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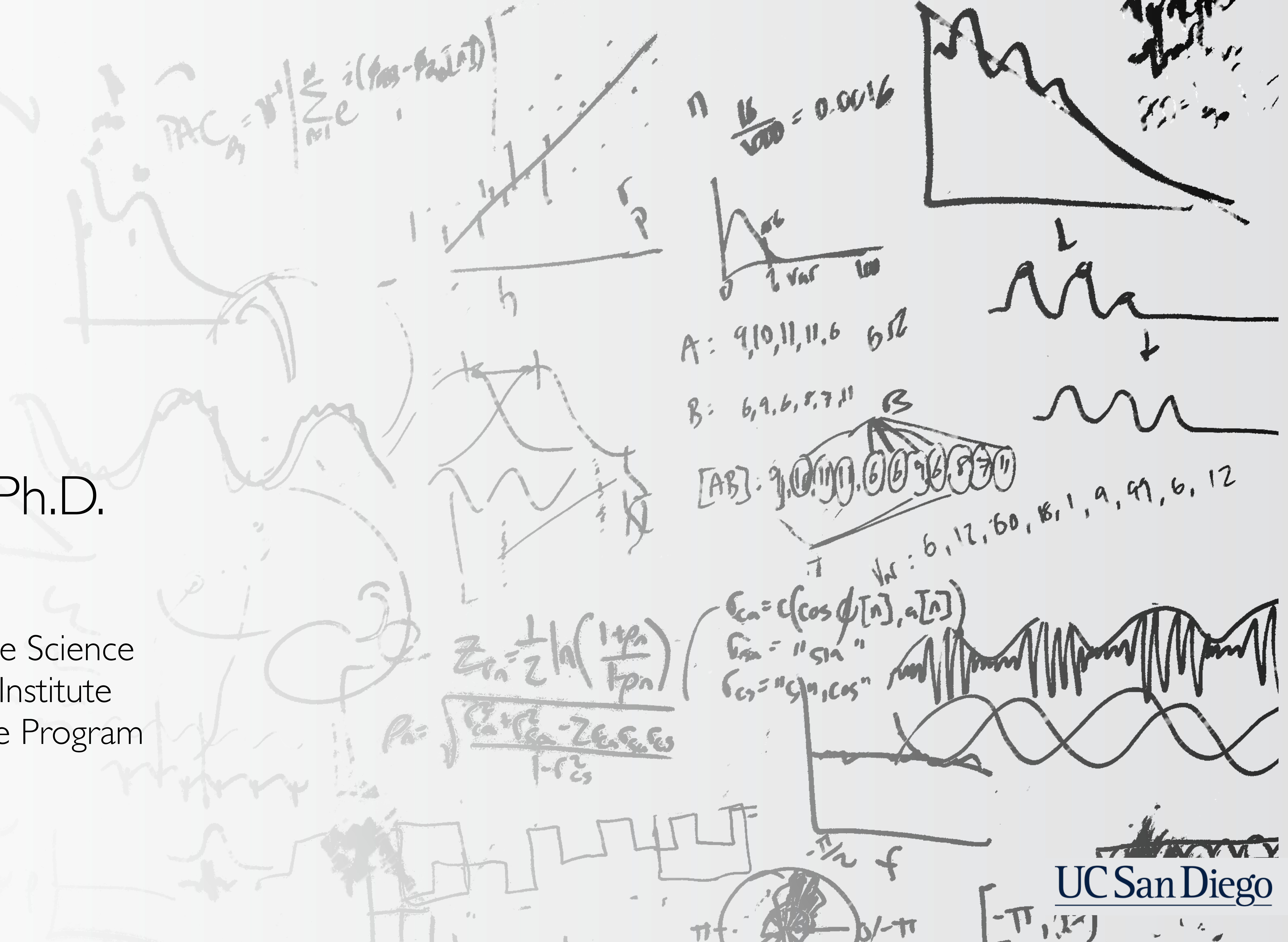

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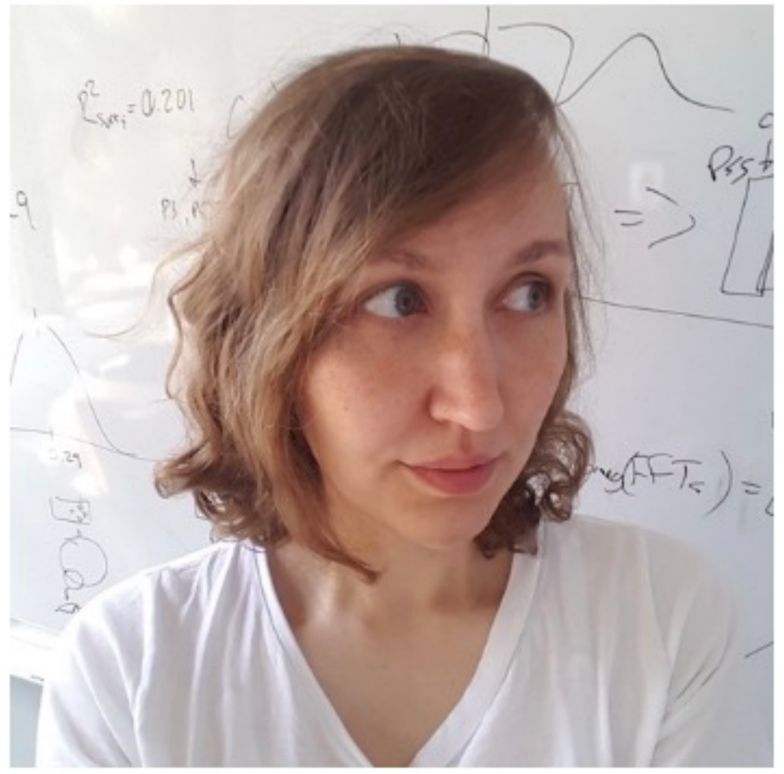
Who is this guy?


Besos
NORTH
23

VOYTEKlab

Natalie Schaworonkow, PhD
Post-doctoral Fellow



Thomas Donoghue, PhD
Just-defended (!) PhD

Richard Gao
Just-defended (!) PhD

Ryan Hammonds
Software Developer

Andrew Bender
Neuroscience PhD student

Eena Kosik
Cogsci PhD student

Michael (MJ) Preston
Neuroscience PhD student

Sydney Smith
Neuroscience PhD student

Quirine van Engan
Cogsci PhD student

http://voyteklab.com/

Support

- Alfred P. Sloan Research Fellowship in Neuroscience
- Whitehall Foundation
- NSF BCS COGNEURO 1736028 (Neuroscience)
- NSF DGE NRT 1735234 (Data Science)
- NIH NIGMS R01 GM134363 (Software Engineering)
- Kavli Innovative Research Grant

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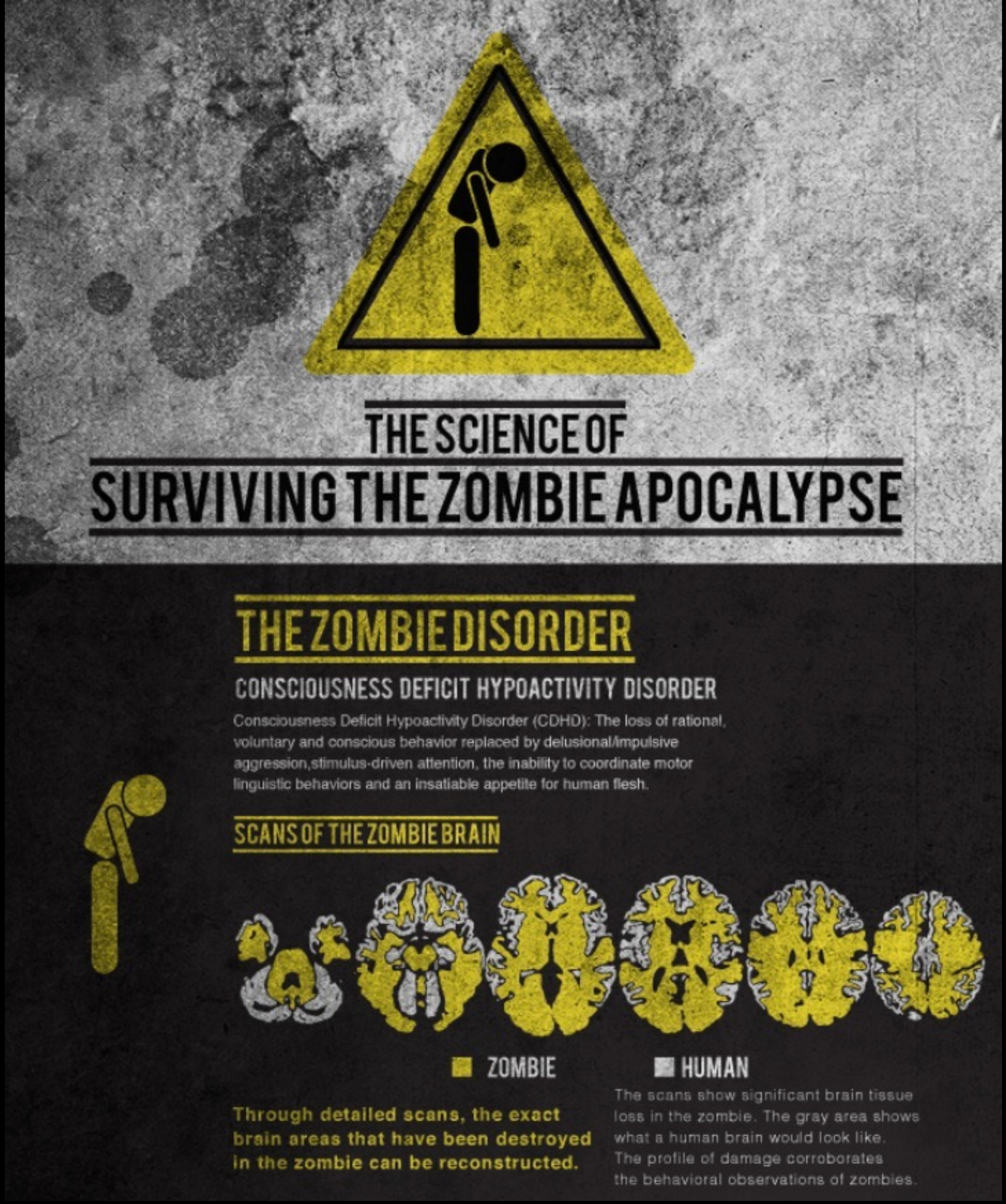
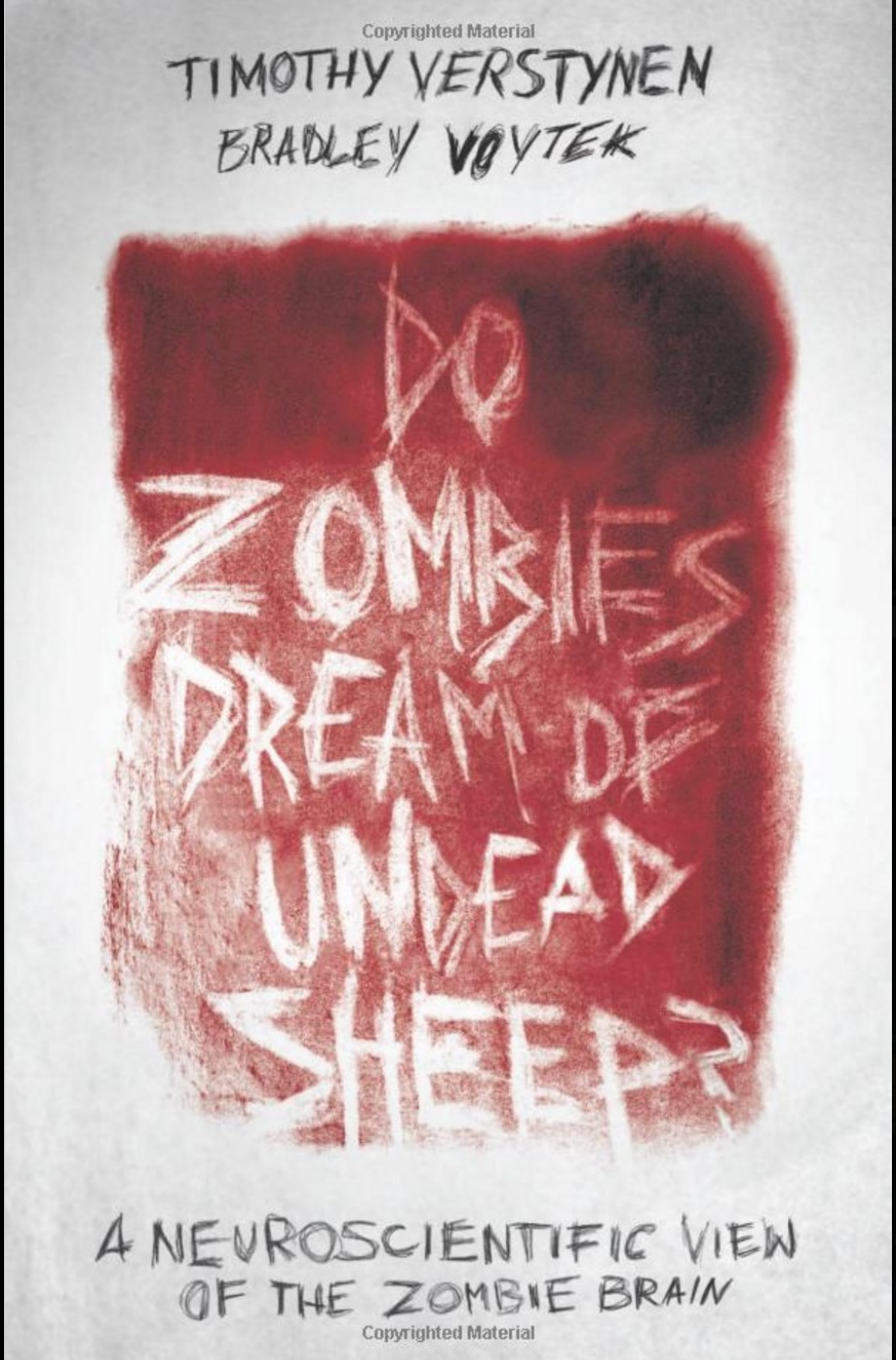
WIRED


