4.5 + 2

Computational Cognitive Neuroscience - CH2

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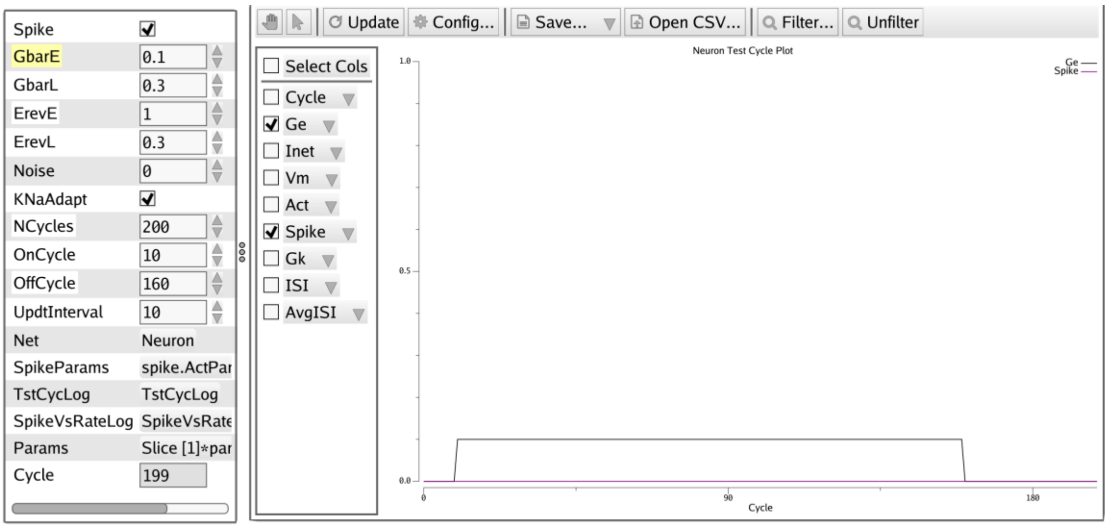
Question 2.1: Describe the effects on the rate of neural spiking of increasing GbarE to .4, and of decreasing it to .2, compared to the initial value of .3 (this is should have a simple answer).

1 As GbarE increases, the rate of neural spiking is also getting bigger. GbarE decreases as the rate of neural spiking decreases.

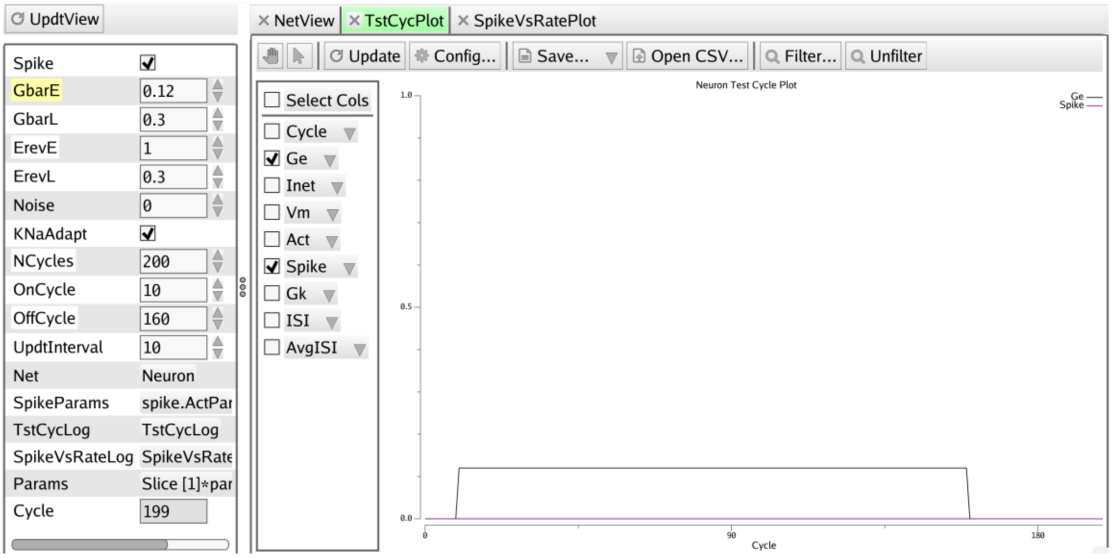
Question 2.2: Is there a qualitative difference in the neural spiking when GbarE is decreased to .1, compared to the higher values -- what important aspect of the neuron's behavior does this reveal?

