Fit of dendritic neuron

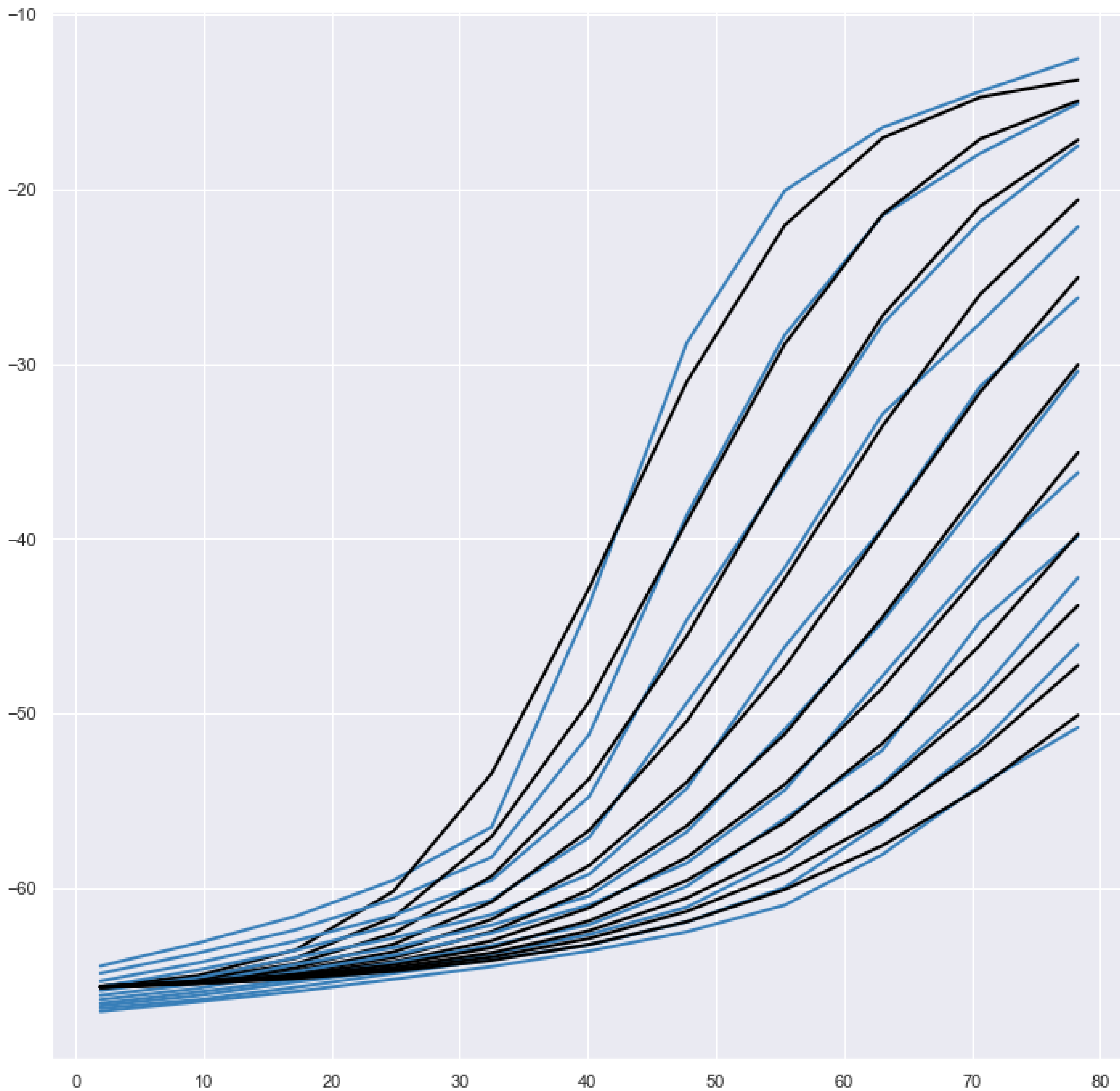
In order to fit the mean dendritic voltage to the inhibitory and excitatory inputs, I use the following function:

$$y = \frac{(I_{exc} - (\beta * I_{inh} + \delta))}{(\zeta * I_{inh} + \mu)}$$

$$< V_D >= \alpha(-0.5 + \frac{1}{1+\exp(-y)}) + \gamma$$

A few key points:

- Instead of the exponential, I just use a normalization by the inhibitory current. Fitting are similar (even better) and the formula seems more natural
- Using the sigmoind instead of the hyperbolic tangent leads to an accurate fit and remove the low excitation issue
- In average, the increase of firing rate dues to increase of inhibition was only happening at very low excitatory rates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−20
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−40
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0
10
20
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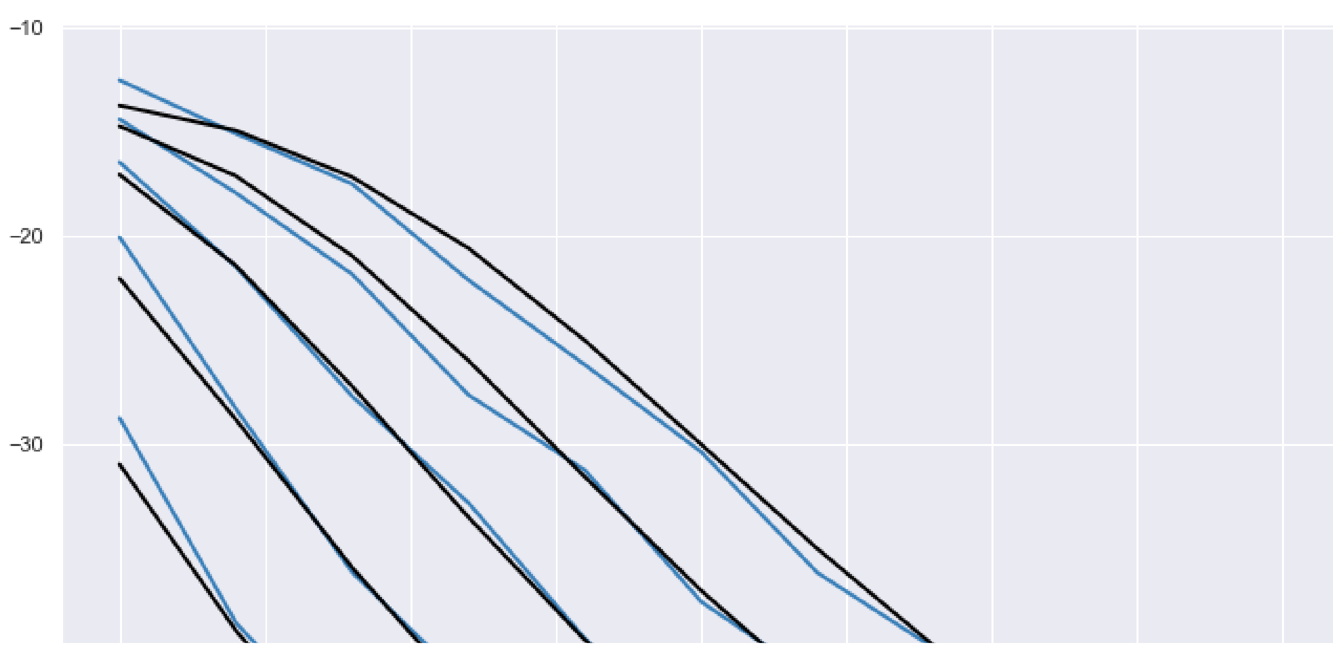
40
50
60
70
80


