Table S1

Table S1A. Rate Model summary

<table>
<thead>
<tr>
<th>Type</th>
<th>Wilson Cowan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer function</td>
<td>Sigmoid logistic function $S(x) = \frac{1}{1 + e^{-p(x-\theta)}}$, $p = 1.2$, $\theta = 2.8$</td>
</tr>
<tr>
<td>maximum rates</td>
<td>$k_A = k_B = 0.97$</td>
</tr>
<tr>
<td>refractoriness</td>
<td>$r_A = r_B = 10^{-3}$</td>
</tr>
<tr>
<td>learning rates</td>
<td>$a_A = a_B = 0.15$</td>
</tr>
</tbody>
</table>

Table S1B. SNN Model summary

| Populations | two: excitatory neurons (EXC), inhibitory neurons (INH) |
| Topology    | none |
| Connectivty | Random divergent connections prescribed by experimental findings |
| Neuron model| Leaky-integrate-and-fire, fixed threshold, absolute refractory period (2ms) |
| Channel models | - |
| Synapse models | Conductance-based difference of exponentials (AMPA, GABA_A) |
| Plasticity  | CS and contextual projections onto EXC neurons |
| Input       | all neurons: conditioned stimulus (CS), background input (BKG), EXC receive in addition contextual (CTX) input |
| Measurements| Membrane potential, spike rates |

Table S1C. Populations

<table>
<thead>
<tr>
<th>Name</th>
<th>Elements</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXC</td>
<td>LIF neuron</td>
<td>3400</td>
</tr>
<tr>
<td>INH</td>
<td>LIF neuron</td>
<td>600</td>
</tr>
</tbody>
</table>

Table S1D. Topology

none

Table S1E. Connectivity

<table>
<thead>
<tr>
<th>Projection</th>
<th>Type</th>
<th>Connection probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXC to EXC</td>
<td>Divergent connections</td>
<td>0.01</td>
</tr>
<tr>
<td>EXC to INH</td>
<td>Divergent connections</td>
<td>0.15 (0.5)</td>
</tr>
<tr>
<td>INH to EXC</td>
<td>Divergent connections</td>
<td>0.15 (0.5)</td>
</tr>
<tr>
<td>INH to INH</td>
<td>Divergent connections</td>
<td>0.1 (0.1-0.9)</td>
</tr>
<tr>
<td>EXC to EXC,INH</td>
<td>Static, drawn from normal distribution with $\mu = 1.25$ nS and $\sigma = 0.1$nS</td>
<td>-</td>
</tr>
<tr>
<td>INH to EXC,INH</td>
<td>Static, drawn from normal distribution with $\mu = 2.5$ nS and $\sigma = 0.1$nS</td>
<td>-</td>
</tr>
<tr>
<td>CS/CTX to EXC</td>
<td>Plastic, drawn from normal distribution with 1 nS and $\sigma = 0.1$nS</td>
<td>-</td>
</tr>
<tr>
<td>CS to INH</td>
<td>Static, drawn from normal distribution with 1 nS and $\sigma = 0.1$nS</td>
<td>-</td>
</tr>
<tr>
<td>Delays</td>
<td>Fixed, drawn from normal distribution with $\mu = 2$ms and $\sigma = 0.1$ms</td>
<td>-</td>
</tr>
</tbody>
</table>
**Table S1F. Neuron Model**

<table>
<thead>
<tr>
<th>Name</th>
<th>LIF neuron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Leaky integrate-and-fire, conductance based synapses</td>
</tr>
<tr>
<td>Subthreshold dynamics</td>
<td>( \tau_m \frac{dV}{dt} = (E_0 - V) + g_{ex}(E_{ex} - V) + g_{inh}(E_{inh} - V) )</td>
</tr>
<tr>
<td>If ( V(t-) &lt; \theta \wedge V(t+) &gt; \theta ), 1. set ( t^* = t )</td>
<td></td>
</tr>
<tr>
<td>Spiking</td>
<td>2. emit spike with time-stamp ( t^* )</td>
</tr>
<tr>
<td></td>
<td>3. reset ( V(t) = E_K )</td>
</tr>
<tr>
<td></td>
<td>4. clamp ( V(t) ) for 2 ms</td>
</tr>
</tbody>
</table>

**Table S1G. Synapse Models**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMPA/GABA_A</td>
<td>( g(t) = g_{peak} \frac{e^{-t/\tau_1} - e^{-t/\tau_2}}{e^{-tpeak/\tau_1} - e^{-tpeak/\tau_2}} )</td>
</tr>
</tbody>
</table>

**Table S1H. Plasticity**

<table>
<thead>
<tr>
<th>Description</th>
<th>Phenomenological rule of synaptic weight modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Update rule</td>
<td>( w_+ = w_- + \alpha_1 m \left</td>
</tr>
<tr>
<td></td>
<td>( w_+ = w_- - \alpha_2 m \left</td>
</tr>
<tr>
<td>Variables</td>
<td>( \dot{c} = -\frac{c}{\tau_c} + A \delta(t_{pre}) )</td>
</tr>
<tr>
<td></td>
<td>( \dot{h} = -\frac{h}{\tau_h} + B \delta(t_{pre}) )</td>
</tr>
<tr>
<td>Parameters</td>
<td>m: (non-specific) neuromodulator</td>
</tr>
<tr>
<td></td>
<td>m=1: neuromodulator present</td>
</tr>
<tr>
<td></td>
<td>m=0: neuromodulator absent</td>
</tr>
<tr>
<td></td>
<td>learning rates ( a_1 = a_2 = 16 \times 10^{-4} )</td>
</tr>
<tr>
<td></td>
<td>( (w_{max} - w_-) ): step-size increase</td>
</tr>
</tbody>
</table>

**Table S1I. Input**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS to EXC/INH</td>
<td>One Poisson generator per neuron in EXC and INH, phasic drive: 50ms, spiking rate: 500 Hz</td>
</tr>
<tr>
<td>CTX to EXC/INH</td>
<td>One Poisson generator per neuron in EXC, tonic drive, spiking rate: 300 Hz</td>
</tr>
<tr>
<td>BKG to EXC</td>
<td>Current injection: ( DC = 330 ) pA , ( AC = 85 ) pA</td>
</tr>
<tr>
<td>BKG to INH</td>
<td>Current injection: ( DC = 220 ) pA , ( AC = 110 ) pA</td>
</tr>
</tbody>
</table>

**Table S1J. Measurements**

| Membrane potential \( V \) and spike times for randomly selected neurons in EXC and INH |