



BiInspired Computing A Two-Way Highway

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Why do neuroscientists/biologists
need computer scientists/engineers?

Three data vignettes...

"What types of biological problems/data should CSE focus on?"

Serotonin: Is There Anything It Can't Do?



Serotonin has been linked to:

Depression

Autism

Eating disorders

Schizophrenia

Obsessive/compulsive disorder

Premenstrual syndrome

Anxiety

Panic disorder

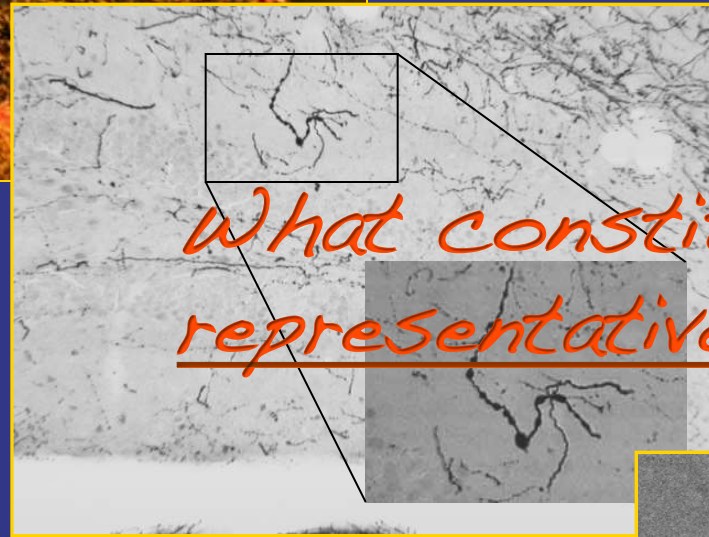
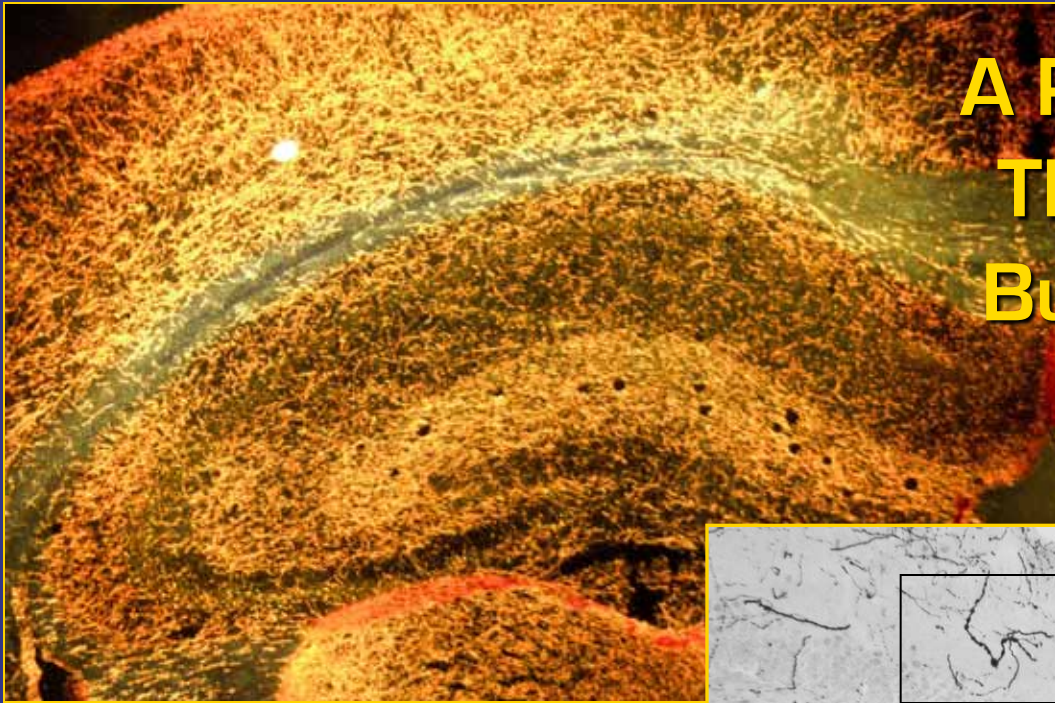
Seasonal affective disorder

Aggression, suicide

Migraine

Addiction

A Picture is Worth a Thousand Words – But Does it Tell The Truth?



Counterman, A. E., D'Onofrio, T. G., Andrews, A. M., and Weiss, P. S. (2006) A physical model of axonal damage due to oxidative stress, Proc. Natl. Acad. Sci. U.S.A. 103, 5262-5266.

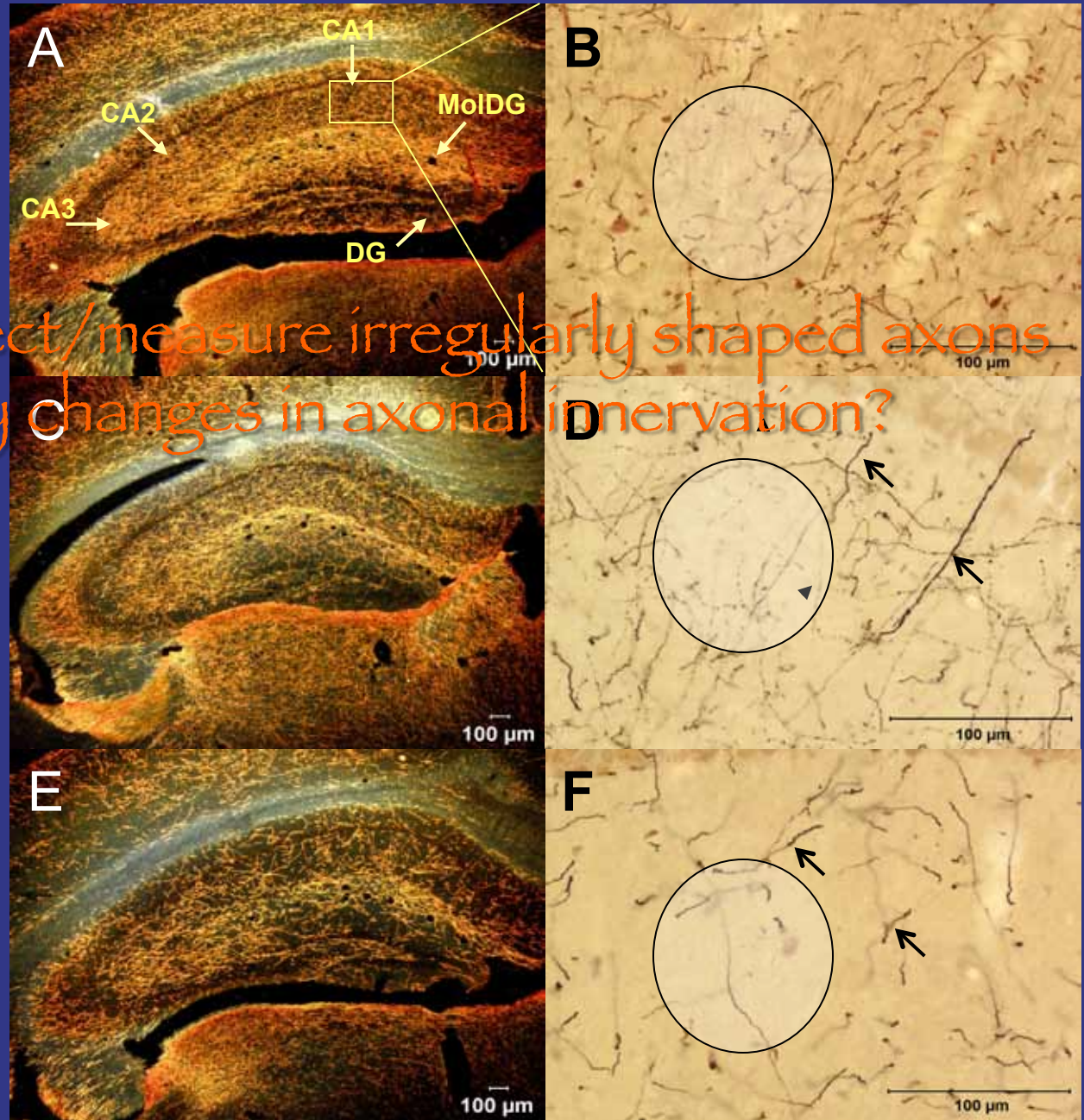
Degeneration of Hippocampal 5-HT Axons

Control

How can we detect/measure irregularly shaped axons to quantify changes in axonal innervation?