THE SCIENCE OF
SURVIVING THE ZOMBIE APOCALYPSE
THE ZOMBIE DISORDER
CONSCIOUSNESS DEFICIT HYPOACTIVITY DISORDER
Consciousness Deficit Hypoactivity Disorder (CDHD): The loss of rational, voluntary and conscious behavior replaced by delusional/impulsive aggression,stimulus-driven attention, the inability to coordinate motor linguistic behaviors and an insatiable appetite for human flesh.
SCANS OF THE ZOMBIE BRAIN
ZOMBIE
HUMAN
Through detailed scans, the exact brain areas that have been destroyed in the zombie can be reconstructed.
The scans show significant brain tissue loss in the zombie. The gray area shows what a human brain would look like. The profile of damage corroborates the behavioral observations of zombies.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DO ZOMBIES DREAM OF UNDEAD SHEEP?
A NEUROSCIENTIFIC VIEW OF THE ZOMBIE BRAIN
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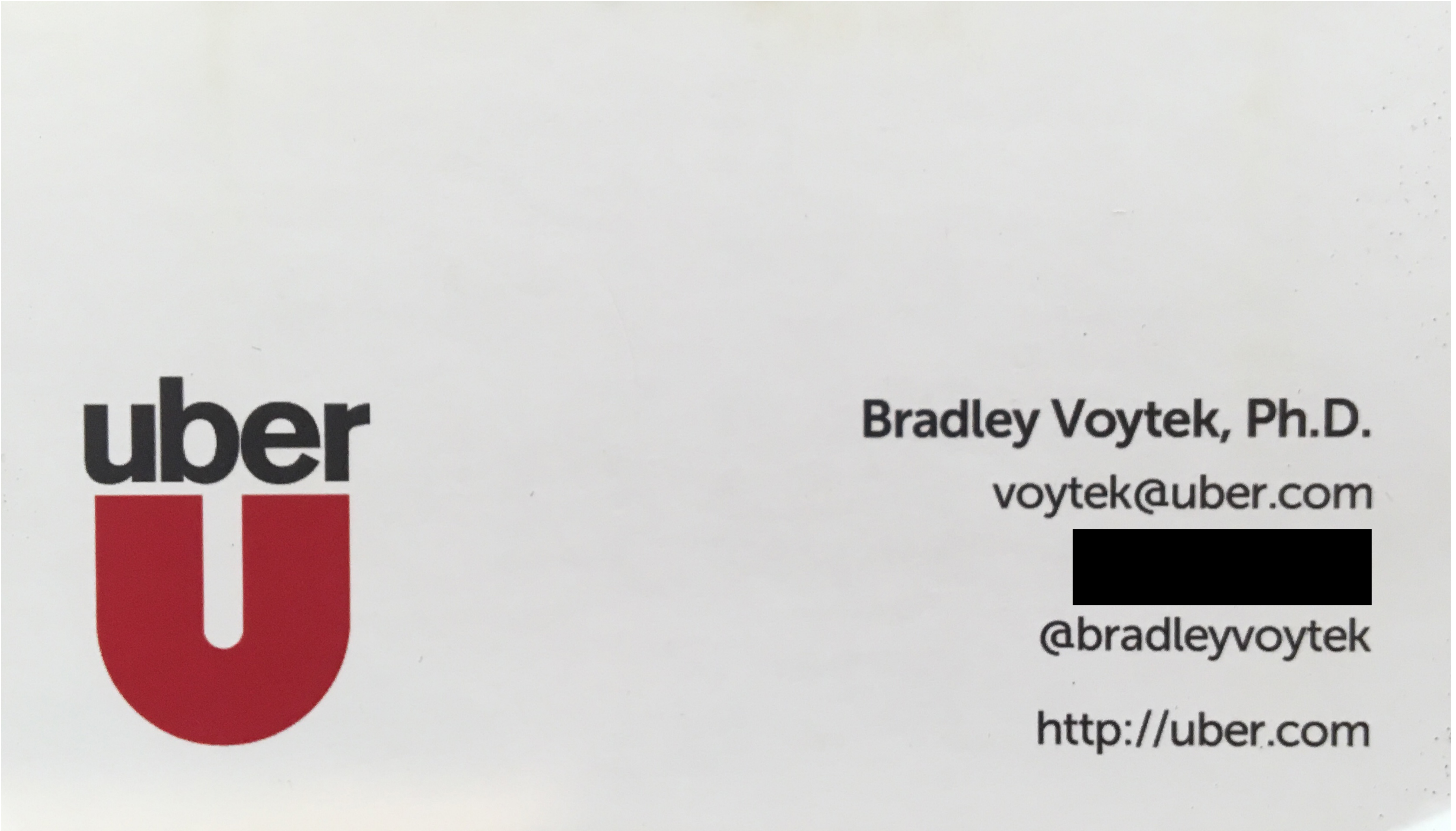
My path as a data scientist

Uber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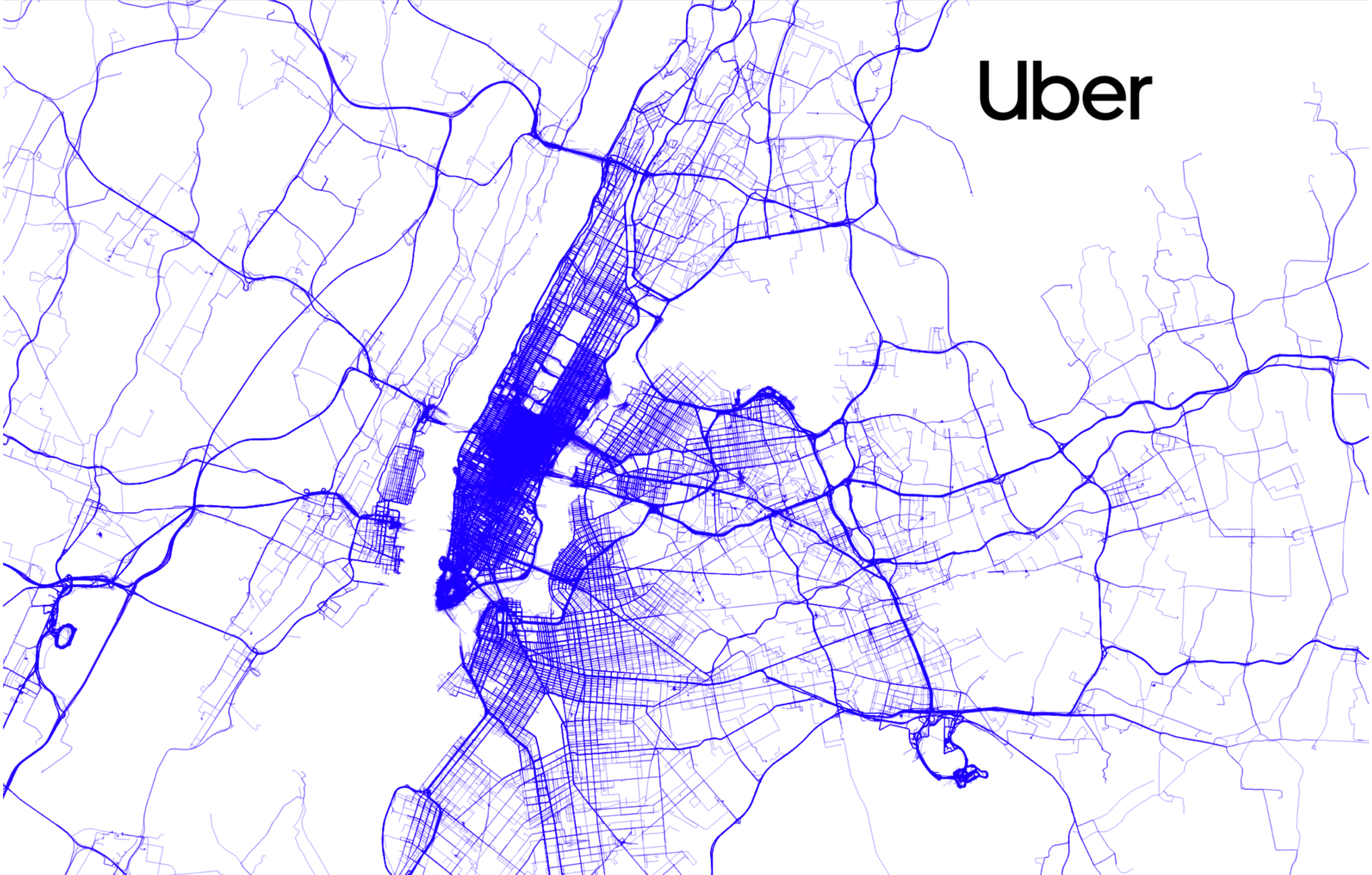
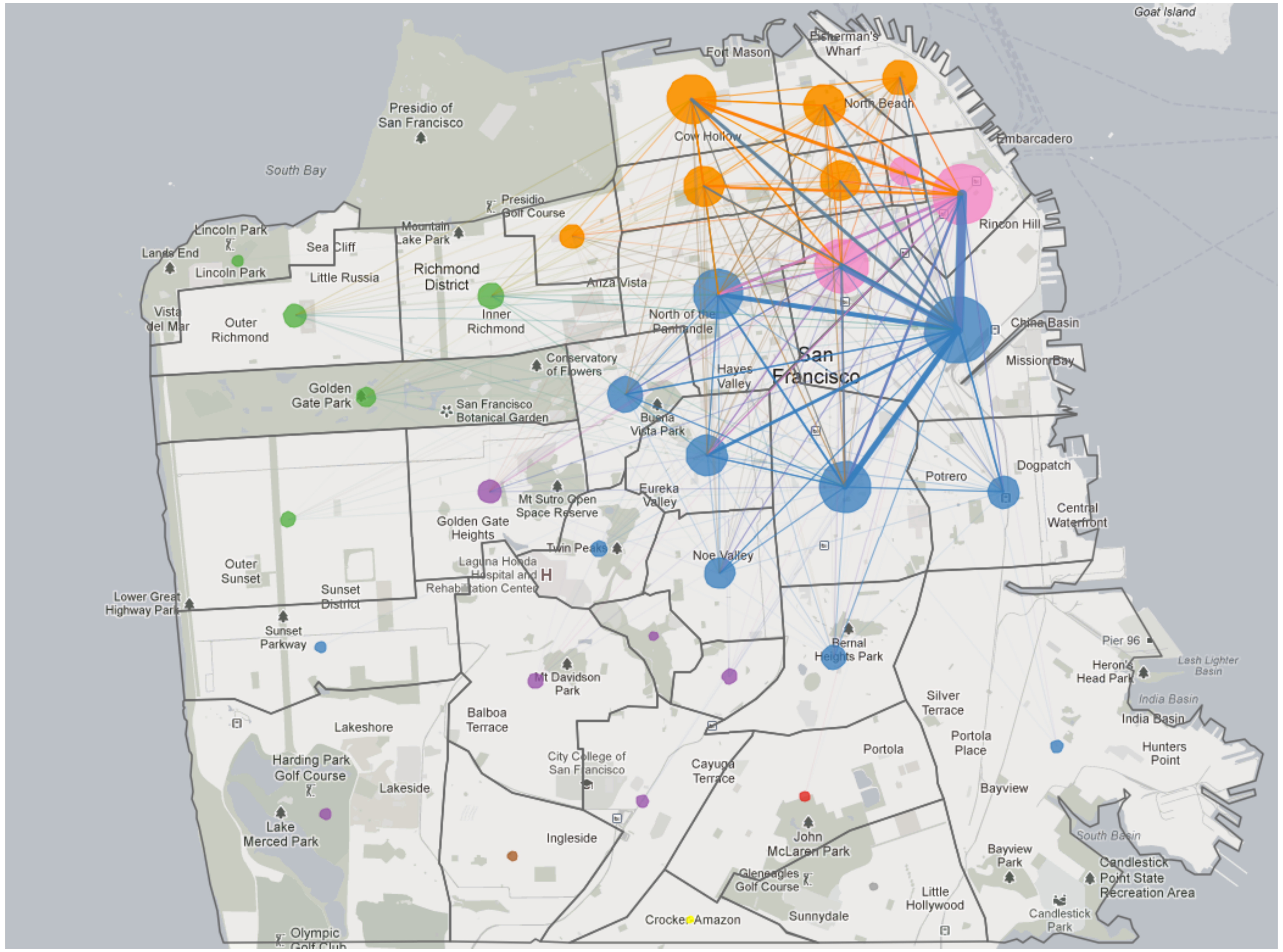

Uber

City dynamics



- Aggregating data into arbitrary geographical units: here neighborhoods, but under the hood you'd use e.g., hexagonal tiling.
- Turns lat/lng pairs and time into temporal profiles of demand between parts of a city.

Source: Voytek, *Uber, Inc.*

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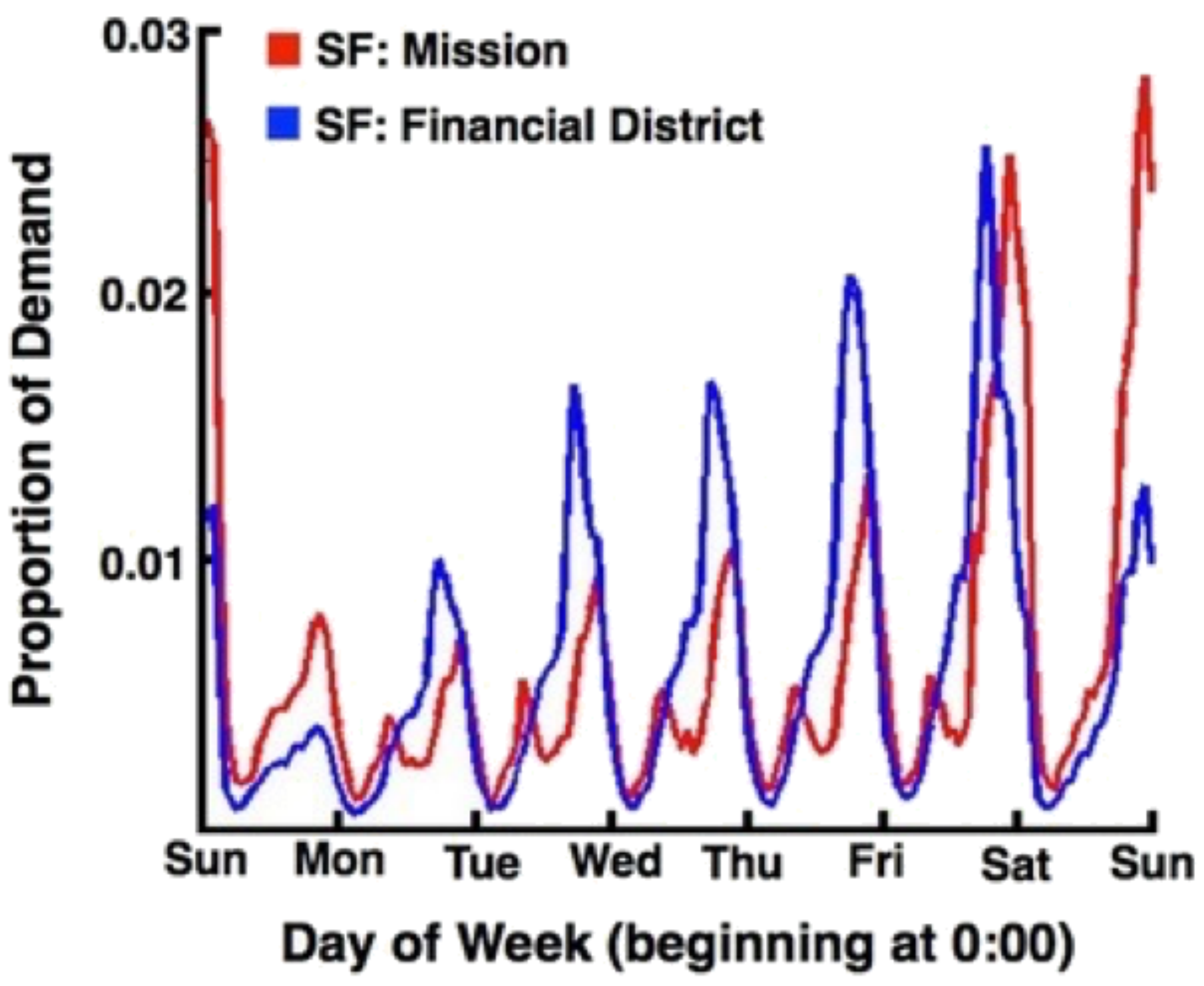
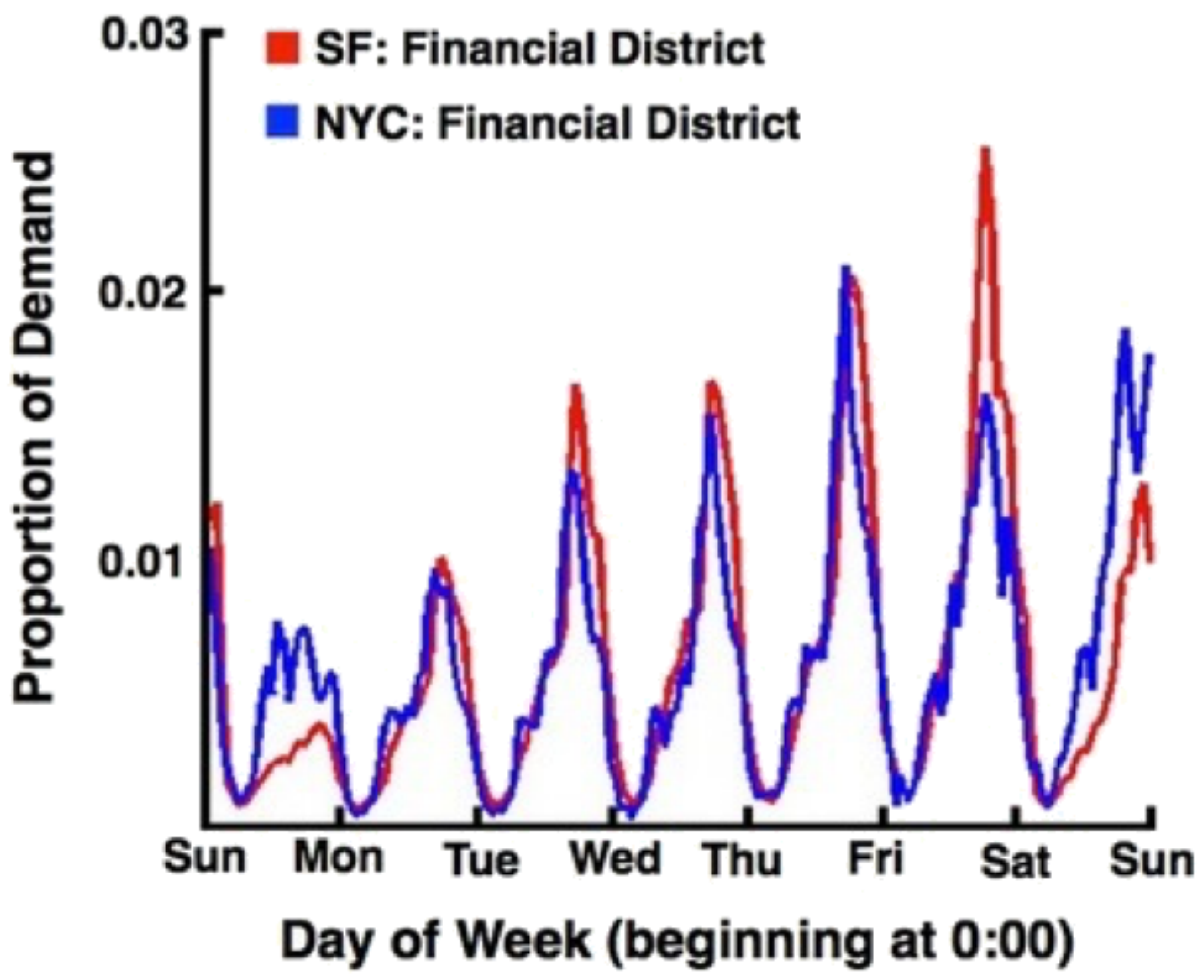
Spatiotemporal dynamics