The GbarE reduction to 0.1 does not produce the action potential. This is because the
1 voltage-gated Na+ channel opens only when the membrane potential exceeds a threshold.

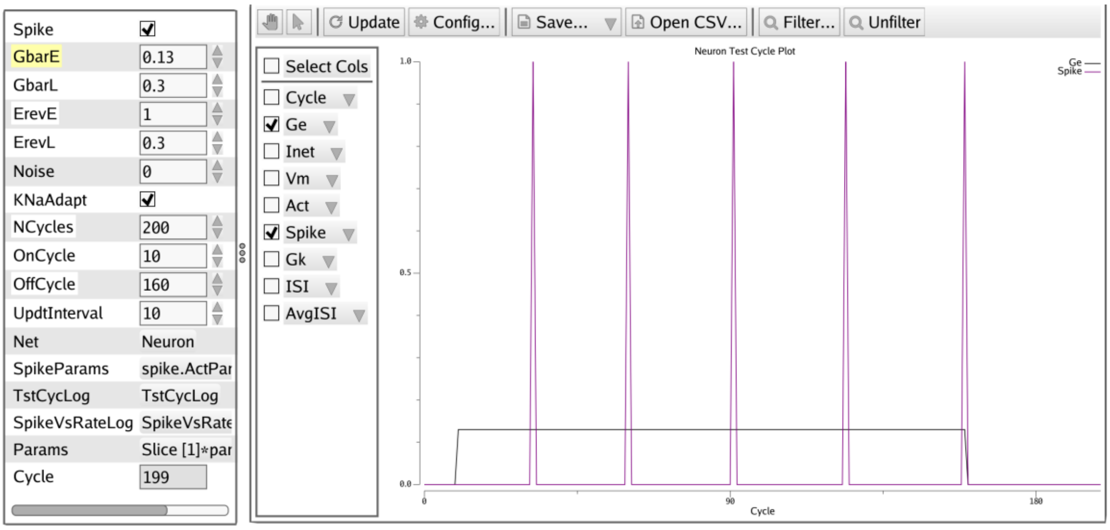


Question 2.3: To 2 decimal places (e.g., 0.15), what value of GbarE puts the neuron just over threshold, such that it spikes at this value, but not at the next value below it?

1 When GbarE is 0.13 just over threshold.



GbarE = 0.12



GbarE = 0.13

Question 2.4 (advanced): Using one of the equations for the equilibrium membrane potential from the Neuron chapter, compute the exact value of excitatory input conductance required to keep Vm in equilibrium at the spiking threshold. Show your math. This means rearranging the equation to have excitatory conductance on one side, then substituting in known values. (note that: Gl is a constant = .3; Ge is 1 when the input is on; inhibition is not present here and can be ignored) -- this should agree with your empirically determined value.

$$V_m = \frac{I_e R_e + G_l \cdot R_l}{I_e + G_l}$$

ge = gl*(El-theta)/(theta-Ee)