−10
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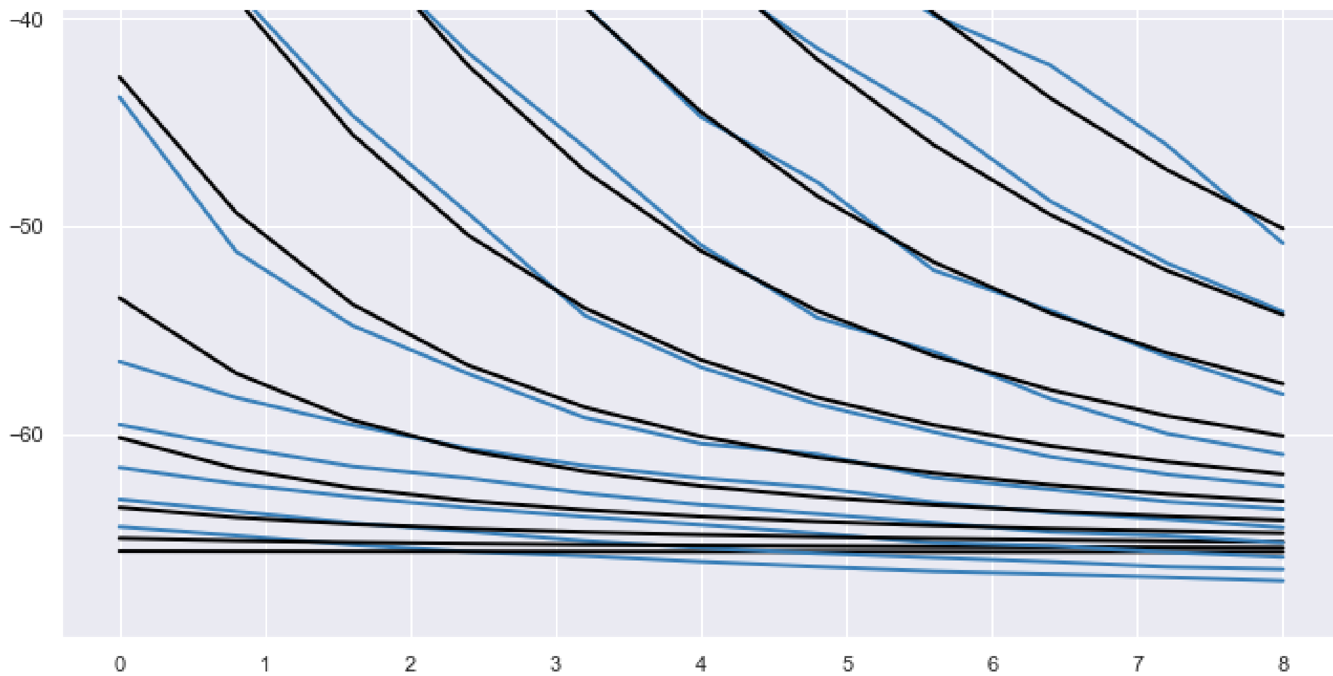


