(1-exp(\frac{-(V+33)}{10}))}$

$\beta_m = 4exp(\frac{-(V+53.7)}{12})$

$\dot{h} = \phi \cdot (\alpha_h \cdot (1-h)) - \beta_h \cdot h$

$\alpha_h = 0.07 \cdot exp(\frac{-(V+50)}{10})$

$\beta_h = 1/(1 + exp(\frac{-(V+20)}{10})$

3.3 (K) K Channel

$$I_K = \bar{g}_K n^4 (V - E_K)$$

Parameters:

$\bar{g}_K = 10.5 \frac{mS}{cm^2}$

$E_K = -100mV$

$\phi = 4$

State Variable Equations: n

$\dot{n} = \phi \cdot (\alpha_n \cdot (1-n)) - \beta_n \cdot n$

$\alpha_n = \frac{0.01(V+34)}{(1-exp(\frac{-(V+34)}{10}))}$

$\beta_n = 0.125exp(\frac{-(V+44)}{25})$

3.4 (A) Fast A-type K Channel

$$I_A = \bar{g}_A m_\infty^3 h (V - E_A)$$

Parameters:

$\bar{g}_A = 1 \frac{mS}{cm^2}$

$E_A = -100mV$

$\phi = 1$

$\tau_h = 15ms$

State Variable Equations: h

$\dot{h} = \phi \cdot \frac{h_\infty - h}{\tau_h}$

$\alpha_h = 1/(1 + exp(\frac{-(V+50)}{20}))$

$\beta_h = 1/(1 + exp(\frac{(V+80)}{6}))$

3.5 (KS) Non-inactivating K Channel

$$I_{KS} = \bar{g}_{KS} m^3 (V - E_{KS})$$

Parameters:

$\bar{g}_{KS} = 0.576 \frac{mS}{cm^2}$

$E_{KS} = -100mV$

$\phi = 1$

State Variable Equations: m

$\dot{m} = \phi \cdot \frac{m_\infty - m}{\tau_m}$

$m_\infty = 1/(1 + exp(\frac{-(V+34)}{6.5}))$

$\tau_m = 8/\big(exp(\frac{-(V+55)}{30}) + exp(\frac{(V+55)}{30})\big)$

3.6 (Leak) Leak Channel

$$I_{Leak} = \bar{g}_{Leak} (V - E_{Leak})$$

Parameters:

$\bar{g}_{Leak} = 0.0667 \frac{mS}{cm^2}$

$E_{Leak} = -60.95mV$

4 (IN) Cortical Interneuron Cell Equations

4.1 Voltage / Membrane Potential

$$\dot{V}_{IN} = \frac{1}{C_m}(-I_{Na} - I_K - I_{Leak} - I_{syn})$$

4.2 (Na) Na Channel

$$I_{Na} = \bar{g}_{Na} m_\infty^3 h (V - E_{Na})$$

Parameters:

$\bar{g}_{Na} = 35 \frac{mS}{cm^2}$

$E_{Na} = 55mV$

State Variable Equations: m, h

$$m_\infty = \frac{\alpha_m}{\alpha_m+\beta_m}$$
$$\alpha_m = \frac{0.5(V+35)}{(1-exp(\frac{-(V+35)}{10}))}$$
$$\beta_m = 20exp(\frac{-(V+60)}{18})$$
$$\dot{h} = (\alpha_h \cdot (1-h)) - \beta_h \cdot h$$
$$\alpha_h = 0.35 \cdot exp(\frac{-(V+58)}{20})$$
$$\beta_h = 5/(1+exp(\frac{-(V+28)}{10})$$

4.3 (K) K Channel

$$I_K = \bar{g}_K n^4 (V - E_K)$$

Parameters:

$$\bar{g}_K = 9\frac{mS}{cm^2}$$
$$E_K = -90mV$$

State Variable Equations: n

$$\dot{n} = (\alpha_n \cdot (1-n)) - \beta_n \cdot n$$
$$\alpha_n = \frac{0.05(V+34)}{(1-exp(\frac{-(V+34)}{10}))}$$
$$\beta_n = 0.625exp(\frac{-(V+44)}{80})$$