$$-55mV = \frac{I_e \cdot R_e + 0.3 \times 0.3}{I_e + 0.3}$$

0.5

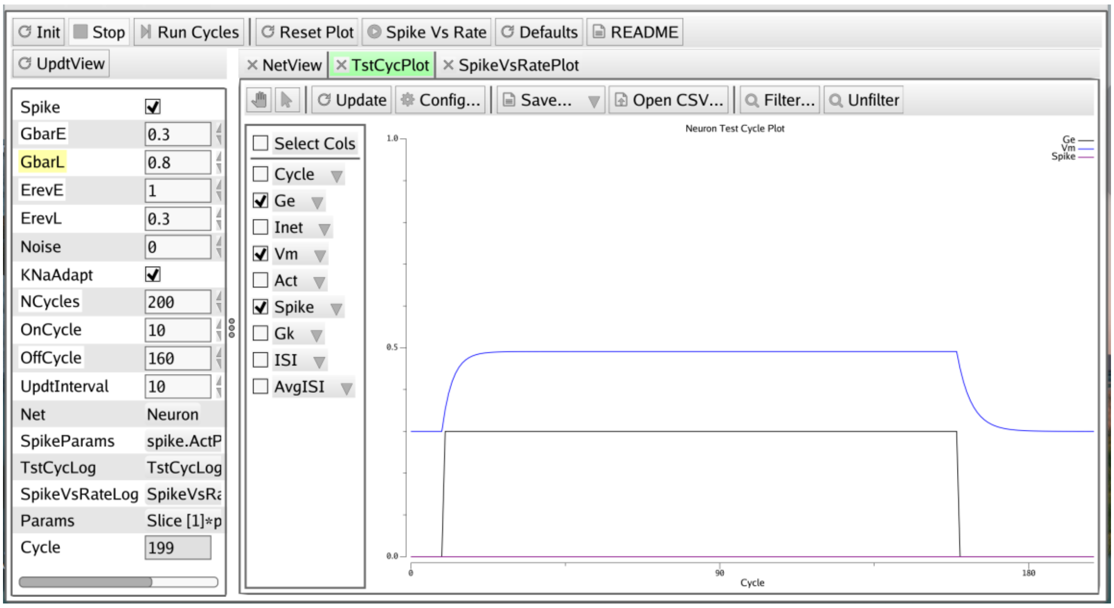
$$= -71.5mV - 0.3 \times 0.3$$

$$= -71.59mV$$

ans = 0.12

Question 2.5: What value of GbarL just prevents the neuron from being able to spike (in .1 increments) -- explain this result in terms of the tug-of-war model relative to the GbarE excitatory conductance.

1 When GbarL=0.8 it is just enough to prevent it from generating an action potential, because the potassium ions outflow at this time is equal to the incoming sodium ions.



GbarL = 0.8

Question 2.6 (advanced): Use the same technique as in question 2.4 to directly solve for the value of GbarL that should put the neuron right at it's spiking threshold using the default values of other parameters -- show your math.

$$-55mV = \frac{Re(-55mV) + 0.3NI}{Re + 0.3}$$

$$= \frac{-55 \cdot 0.3}{-55 \cdot (Re - 0.3)}$$

0.5

$$= \frac{-0.3}{55.1 \cdot 71.59 + 0.3}$$

$$\approx -0.000075$$

you need to use simulation values for this calculation

Question 2.7: Compare the spike rates with rate coded activations by reporting the act values just before cycle 160 (e.g., cycle 155) for GbarE = .2, .3, .4 with Spike = false, and the corresponding values in the Spike = true case for the same GbarE values. For now, you'll have to click on the TstCycLog and scroll to cycle 155 to see the exact numbers -- a future release will hopefully enable you to just hover over the line and see the value on the graph directly.

etable.Table TstCycLog

Record of testing per cycle testing trial–level log data –– click to see record of network's response to each input

UpdtView | Config | Add Rows | Sort... | Filter... | Show All | Open CSV... | Save CSV...

Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.2	−0.000216354	0.51281	0.304393	0	0.128642	−1	−1
00153	153	0.2	−0.000213262	0.512745	0.303379	0	0.128785	−1	−1
00154	154	0.2	−0.000210252	0.512682	0.302376	0	0.128926	−1	−1
00155	155	0.2	−0.00020729	0.512619	0.301383	0	0.129066	−1	−1
00156	156	0.2	−0.000204384	0.512557	0.300402	0	0.129203	−1	−1
00157	157	0.2	−0.000201568	0.512496	0.29943	0	0.129339	−1	−1
00158	158	0.2	−0.000198789	0.512435	0.298469	0	0.129473	−1	−1
00159	159	0.2	−0.000196062	0.512376	0.297517	0	0.129606	−1	−1
00160	160	0	−0.0977182	0.482764	0.20736	0	0.129376	−1	−1
00161	161	0	−0.0849434	0.457024	0.144524	0	0.128899	−1	−1