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PlotlyJSBackend()
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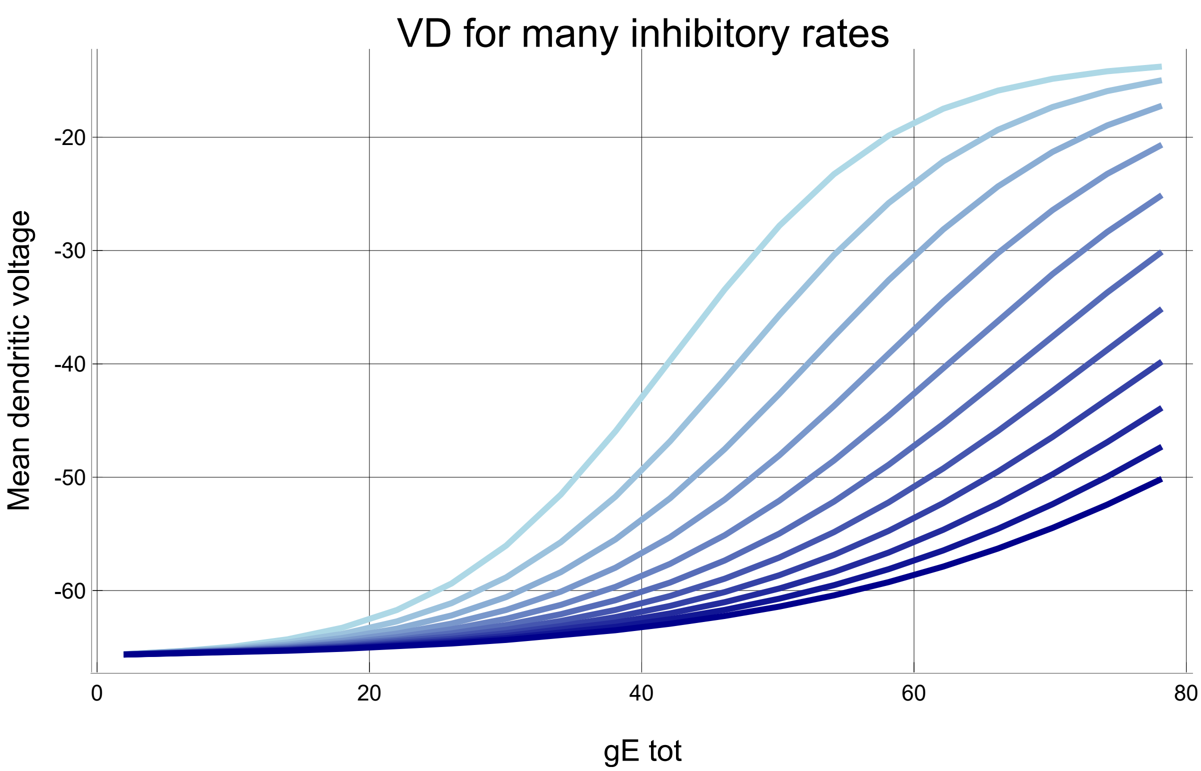
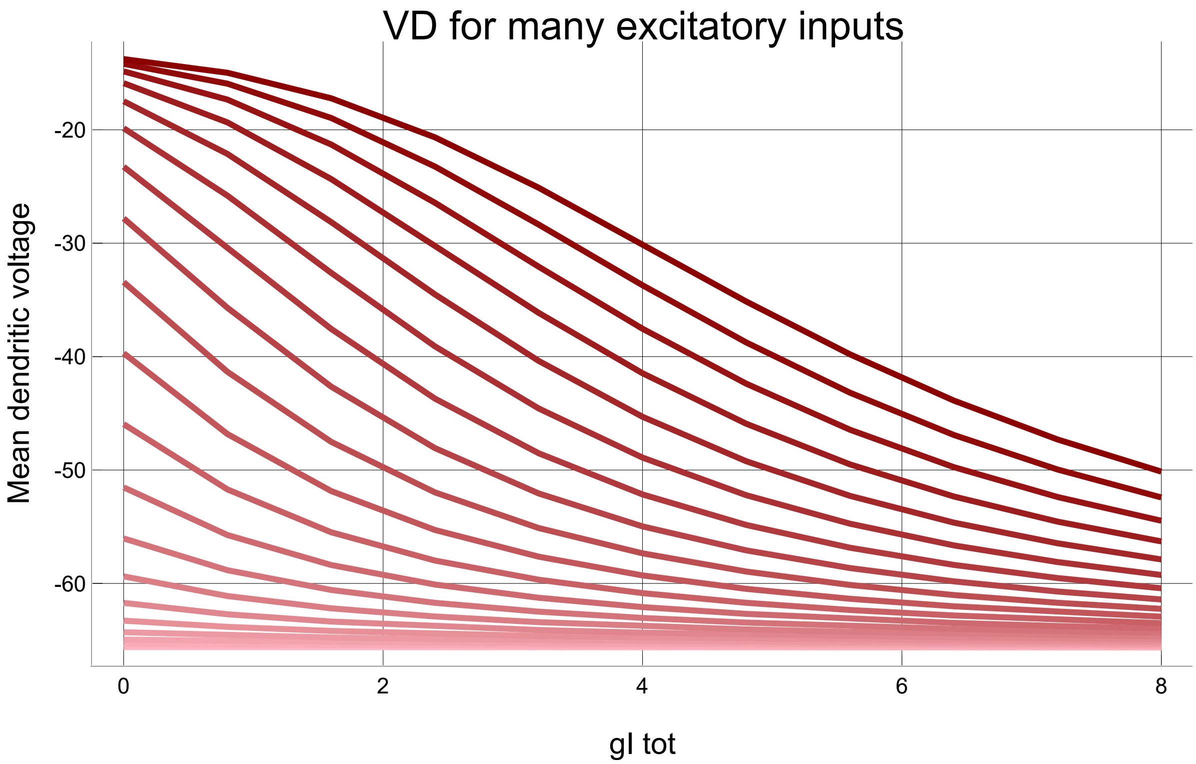
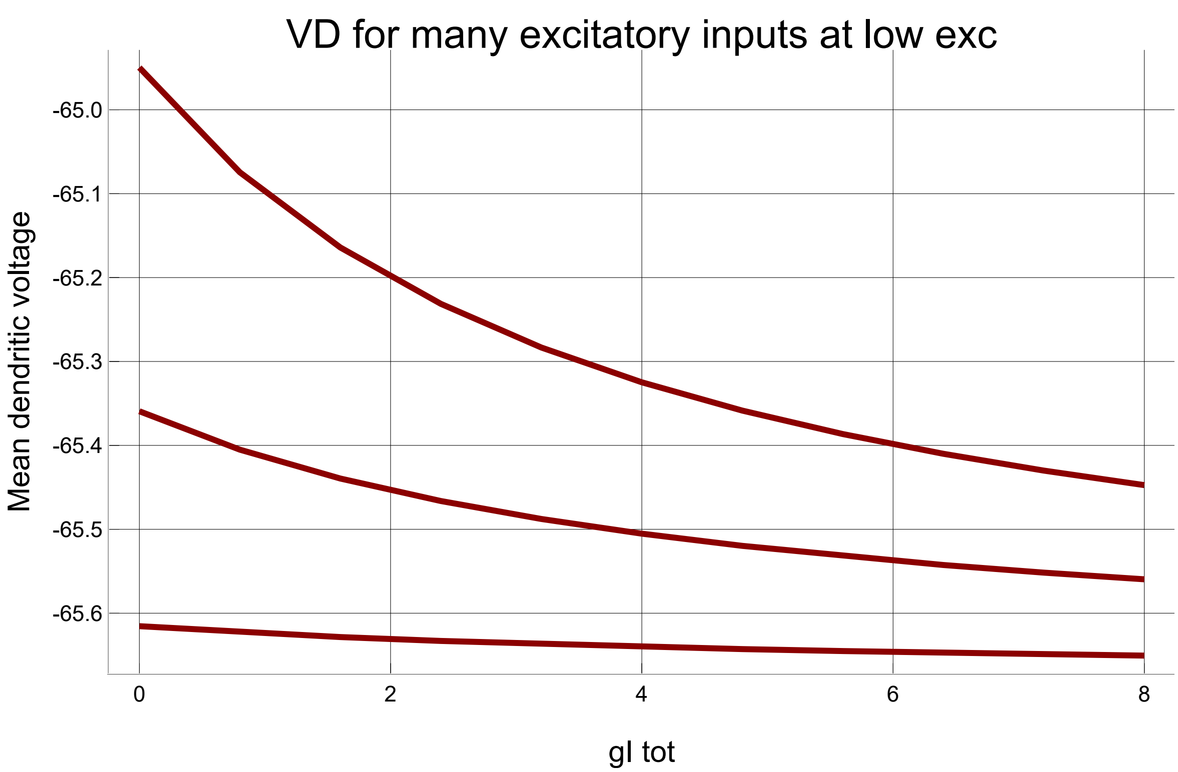