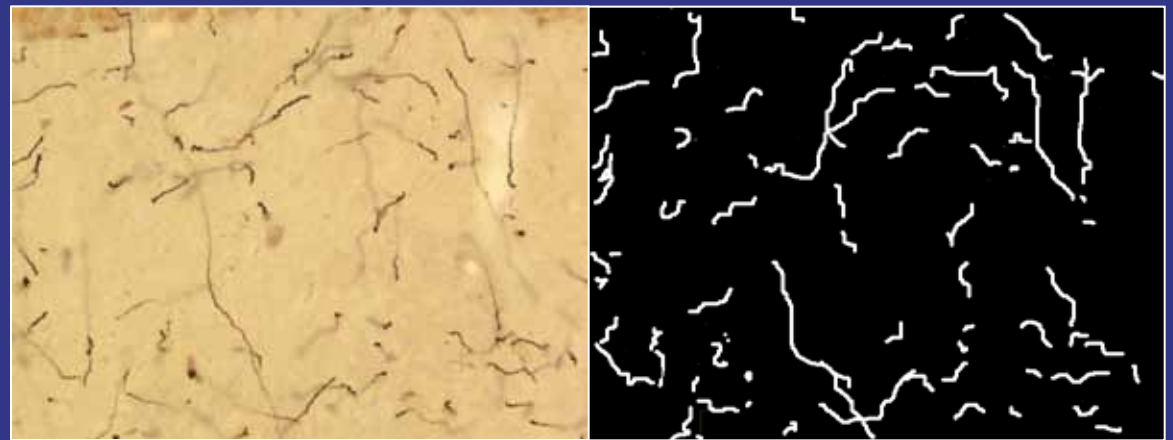
3 days post
2'-NH₂-MPTP

21 days post
2'-NH₂-MPTP

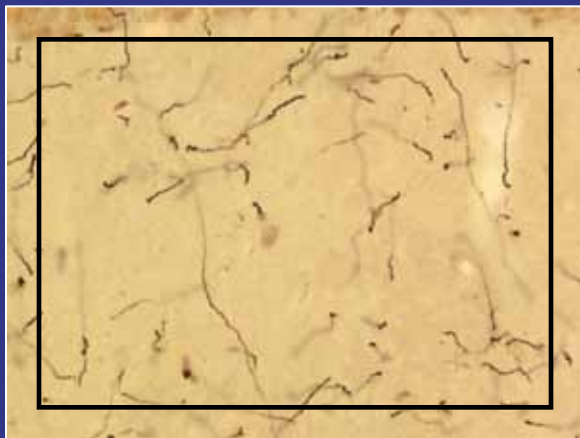


Digitized Imaging for Measuring Changes in Neuronal Densities

- 1) Digitize image  2) Histogram values differentiate axons from background

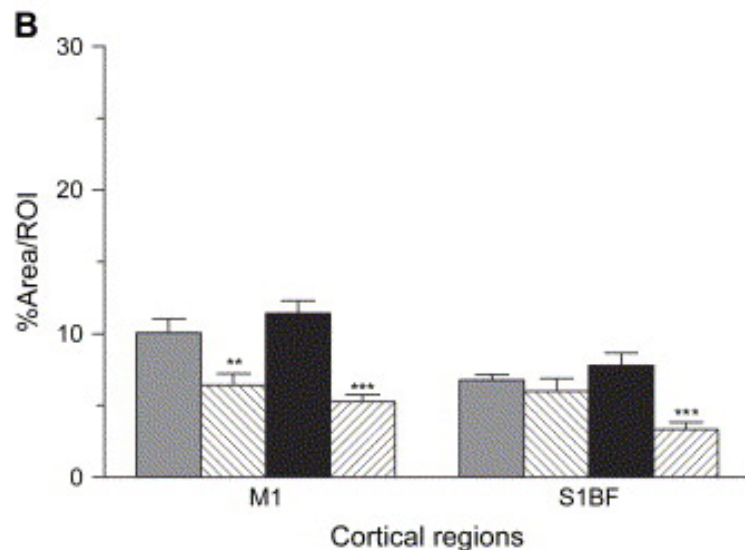
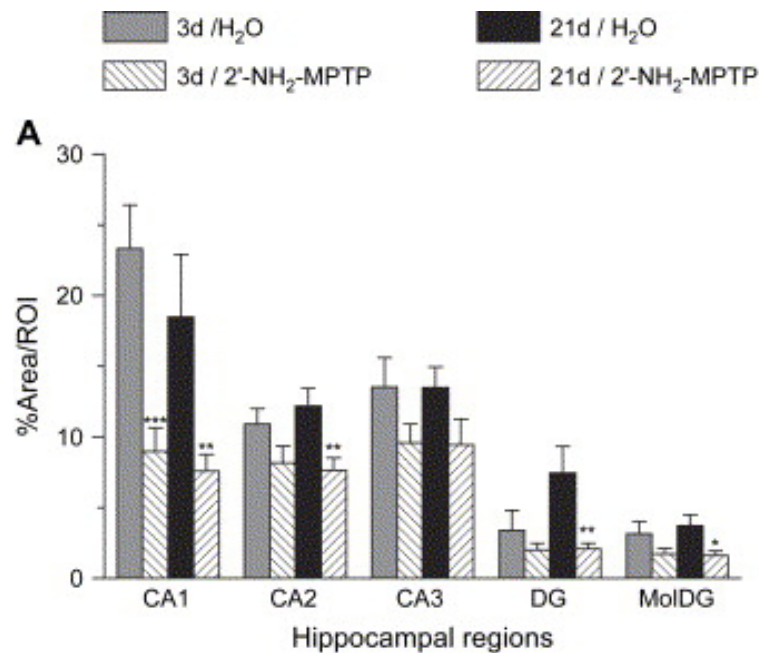


- 3) Outline region of interest (ROI)



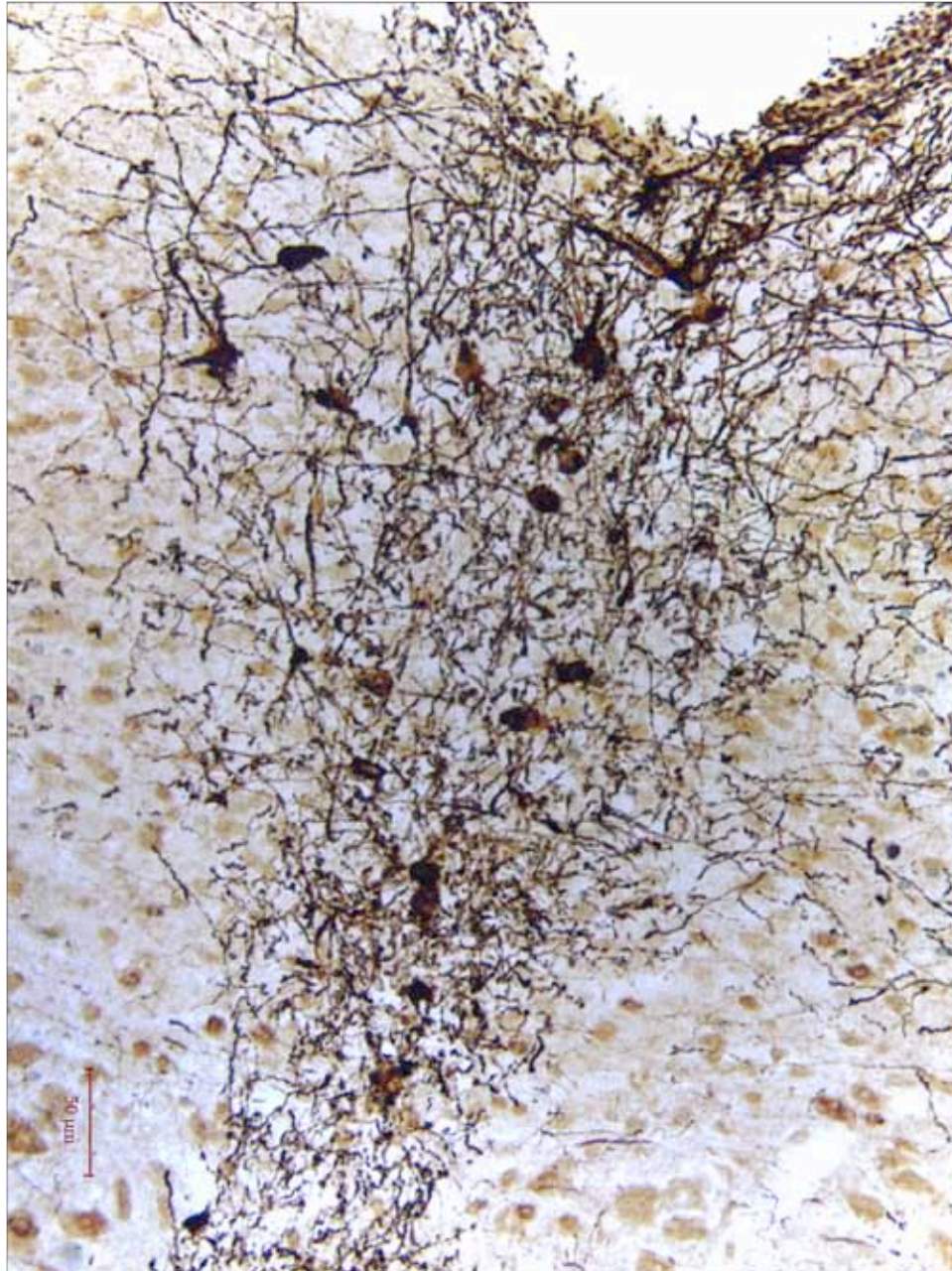
-  4) Calculation of Axon Area /ROI Area