4.4 (Leak) Leak Channel

$$I_{Leak} = \bar{g}_{Leak}(V - E_{Leak})$$

Parameters:

$$\bar{g}_{Leak} = 0.1025\frac{mS}{cm^2}$$
$$E_{Leak} = -63.8mV$$

5 (TC) Thalamocortical Cell Equations

5.1 Voltage / Membrane Potential

$$\dot{V}_{TC} = \frac{1}{C_m}(-I_{Na} - I_K - I_T - I_H +$$
$$-I_{Leak} - I_{KLeak} - I_{syn})$$

5.2 (Na) Na Channel

$$I_{Na} = \bar{g}_{Na} m^3 h (V_T - E_{Na})$$

Parameters:

$$V_T = V + 40mV$$
$$\bar{g}_{Na} = 90\frac{mS}{cm^2}$$
$$E_{Na} = 50mV$$

State Variable Equations: m, h

$$\dot{m} = \alpha_m \cdot (1-m) - \beta_m \cdot m$$
$$\alpha_m = \frac{0.32\cdot(13-V_T)}{exp(\frac{13-V_T}{4})-1}$$
$$\beta_m = \frac{0.28\cdot(V_T-40)}{exp(\frac{V_T-40}{5})-1}$$
$$\dot{h} = \alpha_h \cdot (1-h) - \beta_h \cdot h$$
$$\alpha_h = 0.128 \cdot exp(\frac{17-V_T}{18})$$
$$\beta_h = \frac{4}{exp(\frac{40-V_T}{5})+1}$$

5.3 (K) K Channel

$$I_K = \bar{g}_K n^4 (V_T - E_K)$$

Parameters:

$$V_T = V + 25mV$$
$$\bar{g}_K = 10\frac{mS}{cm^2}$$
$$E_K = -100mV$$

State Variable Equations: n

$$\dot{n} = \alpha_n \cdot (1-n) - \beta_n \cdot n$$
$$\alpha_n = \frac{0.032(15-V_T)}{exp(\frac{15-V_T}{5})-1}$$
$$\beta_n = 0.5exp(\frac{10-V_T}{40})$$

5.4 (T) T-type Calcium Channel

$$I_T = \bar{g}_T m_\infty^2 h (V_T - E_T)$$

Parameters:

$$V_T = V + 2mV$$
$$\bar{g}_T = 2\frac{mS}{cm^2}$$
$$E_T = 1000\frac{8.31441*309.15}{2*96486} ln\frac{2}{[Ca]_i} mV$$
$$\phi_h = 3.73$$
$$A = \frac{10}{2\cdot 96489}\frac{mM\cdot cm^2}{ms\cdot\mu A}$$
$$[Ca_i]_{initial} = 0.000001mM$$

State Variable Equations: m

$$m_\infty = \frac{1}{1+exp(\frac{-(V_T+57)}{6.2})}$$

State Variable Equations: h

$$\dot{h} = \frac{h_\infty - h}{\tau_h}$$
$$h_\infty = \frac{1}{1+exp(\frac{V_T+81}{4})}$$
$$\tau_h = \left(30.8 + \frac{211.4+exp(\frac{V_T+113.2}{5})}{1+exp(\frac{V_T+84}{3.2})}\right)/\phi_h$$

State Variable Equations: $[Ca]_i$

$$[\dot{Ca}]_i = max\left(\frac{-10 \cdot I_T}{2 \cdot 96489}, 0\right) + \frac{0.00024 - [Ca]_i}{5}$$

5.5 (H) Hyperpolarization-activated Cation Channel

$$I_H = \bar{g}_H(O_U + 2O_L)(V - E_H)$$

Note: This is the more complex [Destexhe et al., b] formulation of the H-current, not that of [Destexhe et al., a]. O_U is the proportion of unlocked channels, O_L is the proportion of locked-open channels, and P_1 is the proportion of utilized substrate for channel locking.

Parameters:

$\bar{g}_H = 0.005 \frac{mS}{cm^2}$ (depending on dose)

$E_H = -40mV$

$k_2 = 0.0004$

$k_4 = 0.001$

$[Ca]_{crit} = 0.002$ (mM of Calcium)

$n_{Ca} = 4$ (number binding sites of Ca on protein)

$n_{exp} = 1$ (number binding sites on H-channel)

$\bar{g}_H$ changes depending on the simulation under investigation. See Propofol Effects section for more detail.