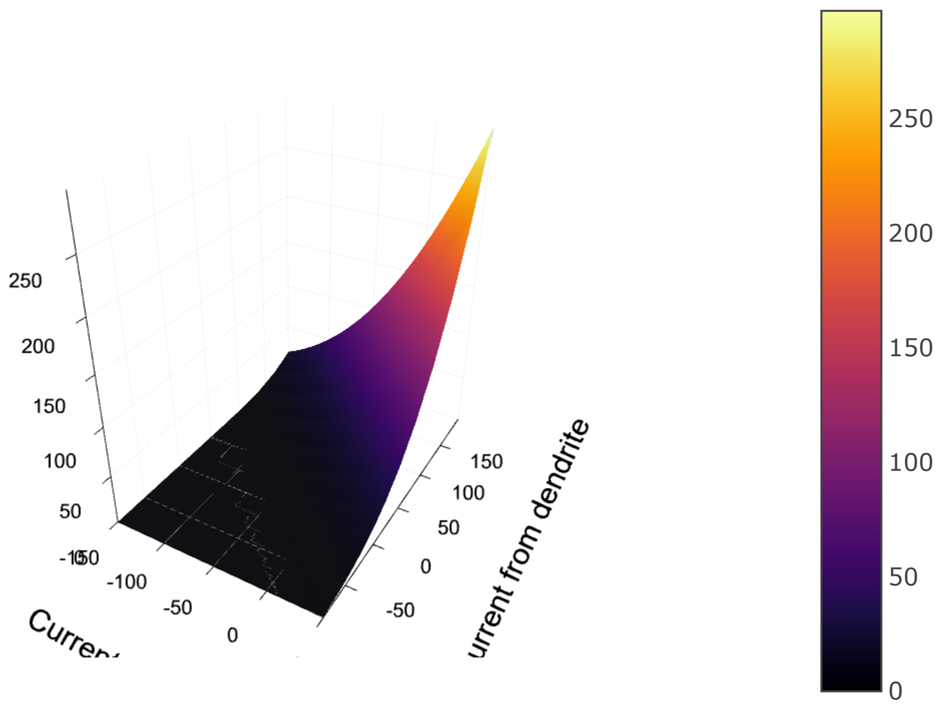




Now it's time to look at the 2D f-I curve of this kind of dendritic neuron to be sure it's behaving accordingly to the few experimental data

The first thing is to see if the behavior of the somatic firing rate is non-linear with the assymetry in dendritic and somatic inputs.

Due to the assymetry in excitation and inhibition, it's necessary to work at fixed inhibition toward the distal dendrites.



Now let's study a simplified model of the dendritic model. The mean dendritic voltage is directly inserted into current from dendrite to soma just to ismplified the writing.

$$y = \frac{(I_{exc} - (\beta * I_{inh} + \delta))}{(\zeta * I_{inh} + \mu)}$$

$$I_{dend \rightarrow soma} = \alpha(-0.5 + \frac{1}{1 + \exp(-y)}) + \gamma$$

```
md"""
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"""
```
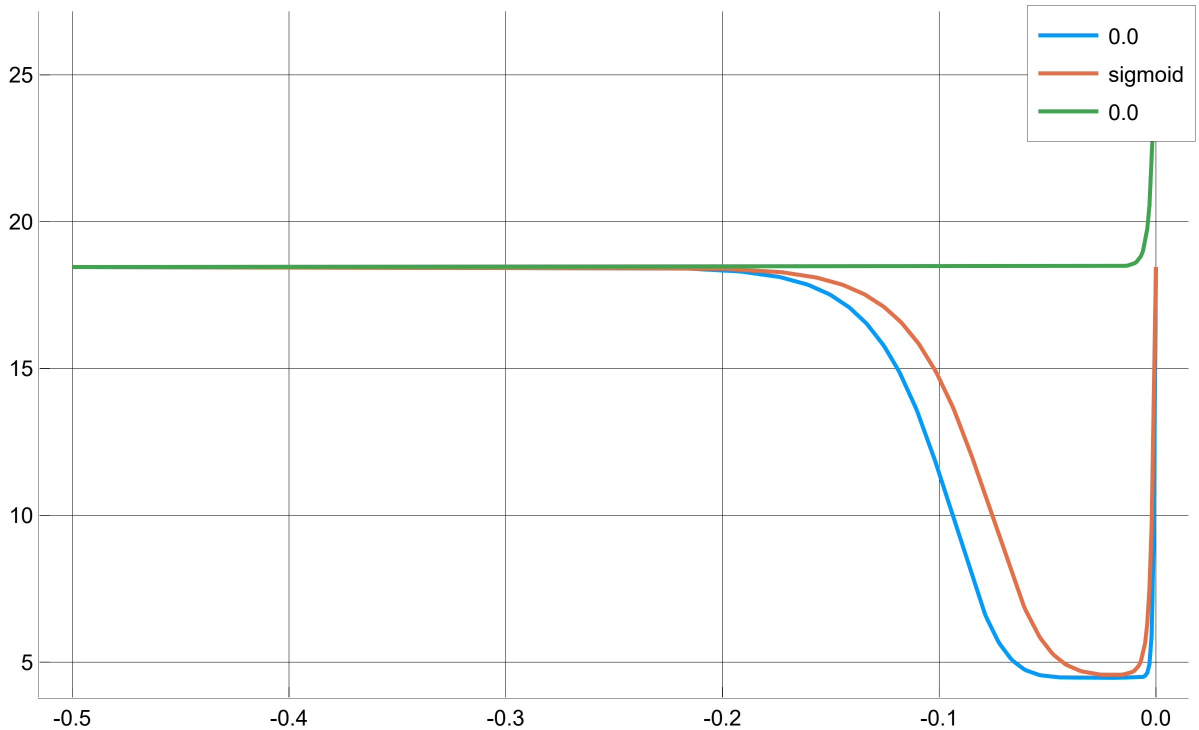

FIseansigmoidv2 (generic function with 1 method)

```
@bind Iexc_cst Slider(0.0:0.1:1.0)
```