Quantification of Axon Densities

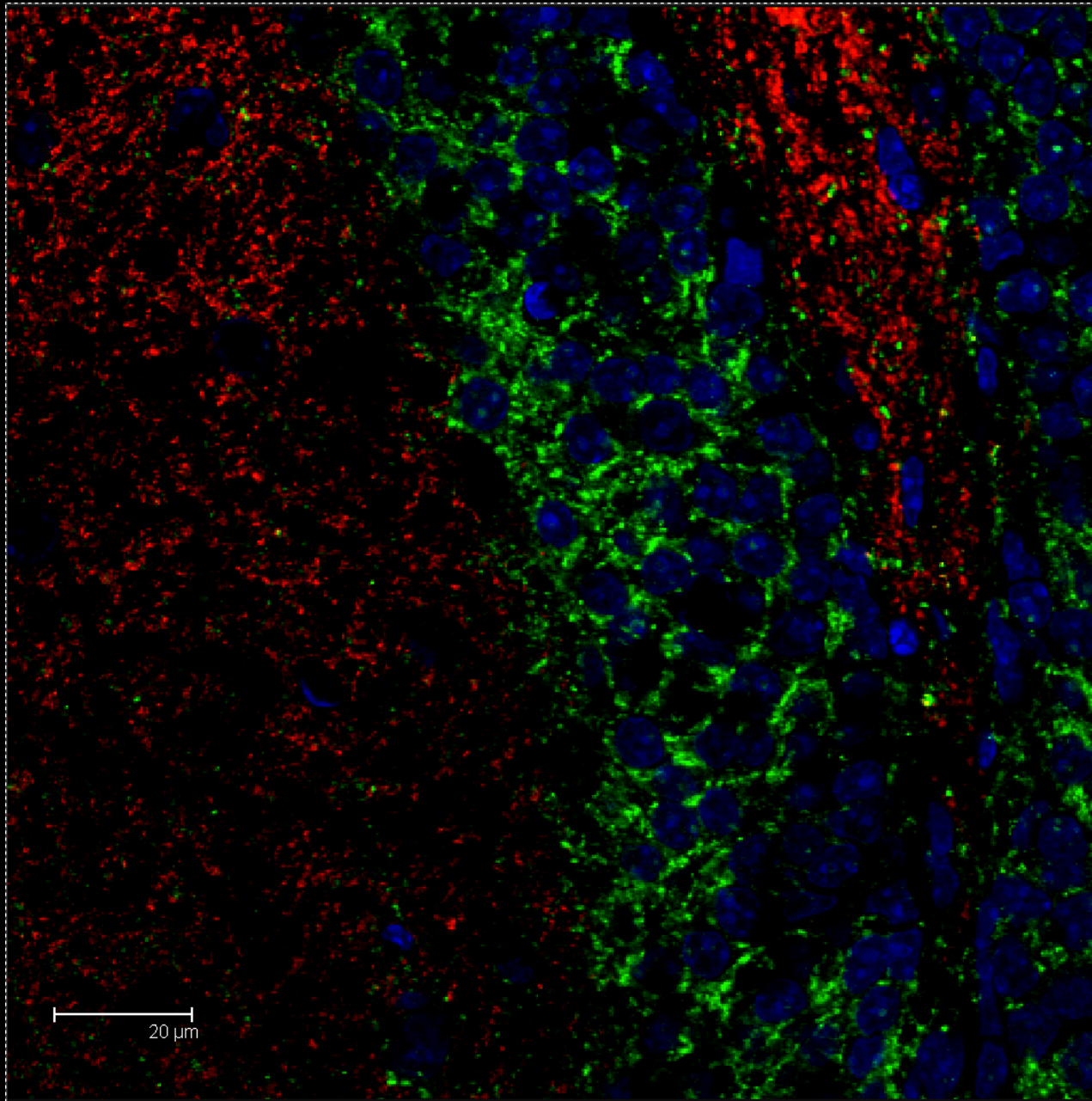


Histogram technique yields data indicative of axon loss

- Statistical analyses can be applied
- No ability to analyze more complex features of degeneration
 - Tortuosity
 - Axon lengths
 - Branching
 - Stereological data



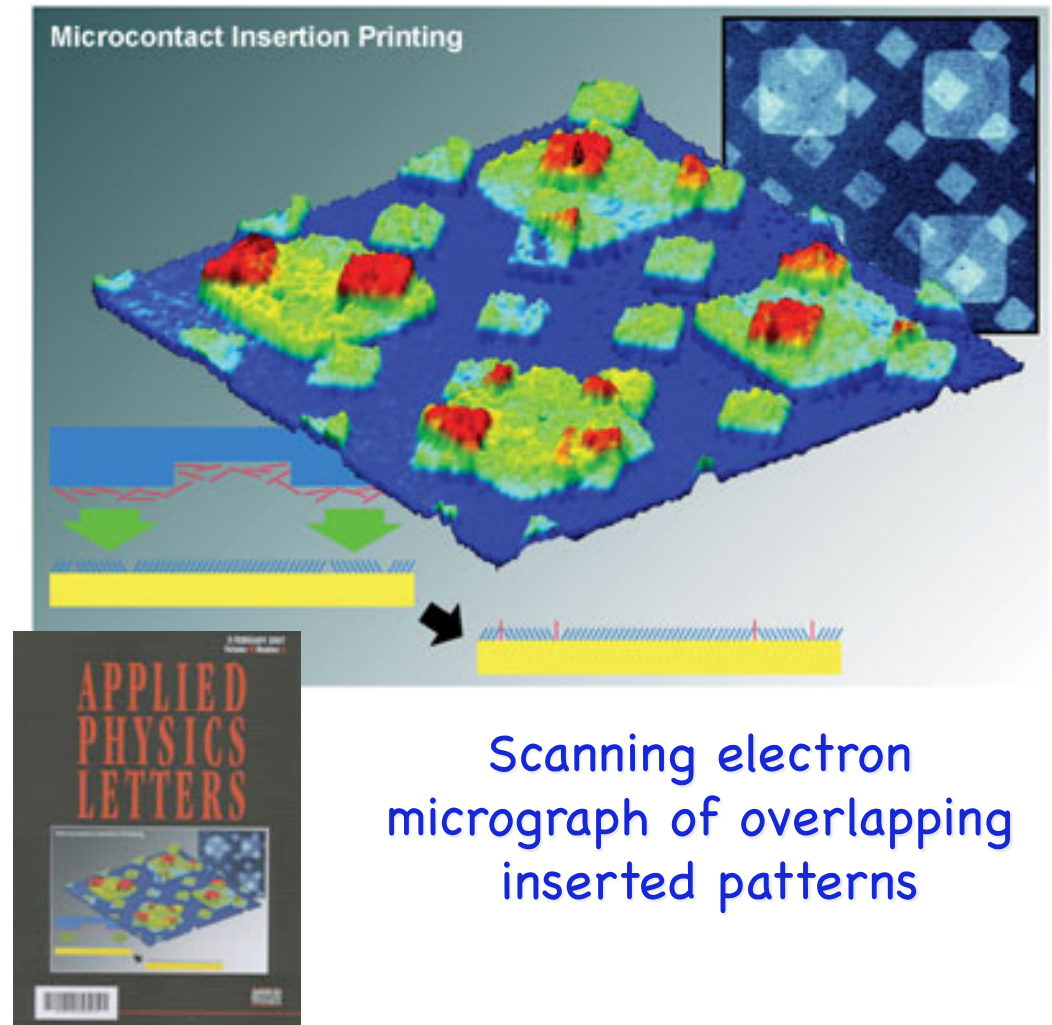
Quantitative
Image
Information
On
Dendrites
And Cell
Bodies