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Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.2	0.0560868	0.459025	0.438479	0	0.0410884	9	12.6723
00153	153	0.2	0.0477257	0.473487	0.438455	0	0.0406814	10	12.6723
00154	154	0.2	0.0406315	0.485799	0.438439	0	0.0402813	11	12.6723
00155	155	0.2	0.0346112	0.496288	0.438427	0	0.039888	12	12.6723
00156	156	0.2	0	0.3	0.437736	1	0.0395012	0	12.7379
00157	157	0.2	0	0.3	0.437254	0	0.0395012	1	12.7379
00158	158	0.2	0	0.3	0.436918	0	0.0395012	2	12.7379
00159	159	0.2	0	0.3	0.436684	0	0.0395012	3	12.7379
00160	160	0	−0.00213507	0.299353	0.436521	0	0.045057	4	12.7379
00161	161	0	−0.00190253	0.298777	0.436407	0	0.0446058	5	12.7379

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Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.3	−0.000667825	0.551627	0.70702	0	0.197883	−1	−1
00153	153	0.3	−0.000662602	0.551426	0.706299	0	0.198397	−1	−1
00154	154	0.3	−0.000657436	0.551227	0.705579	0	0.198908	−1	−1
00155	155	0.3	−0.000652395	0.551029	0.704861	0	0.199416	−1	−1
00156	156	0.3	−0.000647385	0.550833	0.704144	0	0.199921	−1	−1
00157	157	0.3	−0.000642456	0.550638	0.703428	0	0.200423	−1	−1
00158	158	0.3	−0.000637624	0.550445	0.702714	0	0.200922	−1	−1
00159	159	0.3	−0.00063283	0.550253	0.702001	0	0.201418	−1	−1
00160	160	0	−0.135552	0.509177	0.489273	0	0.201285	−1	−1
00161	161	0	−0.114921	0.474352	0.341009	0	0.200727	−1	−1

etable.Table TstCycLog

Record of testing per cycle testing trial–level log data –– click to see record of network's response to each input

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0.75

Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.3	0	0.3	0.632952	0	0.0572003	3	8.79029
00153	153	0.3	0.186163	0.356413	0.632667	0	0.0617973	4	8.79029
00154	154	0.3	0.152646	0.402669	0.632468	0	0.0611889	5	8.79029
00155	155	0.3	0.125221	0.440615	0.632329	0	0.0605908	6	8.79029
00156	156	0.3	0.102774	0.471759	0.632233	0	0.0600027	7	8.79029
00157	157	0.3	0.0843984	0.497334	0.632166	0	0.0594245	8	8.79029
00158	158	0.3	0	0.3	0.631209	1	0.0588559	0	8.83223
00159	159	0.3	0	0.3	0.630543	0	0.0588559	1	8.83223
00160	160	0	0	0.3	0.630078	0	0.0588559	2	8.83223
00161	161	0	0	0.3	0.629754	0	0.0588559	3	8.83223

etable.Table TstCycLog

Record of testing per cycle testing trial–level log data –– click to see record of network's response to each input

UpdtView | Config | Add Rows | Sort... | Filter... | Show All | Open CSV... | Save CSV...

Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.4	−0.000786677	0.594856	0.838592	0	0.215691	−1	−1
00153	153	0.4	−0.000781655	0.594619	0.838347	0	0.216306	−1	−1
00154	154	0.4	−0.000776693	0.594384	0.838103	0	0.216918	−1	−1
00155	155	0.4	−0.000771791	0.59415	0.837859	0	0.217527	−1	−1
00156	156	0.4	−0.000766955	0.593918	0.837616	0	0.218133	−1	−1
00157	157	0.4	−0.000762224	0.593687	0.837373	0	0.218736	−1	−1
00158	158	0.4	−0.00075756	0.593457	0.837131	0	0.219337	−1	−1
00159	159	0.4	−0.000752971	0.593229	0.836889	0	0.219935	−1	−1
00160	160	0	−0.163457	0.543697	0.583286	0	0.21984	−1	−1
00161	161	0	−0.137675	0.501977	0.406533	0	0.219277	−1	−1

etable.Table TstCycLog

Record of testing per cycle testing trial–level log data –– click to see record of network's response to each input

UpdtView | Config | Add Rows | Sort... | Filter... | Show All | Open CSV... | Save CSV...