0.0
sigmoid
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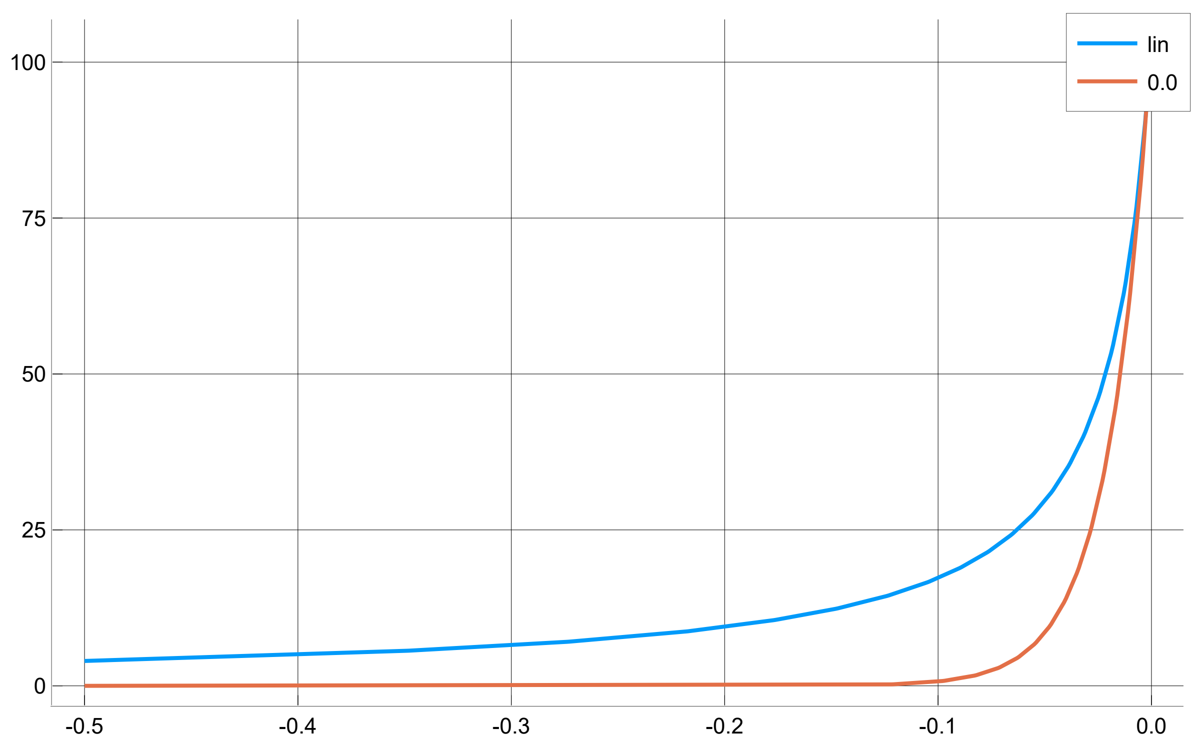
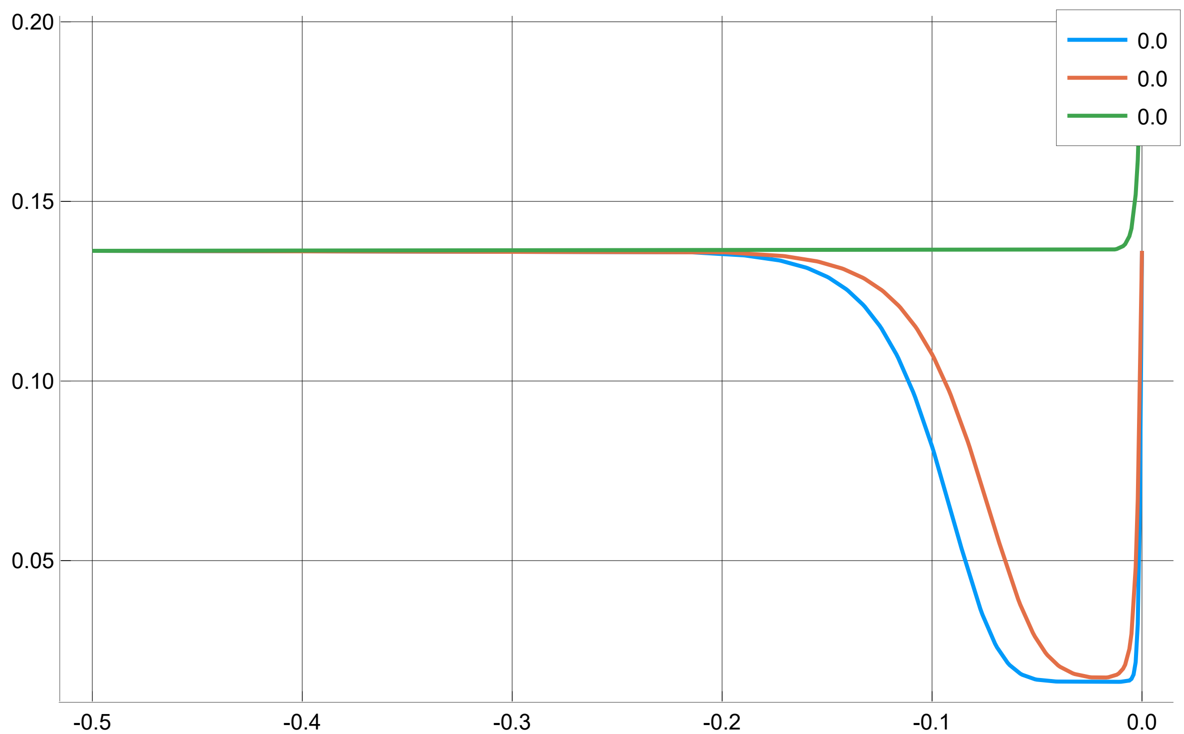
25
20
15
10
5
-0.5
-0.4
-0.3
-0.2
-0.1
0.0