Source: Voytek, *Uber, Inc.*

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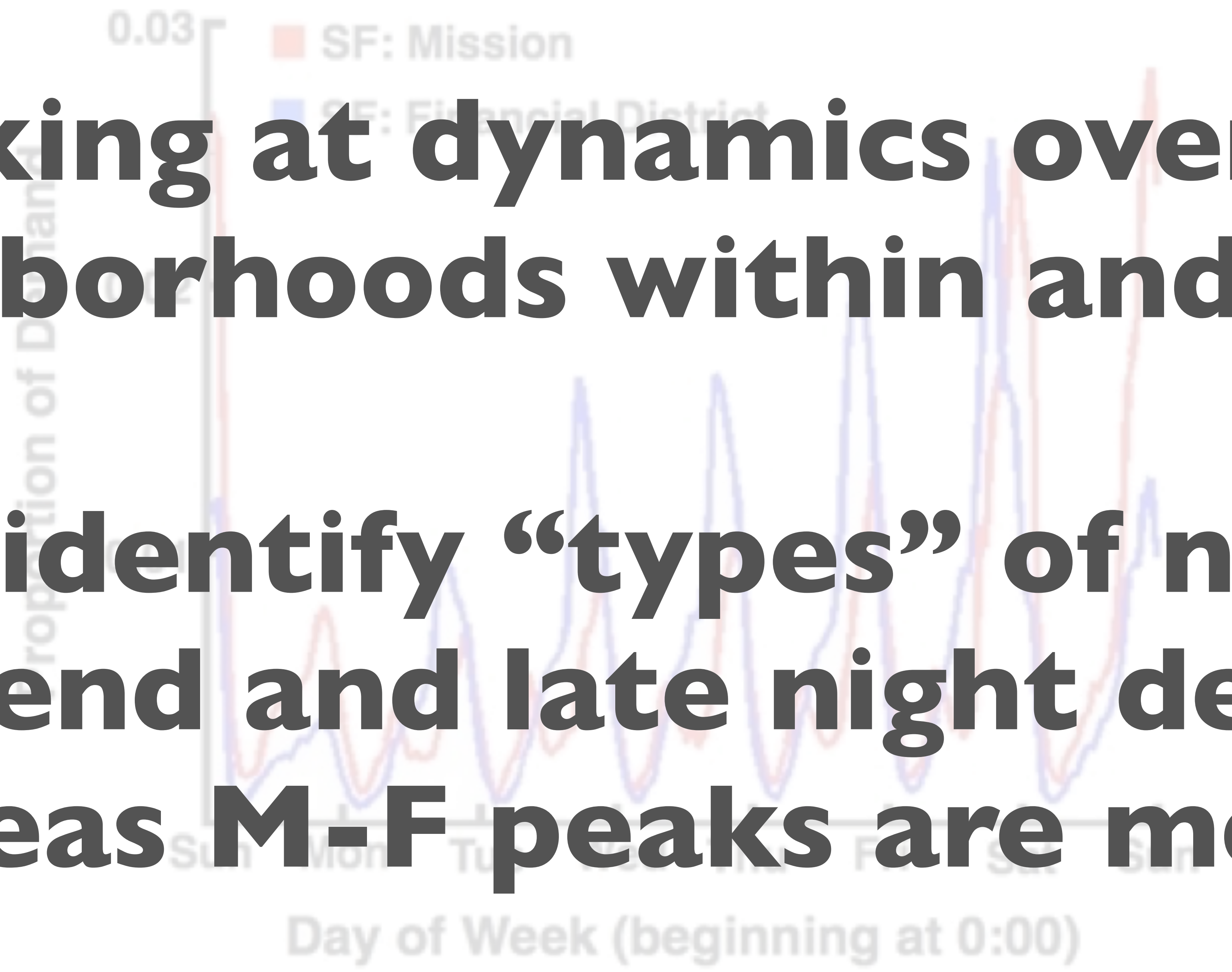
Spatiotemporal dynamics



- **Looking at dynamics over time allows you to correlate neighborhoods within and between cities.**

- **Can identify "types" of neighborhoods: those with peak weekend and late night demands are more "party"-like whereas M-F peaks are more "business" regions.**

Source: Voytek, *Uber, Inc.*

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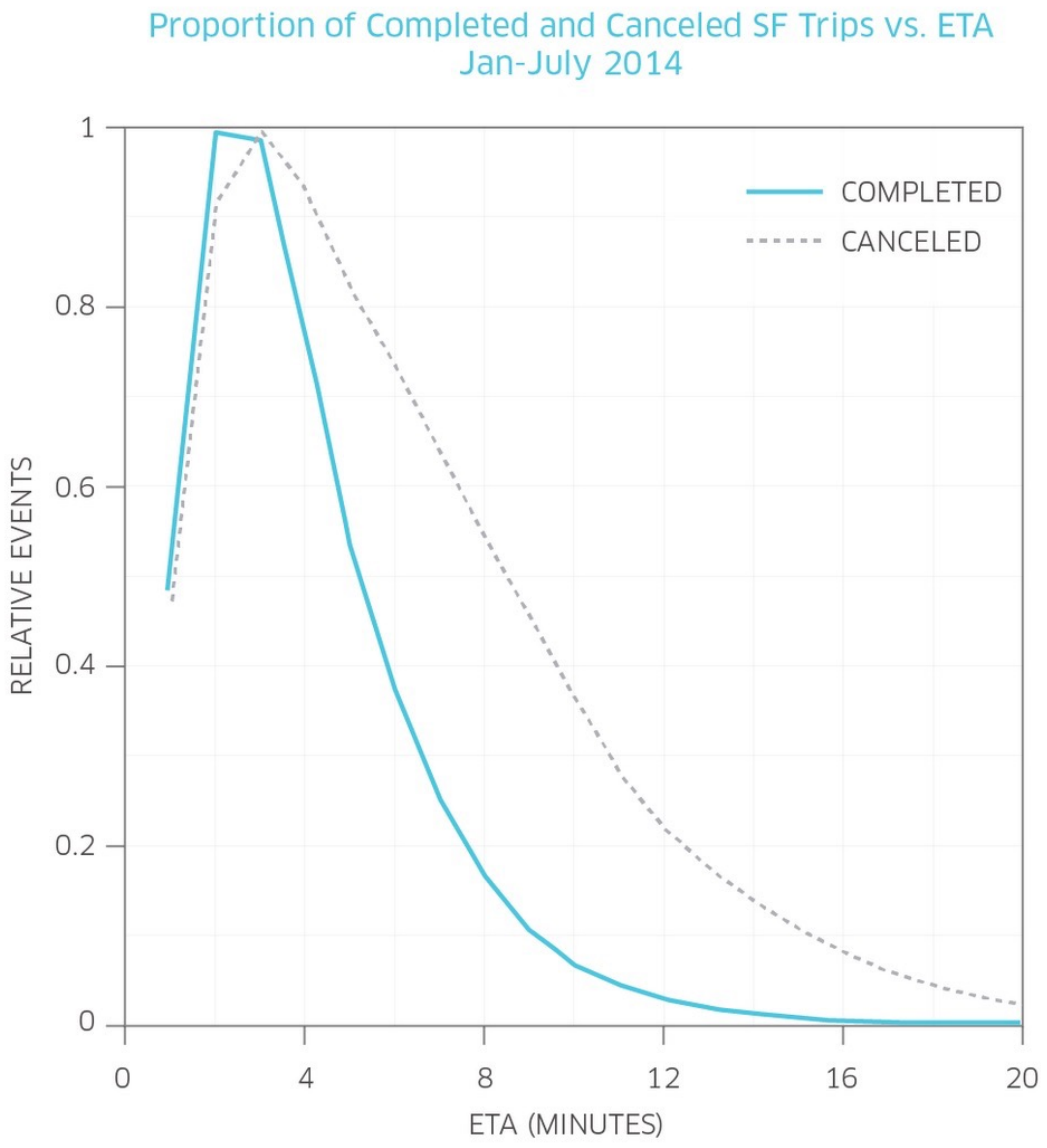
Rider patience



- Plot histograms of ride completion rates as a function of the ETA of the nearest available car.
- Clear peaks and decays.
- Decay rate reveals how "patient" riders are in each country, city, or neighborhood: how long they're willing to wait for a car.

Source: Voytek, *Uber, Inc.*

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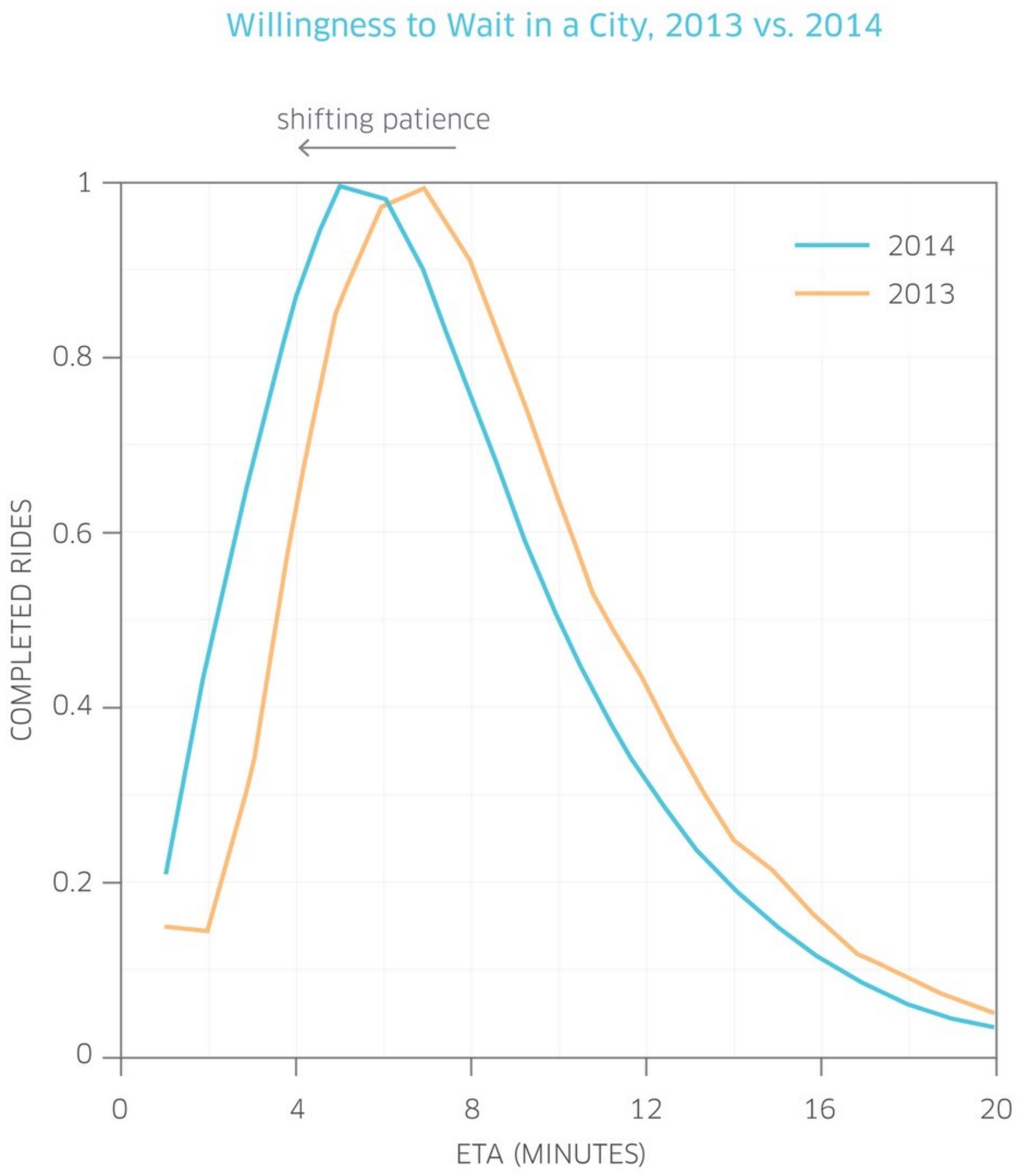
Rider patience



- The entire curve moves backward with each year Uber is in a city.
- From this we can infer that people are getting more accustomed to the service and expect more of it over time.