Index	Cycle	Ge	Inet	Vm	Act	Spike	Gk	ISI	AvgISI
00152	152	0.4	0.153763	0.479211	0.793651	0	0.0714785	6	7
00153	153	0.4	0	0.3	0.793651	1	0.0707813	0	7
00154	154	0.4	0	0.3	0.793651	0	0.0707813	1	7
00155	155	0.4	0	0.3	0.793651	0	0.0707813	2	7
00156	156	0.4	0	0.3	0.793651	0	0.0707813	3	7
00157	157	0.4	0.243842	0.373892	0.793651	0	0.0746455	4	7
00158	158	0.4	0.193424	0.432505	0.793651	0	0.0739169	5	7
00159	159	0.4	0.153516	0.479025	0.793651	0	0.0732004	6	7
00160	160	0	–0.0663426	0.458921	0.793651	0	0.072496	7	7
00161	161	0	–0.0591467	0.440998	0.793651	0	0.0718033	8	7

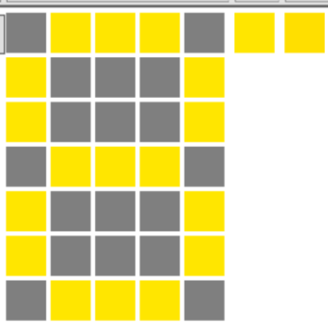
As GbarE increases the act values also increases and the spike rates becomes faster and faster. After set the Spike = true case for the same GbarE values, the act values will decrease slightly.

Question 2.8: For each digit, report the number of active Input units where there is also a weight of 1 according to the 8 digit pattern. In other words, report the overlap between the input activity and the weight pattern. HINT: Strictly speaking, the 8 display in the DigitPats window is NOT representing the weights per se, but as we saw earlier using the r.Wt functionality in NetView, they are the same pattern -- and displaying the windows side-by-side just makes the counting easier.

Record of testing per input pattern testing trial–level log data –– click to see record of network's response to each input

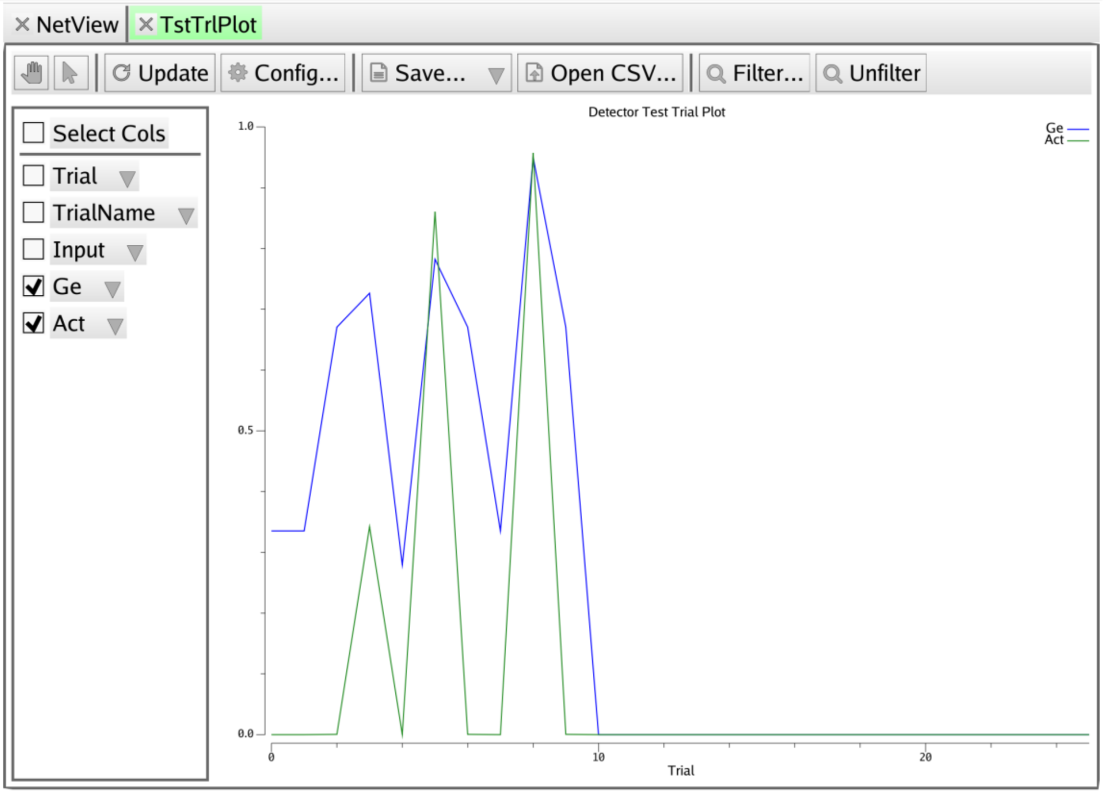
UpdtView | Config | Add Rows | Sort... | Filter... | Show All | Open CSV... | Save CSV...