VGAT (red)
VGluT1 (green)
63x
Hippocampus

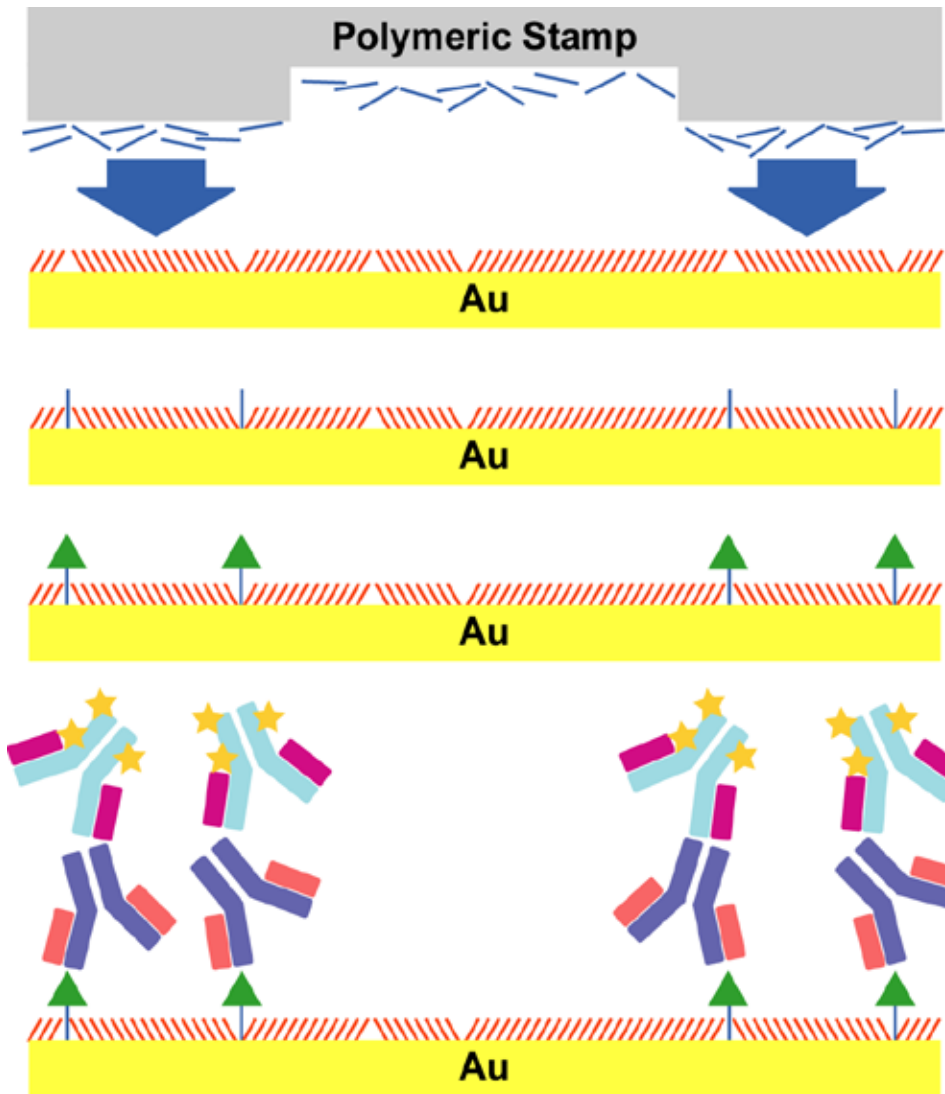
2. Chemical Patterning: Placing Single Molecules

- Patterning of single isolated molecules in controlled matrices
- Inserted molecules can be further functionalized
- Multiple steps enable multiplexed patterns
- Chemical patterns have applications in biospecific capture surfaces for functional proteomics, neuroscience, and chemical warfare defense

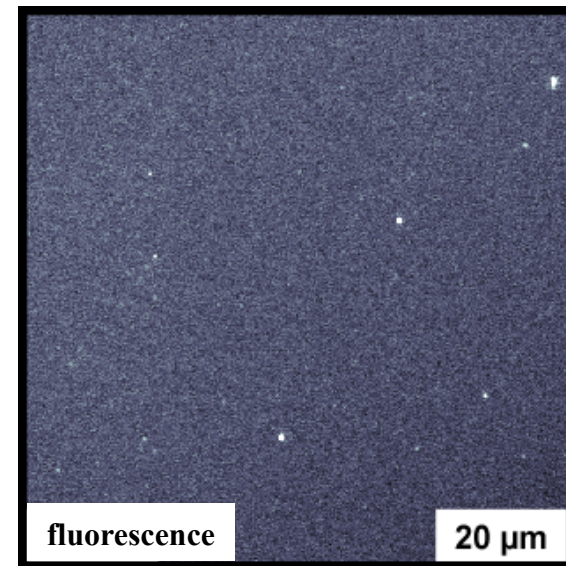


Mullen, T. J., Srinivasan, C., Hohman, J. N., Gillmor, S. D., Shuster, M. J., Horn, M. W., Andrews, A. M., and Weiss, P. S. (2007) Microcontact insertion printing, *Appl. Phys. Lett.* 90, 063114 (063111-063113).

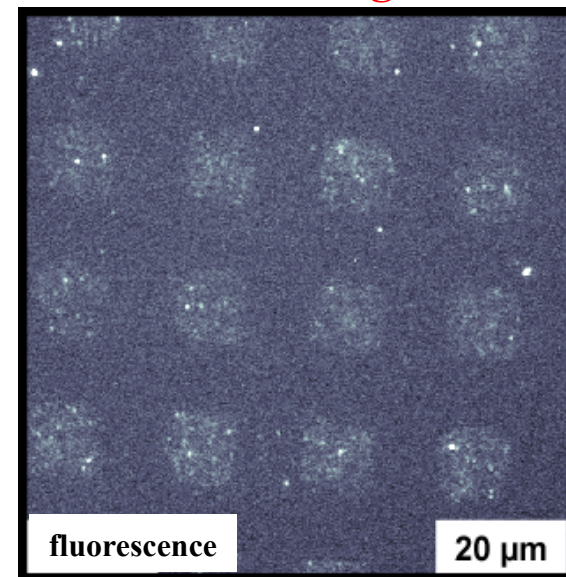
Microcontact Insertion Patterning



Unpatterned Region



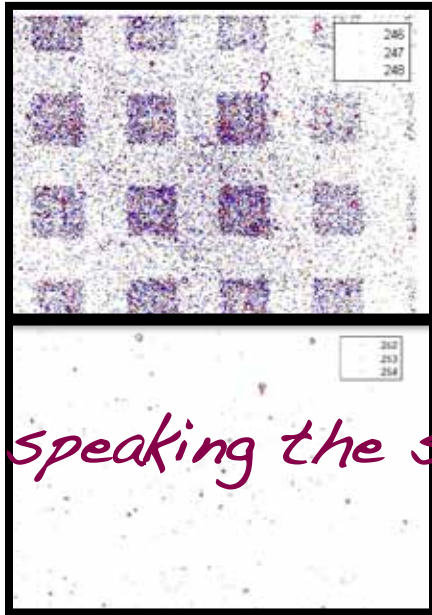
Patterned Region



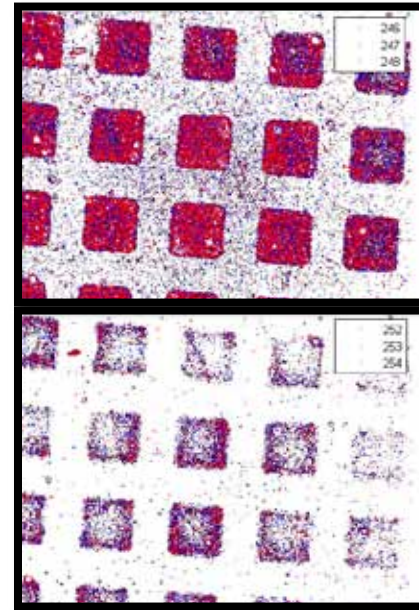
M.J. Shuster, A. Vaish, H. Cao, W. S. Lao, P.S. Weiss, and A.M. Andrews, unpublished

Quantitative Pattern Analysis

Nonspecific binding



Total Binding



Are we speaking the same language?