State Variable Equations: O_U, P_1, O_L

$\dot{O}_U = \alpha_h(1 - O_U - O_L) - \beta_h O_U$

$\dot{P}_1 = k_2(\frac{[Ca_i]}{[Ca_i]_{crit}})^{n_{Ca}}(1 - P_1) - k_2 P_1$

- $[Ca]_i$ is a state variable determined by the T-current.

$\dot{O}_L = k_4(\frac{P_1}{0.007})^{n_{exp}} O_U - k_4 O_L$

$\alpha_h = \frac{h_\infty}{\tau_s}$

$\beta_h = \frac{1 - h_\infty}{\tau_s}$

$h_\infty = 1/(1 + exp(\frac{V+75}{5.5}))$

$\tau_s = 20 + \frac{1000}{exp(\frac{V+71.5}{14.2}) + exp(\frac{-(V+89)}{11.6})}$

5.6 (Leak) Leak Current

$$I_{Leak} = \bar{g}_{Leak}(V - E_{Leak})$$

Parameters:

$\bar{g}_{Leak} = 0.01 \frac{mS}{cm^2}$

$E_{Leak} = -70mV$

5.7 (KLeak) K Leak Current

$$I_{KLeak} = \bar{g}_{KLeak}(V - E_{KLeak})$$

Parameters:

$\bar{g}_{KLeak} = 0.0172 \frac{mS}{cm^2}$

$E_{KLeak} = -100mV$

6 (TRN) Thalamic Reticular Nucleus Cell Equations

6.1 Voltage / Membrane Potential

$\dot{V}_{TRN} = \frac{1}{C_m}(-I_{Na} - I_K - I_T - I_{Leak} +$
$-I_{KLeak} - I_{syn})$

6.2 (Na) Na Channel

$$I_{Na} = \bar{g}_{Na} m^3 h(V_T - E_{Na})$$

Parameters:

$V_T = V + 55mV$

$\bar{g}_{Na} = 200 \frac{mS}{cm^2}$

$E_{Na} = 50mV$

State Variable Equations: m, h

$\dot{m} = \alpha_m \cdot (1 - m) - \beta_m \cdot m$

$\alpha_m = \frac{0.32 \cdot (13 - V_T)}{exp(\frac{13 - V_T}{4}) - 1}$

$\beta_m = \frac{0.28 \cdot (V_T - 40)}{exp(\frac{V_T - 40}{5}) - 1}$

$\dot{h} = \alpha_h \cdot (1 - h) - \beta_h \cdot h$

$\alpha_h = 0.128 \cdot exp(\frac{17 - V_T}{18})$

$\beta_h = \frac{4}{exp(\frac{40 - V_T}{5}) + 1}$

6.3 (K) K Channel

$$I_K = \bar{g}_K n^4 (V_T - E_K)$$

Parameters:

$V_T = V + 55mV$

$\bar{g}_K = 20 \frac{mS}{cm^2}$

$E_K = -100mV$

State Variable Equations: n

$\dot{n} = \alpha_n \cdot (1 - n) - \beta_n \cdot n$

$\alpha_n = \frac{0.032(15 - V_T)}{exp(\frac{15 - V_T}{5}) - 1}$

$\beta_n = 0.5exp(\frac{10 - V_T}{40})$

6.4 (T) T-type Calcium Channel

$$I_T = \bar{g}_T m^2 h (V_T - E_T)$$

Parameters:

$V_T = V + 4mV$

$\bar{g}_T = 3\frac{mS}{cm^2}$

$E_T = 120mV$

$\phi_m = 6.81$

$\phi_h = 3.73$

State Variable Equations: m

$\dot{m} = \frac{m_\infty - m}{\tau_m}$

$m_\infty = 1/(1 + exp(\frac{-(V_T+50)}{7.4}))$

$\tau_m = \frac{1}{\phi_m}\left(3 + \frac{1}{exp(\frac{V_T+25}{10}) + exp(\frac{-(V_T+100)}{15})}\right)$