Source: Voytek, *Uber, Inc.*

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With parameterization, we can then run large scale analyses that were not possible without it.

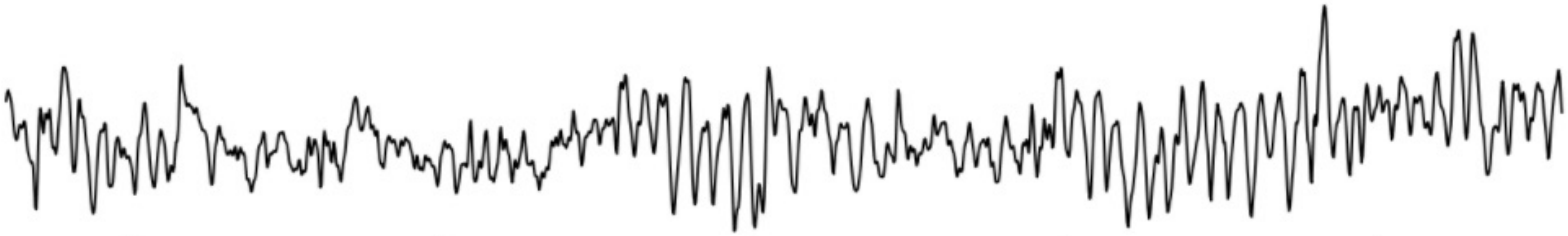
Neural oscillations

Oscillations are correlated with *everything*

Tens-of-thousands of oscillation papers

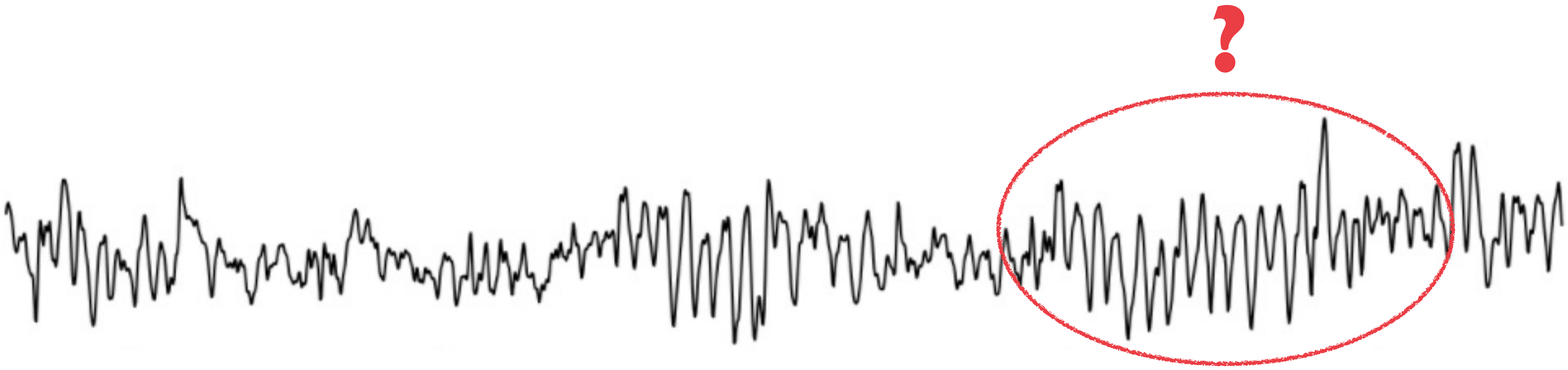
How do we measure oscillations?

what's an oscillation?

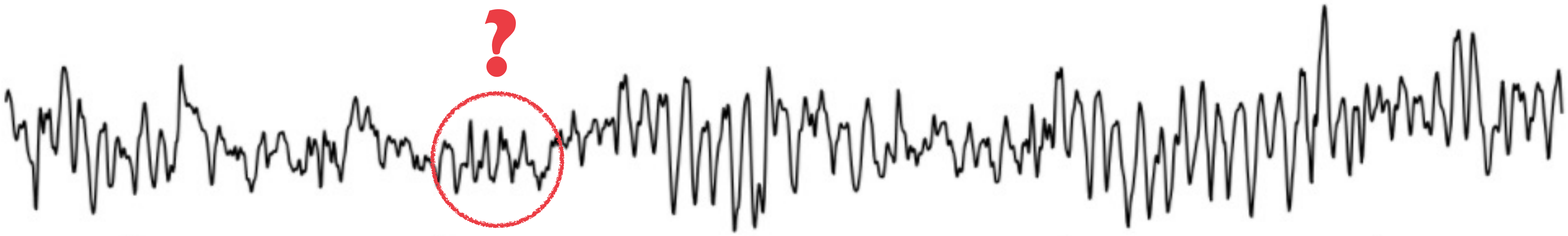


what's an oscillation?

what's an oscillation?

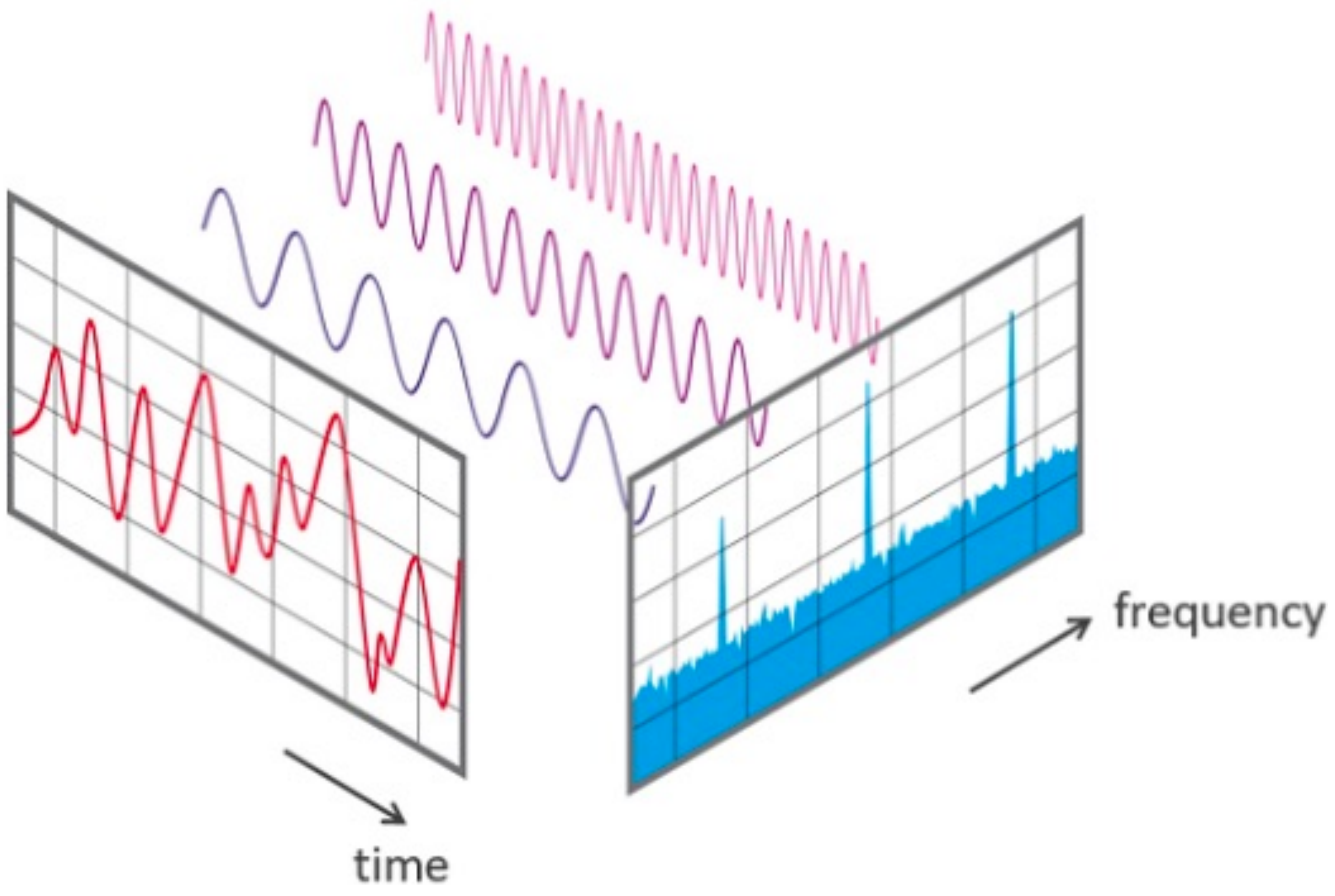


what’s an oscillation?



Detecting oscillations

FFT



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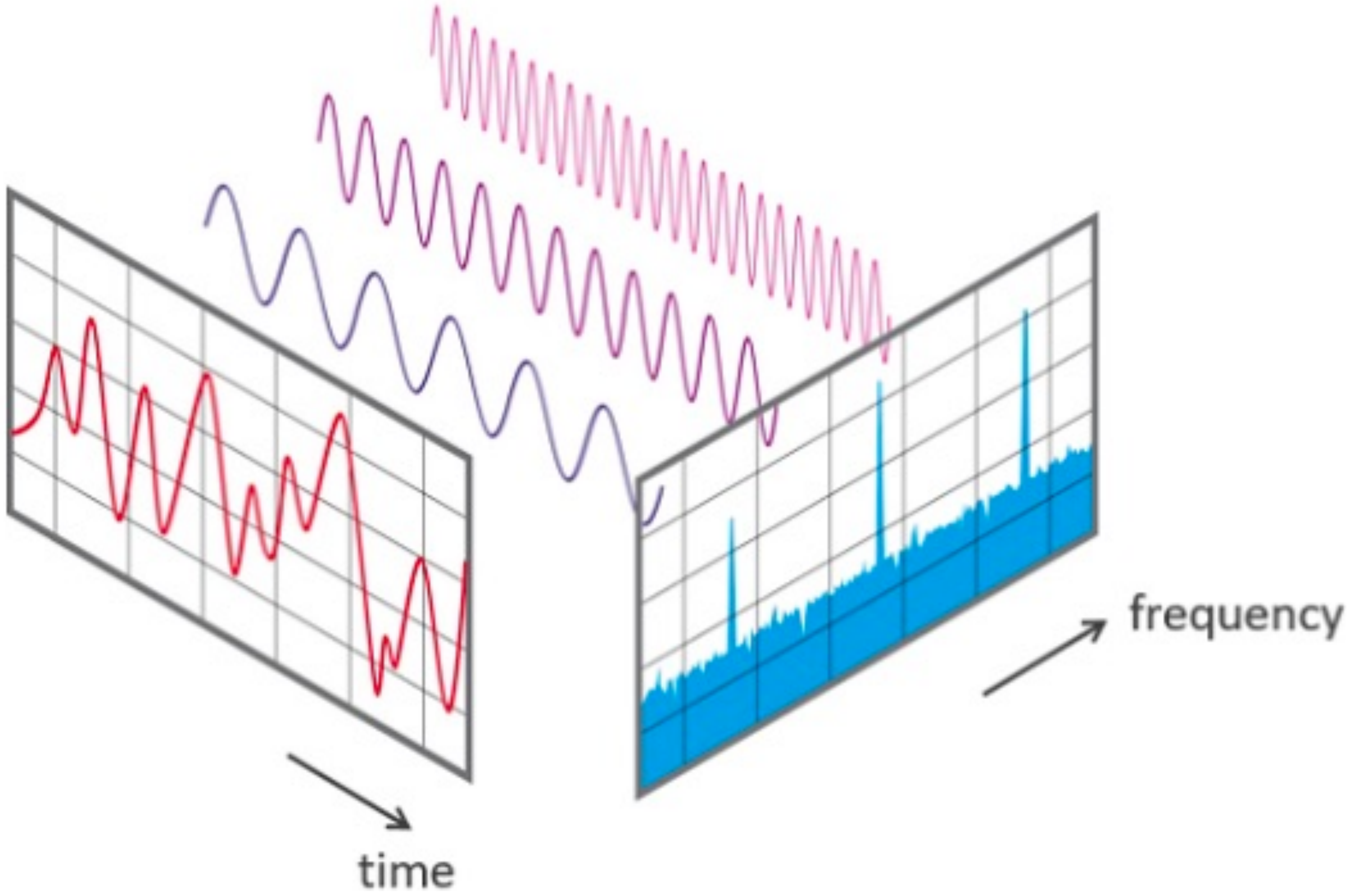
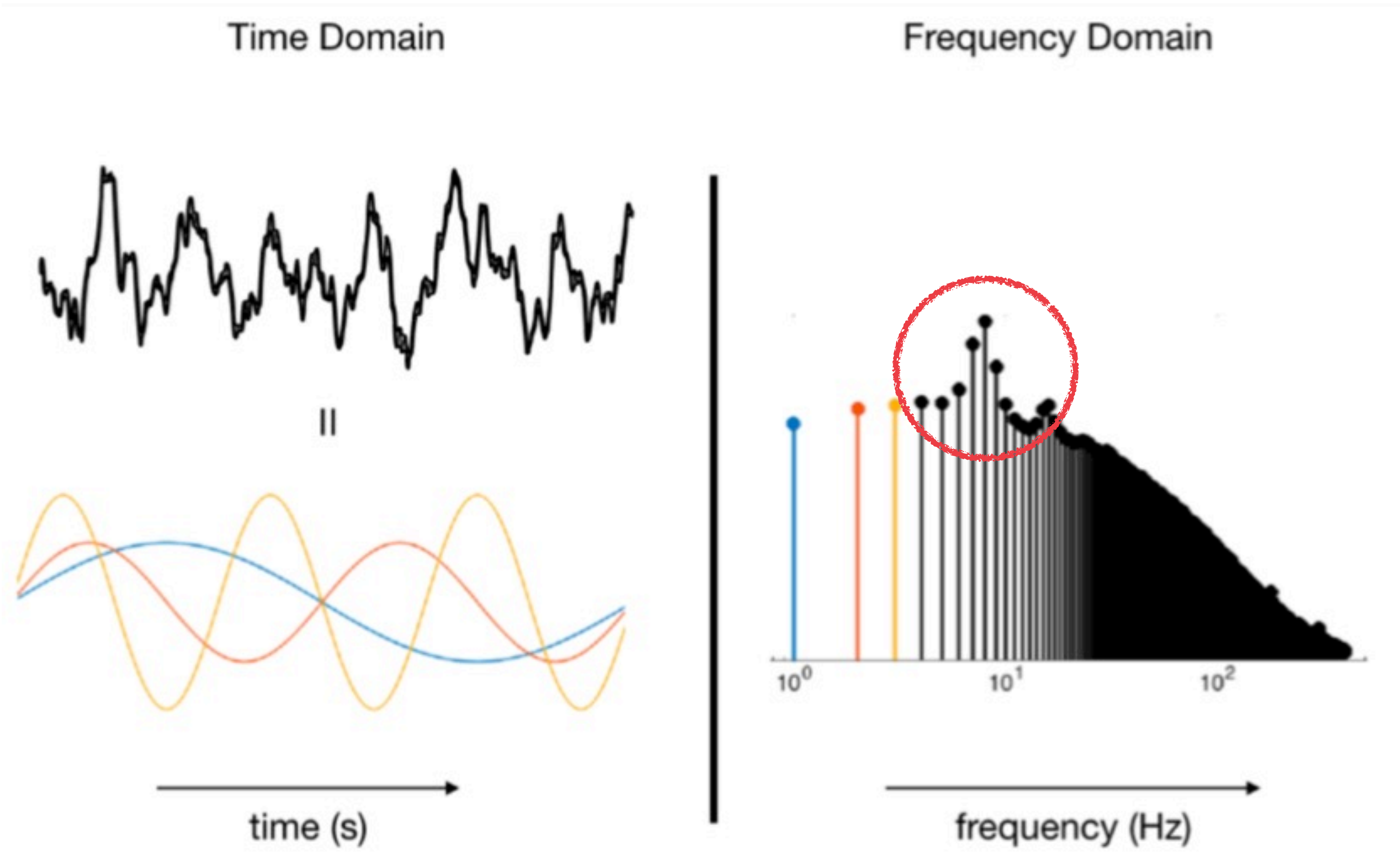
Detecting oscillations

FFT





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Where do oscillations come from?

