

NeuroML-DB: A Model Sharing Resource that Promotes Rapid Selection and Reuse

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Justas Birgiolas, Vergil Haynes, Russell Jarvis, Rick Gerkin

Arizona State University



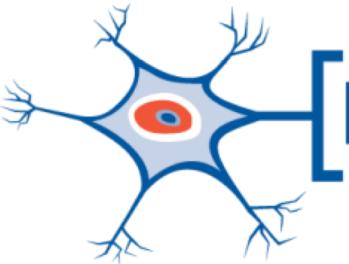
Laboratory for Informatics and
Computation in Open Neuroscience
<https://iconlab.asu.edu>

How can we improve impact of computational models in neuroscience?

FAIR models improve the impact of models on science.
(Findable, Accessible, Interoperable, Reusable)
Making models more accessible and useful!



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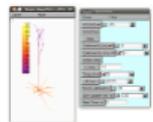
[NeuroML]

<http://neuroml.org>
RRID:SCR_003083

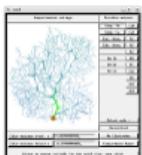
NeuroML: Simulator-independent, model description language providing a community standard for multiscale models in neuroscience



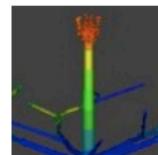
Simulators



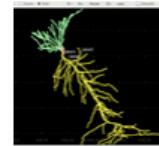
NEURON



GENESIS



MOOSE

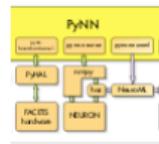


PSICS

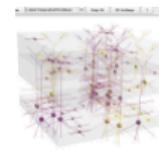


NeuroSpaces

Cross simulator frameworks



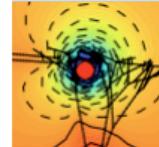
PyNN



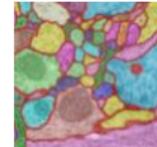
neuroConstruct



OpenWorm



LFPy



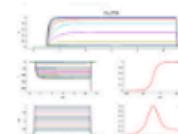
Connectomics

TrakEM

Databases



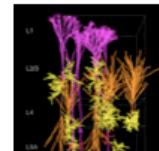
NeuroMorpho



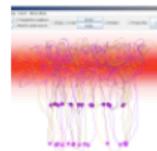
Channelpedia



TREES
toolbox



NeuGen



Neuronal
morphology
generation &
analysis

<http://neuroml.org/tool-support>
RRID:SCR_012844

Collaborative Modeling with NeuroML at Open Source Brain

<http://opensourcebrain.org>
RRID:SCR_001393



search projects

Explore OSB Help Sign in Sign up



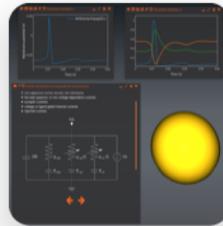
Modelling the brain, together

Open Source Brain is a resource for sharing and collaboratively developing computational models of neural systems.

Learn more about the OSB interface



Learn about the Hodgkin Huxley model



Simulate electrophysiologically detailed cell models



Explore more OSB projects



Or create an account to add your own models and **run simulations!**

Sign up

Sign in



The **Open Source Brain paper** has just been published in Neuron! Read [Gleeson et al. 2019](#).

Join us at the **OSB 2019 meeting** in Sardinia in September! More details [here](#).

<http://neuroml-db.org>
RRID:SCR_013705



[NeuroML] Database

Search NeuroML Models Submit NeuroML Models About NeuroML-DB API Documentation NeuroML Home

Search NeuroML Database

granule cell olfactory bulb

Search

Hint: Use quotes for exact matches (e.g. "layer 2/3" bipolar cell irregular burst)

Keyword Search Results

[Main Olfactory Bulb Granule Cell](#)

From: Migliore, et. al. (2014)

[Fast Inhibitory \(Fl\) Synapse](#)

From: Migliore, et. al. (2010)

[AMPA/NMDA Synapse](#)

From: Migliore, et. al. (2010)

[Passive Leak Channel](#)

From: Hodgkin & Huxley (1952)

[IA A Type Potassium Channel](#)

From: Wang, et. al. (1996)

[KDr Delayed Rectifier Potassium Channel](#)

From: Wang, et. al. (1996)

[NaX Sodium Channel for Axon](#)

From: Poolos, et. al. (2002)

Ontology Based Recommendations

[Main Olfactory Bulb Mitral Cell \(1\)](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main mitral cell body layer**

[Main Olfactory Bulb Mitral Cell \(2\)](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main mitral cell body layer**

[Main Olfactory Bulb Mitral Cell \(3\)](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main mitral cell body layer**

[Main Olfactory Bulb Mitral Cell \(4\)](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main mitral cell body layer**

[Main Olfactory Bulb Mitral Cell \(5\)](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main mitral cell body layer**

[Main Olfactory Bulb Granule Cell](#)

From: Migliore, et. al. (2014)

Located in **Olfactory bulb main granule cell layer**

Main Olfactory Bulb Mitral Cell (1)

Model Type: Cell

Neurolex IDs: [Olfactory bulb \(main\) mitral cell](#)

Keywords: main olfactory bulb, glutamate

Publication: [Migliore, et. al. \(2014\) Distributed organization of a brain microcircuit analyzed by three-dimensional modeling: the olfactory bulb.](#)

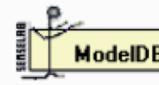
Authors: Michele Migliore Francesco Cavarretta Michael Hines Gordon Shepherd

Translators: Padraig Gleeson Justas Birgoliolas

Sources:



[View OpenSourceBrain Model](#)



[View ModelDB Model](#)



[View GitHub Model](#)

[View OpenSourceBrain on SciCrunch](#)