State Variable Equations: h

$\dot{h} = \frac{h_\infty - h}{\tau_h}$

$h_\infty = \frac{1}{1+exp(\frac{V_T+78}{5})}$

$\tau_h = \frac{1}{\phi_h}\left(85 + \frac{1}{exp(\frac{V_T+46}{4}) + exp(\frac{-(V_T+405)}{50})}\right)$

6.5 (Leak) Leak Currents

$$I_{Leak} = \bar{g}_{Leak}(V - E_{Leak})$$

Parameters:

$\bar{g}_{Leak} = 0.05\frac{mS}{cm^2}$

$E_{Leak} = -90mV$

7 Non-synaptic Connection Equations

7.1 Direct Compartmental Connections

Each PYdr compartment has a special connection to and from a single PYso compartment called I_{COM}, meant to simulate voltage fluctuations between the axo-soma and dendrite of a single cell. Note that these conductances are not exact inverses of each other due to the difference in size between the two compartments. These two currents are calculated using the following:

$I_{COM|PYdr\to PYso} = \bar{g}_{COM|PYdr\to PYso}(V_{PYdr} - V_{PYso})$

$\bar{g}_{COM|PYdr\to PYso} = 11.667\frac{mS}{cm^2}$

$I_{COM|PYso\to PYdr} = \bar{g}_{COM|PYso\to PYdr}(V_{PYso} - V_{PYdr})$

$\bar{g}_{COM|PYso\to PYdr} = 5\frac{mS}{cm^2}$

7.2 (K(Na) Intercompartmental Na-activated K Channel

Additionally, there is a special and very important current, $I_{K(Na)}$, which requires information on the state of the Na present in directly-connected PYso and PYdr compartments. Practically speaking, this can be modeled somewhat easily by programming it as if it is a synaptic current. The equations follow:

$I_{K(Na)} = \bar{g}_{K(Na)}\frac{0.37}{1+(\frac{38.7}{[Na_i]})^{3.5}}(V_{PYso} - E_{K(Na)})$

$\bar{g}_{K(Na)} = 1.33\frac{mS}{cm^2}$

$E_{K(Na)} = -100mV$

$\alpha = 0.01 \cdot 1000\frac{mM}{\mu A \cdot ms}$

$R_{pump} = 0.018\frac{mM}{ms}$

$[Na_{eq}] = 9.5mM$

$[\dot{Na}_i] = -\alpha(0.00015 \cdot I_{Na|PYso} + 0.00035 \cdot I_{NaP|PYdr}) +$

$-R_{pump}(\frac{[Na_i]^3}{[Na_i]^3+15^3} - \frac{[Na_{eq}]^3}{[Na_{eq}]^3+15^3})$

8 Synaptic Equations

8.1 Channel Equations

The electrical current equations for each class of synapse ($AMPA$, $AMPA-D$, $NMDA$, $GABA_A$, and $GABA_B$) were the same within their class, with the sole exception of different connections having different maximal conductances. All conductances of individual synapses were divided by a normalizing factor of how many connections each target cell received.

$AMPA$:

$I_{AMPA} = -\bar{g}_{AMPA} \cdot s_{AMPA} \cdot (V_{target} - E_{AMPA})$

$E_{AMPA} = 1mV$

$\tau_{AMPA} = 2ms$

$\dot{s}_{AMPA} = 5(1 + tanh\frac{V_{source}}{4})(1 - s_{AMPA}) - \frac{s_{AMPA}}{\tau_{AMPA}}$

AMPA − D:

AMPA synapse, with synaptic depression

$I_{AMPA-D} = -\bar{g}_{AMPA-D} \cdot R \cdot s_{AMPA-D} \cdot (V_{target} - E_{AMPA})$

$E_{AMPA} = 0mV$

$\alpha = 3.48$

$\tau_s = 2ms$

$\tau_R = 400ms$

DF = Depression Factor = 0.9

SD = Spike-detection function = if (time since last spike) $< 2 \cdot dt$, where dt is the time resolution of the ODE solver

$\dot{s}_{AMPA-D} = \alpha/(1 + exp\frac{-(V_{source}+20)}{2}) - \frac{s_{AMPA-D}}{\tau_s}$

$\dot{R} = \frac{1-R}{\tau_R} + SD \cdot (\frac{-(1-R)}{\tau_R} + \frac{1}{dt}(DF \cdot R - R))$

