

# 260-2017-01-13-levels-methods

*Rick O. Gilmore*

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## Prelude

Classic “Powers of Ten” movie by Charles and Ray Eames (10 min).

## Today’s Topics

- Levels of analysis in the study of brain and behavior
  - Spatial
  - Temporal
- Methods to the madness

## Review of key concepts

**What does the practice of trephining suggest about our human ancestors?**

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Which of the following statements about the Egyptians is false?

- A. They employed a word meaning “brain”.
- B. They removed the brain in the process of mummification.
- **C. They created detailed drawings of human brain anatomy.**

## Levels of analysis

### Spatial resolution

### Spatial and Temporal Resolution

(Sejnowski, Churchland, and Movshon 2014)

### Spatial Resolution in Detail

- Within an individual
  - molecular
    - \* genetic
    - \* receptor
  - chemical
    - \* neurotransmitter
  - cellular
    - \* neuronal firing

### Spatial Resolution in Detail

- Internal to individuals
  - network
    - \* lateral inhibition
  - area
  - region
  - system

### Spatial Resolution in Detail

- External to individuals
  - Social
    - \* Friends, family, teachers, others
  - Non-social
    - \* neighborhood, school, state/region, country
    - \* Physical environment

### Temporal Resolution in Detail

- Within one lifetime
  - Microseconds
    - \* detection position from acoustic stimulation
  - Milliseconds
    - \* action potential

- Seconds
  - \* changes in EEG power
  - \* short-term memory

## Temporal Resolution in Detail

- Within one lifetime
  - Minutes
    - \* synaptic plasticity
  - Hours
    - \* memory consolidation
  - Days
  - Weeks
  - Months

## Temporal Resolution in Detail

- Within one lifetime
  - Years
    - \* education & training
    - \* disease processes
    - \* cultural change

## Temporal Resolution in Detail

- Across lifetimes
  - Centuries
    - \* cultural changes
  - Millenia

## Why does this matter?

- Different methods, different levels of analysis.
- Challenge of interpretation.
- Challenge of linking phenomena across levels.
  - How does the micro affect macro or vice versa?

## Neuroscience methods

### Methods to the madness

- Tools in the neuroscientist's toolkit
- What they tell us, and what they don't

### Evaluating methods

- What is the question?
- What are we measuring?
  - Structure

- Activity
- Strengths & Weaknesses
  - Cost
  - Invasiveness
  - Spatial/temporal resolution

## Spatial and Temporal Resolution

(Sejnowski, Churchland, and Movshon 2014)

## Types of methods

- Structural
  - Mapping the circuitry
  - Anatomy
- Functional (next time)
  - What does it do?
  - Physiology/Activity

## Mapping structures

- Cell/axon stains
  - Golgi stain – whole cells
    - \* Camillo Golgi
  - Nissl stain – cell bodies only
    - \* Franz Nissl
  - Cellular distribution, concentration, microanatomy

## Golgi stain

## Nissl stain

## Retrograde vs. anterograde histochemical tracers

- *Retrograde* (from axon terminal to cell body); *anterograde* (from cell body to axon terminal)
- What connects where

## Retrograde vs. anterograde tracers

## Brainbow

(Lichtman, Livet, and Sanes 2008)

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**Eyewire.org**

**Clarity**

**Mapping structures**

- Computed axial tomography (CAT), CT
- X-ray based

**Tomography**

**Tomography**

<http://static.howstuffworks.com/gif/cat-scan-pineapple.jpg>

**CT scan of stroke**

**Magnetic Resonance Imaging (MRI)**

- Magnetic resonance
- Protons have spin (magnetic dipole)
- Align with strong magnetic field
- When perturbed, speed of realignment varies by tissue
- Realignment gives off radio frequency signals

**MRI**

<http://s.hswstatic.com/gif/mri-steps.jpg>

**How MRI works**

**Structural MRI**

- Tissue density/type differences
- Gray matter (neurons & dendrites & axons & glia) vs. white matter (mostly axons)
- MR Spectroscopy
- Region sizes/volumes

**Structural MRI of the brain**

**Diffusion tensor imaging (DTI)**

<https://www.simonsfoundation.org/wp-content/uploads/2012/02/hitting-nerve3.jpeg>

**Diffusion tensor imaging (DTI)**

- Type of structural MRI
- Reveals integrity/density of axon fibers
- Measure of connectivity

## Voxel-based morphometry (VBM)

- Voxels (volume-based elements)
- Morphometry, measure (“metry”) form/morphology.
- How does brain size or thickness vary by age, disease status, etc.?

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[http://www.frontiersin.org/files/Articles/18691/fnhum-06-00184-HTML/image\\_m/fnhum-06-00184-g003.jpg](http://www.frontiersin.org/files/Articles/18691/fnhum-06-00184-HTML/image_m/fnhum-06-00184-g003.jpg)

## Next time

- Functional methods, including functional MRI (fMRI)

## References

- Lichtman, Jeff W., Jean Livet, and Joshua R. Sanes. 2008. “A Technicolour Approach to the Connectome.” *Nature Reviews Neuroscience* 9 (6): 417–22. doi:10.1038/nrn2391.
- Sejnowski, Terrence J, Patricia S Churchland, and J Anthony Movshon. 2014. “Putting Big Data to Good Use in Neuroscience.” *Nature Neuroscience* 17 (11). Nature Publishing Group: 1440–1. doi:10.1038/nn.3839.