[View ModelDB on SciCrunch](#)

[View GitHub on SciCrunch](#)

Files:

[Download NeuroML Version](#)

[Download Blender Version](#)

[Download gif Version](#)

[Download NEURON Version](#)

[Download swc Version](#)

Model ID

NeuroML File

[NMLCL001129](#)

Mitral_0_0.cell.nml

(view XML)

[NMLCH000134](#)

kamt.channel.nml

(view XML)

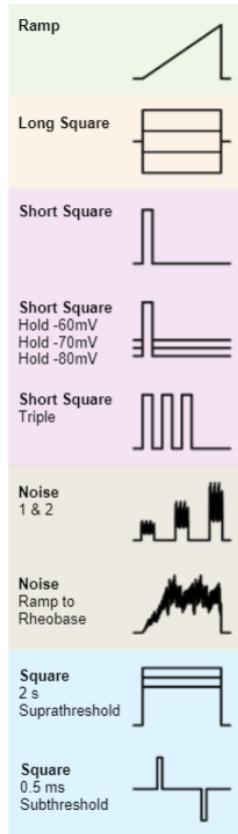
[NMLCH000135](#)

kdrmt.channel.nml

(view XML)

Current Clamp Response:

Instructions



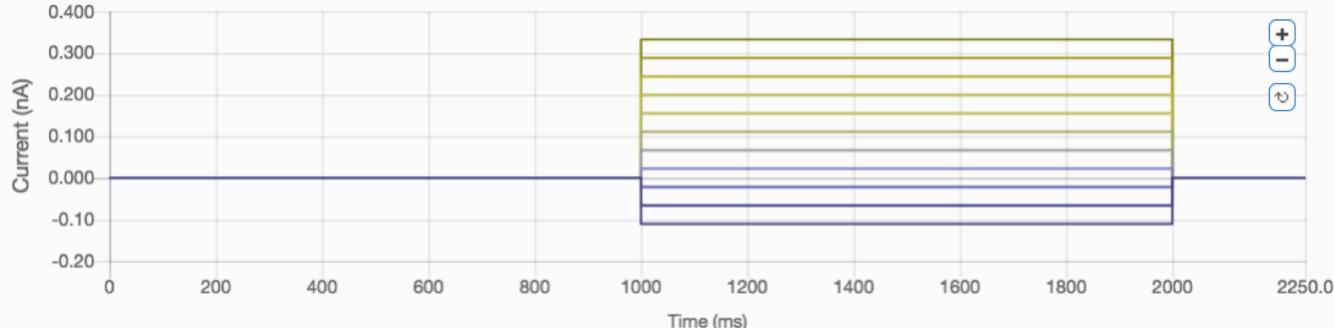
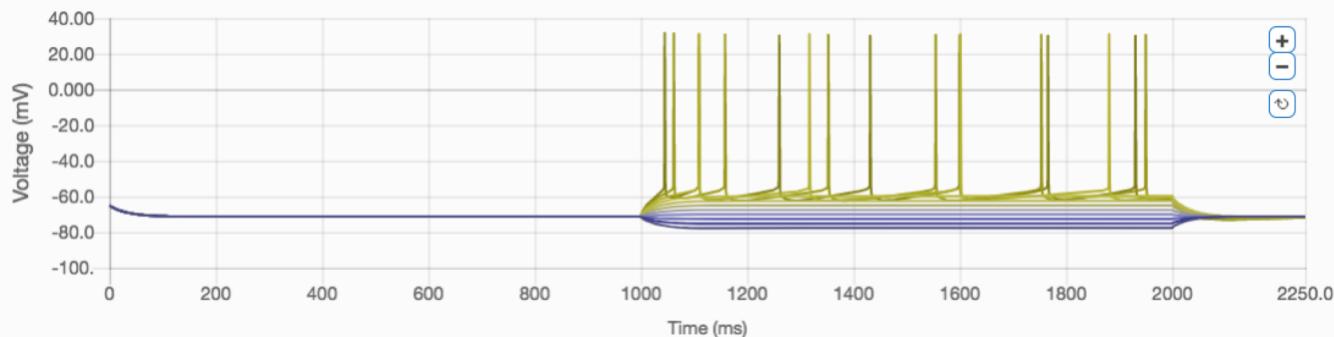
Current Clamp Response:

Instructions ⓘ

Protocol:

Square

Stimulus: ALL

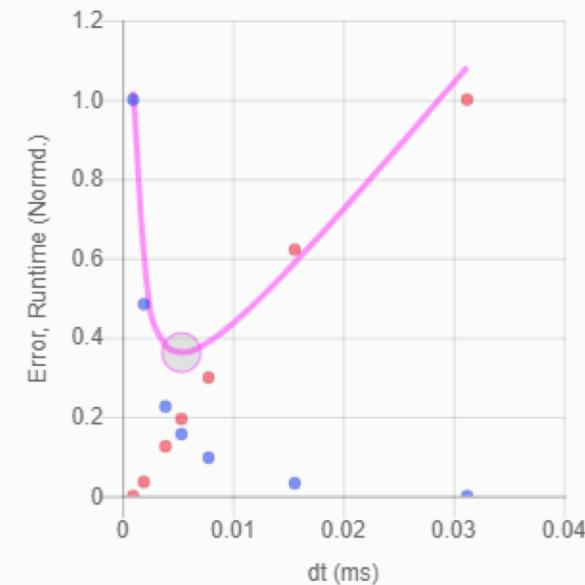


Morphology:

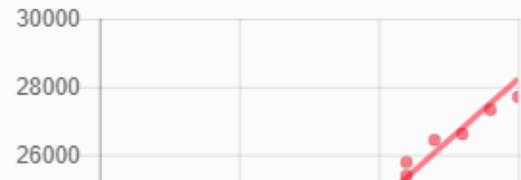
L-Measure Metric	Value
Soma Surface	8814.77 μm^2
Number of Stems	6.0
Number of Bifurcations	20.0
Number of Branches	44.0
Overall Width	1000.31 μm
Overall Height	1307.59 μm
Overall Depth	699.29 μm
Average Diameter	2.41249 μm
Total Length	13284.4 μm

**Model Properties:**

Membrane Properties	
Is Passive	No
Is Intrinsically Spiking	No
Resting Voltage	-67.25 mV
Rheobase Current Interval	(0.5784, 0.5827] nA
Threshold Current Interval	(1.0547, 1.1133] nA
Bias Current (to -80.00 mV)	-0.7106 nA
Testing Temperature	35.0 °C

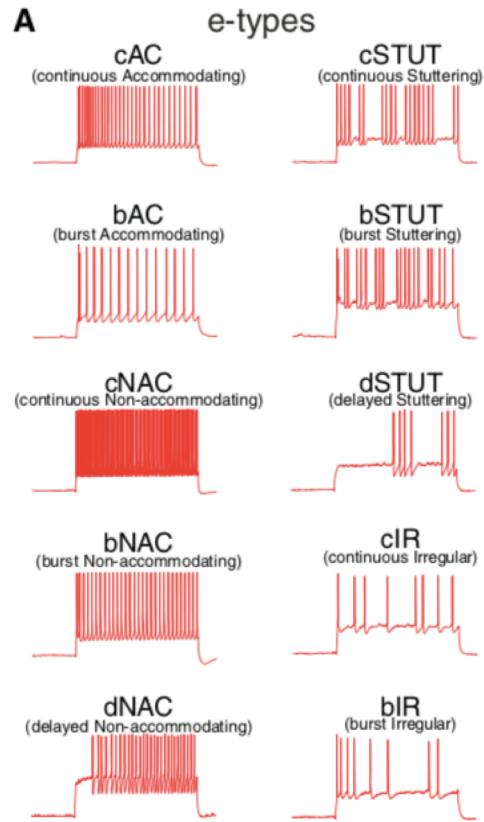
**Complexity Properties**

Sections	42
Compartments	667
State Equations	4002
Stability Interval	[-5.0, 15.0] nA



Do the features of the dynamical behaviors of neuron models well differentiate neuron types?

Do the features of the dynamical behaviors of neuron models well differentiate neuron types?



