Week 2: Tones and Shocks

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Abstract

This week's report shows how to deliver tones and shocks to the model neurons.

1 Tone

The experimental protocol consists of a habituation, conditioning, gap and extinction phases (see figure 2C in the paper associated with the model, "Mechanisms contributing to the induction and storage of Pavlovian fear memories in the lateral amygdala", Kim et al, 2013). Each trial consists of 3.5 seconds of no stimulation and then 0.5 seconds of presenting the conditioned stimulus (tone) and during conditioning also 100 ms of unconditioned stimulus (shock). Habituation consists of 8 such trials, conditioning of 16 trials, the gap is 100 seconds long and extinction is 20 trials. The tones were spike trains with 20 Hz frequency during habituation and 40 Hz during conditioning. They were delivered via glutamatergic AMPA and NMDA synapses onto the lateral amygdala (LA) cells.
The tone is delivered to the cells through the thalamic and cortical pathways. The cells in the model were divided into two groups, LAdd (corresponding to the dorsal part of LAd) and LAdv (corresponding to the ventral part of LAd). 70% of LAdd and 35% of LAdv cells received thalamic input. Conversely, 35% of LAdd and 70% LAdv cells received cortical input.
Here we deliver a thalamic tone to a principal cell. The code for this is given below. Figure 1 illustrates the result.

```
load_file("nrngui.hoc")
load_file("LAcells_template.hoc")
load_file("interneuron_template.hoc")
load_file("function_ToneGen.hoc")
load_file("function_NetStimOR.hoc")
load_file("function_ToneSignalGen_Th.hoc")

objectvar cell_exc

objref r
tstop = 276000
{load_file("function_TimeMonitor.hoc")}
dt = 0.01
r = new Random() //random number generator for random delays
```

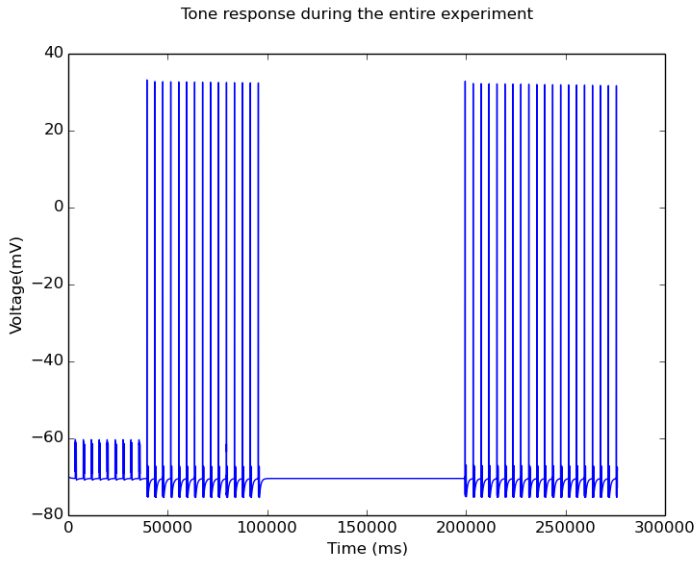

Figure 1: Tone delivered to a principal cell according to the experimental protocol

```
objref Tone_gen, tone2LAPsyn, tone2LAPcon
//Thalamic pathway
//create spike train for stimulating the cell
Tone_gen = new ToneSignalGen_D(tstop,dt)
//create synapse through which the cell is stimulated
cell_exc.dend tone2LAPsyn = new tone2pyrD(0.9)
Rdm_D = r.discunif(10, 20) //Random delay
//deliver tone through NetCon object
tone2LAPcon = new NetCon(Tone_gen.tone.intfire1,tone2LAPsyn,0.5,Rdm_D,1)
```

2 Shock

The shock inputs were distributed uniformly to 70% of LA cells. The shock was delivered through AMPA and NMDA synapses. Here we apply the shock protocol to a single excitatory cell. The results are illustrated in Figure 2.

```
load_file("nrngui.hoc")
load_file("LAcells_template.hoc")
load_file("interneuron_template.hoc")
load_file("function_ToneGen.hoc")
load_file("function_NetStimOR.hoc")
load_file("function_ToneSignalGen_Th.hoc")
load_file("shockcondi.hoc")

objectvar cell_exc
```

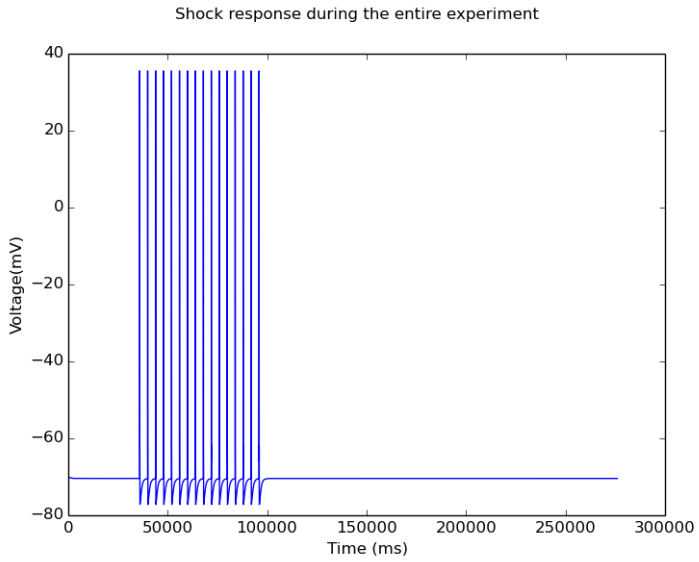

Figure 2: Shock delivered to a principal cell according to the experimental protocol

```
objref r
tstop = 276000
{load_file("function_TimeMonitor.hoc")}
dt = 0.01
r = new Random() //random number generator for random delays

objref shock2LAPsyn, shock2LAPcon
Rdm_D = r.discunif(10, 20) //Random delay
cell_exc.dend shock2LAPsyn = new shock2pyrD(0.9)
shock2LAPcon = new NetCon(shock,shock2LAPsyn,0.5,Rdm_D,1)
```

3 Summary

This week's experiments delivered the tone and shock protocol to a single excitatory cell.