Cortical organoids

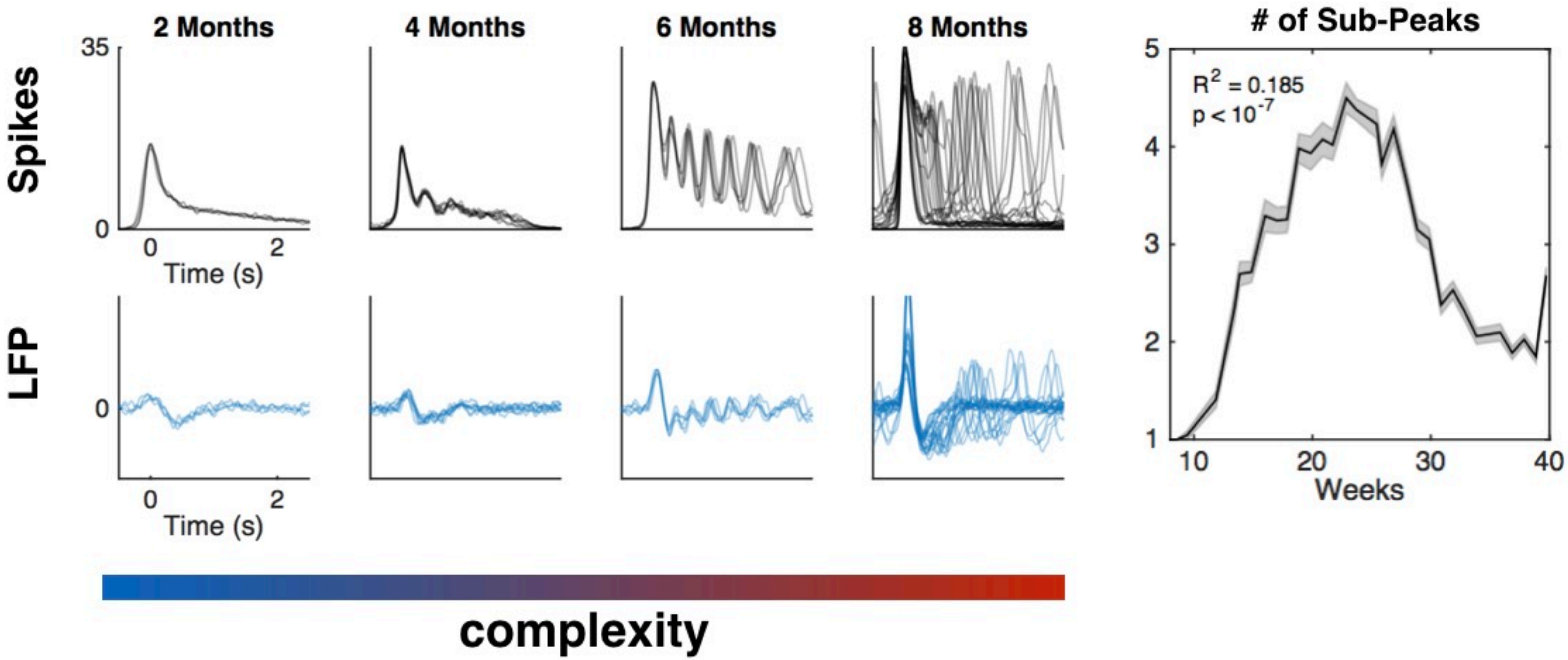
~ 4mm diameter
~ 100,000 neurons

Richard Gao

UC San Diego

Source: Trujillo*, Gao*, Nagreas*… Voytek†, Muotri†, *Cell Stem Cell* 2019

Origin of oscillations



Source: Trujillo*, Gao*, Nagreas*… Voytek†, Muotri†, *Cell Stem Cell* 2019

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Parameterization in my lab

Python packages

pip install:

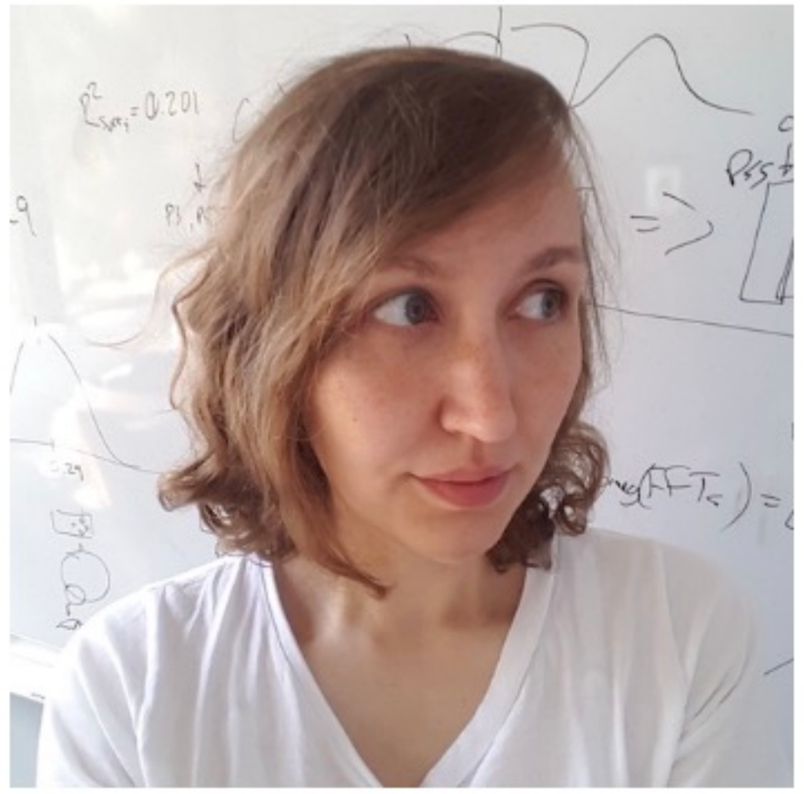
- neurodsp (Cole *et al.*, *J Open Source Softw* 2019)
- fooof (Haller *et al.*, *bioRxiv* 2018)
- bycycle (Cole & Voytek, *J Neurophysiol* 2019)

Thomas Donoghue, PhD

Ryan Hammonds

Scott Cole, PhD

Natalie Schaworonkow, PhD



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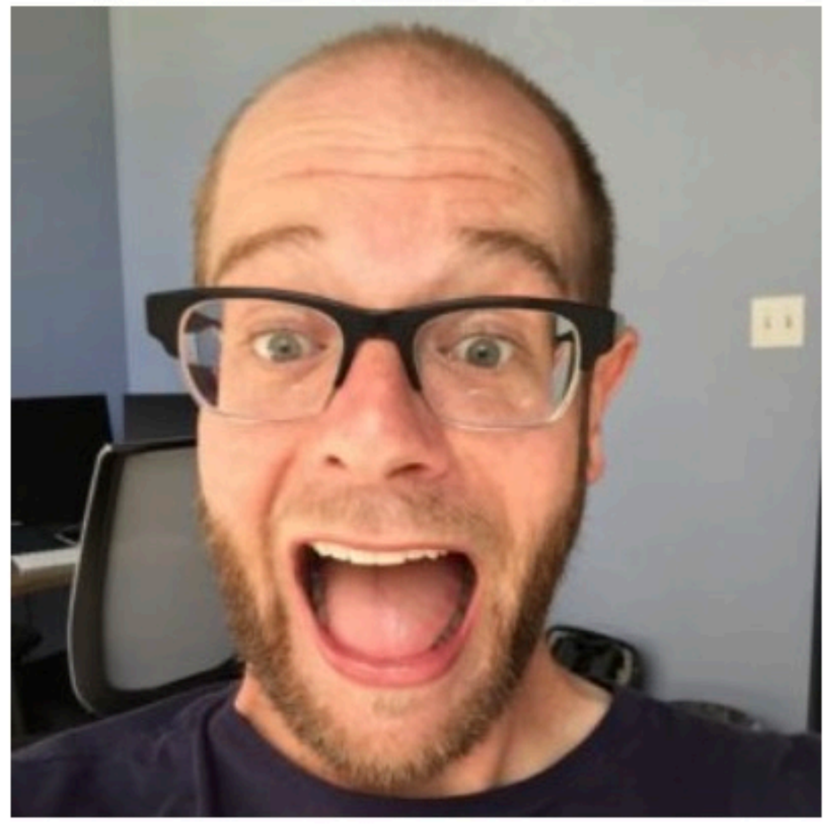
Parameterize our spectra!

Tom Donoghue, PhD

Matar Haller, PhD & Avgusta Shestyuk, PhD

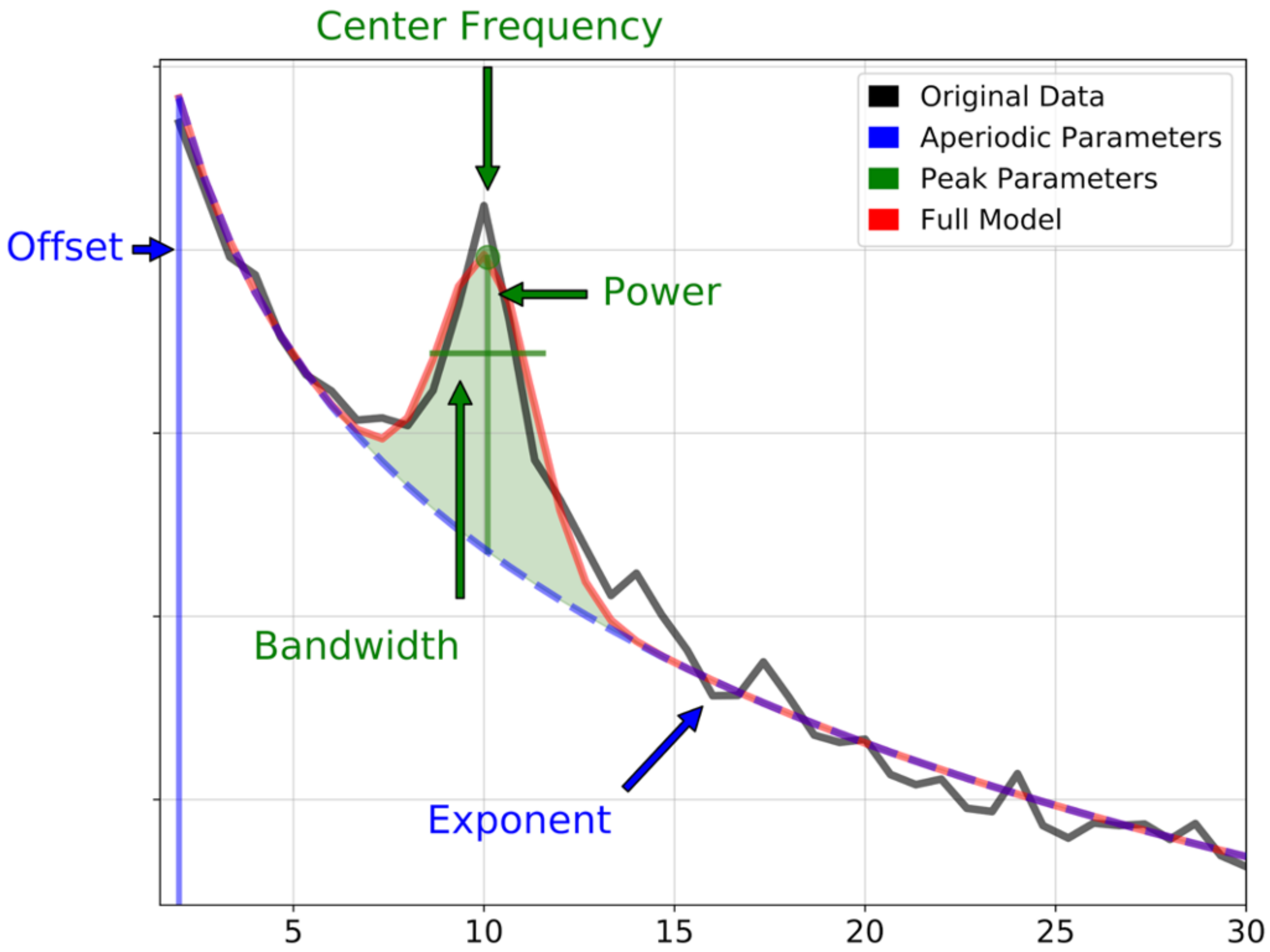
Erik Peterson, PhD



Luyanda Mdanda

Julio Dominguez

Parameterizing neural power spectra



Source: Donoghue*, Haller*, Peterson*, … Shestyuk†, Voytek†, *Nature Neurosci* 2020 Code: https://github.com/fooof-tools/fooof