0.25

Index	Trial	TrialName	Input	Ge	Act
00008	8	8			

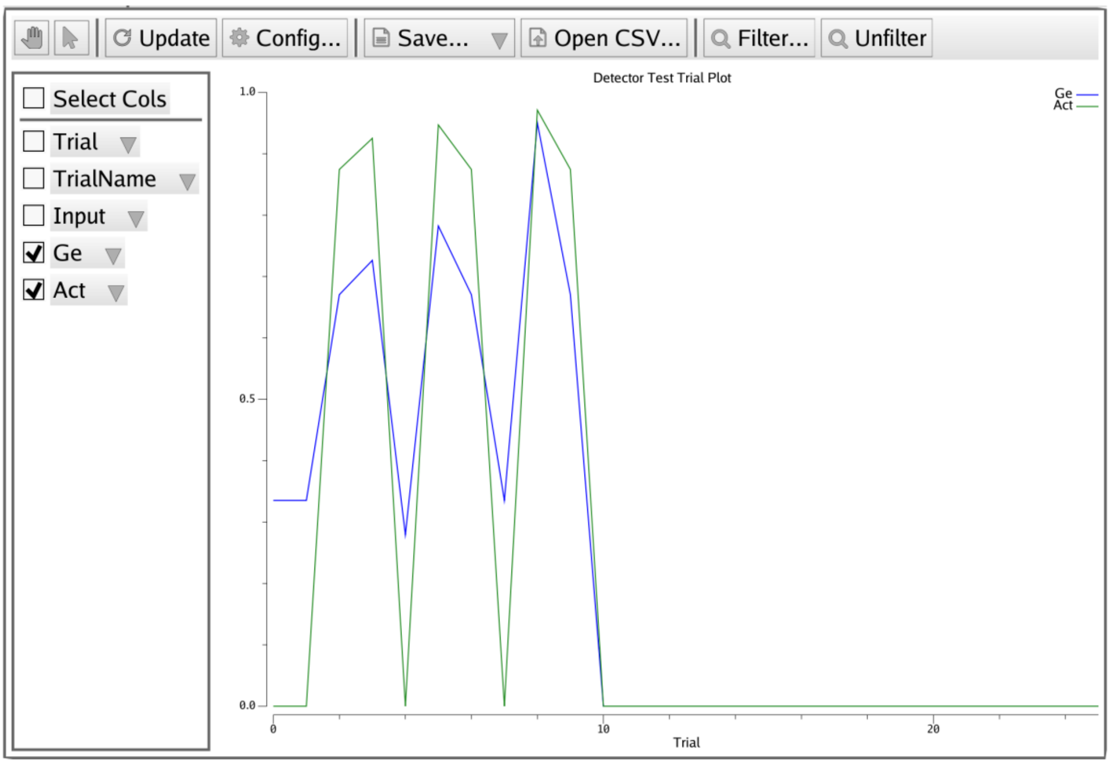
Overlap = 17.