Specific Binding (pixels) = Total Binding (pixels) - Nonspecific Binding (pixels)

263,534 pixels = 299,810 pixels - 36,276 pixels

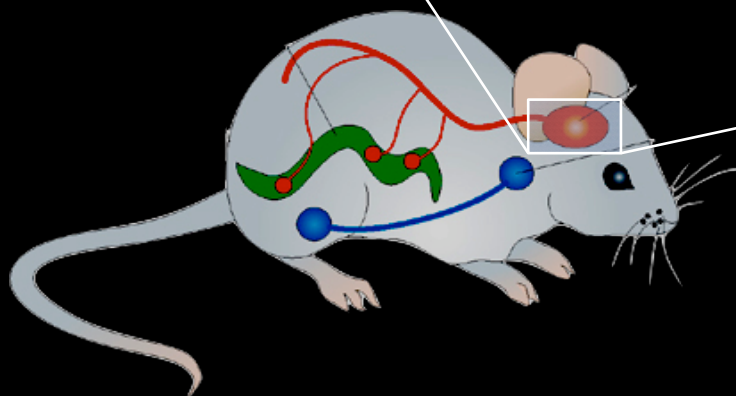
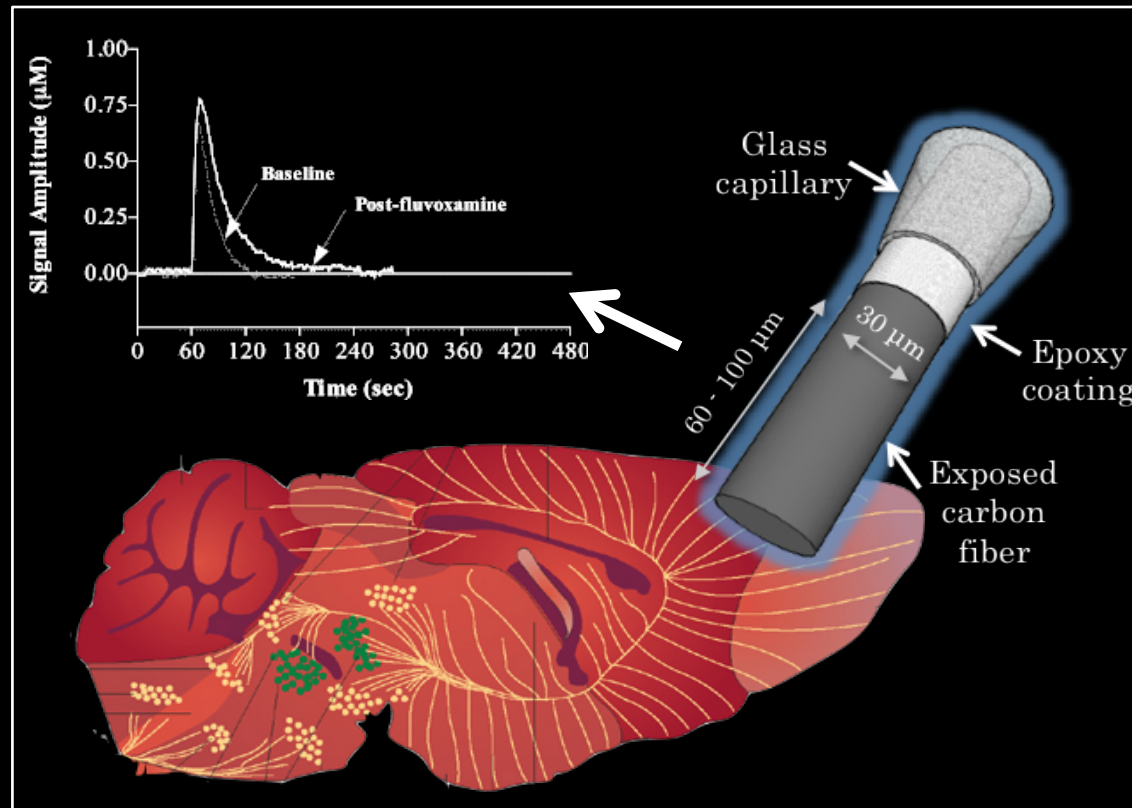
Specific Binding % = 100 * (Specific Binding (pixels)) / (Total Binding (pixels))

87.90 % = 263,534 pixels / 299,810 pixels

Coverage Area % = 100 * (Specific Binding (pixels)) / (Total Pixels in Image)

21.78 % = 263,534 pixels / 1,367,256 pixels

3. *In Vivo* Serotonin Neurotransmission

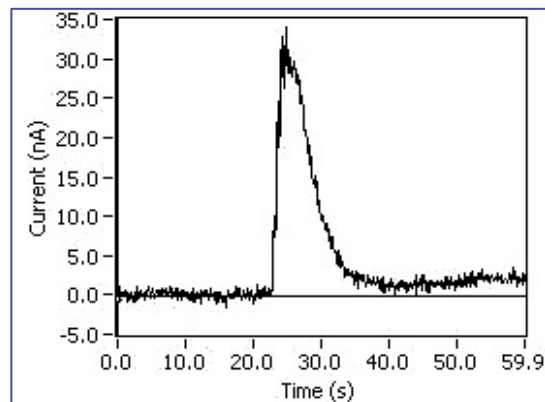
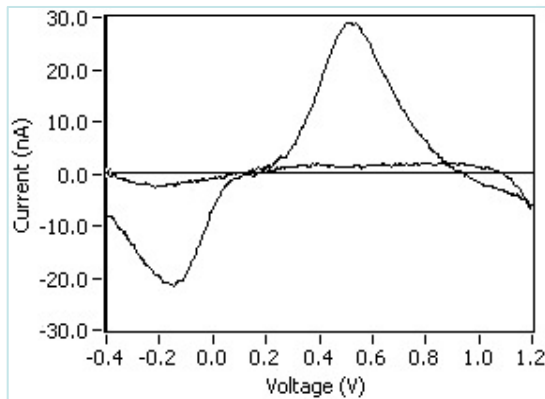


Murphy DL and Lesch KP. (2008). *Nature Reviews Neuroscience*. 9:85-96.