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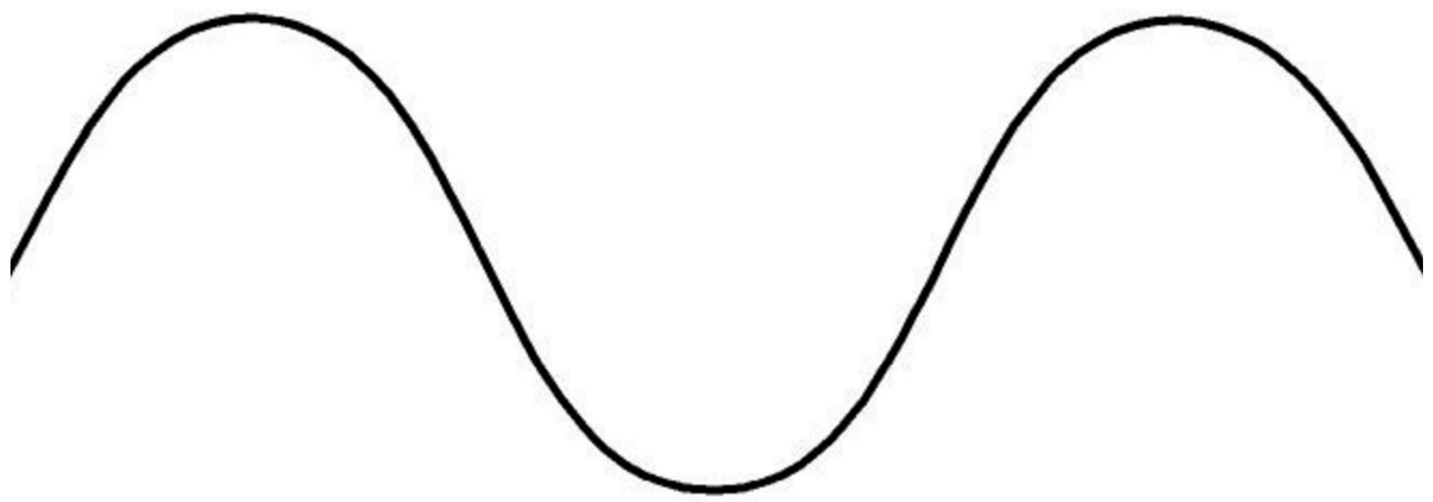
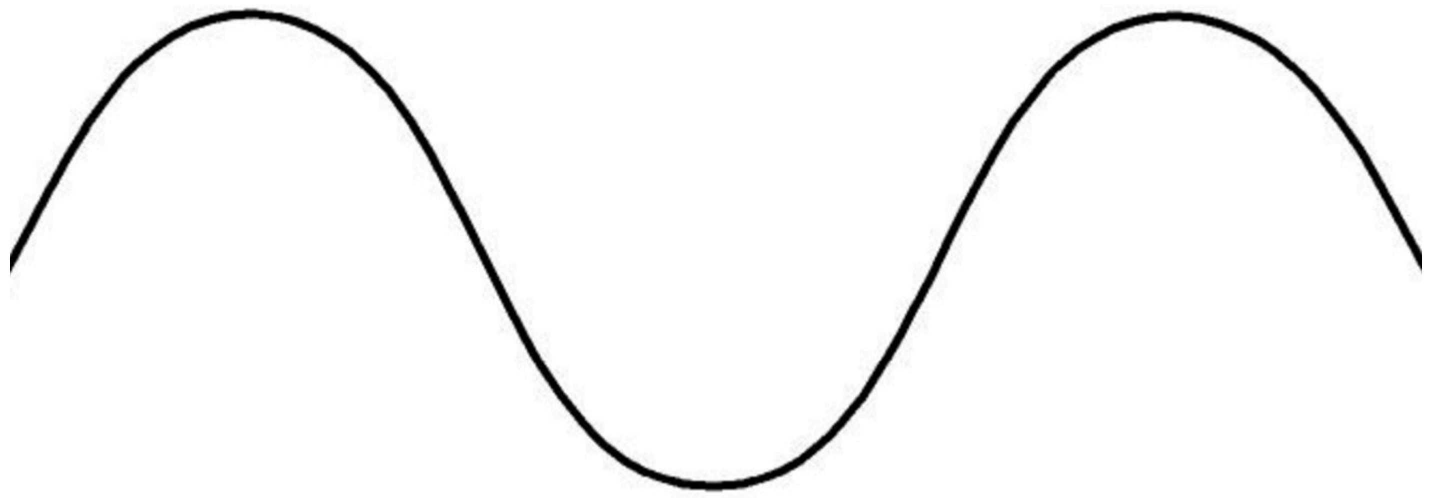
Parameterization matters

Meet *sin*

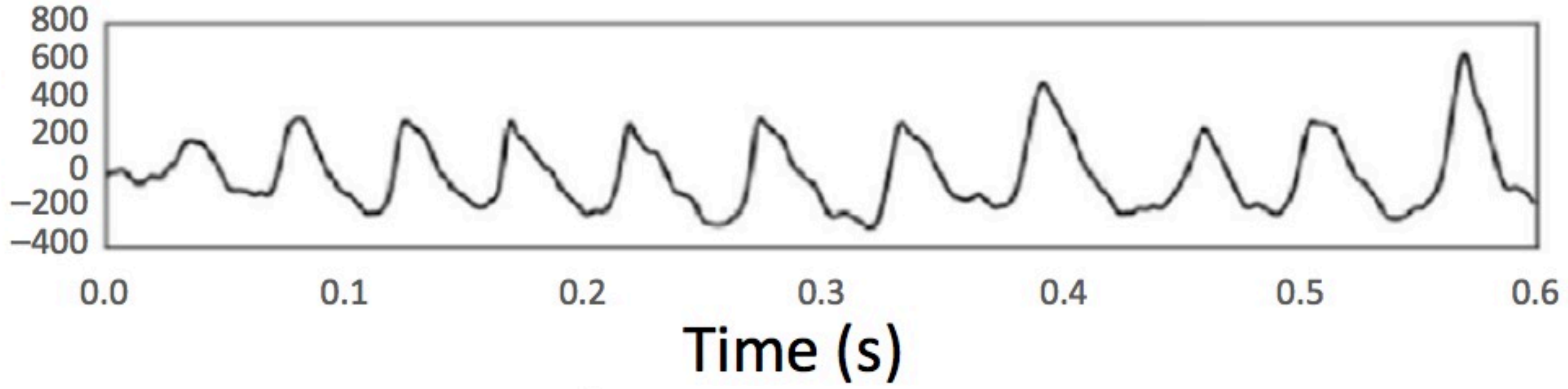


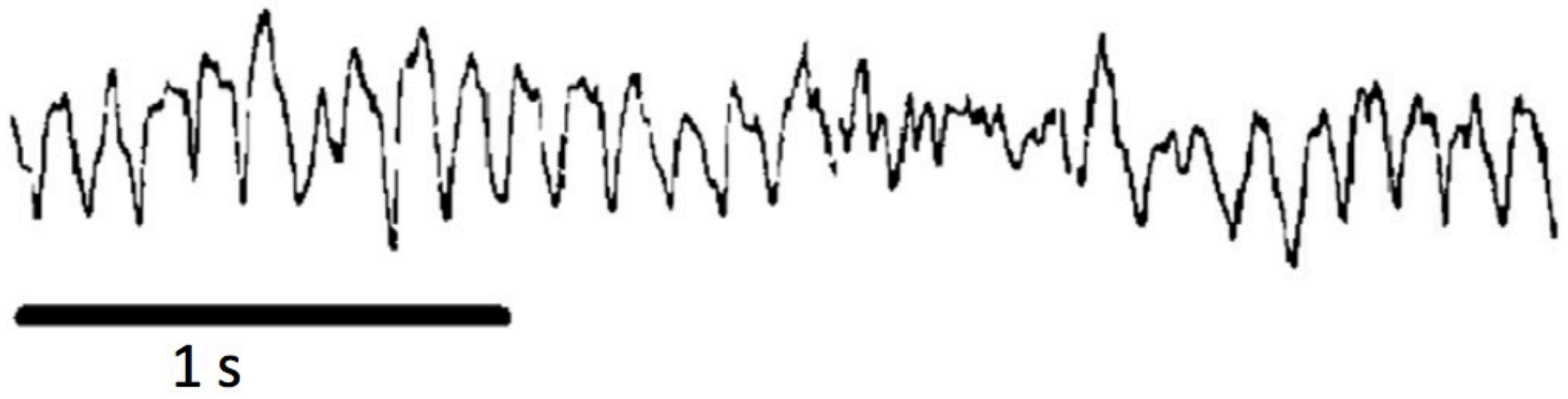
sinusoid

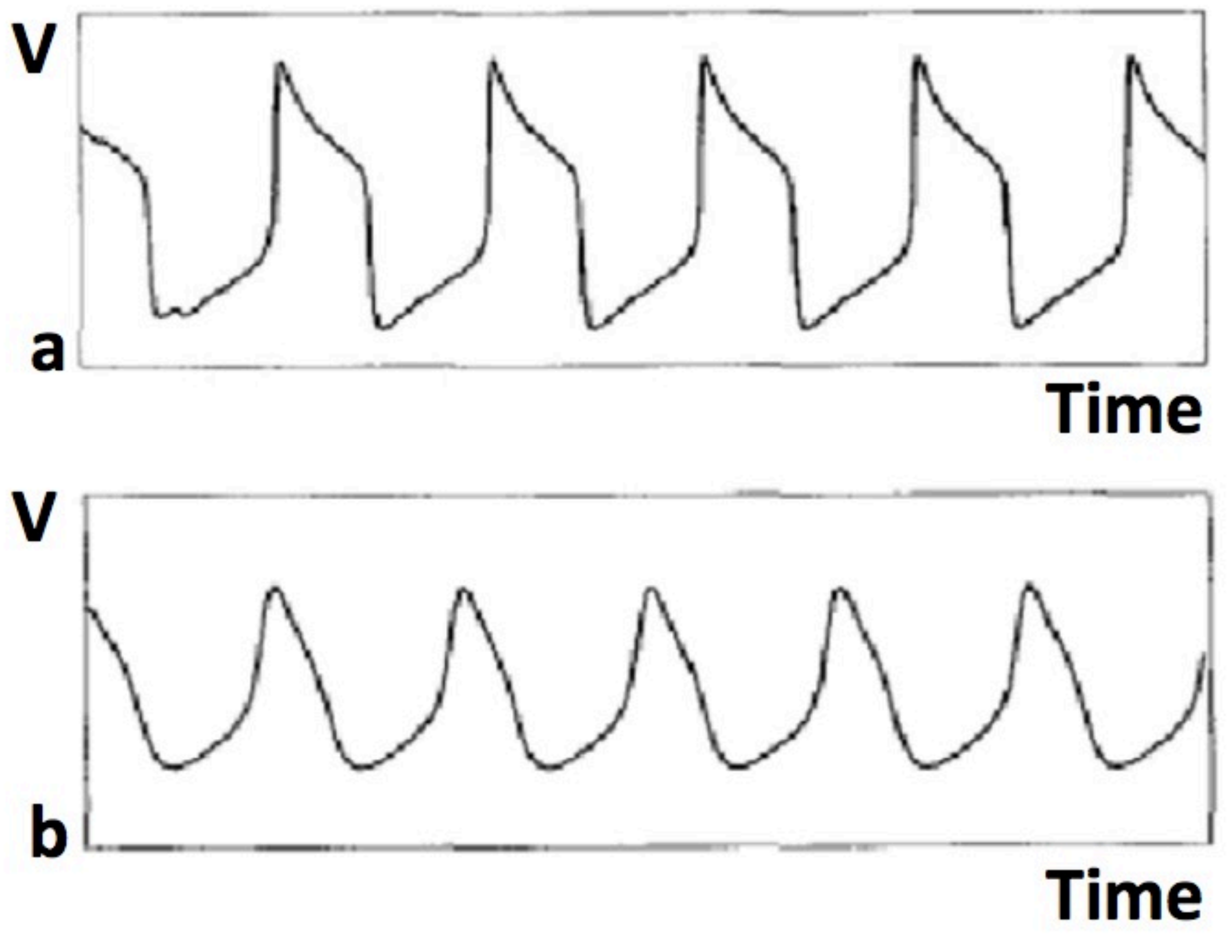
Neural oscillations are *not* sinusoidal



sinusoid







not sinusoids

Source: Cole & Voytek *Trends Cogn Sci* 2017

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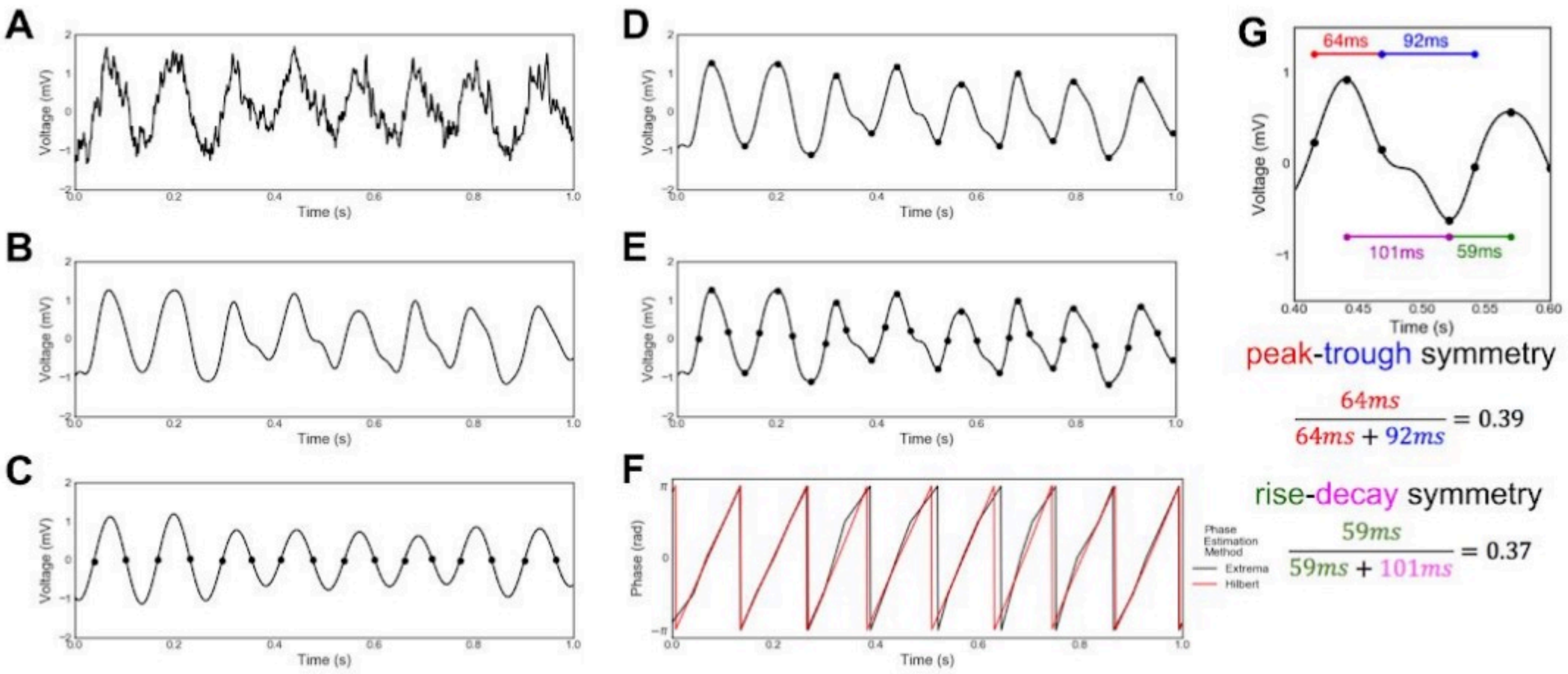
Cycle-by-cycle waveform analyses



