20180117 COGS 101b Lecture Notes

Cabinet COGS101b Lecture Notes

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Cognitive Neuroscience

Methods used in Cognitive Neuroscience

Single-unit recording

- Recording electrode & reference electrode

- When a neuron is at rest it has a charge that is 70mV more negative than outside (resting potential)
- As nerve impulse (action potential) is transmitted, inside rises to +40 mVs compared to outside

> Increased stimulation does **not** affect these voltages. But it does increase the frequency.

Transcranial Magnetic Stimulation (TMS)

a.k.a. temporary lesioning

Rapidly changing magnetic field induces electrical current in cortical neurons briefly disrupting brain function in a targeted area. This is used for causal inference.

If it disrupts your ability to complete a task, we infer that the targeted brain region is critical for completing that task.

Can also create perceptions - if done over occipital lobe the subject will see spots of light that are not there.

Representation

The mind is a system that creates representation of the world - internal symbols in our mind are responsible for our experience of external reality

Principal of neural representation: everything we experience is based not on direct contact with stimuli, but on *representation* of it in the nervous system.

Action potentials all have basically the same height and shape – if all nerve impluses are basically the same how can these impulses stand for different qualities?

The problem of sensory coding: how do neurons represent stimuli from the environment?

Representation in Single Neurons

Hierarchical processing: The signals from neurons responding to simpler stimuli are pooled, creating neurons that respond to ever more complex stimuli.

Examples from vision:

- Neurons in the visual cortex respond to specific simple stimuli features
- Neurons in the temporal lobe respond to complex geometrical stimuli

- Neurons in other ares of temporal lobe respond to even more complex objects: hands, faces, etc.

Coding

So, is every individual object in teh world ultimately represented by one really high-level neuron?

Specificity Coding: the idea that an object could be represented by the firing of a specialized neuron that responds only to that object (e.g. the grandmother neuron).

This is unlikely to be true: having one neuron is not robust. Damage to that one neuron risks the entire conception of the object.

A more likely idea is…

Population coding: representation of a particular object by the pattern of the firing of a large number of neurons.

This is simliar to…

Sparse Coding: Representation of a particular object by only a small number of neurons, with the majority neurons remaining silent.

Population vs. Sparse → Majority vs. Minority

Epilepsy surgery patients

- Single unit recording from medial temporal lobe of epilepsy surgery patients
- Only 30 minutes to record, concluded likely sparse coding > population coding

Point: Don't have a definitive answer for many objects of *perception* – neural representation of things like a memory is even harder to study, but the same possibilities exist

This has implications for measuring memory: it's hard!

Localization vs. Distributed Representation

Many areas with strong evidence for **Localization**:

- Broca's area & Wernicke's area
- Fusiform face area
- Parahippocampal place areas
- Extrastriate body area

Although there are areas, evidence suggest the processing is more continuous than discrete.

This is known as **distributed representation**, the idea that specific cognitive functions activate many areas of the brain (e.g. faces, memory).

Attention and Memory

Attention

- Behavior: when you attend to something it is easier for you to find
- Neuro: This cortical map can expand or contract based on what you are attending to.

I.E. When attending to animals, the map for animals becomes larger.

Memory

- Behavior: based on behavior, Tulving made the distinction between Episodic and semantic memory
- Neuro: damage to the parahippocampal region impairs semantic memory. Damage to the entorhinal cortex impairs episodic memory.

Learning

- What is learning?
    - ”Profiting from experience”?
        - But, it’s not *always* adapative (phobias)
    - “Any behavorial change based on experience”?
        - But sometimes no performance changes
    - Storage of information in memory as a consequence of experience.

Biological Backdrop of Learning

Constraints that guide learning

- Learning is challenging
    - How do we figure out what goes with what, when there are thousands of possible associations?

    - One solution: animals are born with certain biases that make learning somethings easier than other things

In-born functions

Simple reflexes: Automatic response to stimulus. I.e. startle response, orienting response, suckling

Fixed-action pattern: Innate skills or behavior sequences that animals do not have to learn. See longtail tailor bird.

- Fixed-action patterns are initiated by very specific stimuli known as **releasers**.
    - Once initiated behavior patterns run their course automatically.
    - **Supernormal stimulus** is an exaggerated artificial stimlus that acts as *stronger* releasers. See cowbird.
    - Most rigid, built-in, no learning involved

Critical Period

Most favorable (or necessary) period in development for learning a particular behavior.

- **Imprinting**: forms the basis of young animals attachment to parents
- See bird song and Human language learning.