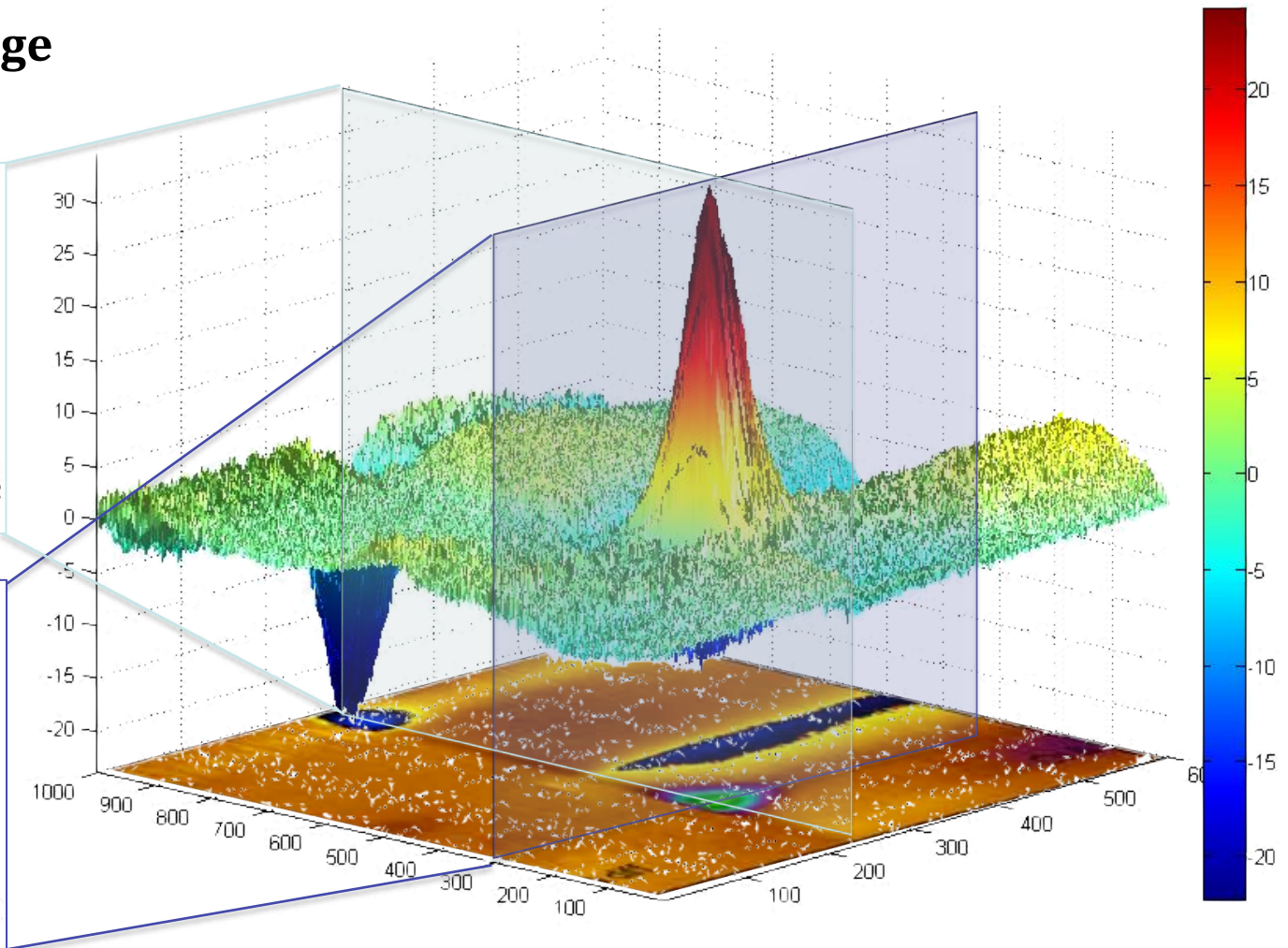
Montañez et al. (2002). *Brain Research*. 955:236-244.