Source: Cole & Voytek *J Neurophysiol* 2019

Code: https://github.com/bycycle-tools/bycycle

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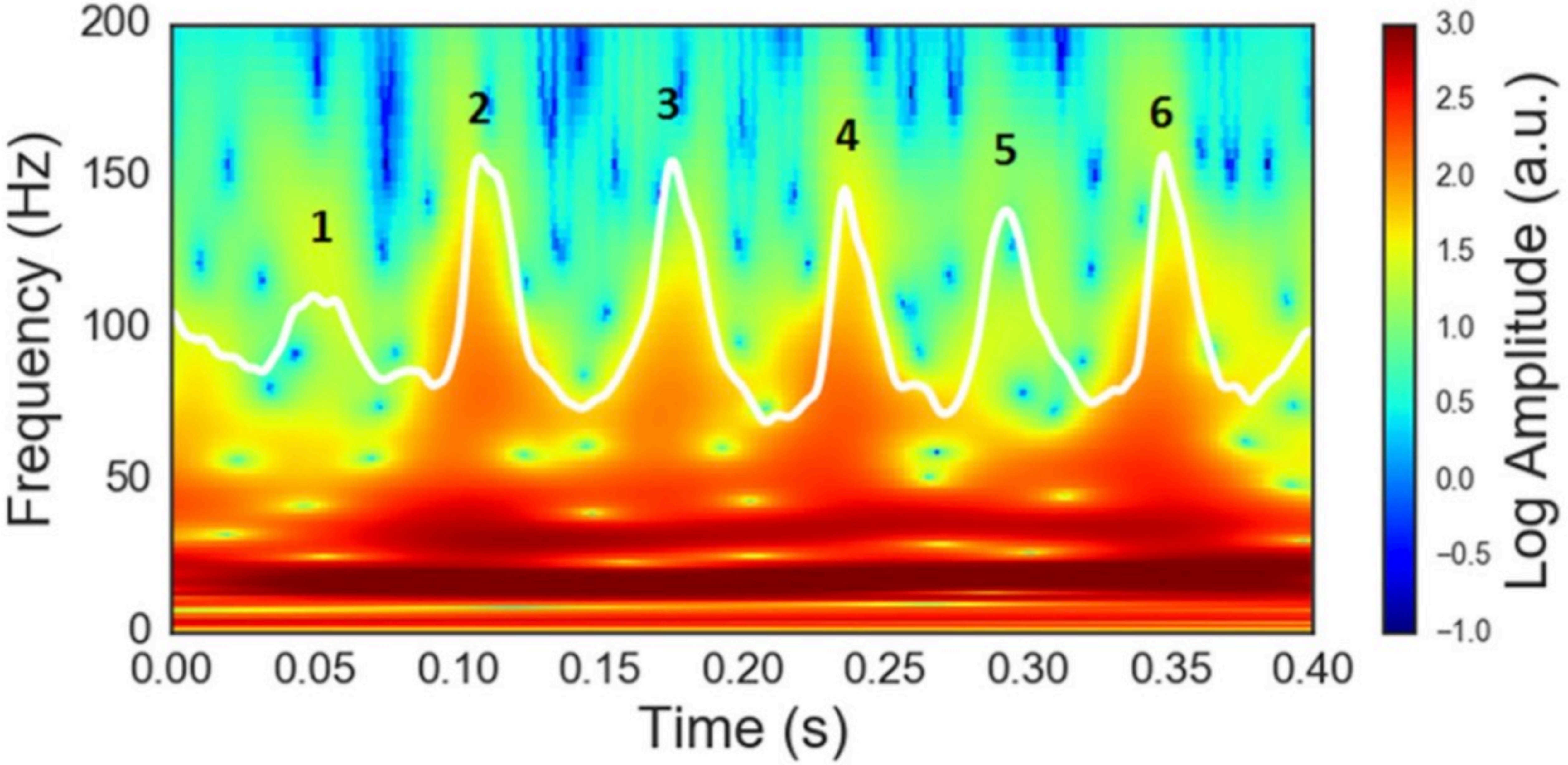
This matters

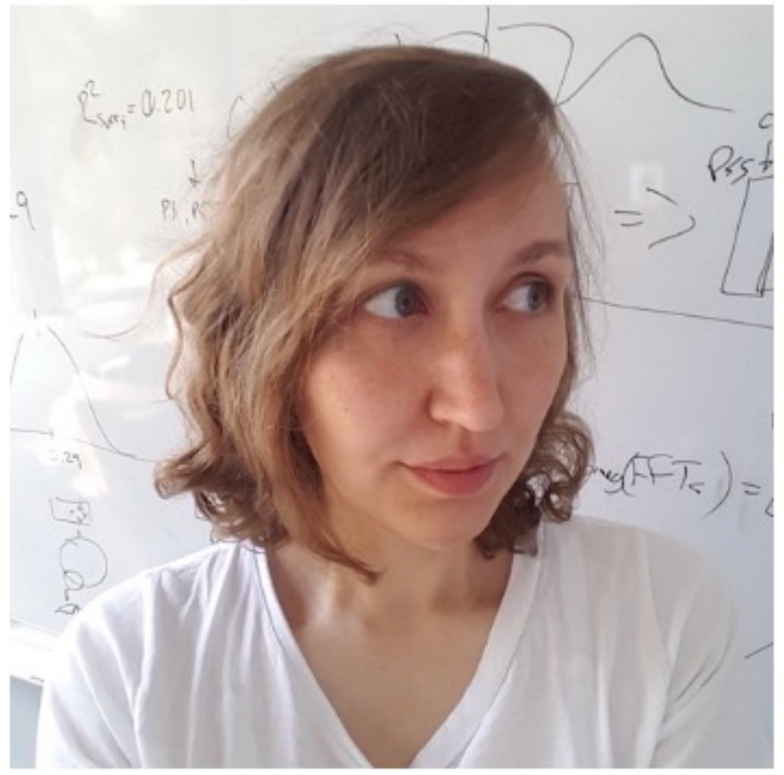
Oscillations in Parkinson's disease

Peak #	1	2	3	4	5	6
Sharpness	29	198	194	267	110	253 uV



Scott Cole (twitter, web, CV)
Formerly: PhD Student
Currently: Data Scientist, San Francisco

Postdoctoral Researcher
Natalie Schaworonkow



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Source: Cole *et al.*, *J Neurosci* 2017

Let’s step back for a second and talk about data-driven approaches to **knowledge discovery**: using data to guide us to new hypotheses and ideas.

Note that data-driven approaches to **knowledge discovery** are analogous to *the human process of hypothesis generation*, but automated.

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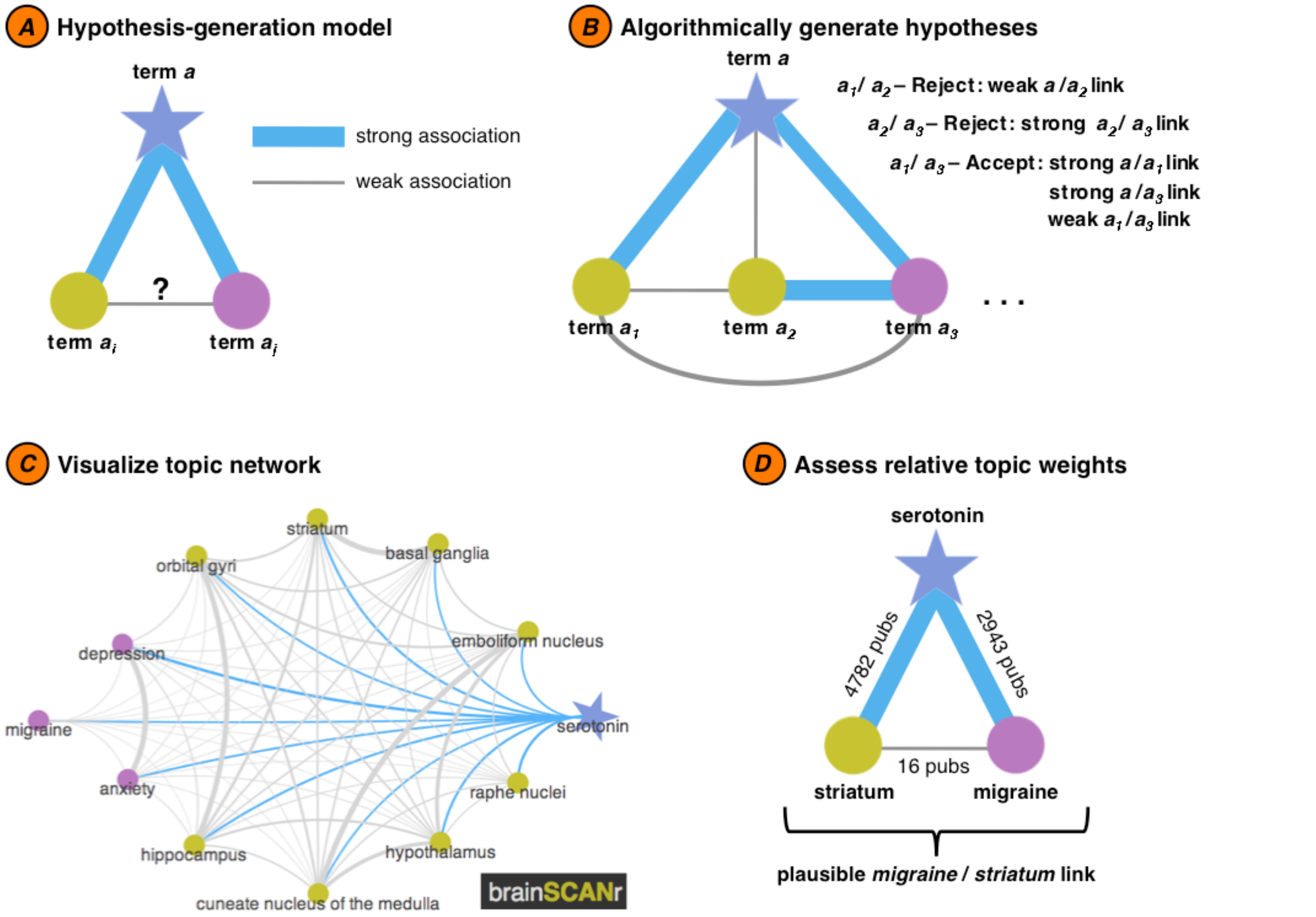
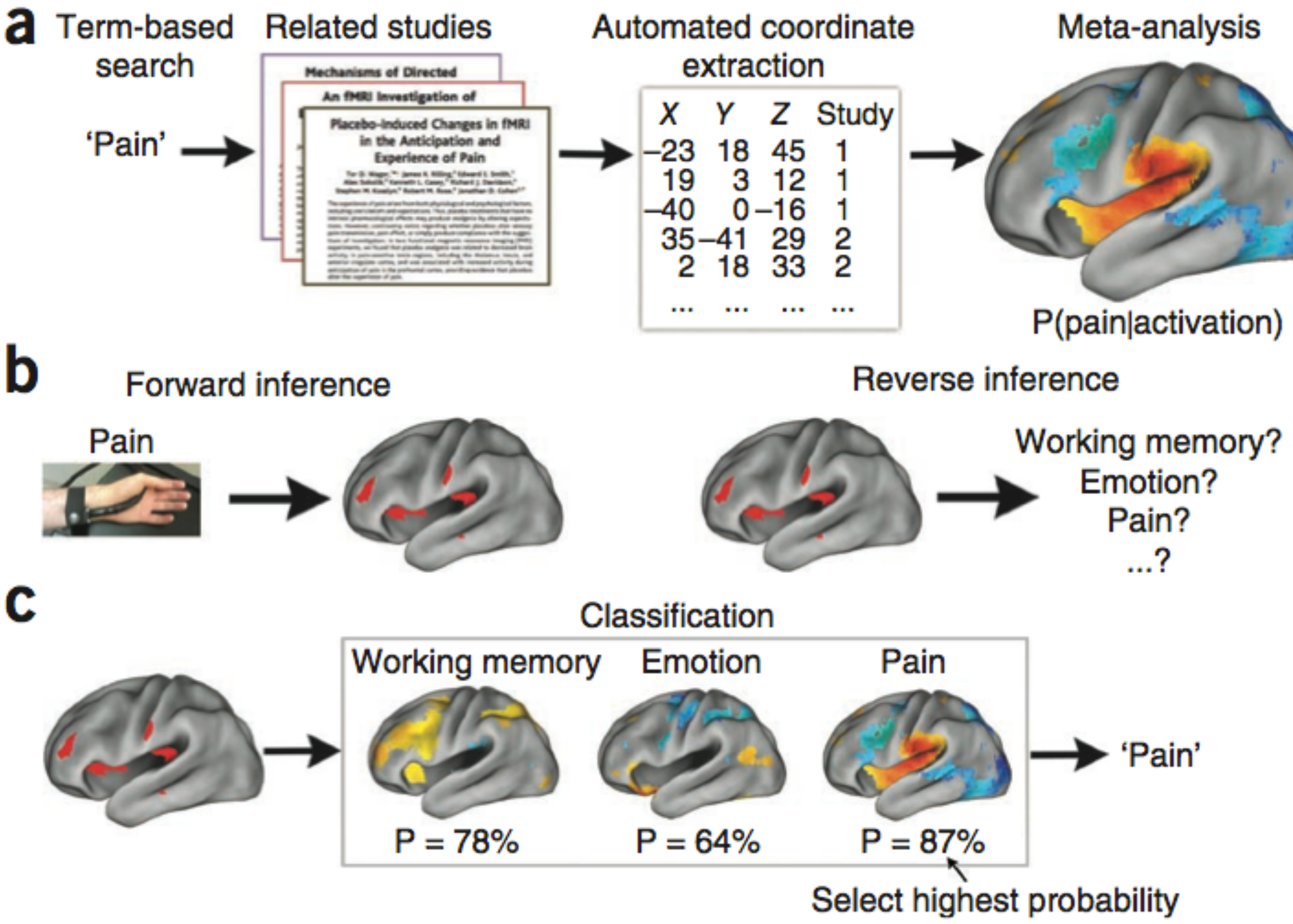


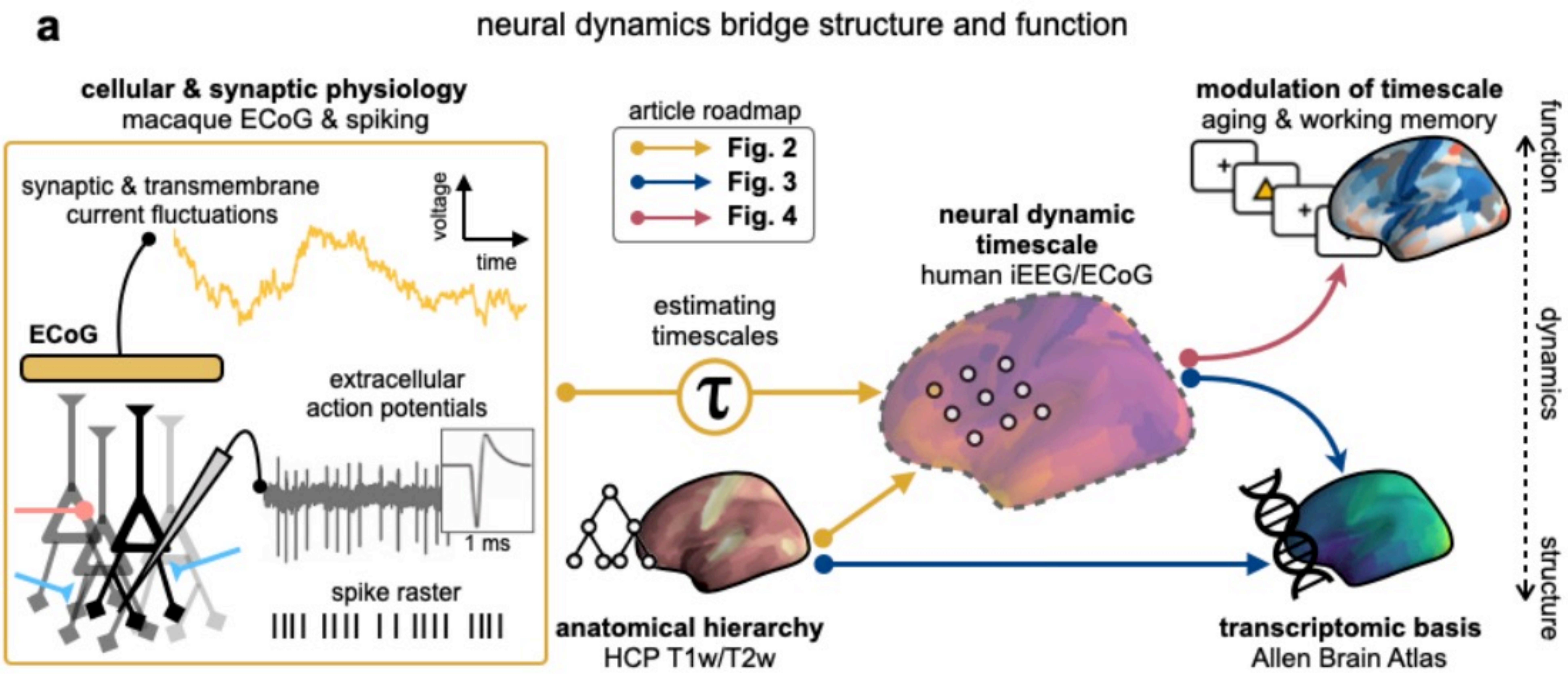
Source: Voytek & Voytek, *J Neurosci Methods* 2012