c: continuous

d: delayed

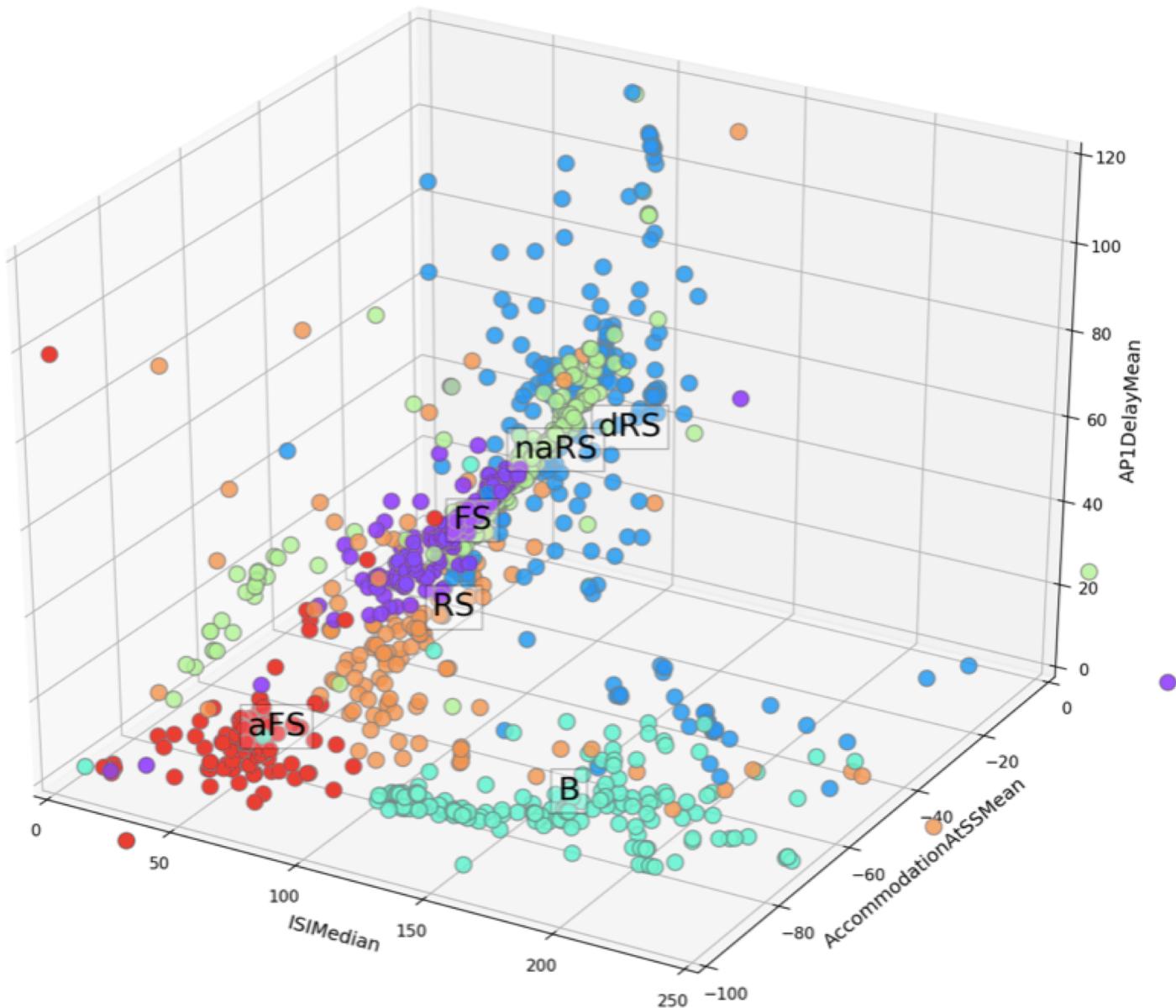
b: bursting

AC: accommodating

NAC: non-accommodating

STUT: stuttering

IR: irregular

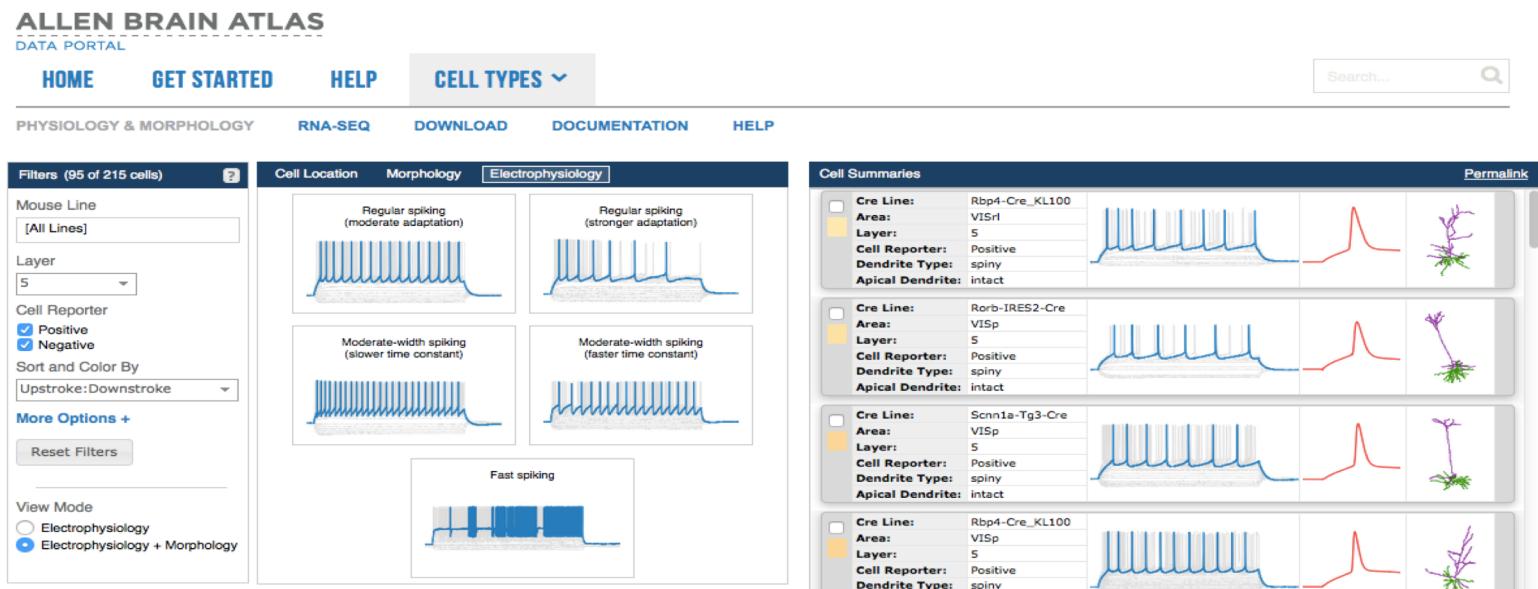


How well do models cover the diversity of experimentally recorded neurons?

Are there models of neurons that are outliers when compared to each other and to cortical neuron electrophysiology data?