Fast Cyclic Voltammetry to Measure Serotonin in the Brain

Current vs voltage

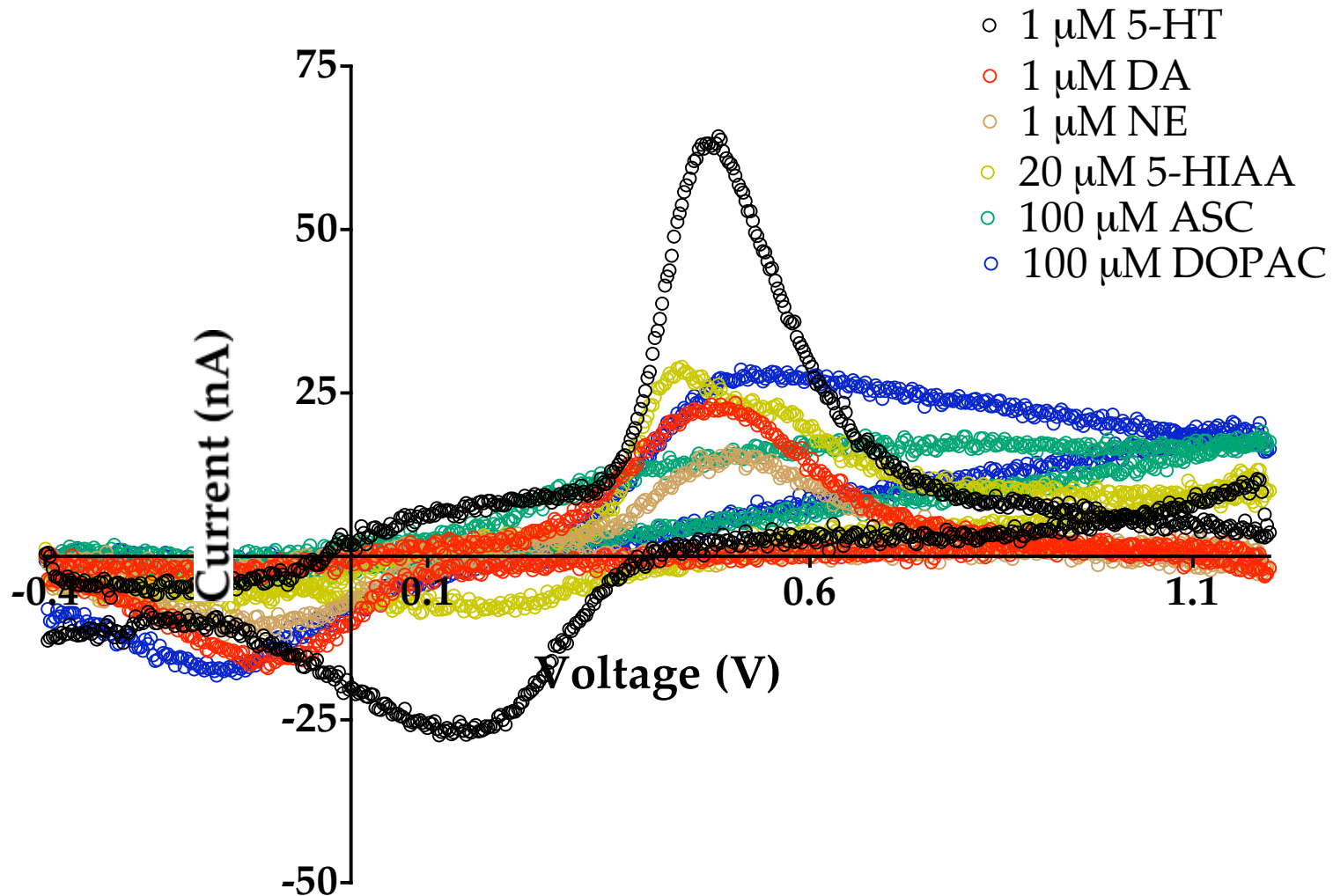


Current vs time

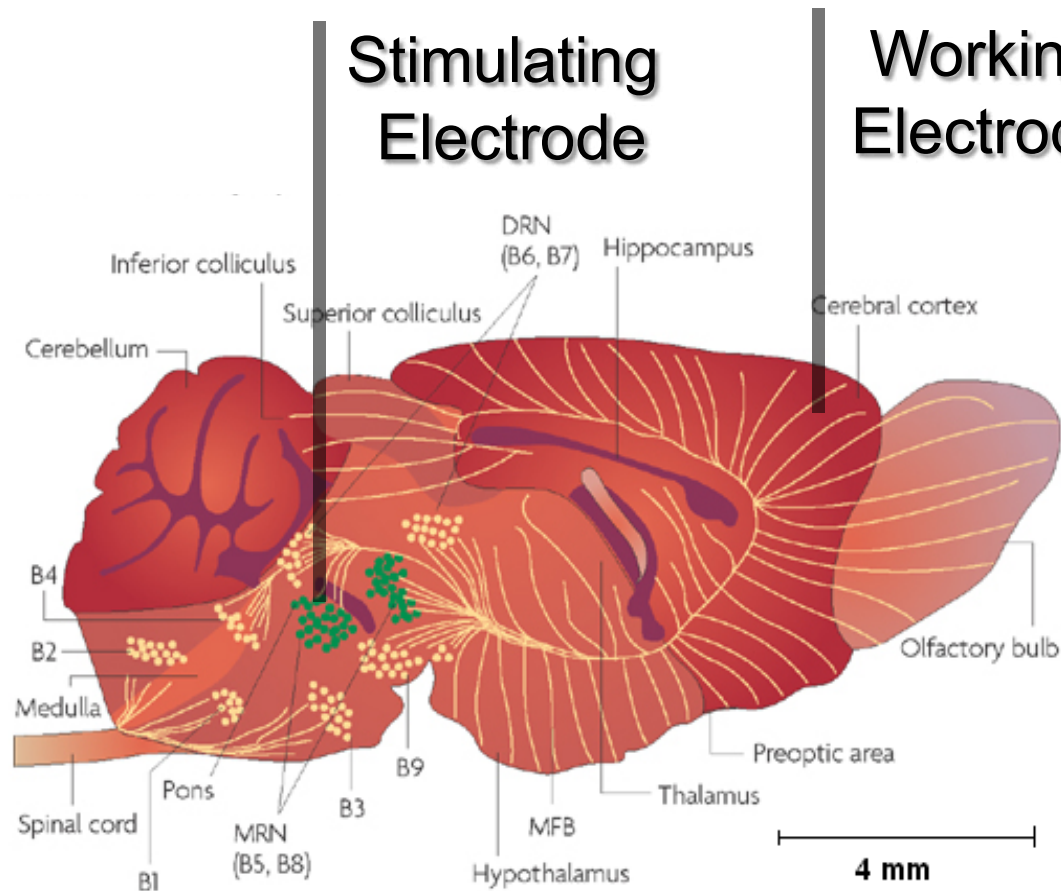


False Color Plot

We Cannot Monitor Signal at Any Single Voltage and Measure Only Serotonin



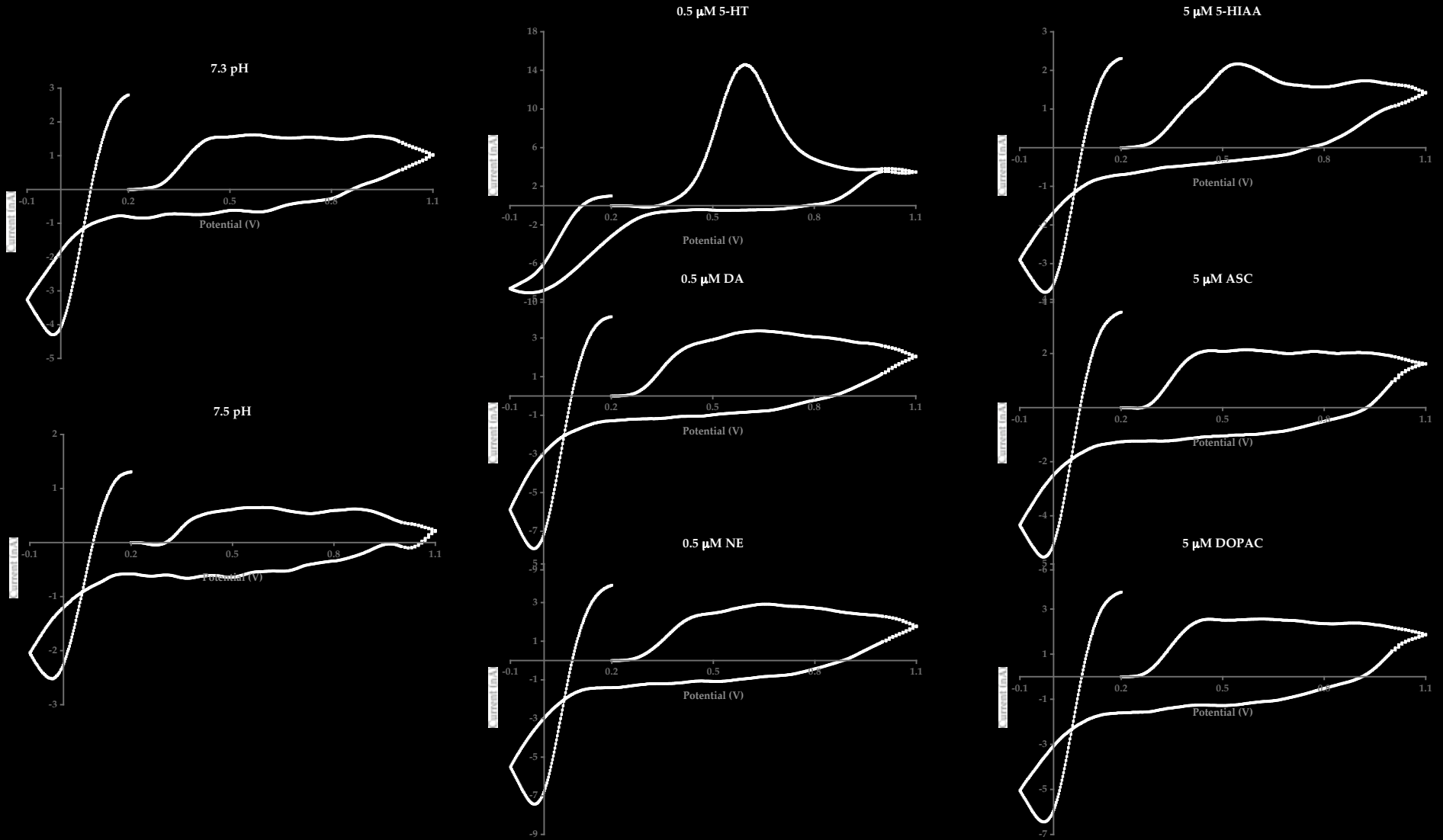
Biologist's Solution: Selective Stimulation



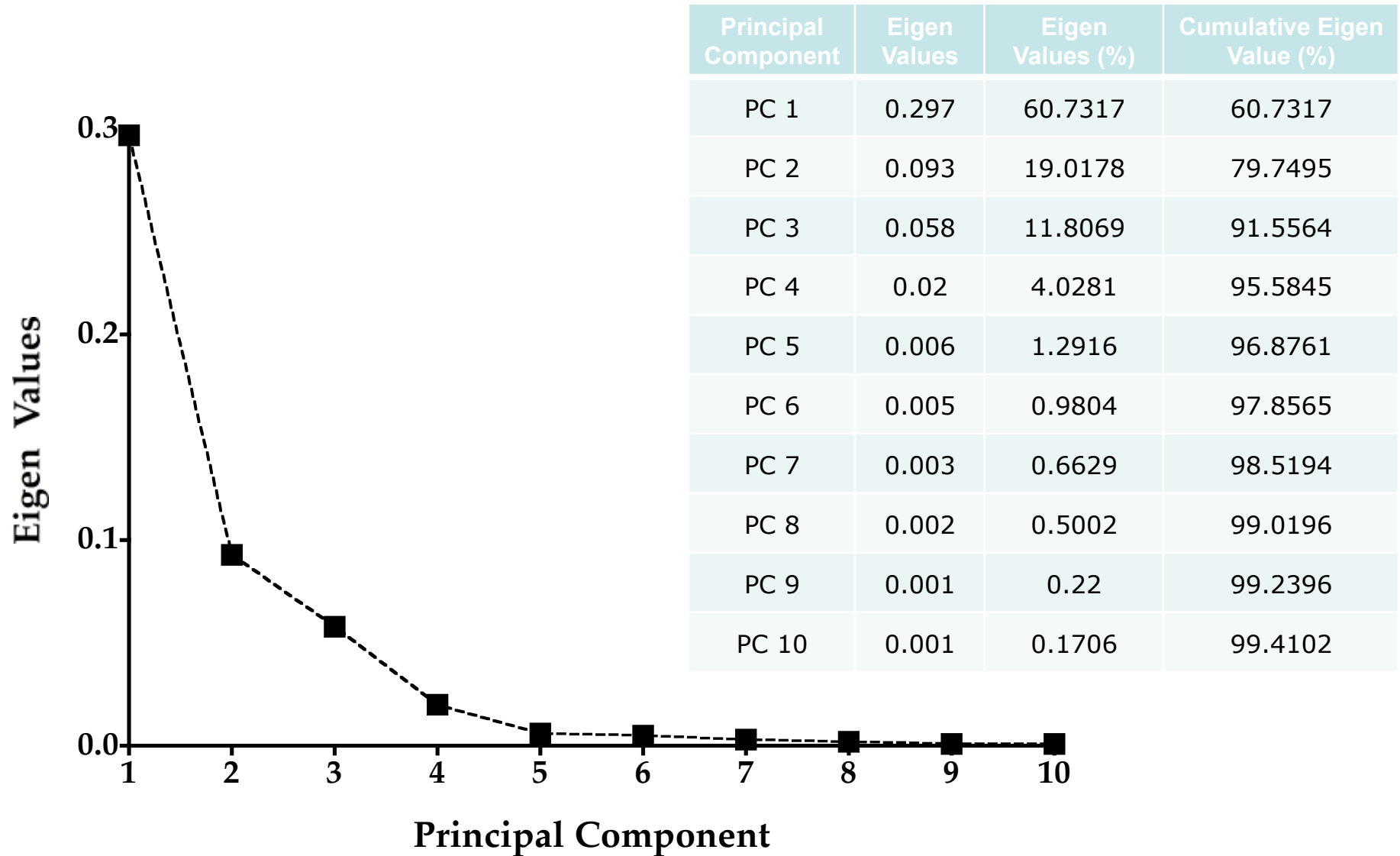
*YS Singh, LE Sawarynski, and
AM Andrews, in preparation*

Brain figure: Murphy DL and Lesch KP. (2008) Targeting the murine serotonin neurotransmitter: insights into human neurobiology. *Nature Reviews Neuroscience*. 9:85-96.