NeuroSynth



Source: Yarkoni *et al.*, Nature Methods 2011

Integrating *tons* of neural data



Richard Gao

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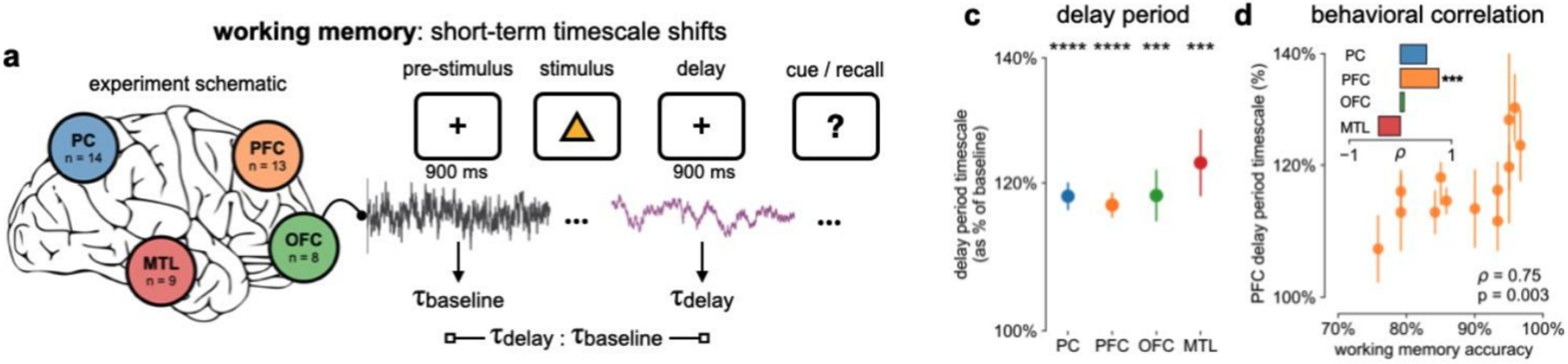
Source: Gao, van den Brink, Pfeffer, & Voytek, *eLife* 2020

Aperiodic timescales in memory and aging



Data sources: Frauscher *et al.*, *Brain* 2018 & Johnson *et al.*, *PLOS Biology* 2018

Source: Gao, van den Brink, Pfeffer, & Voytek, *eLife* 2020

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We can look for connections between all of these—cell types, gene expression, function, oscillations, connectivity—to see how they all interrelate.

And we can find *gaps*—missing connections where topics *should be* related but aren't.

We can mine through these connections to find potential *missing links*.

That is, we can use the data themselves to generate new hypotheses *for us*.

Feature mapping

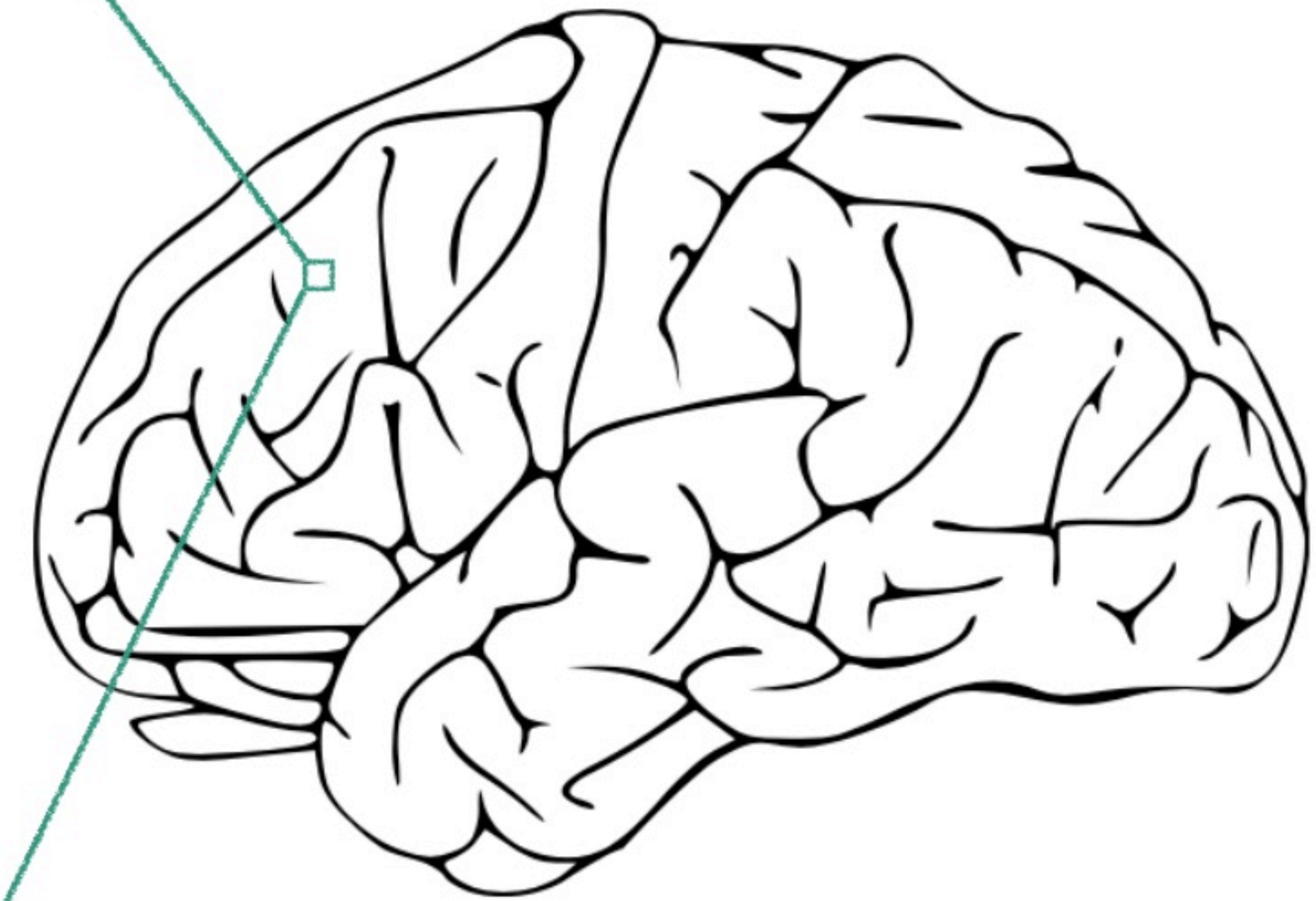
voxel-level information

architecture
- cortical thickness
- white matter connectivity
- myelination
- neuronal density

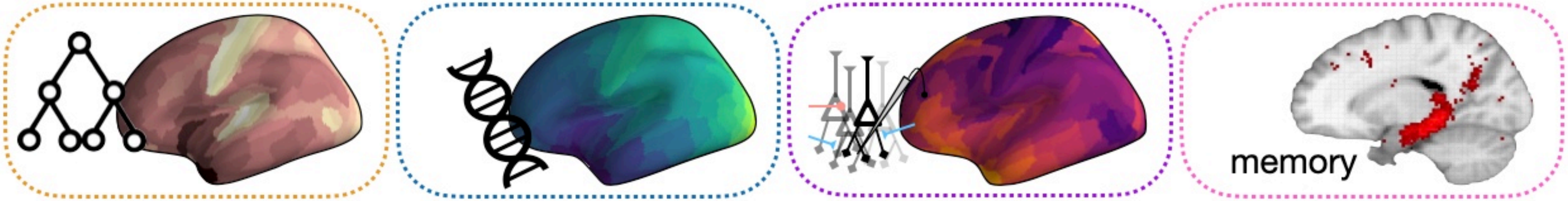
cellular
- cell type and morphology
- gene expression
- receptors
- neurotransmitters / modulators

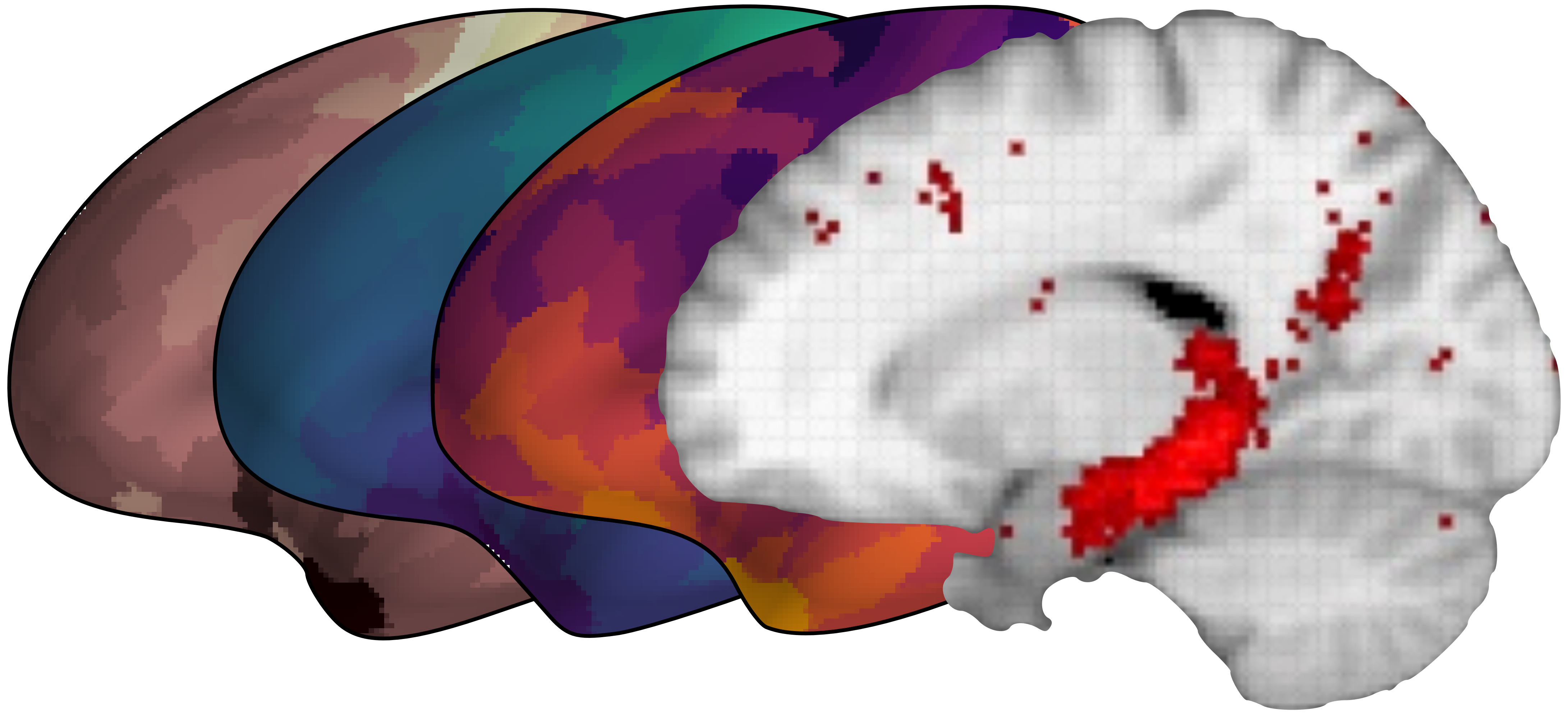
dynamics
- single-unit
- field potential / oscillations

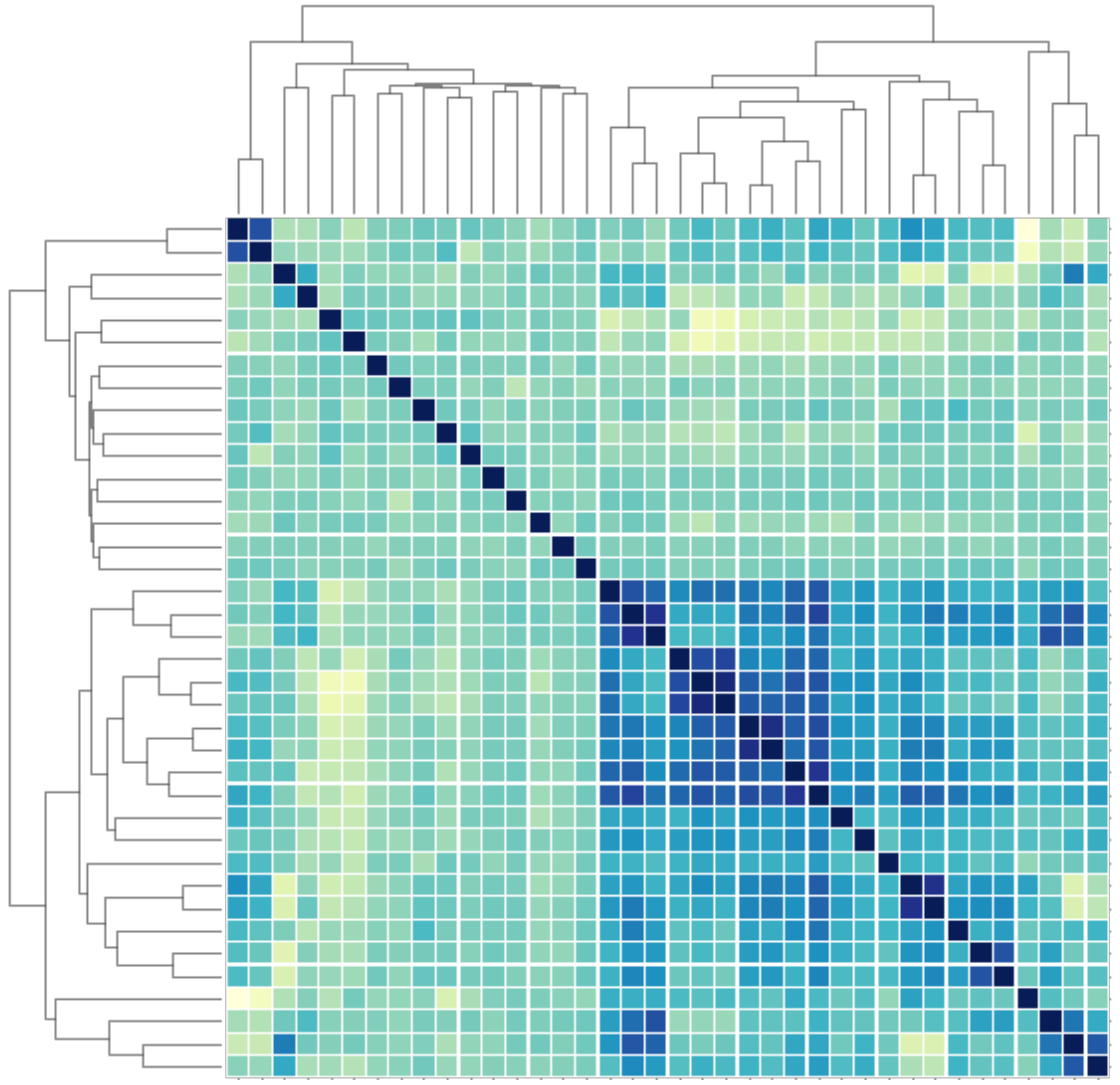
function
- cognitive correlates
- disease relationships
- development and aging



Integration and mining







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Source: Huth *et al.*, *Nature* 2016