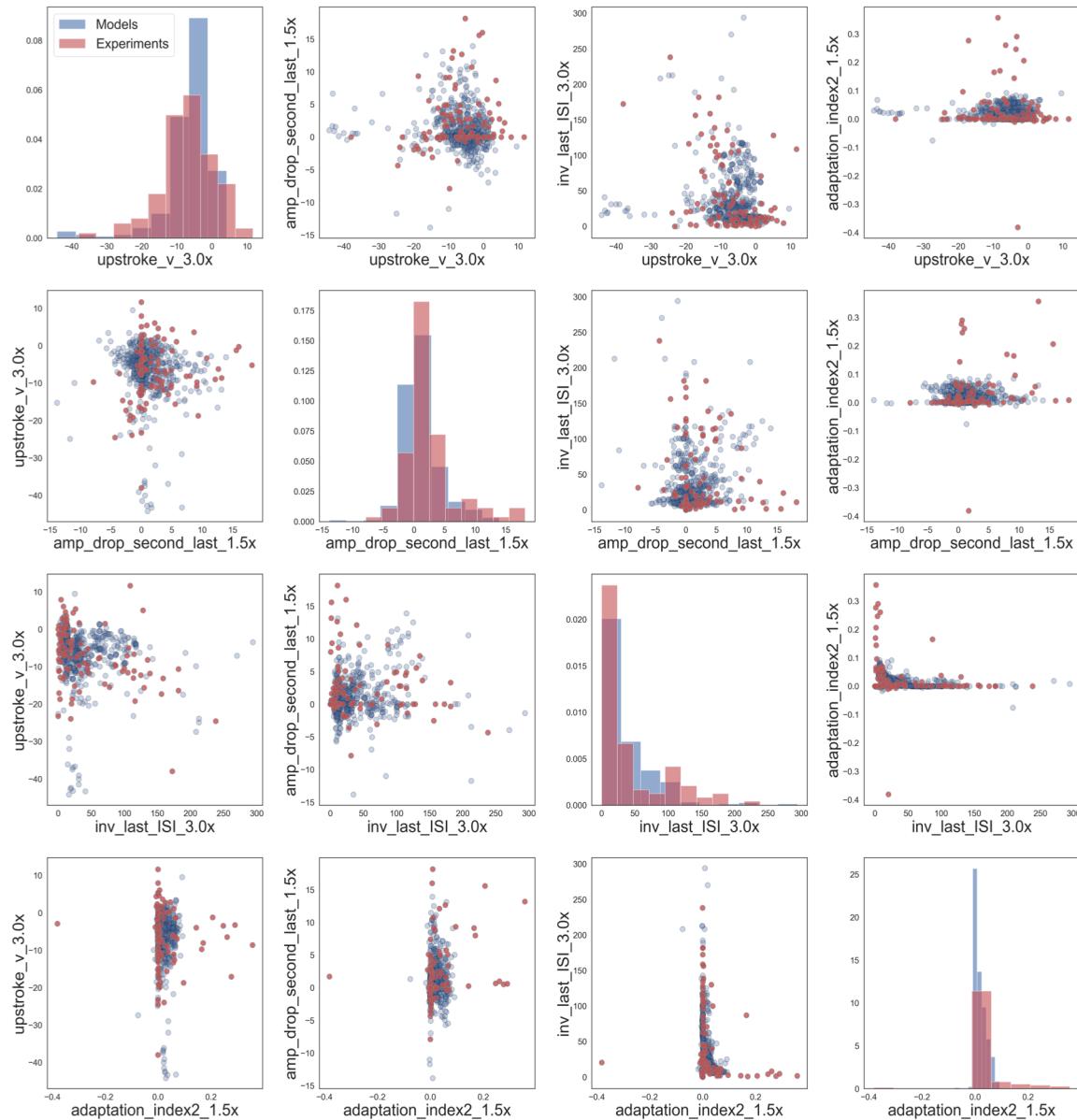
How well do models cover the diversity of experimentally recorded neurons?

Are there models of neurons that are outliers when compared to each other and to cortical neuron electrophysiology data?



Allen Institute for Brain Science <http://celltypes.brain-map.org>
Hawrylycz et al. (2016) PNAS. 113(27):7337–44.

Pairwise Features for Models vs Experiments



How can we improve impact of computational models in neuroscience?

FAIR models improve the impact of models on science. Models are **more accessible and useful** through **NeuroML** and associated resources and tools like **NeuroML-DB** and **OpenSourceBrain**.

Rigorous model **development** requires transparency about which data or features of data are used to *constrain* and *optimize* models.

Rigorous model **evaluation** requires transparency about which data or features of data are used to *validate* models.

Requires accessible, useful data and results in better models.



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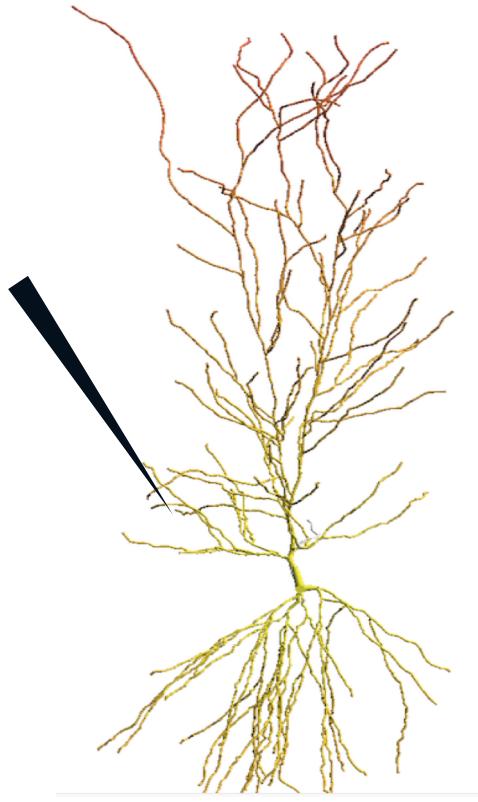
Solution: Unit Testing

	Test 1	Test 2	Test 3	Test 4	Overall
Model 1	0.1	-0.1	2.0	-0.3	0.6
Model 2	0.7	1.0	-0.1	-0.3	0.5
Model 3	0.3	0.3	-0.4	-0.3	0.3
Model 4	0.0	0.1	-0.1	-0.3	0.1
Model 5	-1.5	2.9	-2.4	-0.2	1.8
Overall	0.5	0.9	1.0	0.3	



