Supplementary Material S1: Communication Before Coherence

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This Supplementary Material S1 summarizes the parameters used in the simulations shown in the paper and provides a tabular description of the network following the prescription of (Nordlie, Gewaltig & Plesser 2009).

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<tr>
<th>A</th>
<th>Model Summary for each of the two networks</th>
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<td>Populations</td>
<td>Two: excitatory, inhibitory</td>
</tr>
<tr>
<td>Topology</td>
<td>—</td>
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<tr>
<td>Connectivity</td>
<td>Fully connected</td>
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<tr>
<td>Neuron model</td>
<td>Leaky integrate-and-fire, fixed threshold, fixed refractory period, NMDA</td>
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<td>Channel models</td>
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<td>Synapse model</td>
<td>Instantaneous jump and exponential decay for AMPA and GABA and exponential jump and decay for NMDA receptors</td>
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<td>Input</td>
<td>Independent fixed-rate Poisson spike trains to each selective population</td>
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<td>Measurements</td>
<td>Spike activity</td>
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<table>
<thead>
<tr>
<th>B</th>
<th>Populations of neurons in each Network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of neurons</td>
<td>$N = 1000$</td>
</tr>
<tr>
<td>Excitatory neurons</td>
<td>$N_E = 0.8 \times N$</td>
</tr>
<tr>
<td>Inhibitory neurons</td>
<td>$N_I = 0.2 \times N$</td>
</tr>
<tr>
<td>Neurons in each selective pool</td>
<td>$N_{\text{selective}} = N_E \cdot \text{sparseness}$</td>
</tr>
</tbody>
</table>
### Neuron and Synapse Model

**Type**
Leaky integrate-and-fire, conductance-based synapses

#### Subthreshold dynamics

\[
\frac{dV(t)}{dt} = -g_m(V(t) - V_L) - I_{\text{syn}}(t),
\]

\[
I_{\text{syn}}(t) = I_{\text{AMPA,ext}}(t) + I_{\text{AMPA,rec}}(t) + I_{\text{NMDA}}(t) + I_{\text{GABA}}(t)
\]

#### Spiking

If \( V(t) > V_{\theta} \land t > t^* + \tau_p \)

1. set \( t^* = t \)
2. emit spike with time-stamp \( t^* \)
3. \( V(t) = V_{\text{reset}} \)

#### Synaptic currents

\[
I_{\text{AMPA,ext}}(t) = g_{\text{AMPA,ext}}(V(t) - V_E) \sum_{j=1}^{N_E} s_j^{\text{AMPA,ext}}(t)
\]

\[
I_{\text{AMPA,rec}}(t) = g_{\text{AMPA,rec}}(V(t) - V_E) \sum_{j=1}^{N_E} w_j s_j^{\text{AMPA,rec}}(t) u_j(t)
\]

\[
I_{\text{NMDA}}(t) = \frac{g_{\text{NMDA}}(V(t) - V_E)}{1 + \gamma \exp(-\beta V(t))} \sum_{j=1}^{N_E} w_j s_j^{\text{NMDA}}(t) u_j(t)
\]

\[
I_{\text{GABA}}(t) = g_{\text{GABA}}(V(t) - V_I) \sum_{j=1}^{N_I} s_j^{\text{GABA}}(t)
\]

#### Fraction of open channels

\[
\frac{ds_j^{\text{AMPA,ext}}(t)}{dt} = -s_j^{\text{AMPA,ext}}(t)/\tau_{\text{AMPA}} + \sum_k \delta(t - t^*_j - \delta)
\]

\[
\frac{ds_j^{\text{AMPA,rec}}(t)}{dt} = -s_j^{\text{AMPA,rec}}(t)/\tau_{\text{AMPA}} + \sum_k \delta(t - t^*_j - \delta)
\]

\[
\frac{ds_j^{\text{NMDA}}(t)}{dt} = -s_j^{\text{NMDA}}(t)/\tau_{\text{NMDA,decay}} + ax_j(t)(1 - s_j^{\text{NMDA}}(t))
\]

\[
\frac{dx_j(t)}{dt} = -x_j(t)/\tau_{\text{NMDA,rise}} + \sum_k \delta(t - t^*_j - \delta)
\]

\[
\frac{ds_j^{\text{GABA}}(t)}{dt} = -s_j^{\text{GABA}}(t)/\tau_{\text{GABA}} + \sum_k \delta(t - t^*_j - \delta)
\]
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson generators</td>
<td>Fixed rate $N_{ext}$ synapses per neuron, with each synapse driven by a Poisson process</td>
</tr>
</tbody>
</table>

**Measurements**

- Spike activity
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_m$ (excitatory)</td>
<td>0.5 nF</td>
</tr>
<tr>
<td>$C_m$ (inhibitory)</td>
<td>0.2 nF</td>
</tr>
<tr>
<td>$g_m$ (excitatory)</td>
<td>25 nS</td>
</tr>
<tr>
<td>$g_m$ (inhibitory)</td>
<td>20 nS</td>
</tr>
<tr>
<td>$V_L$</td>
<td>-70 mV</td>
</tr>
<tr>
<td>$V_{thr}$</td>
<td>-50 mV</td>
</tr>
<tr>
<td>$V_{reset}$</td>
<td>-55 mV</td>
</tr>
<tr>
<td>$V_E$</td>
<td>0 mV</td>
</tr>
<tr>
<td>$V_I$</td>
<td>-70 mV</td>
</tr>
<tr>
<td>$g_{AMPA,ext}$ (excitatory)</td>
<td>2.08 nS</td>
</tr>
<tr>
<td>$g_{AMPA,rec}$ (excitatory)</td>
<td>0.104 nS</td>
</tr>
<tr>
<td>$g_{NMDA}$ (excitatory)</td>
<td>0.327 nS</td>
</tr>
<tr>
<td>$g_{GABA}$ (excitatory)</td>
<td>1.2875 nS</td>
</tr>
<tr>
<td>$g_{AMPA,ext}$ (inhibitory)</td>
<td>1.62 nS</td>
</tr>
<tr>
<td>$g_{AMPA,rec}$ (inhibitory)</td>
<td>0.081 nS</td>
</tr>
<tr>
<td>$g_{NMDA}$ (inhibitory)</td>
<td>0.258 nS</td>
</tr>
<tr>
<td>$g_{GABA}$ (inhibitory)</td>
<td>0.973 nS</td>
</tr>
<tr>
<td>$\tau_{NMDA,decay}$</td>
<td>100 ms</td>
</tr>
<tr>
<td>$\tau_{NMDA,rise}$</td>
<td>2 ms</td>
</tr>
<tr>
<td>$\tau_{AMPA}$</td>
<td>2 ms</td>
</tr>
<tr>
<td>$\tau_{GABA}$</td>
<td>10 ms</td>
</tr>
<tr>
<td>$\tau_{rp}$ (excitatory)</td>
<td>2 ms</td>
</tr>
<tr>
<td>$\tau_{rp}$ (inhibitory)</td>
<td>1 ms</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.5 ms$^{-1}$</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>$[Mg^{2+}] / (3.57 \text{mM}) = 0.280$</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.062 mV$^{-1}$</td>
</tr>
<tr>
<td>sparseness, $a$</td>
<td>0.10</td>
</tr>
<tr>
<td>$N_{ext}$</td>
<td>800</td>
</tr>
</tbody>
</table>
Table 2: Connection parameters used within each network in the model

<table>
<thead>
<tr>
<th>$w_+$</th>
<th>2.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_-$</td>
<td>0.877</td>
</tr>
</tbody>
</table>

References