NMDA:

$I_{NMDA} = -\bar{g}_{NMDA} \cdot R \cdot s_{NMDA} \cdot (V_{target} - E_{NMDA})$

$E_{AMPA} = 0mV$

$\tau_{AMPA} = 2ms$

$\alpha_s = 0.5$

$\tau_s = 100ms$

$\alpha_x = 3.48$

$\tau_x = 2ms$

$\tau_R = 400ms$

DF = Depression Factor = 0.9

SD = Spike-detection function = if (time since last spike) $< 2 \cdot dt$, where dt is the time resolution of the ODE solver

$\dot{s}_{NMDA} = \alpha_s \cdot x_{NMDA} \cdot (1 - s_{NMDA}) - \frac{s_{NMDA}}{\tau_s}$

$\dot{x}_{NMDA} = \alpha_x/(1 + exp(\frac{-(V_{source}-20)}{2})) - \frac{x_{NMDA}}{\tau_x}$

$\dot{R} = \frac{1-R}{\tau_R} + SD \cdot (\frac{-(1-R)}{\tau_R} + \frac{1}{dt}(DF \cdot R - R))$

$GABA_A$:

$I_{GABA_A} = -PM \cdot \bar{g}_{GABA_A} \cdot s_{GABA_A} \cdot (V_{target} - E_{GABA_A})$

$E_{GABA_A} = -80mV$

$\tau_{GABA_A} = PM \cdot 5ms$

$PM = 1$ propofol multiplier, see Propofol Effects section.

Note that PM multiplies both $\bar{g}_{GABA_A}$ and τ_{GABA_A}.

$\dot{s}_{GABA_A} = 2(1 + tanh\frac{V_{source}}{4})(1 - s_{GABA_A}) - \frac{s_{GABA_A}}{PM \cdot \tau_{GABA_A}}$

$GABA_B$:

$I_{GABA_B} = -\bar{g}_{GABA_B} \cdot \frac{s^4_{GABA_B}}{s^4_{GABA_B}+100} \cdot (V_{target} - E_{GABA_A})$

$E_{GABA_B} = -95mV$

$\dot{s}_{GABA_B} = 0.18 \cdot r_{GABA_B} - 0.034 \cdot s_{GABA_B}$

$\dot{r}_{GABA_B} = 0.5(2(1 + tanh\frac{V_{source}}{4}))(1 - r_{GABA_B}) +$

$-0.0012 \cdot r_{GABA_B}$

8.2 Synaptic connectivity and conductances

All intrathalamic synapses ($TC \rightarrow TRN$, $TRN \rightarrow TC$, and $TRN \rightarrow TRN$) were connected in "all-to-all" fashion, and the maximal conductance of each intrathalamic synapse was divided by the total number of source cells.

For all non-intrathalamic synapses, every individual source cell in a synaptic connection was connected to the "nearest neighbor" $1 + 2 \cdot radius$ target cells. For the connection algorithm, see the code file "models/netconNearestNeighbors.m". Additionally, synapse maximal conductances are divided by a Normalization Factor (NF). This NF ensures that the total maximal conductance for a particular synaptic type into a target cell is balanced across the number of source cell synapses. NF is defined as:

$$NF = min(\frac{1+2 \cdot radius}{N_{target}/N_{source}}, N_{source})$$

Where N_{source} and N_{target} are the number of cells in the source and target populations, respectively.

The following table lists all synaptic connection radii and synaptic maximal conductances (before NF has been applied). $PYso \rightarrow PYdr$ synaptic connections only connect to $2 \cdot radius$ target cells so as not to synapse onto their corresponding compartment. All maximal conductances are giving in units of $\frac{mS}{cm^2}$. For all synapses modulated by propofol, see the following section Propofol Effects.