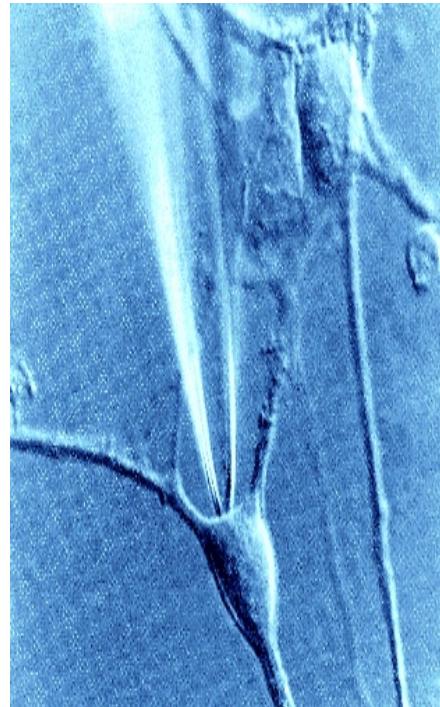
SciUnit

<https://github.com/scidash/sciunit>



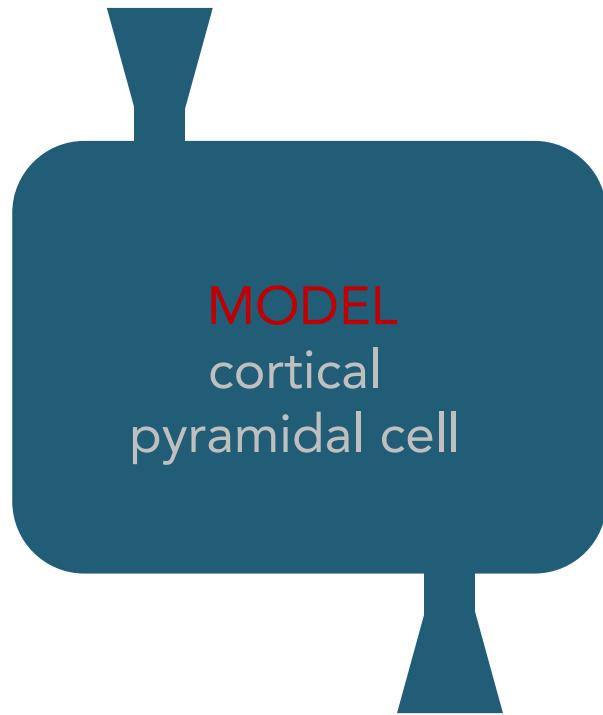
MODEL
cortical
pyramidal cell

=
?



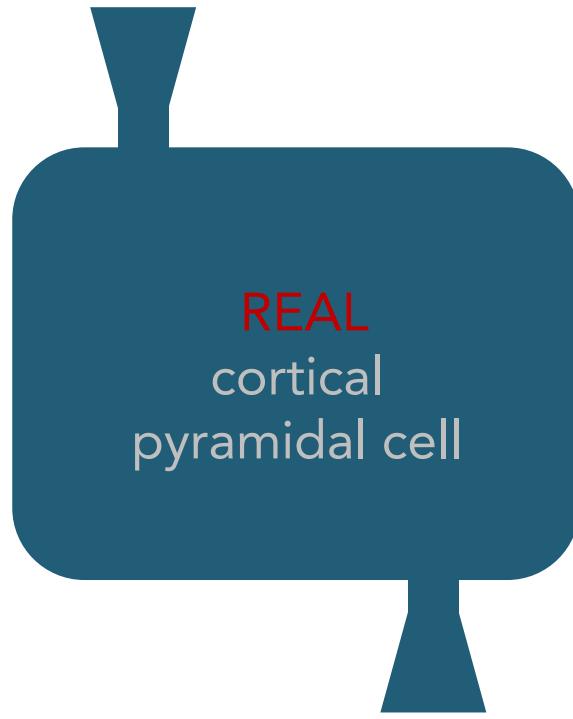
REAL
cortical
pyramidal cell

100 pA current injected
to soma for 800 msec



predicted membrane
potential waveform

100 pA current injected
to soma for 800 msec

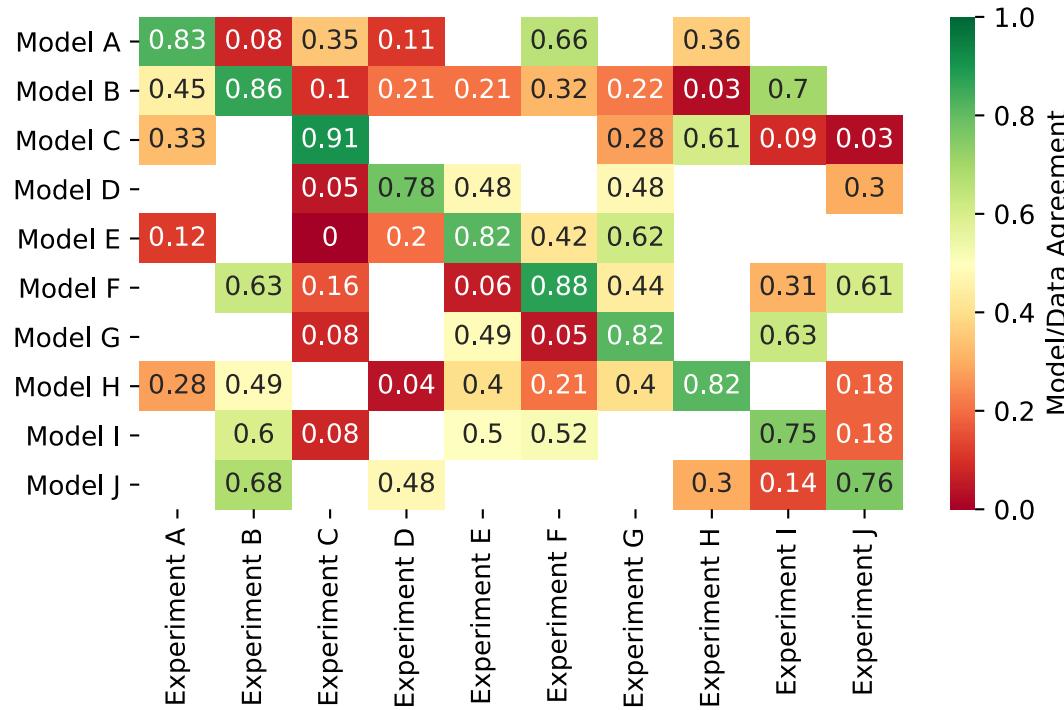


recorded membrane
potential waveform

=
?