Question 2.9: What happens to the pattern of receiving neuron activity over the different digits when you change GbarL to 1.8, 1.5, and 2.3 -- which input digits does it respond to for each case? In terms of the tug-of-war model between excitatory and inhibition & leak (i.e., GbarL = leak), why does changing leak have this effect (a simple one-sentence answer is sufficient)?

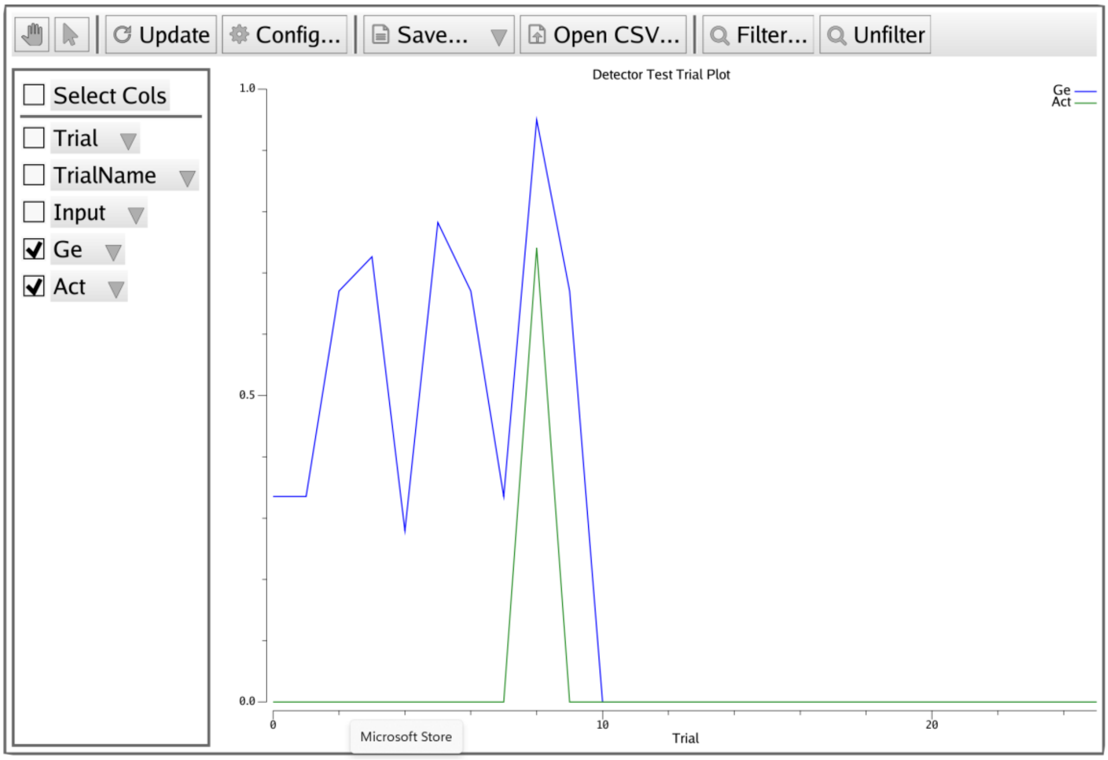


0.5

1.8



1.5



2.3

The decrease in leak may make neurons more easily to fire, and the decrease in outflow of potassium ions may facilitate the accumulation of positive ion concentrations in the membrane faster above the threshold to form an action potential.

Question 2.10: Why might it be beneficial for the neuron to have a lower level of leak (e.g., GbarL = 1.8 or 1.5) compared to the original default value, in terms of the overall information that this neuron can convey about the input patterns it is "seeing"?
0 Because at lower leak values, neurons are more responsive to external stimuli and are better able to recognize subtle differences in patterns.

"Lowering leak allows neurons to respond in a graded way to inputs that are similar to 8. This c