lin
0.0
100
75
50
25
0
-0.5
-0.4
-0.3
-0.2
-0.1
0.0

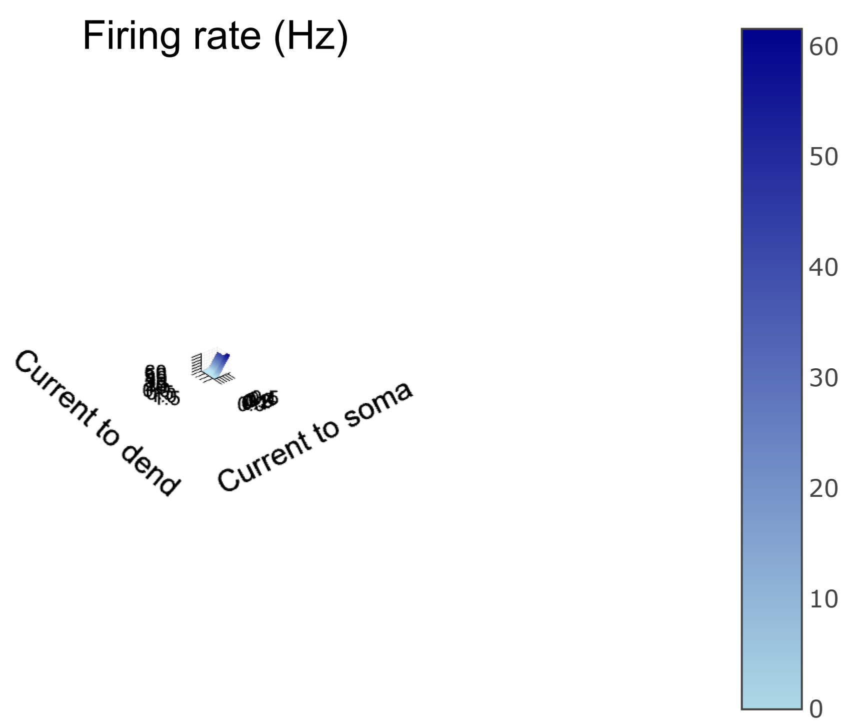


2D fI curve for the sigmoid rate model

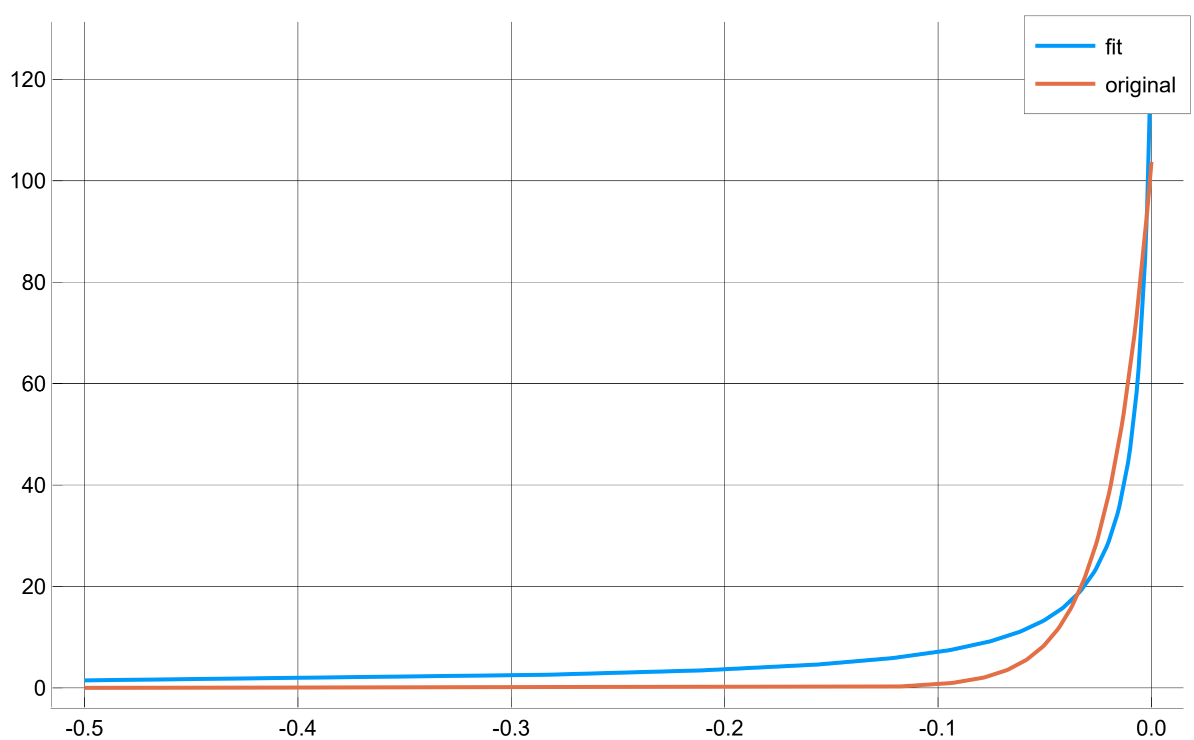
```
md"""
2D fI curve for the sigmoid rate model


"""
```

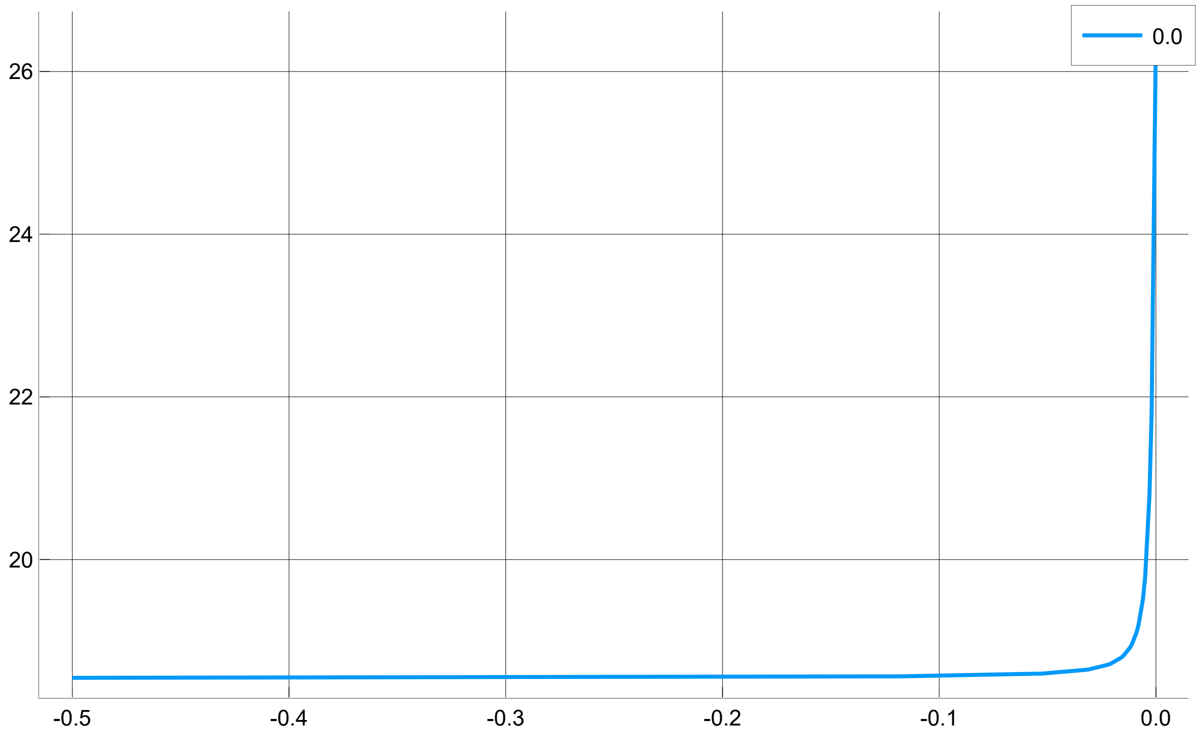
```
@bind cst_Iinh Slider(-0.5:0.05:0.0)
```