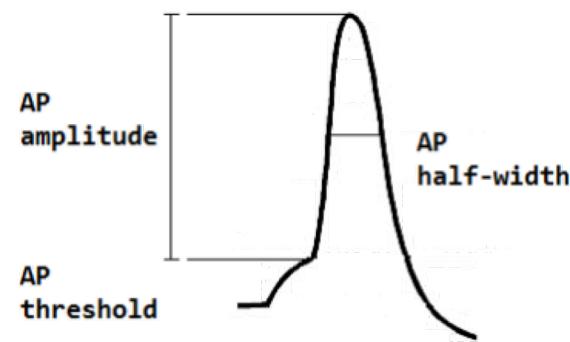
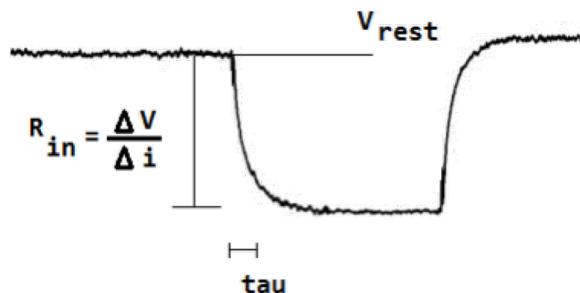


Let's build a collection of empirically-informed **unit tests**.
Let's **validate** models by seeing which tests they pass.





- 8 NEURON models of mitral cells
- Deterministic, spiking models
- Single and multi-compartment models
- Simulation protocols run to reveal membrane and action potential properties



Olfactory bulb (main) mitral cell (Definition)

Electrophysiological properties of *Olfactory bulb (main) mitral cells* from literature:

Legend:

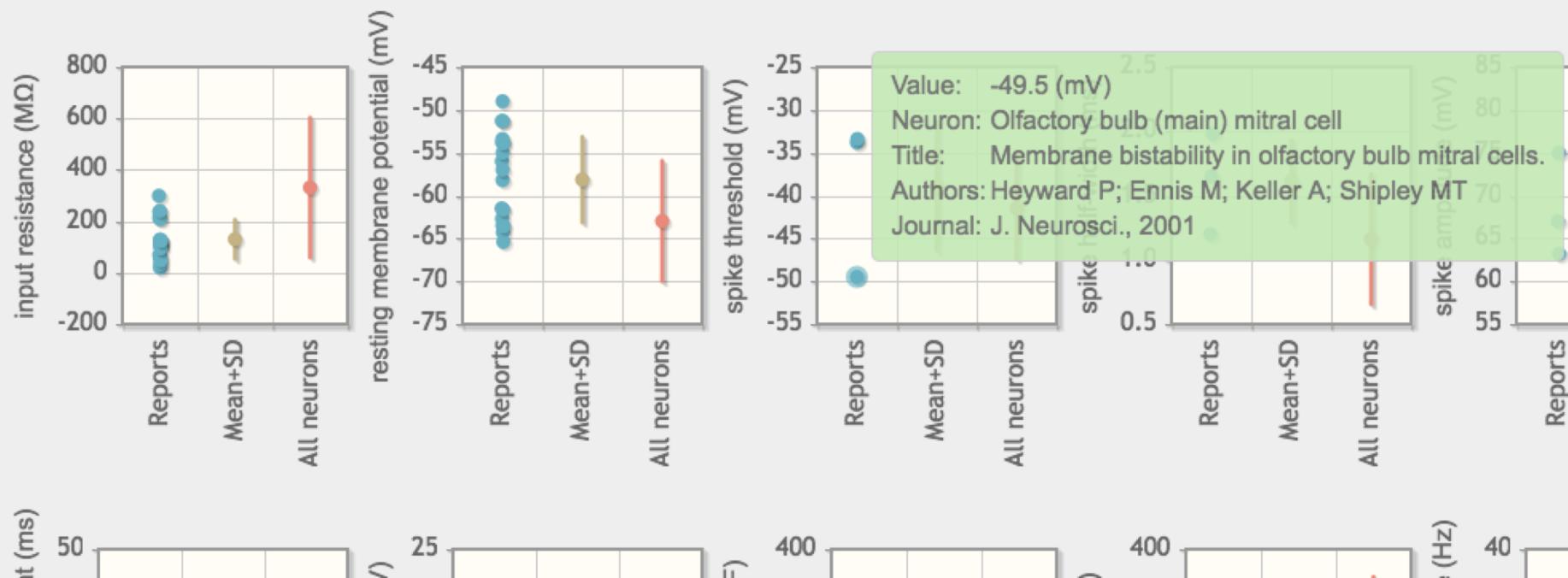
- Reports: Blue dots indicate human-curated values; Orange dots indicate non-human curated values
- Mean+SD: mean and standard deviation of human-curated neuron measurements
- All neurons: mean and standard deviation computed over all neurons in database

Interactivity:

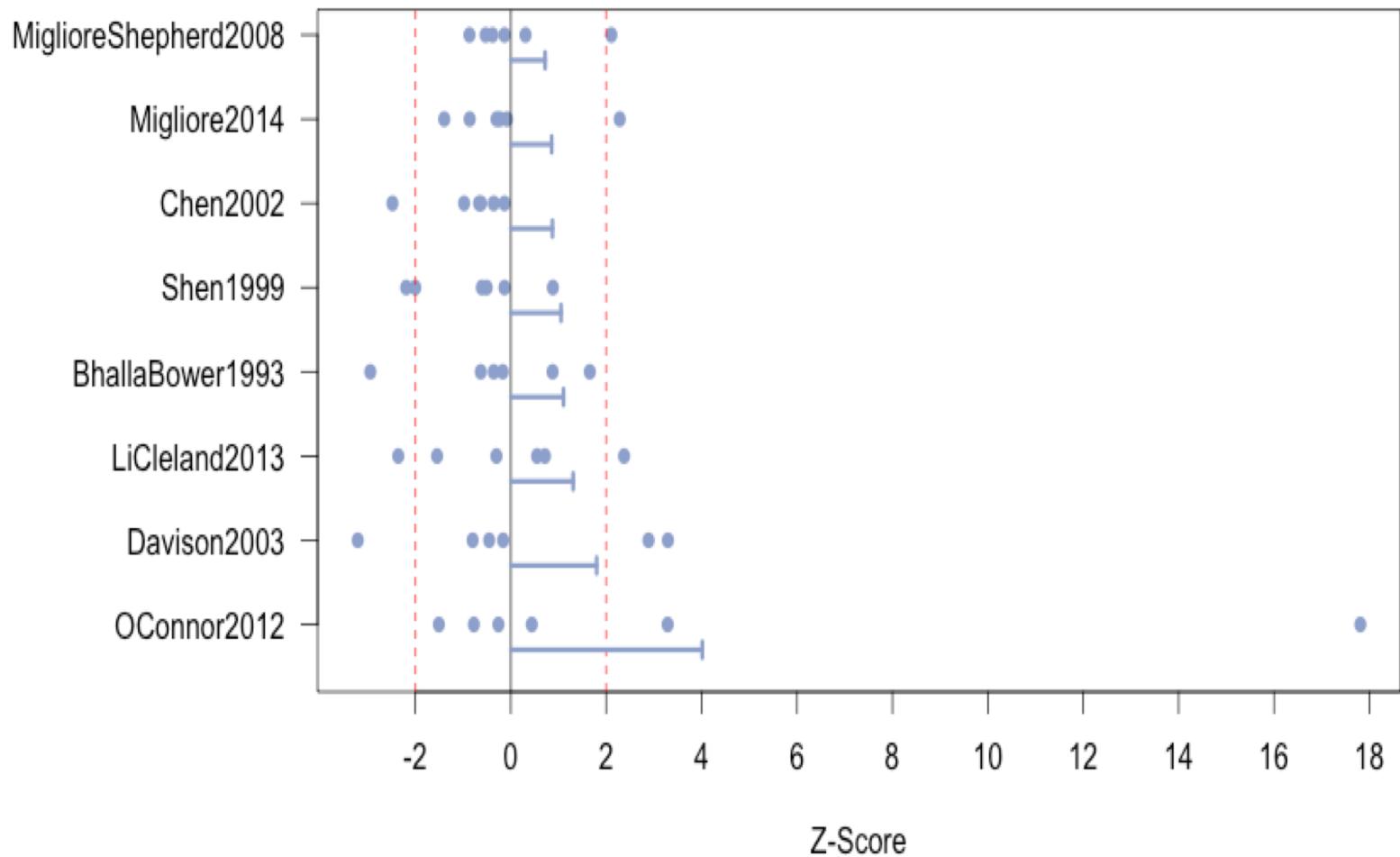
- Mouse over neuron report data points and click to view corresponding publication
- Mouse over y-axis labels to view definition or click to view values across neuron types
- Zoom in on a section of plot by dragging cursor. Zoom out by double clicking on plot.
- Legend: Blue dots = text-mined values human curated; Orange dots = text-mined values not human curated

[View data in table](#)

[Report miscurated data](#)



Overall Model Deviations



Name	Score	Score Type	Model	Hostname	Owner
			Migliore2014		
InjectedCurrentAPAmplitudeTest	0.432	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb
InjectedCurrentAPThresholdTest	-0.231	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb
InjectedCurrentAPWidthTest	0.116	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb
TimeConstantTest	-0.251	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb
InputResistanceTest	-0.679	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb
RestingPotentialTest	-0.399	ZScore	MitralCellModel (Migliore2014)	Justas' PC	justasb



<http://dash.scidash.org>



Name

InjectedCurrentAPAmplitudeTest

InjectedCurrentAPThresholdTest

InjectedCurrentAPWidthTest

TimeConstantTest

InputResistanceTest

RestingPotentialTest

InjectedCurrentAPAmplitudeTest details

Test name: InjectedCurrentAPAmplitudeTest**Score:** 0.432**Normalized score:** 0.67**Test class:** InjectedCurrentAPAmplitudeTest**Score type:** ZScore**Test suite:** N/A**Build info:** ↗ Linux-4.15.0-24-generic-x86_64-with-debian-stretch-sid/Linux**Hostname:** Justas' PC**Timestamp:** July 11, 2018, 3:43:54 PM UTC**Observation:** <https://neuroelectro.org/neuron/129/>

- mean: 68.77
- std: 50.42

Simulator: None

Model details

Class name: MitralCellModel**Class source:**

<https://github.com/JustasB/MitralSuite/tree/88d46e26f9ff435aecd40a810d03cfe77339fd21/Models/Migliore2014>

Class capabilities:

None

Instance name: Migliore2014**Instance source:**

<https://github.com/JustasB/MitralSuite/tree/88d46e26f9ff435aecd40a810d03cfe77339fd21/Models/Migliore2014>

Instance - Run parameters:

None

Timestamp **Reset**

2017-12-01 2018-09-25

July 11, 2018

CLOSE



NeuroML: Angus Silver, Padraig Gleeson, and UCL Team

NeuroML Editors: Upi Bhalla, Andrew Davison, Padraig Gleeson, Boris Marin, Robert McDougal

NeuroML Database: Justas Birgiolas, Suzanne Dietrich

Model Analysis: Justas Birgiolas, Vergil Haynes, Russell Jarvis, Rick Gerkin



NeuronUnit: Rick Gerkin, Justas Birgiolas, Russell Jarvis, Cyrus Omar, Shreejoy Tripathy



SciDash: Rick Gerkin, Metacell



National Science Foundation
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National Institutes of Health (NIMH, NIBIB)