Connection	Synapse Class	$\bar{g}(\frac{mS}{cm^2})$	radius
$PYso \rightarrow PYdr$	$AMPA-D$	0.0154	10
	$NMDA$	0.00257	10
$PYso \rightarrow IN$	$AMPA-D$	1.0	10
	$NMDA$	0.0025	10
$IN \rightarrow PYso$	$GABA_A$	0.1	10
$IN \rightarrow IN$	$GABA_A$	0.000825	10
$PYso \rightarrow TC$	$AMPA$	0.4	10
$PYso \rightarrow TRN$	$AMPA$	0.2	10
$TC \rightarrow PYdr$	$AMPA$	0.1	10
$TC \rightarrow IN$	$AMPA$	0.1	10
$TC \rightarrow TRN$	$AMPA$	0.4	all-to-all
$TRN \rightarrow TC$	$GABA_A$	0.1	all-to-all
$TRN \rightarrow TC$	$GABA_B$	0.001	all-to-all
$TRN \rightarrow TRN$	$GABA_A$	0.1	all-to-all

9 Propofol Effects

For the "relay" non-propofol state, the following parameters were used:

$$\begin{aligned}
PYdr: &\quad \bar{g}_{K(Na)} = 0\frac{mS}{cm^2} \\
PYso \rightarrow PYdr: &\quad \bar{g}_{AMPA-D} = 0.004\frac{mS}{cm^2} \\
TC \rightarrow PYdr: &\quad \bar{g}_{AMPA} = 0.004\frac{mS}{cm^2} \\
TC: &\quad \bar{g}_H = 0.04\frac{mS}{cm^2} \\
PYdr: &\quad \bar{g}_{K(Na)} = 0.0\frac{mS}{cm^2} \\
IN \rightarrow PYso: &\quad PM = 1 \\
IN \rightarrow IN: &\quad PM = 1 \\
TRN \rightarrow TC: &\quad PM = 1 \\
TRN \rightarrow TRN: &\quad PM = 1
\end{aligned}$$

For "direct-effects-only" and "low-dose" propofol administration, the following parameters were used to model "direct" effects of propofol. Note that PM multiplies both $\bar{g}_{GABA_A}$ and τ_{GABA_A}.

$$\begin{aligned}
IN \rightarrow PYso: &\quad PM = 3 \\
IN \rightarrow IN: &\quad PM = 3 \\
TRN \rightarrow TC: &\quad PM = 3 \\
TRN \rightarrow TRN: &\quad PM = 3 \\
TC: &\quad \bar{g}_H = 0.005\frac{mS}{cm^2}
\end{aligned}$$

For "low-dose" propofol administration, the following parameters were used to model "indirect" effects of propofol, i.e. its effects on ACh.

$$\begin{aligned}
PYdr: &\quad \bar{g}_{K(Na)} = 1.33\frac{mS}{cm^2} \\
PYso \rightarrow PYdr: &\quad \bar{g}_{AMPA-D} = 0.0075\frac{mS}{cm^2} \\
TC \rightarrow PYdr: &\quad \bar{g}_{AMPA} = 0.005\frac{mS}{cm^2}
\end{aligned}$$

For "high-dose" propofol administration, the following parameters were used to model "direct" effects of propofol. Note that PM multiplies both $\bar{g}_{GABA_A}$ and τ_{GABA_A}.

$$\begin{aligned}
IN \rightarrow PYso: &\quad PM = 3 \\
IN \rightarrow IN: &\quad PM = 3 \\
TRN \rightarrow TC: &\quad PM = 3 \\
TRN \rightarrow TRN: &\quad PM = 3 \\
TC: &\quad \bar{g}_H = 0.005\frac{mS}{cm^2}
\end{aligned}$$

For "high-dose" propofol administration, the following parameters were used to model "indirect" effects of propofol, i.e. its effects on ACh.

$$\begin{aligned}
PYdr: &\quad \bar{g}_{K(Na)} = 1.5\frac{mS}{cm^2} \\
PYso \rightarrow PYdr: &\quad \bar{g}_{AMPA-D} = 0.01\frac{mS}{cm^2} \\
TC \rightarrow PYdr: &\quad \bar{g}_{AMPA} = 0.01\frac{mS}{cm^2}
\end{aligned}$$

10 Reproducibility and Code

All simulations were run using the MATLAB-based DynaSim software package [Sherfey et al.] on my own personal "git fork" [Soplata, a] , using branch "coupling addition", and using MATLAB 2017a. The individual mechanism files for use with DynaSim are available online [Soplata, c], and so are all the runscripts needed to reproduce simulations of the paper [Soplata, b].

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