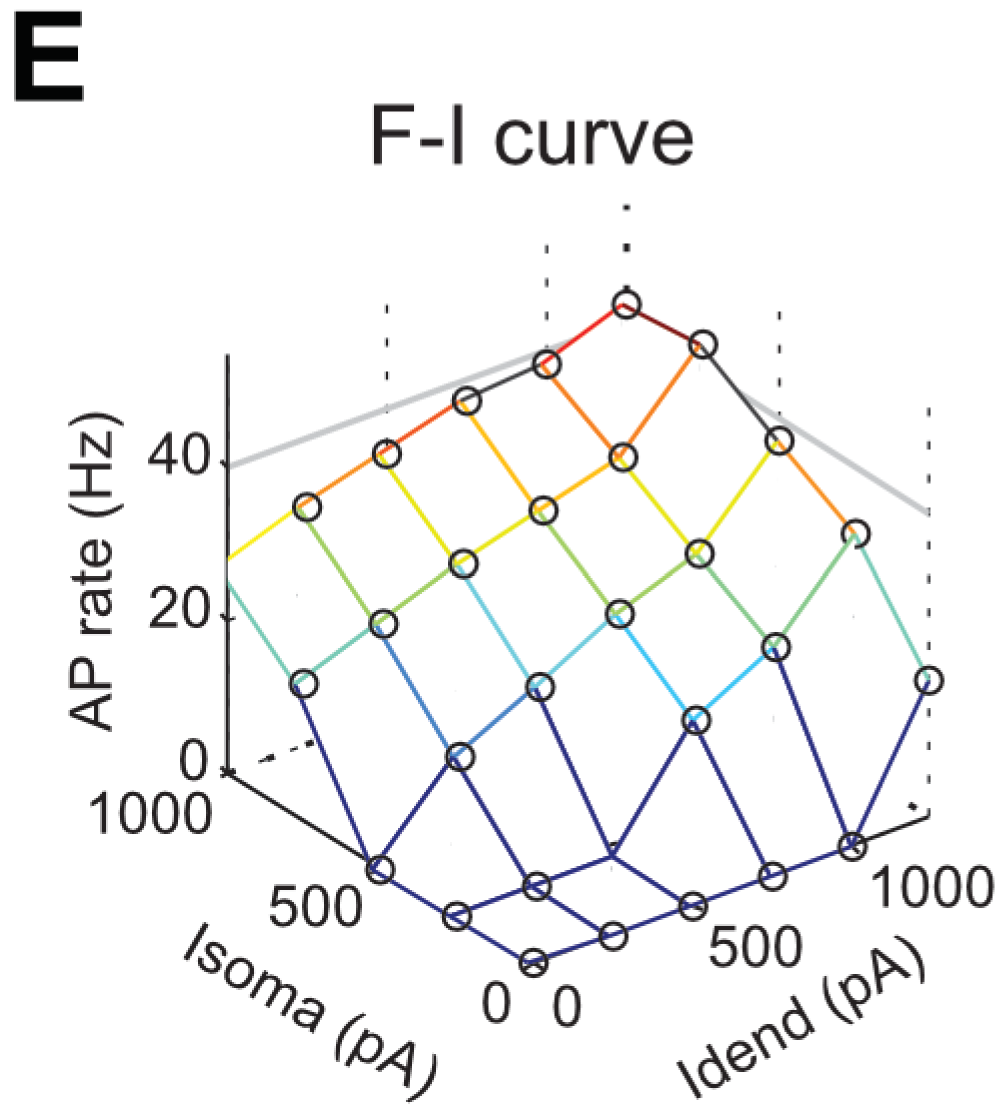
Fitting the exponential funciton in Sean's paper and the linear sigmoid one




```
[0.0:0.01:1.7, -0.5:0.001:0.0]
```

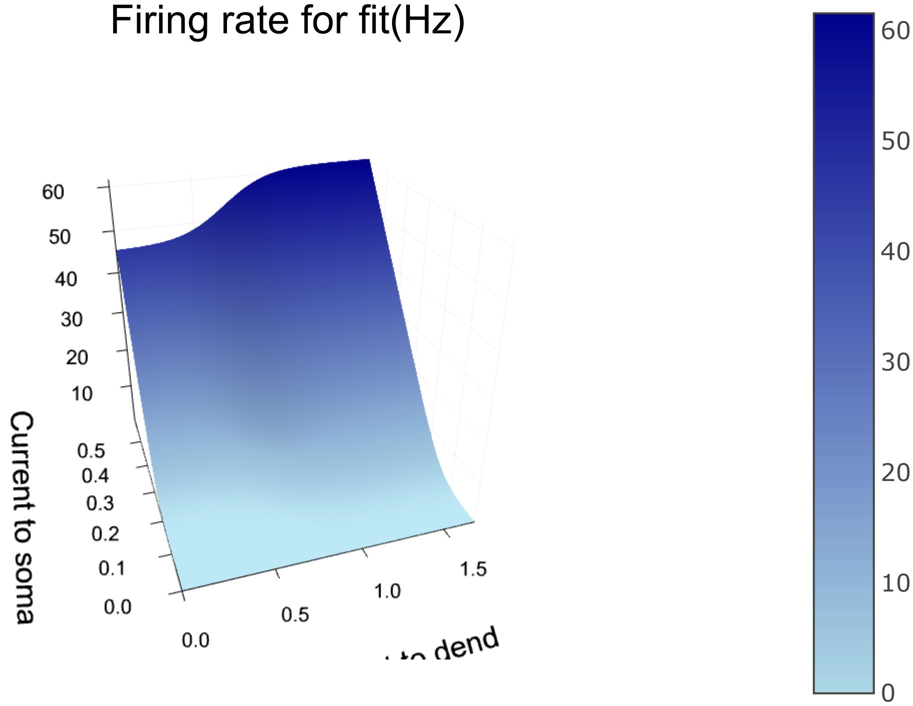



```
@bind cst_Iinh_fit Slider(-0.5:0.05:0.0)
```