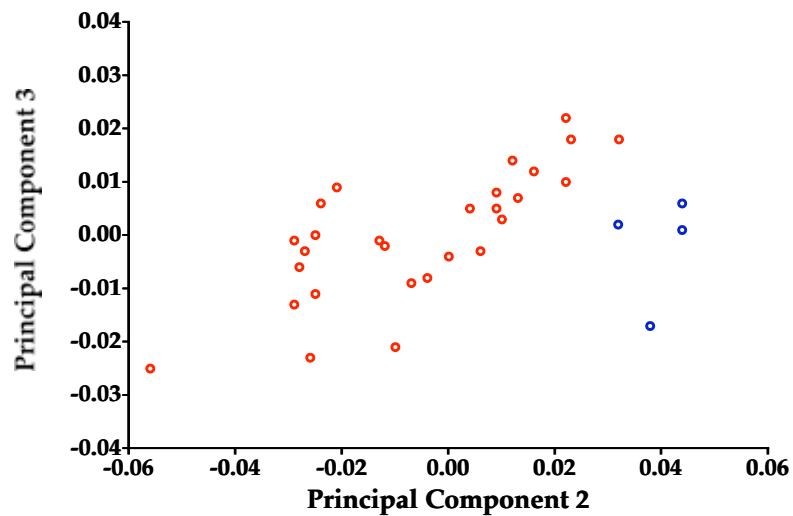
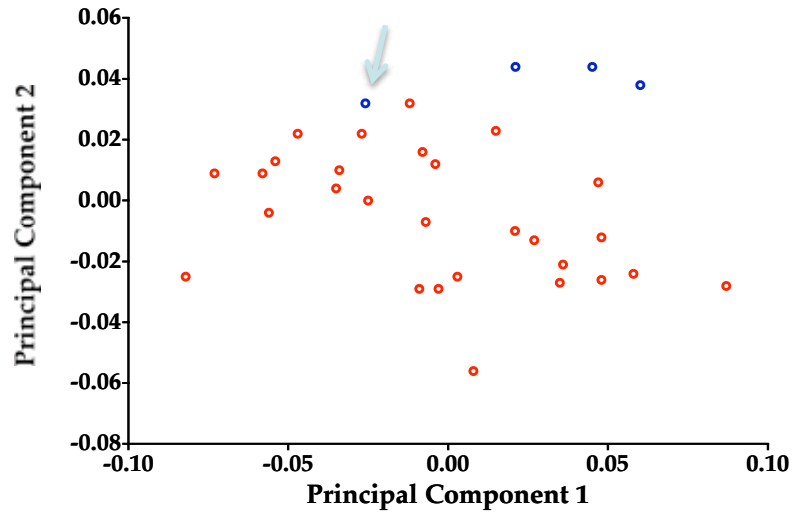
Calibrate Electrodes Using Different Substances



Principal Component Analysis

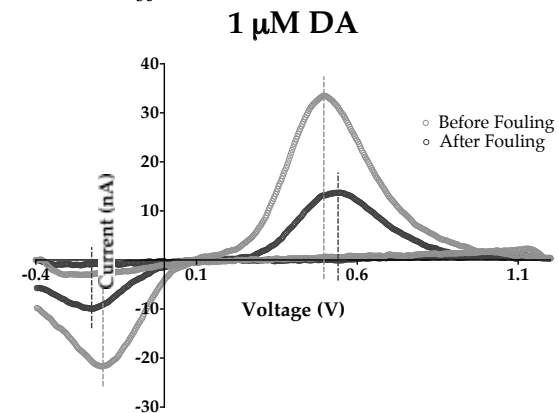
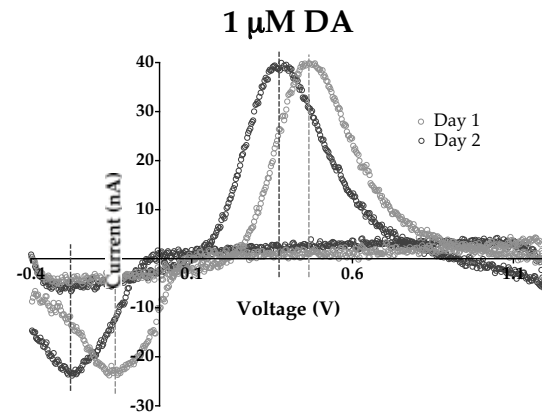
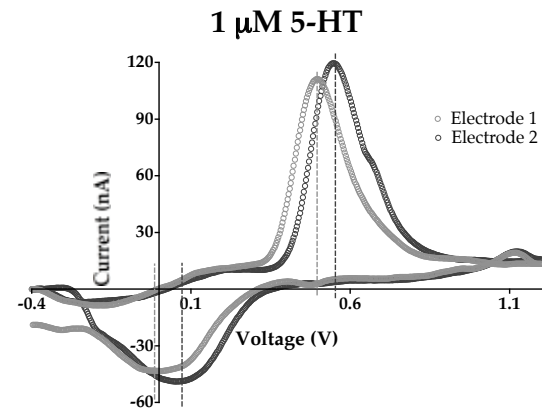


Principal Component Analysis

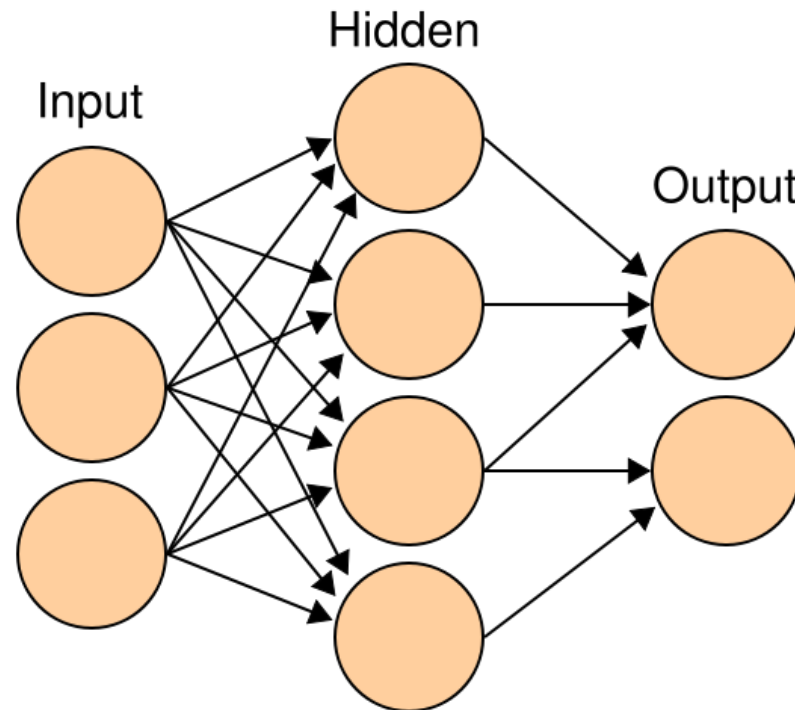


Principal Component	Eigen Values	Eigen Values (%)	Cumulative Eigen Value (%)
PC 1	0.297	60.7317	60.7317
PC 2	0.093	19.0178	79.7495
PC 3	0.058	11.8069	91.5564
PC 4	0.02	4.0281	95.5845
PC 5	0.006	1.2916	96.8761
PC 6	0.005	0.9804	97.8565
PC 7	0.003	0.6629	98.5194
PC 8	0.002	0.5002	99.0196
PC 9	0.001	0.22	99.2396
PC 10	0.001	0.1706	99.4102

Problem: Peak Potentials Are Moving Targets



Artificial Neural Network
or
Principal Component Neural Network
or
a NEW Self Correcting/Learning Algorithm



Video Imaging Animal Behavior