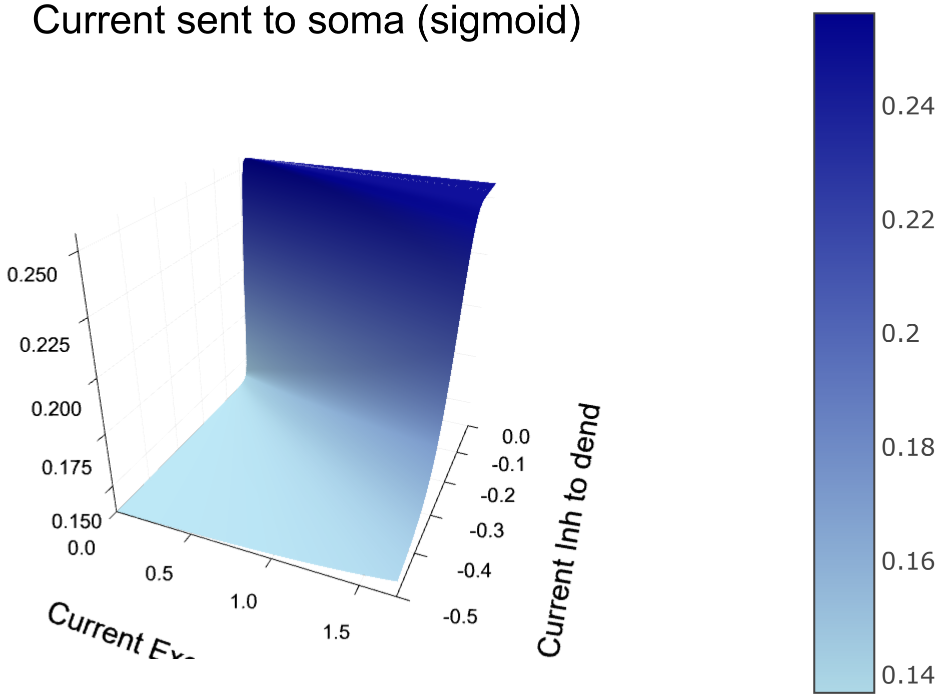


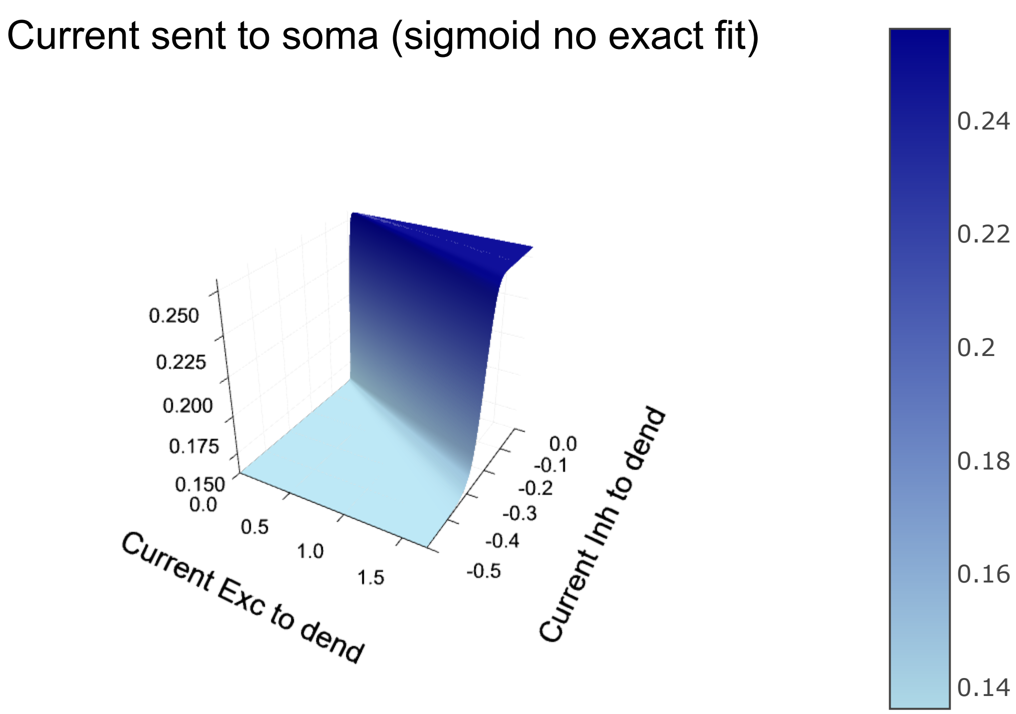

```
md"""
$(LocalResource("C:\\Users\\kevin\\Documents\\MyDocuments\\3-NYU\\1-project-categorical-MMN\\_research\\0-fig-divers\\larkum2019.png"))
"""
```

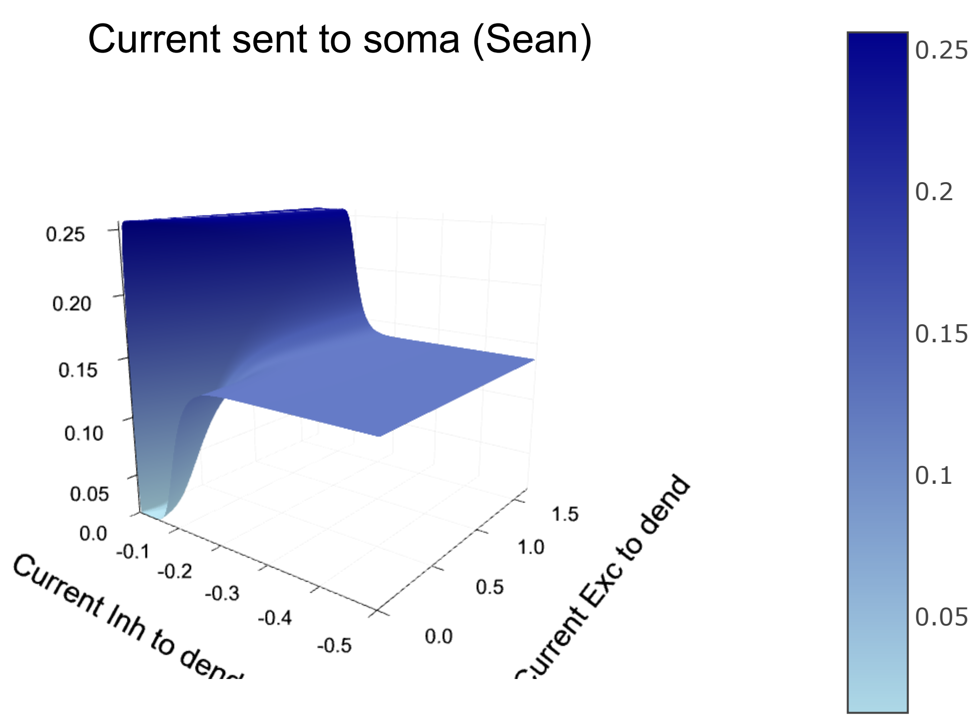
Firing rate for fit(Hz)



Current sent to soma (sigmoid)








```
begin
    current_2DSean = zeros(length(Iinh),length(exc_dend_list))

    for i=1:length(Iinh)
        for j=1:length(exc_dend_list)
            current_2DSean[i,j] = FIsean(exc_dend_list[j],Iinh[i])
        end
```

```julia
    end

    plot(exc_dend_list,Iinh,current_2DSean,st=:surface, c=:blues)
    xlabel!("Current Exc to dend")
    ylabel!("Current Inh to dend")
    title!("Current sent to soma (Sean)")

end
```

To conclude:

- The sigmoid function can be fitted succesfully
- Mathematicla analysis explains why we don't have the issues of the previous function
- In addition the main points in Sean's parameters are kept

If the goal is to have a simpler function (with implicit dendritic voltage use), then I suggest the following (parameters taken from fit and adaptation of Robert or Sean papers):

$$I_{dend \rightarrow soma} = p[1] * \left(-0.5 + \sigma \left(\frac{I_{exc} + p[2] I_{inh}}{p[3] * I_{inh} + p[4]}\right) \right) + p[5]$$

with σ the sigmoid function.

Parameters are:

- $p[1] = 0.12$
- $p[1] = 7.0$
- $p[1] = -0.482$
- $p[4] = 0.00964$
- $p[5] = 0.19624$

The firing rate function is then the standard Abott and Chance one.

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md"""
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```

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Enter cell code...
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