

# Intro to Cognitive Neuroscience

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Numbers and Math

# But first some review

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- Learning and memory depend on changes in synaptic strength.
- Long-term potentiation is one mechanism that seems likely to underly at least some memory formation.
- LTP occurs at glutamatergic synapses, depends on both AMPA and NDMA receptor types.

# Whole-brain perspectives on memory

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- Experiences are represented by patterns of neuron activity distributed throughout the cortex.
- Prefrontal cortex is key for attending to experiences, which is in turn involved in encoding them.
- Medial temporal areas (esp. hippocampus) are a convergence zone with inputs from many cortical association areas.

# Whole-brain perspectives

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- Hippocampus and other MTL areas bind together the different parts of an experience to allow you to access it later.
- Episodic memory involves recapitulation - same pattern of activity as during encoding.
- These connections are what allow one aspect of a memory to cue others.
- Over time, links between cortical representations become stronger, and no longer need the hippocampus/MTL to connect them.

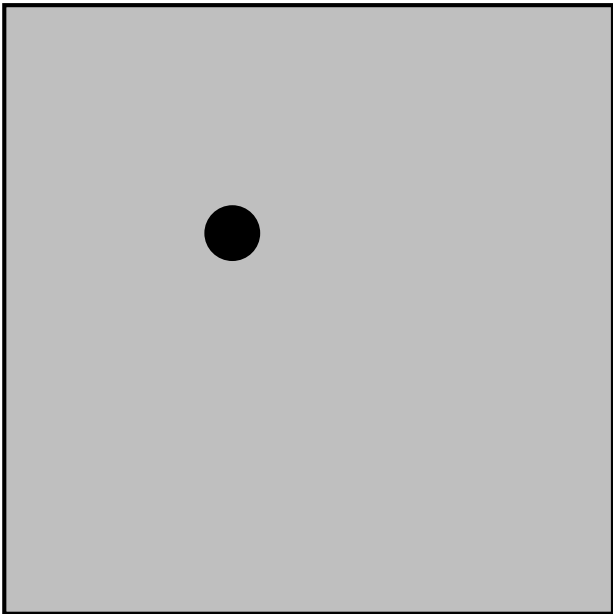
# Now for some math

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- Basic math (ie, arithmetic) ability depends on three abilities
  - a sense of number
  - an ability for named numbers
  - an ability to follow algorithms

# How many dots?

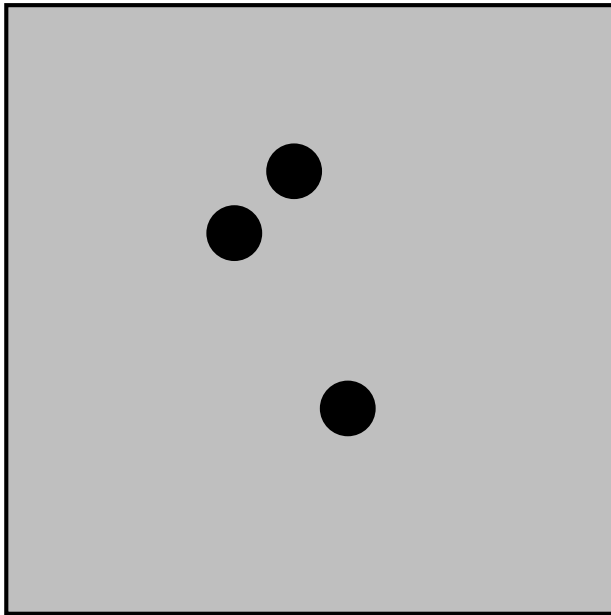
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# How many dots?

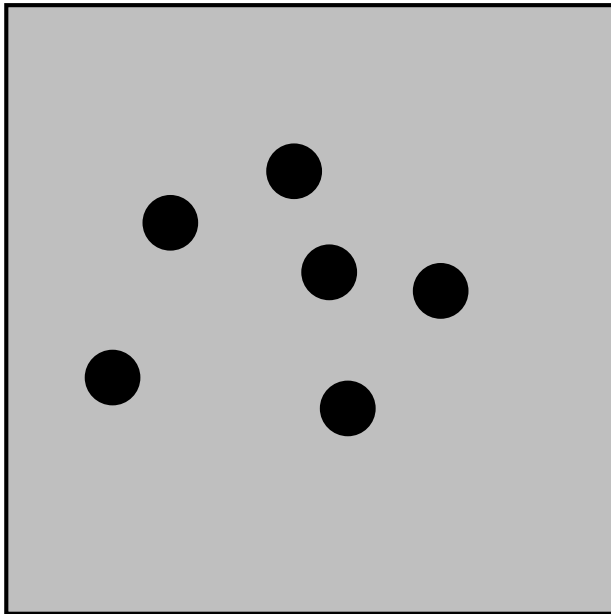
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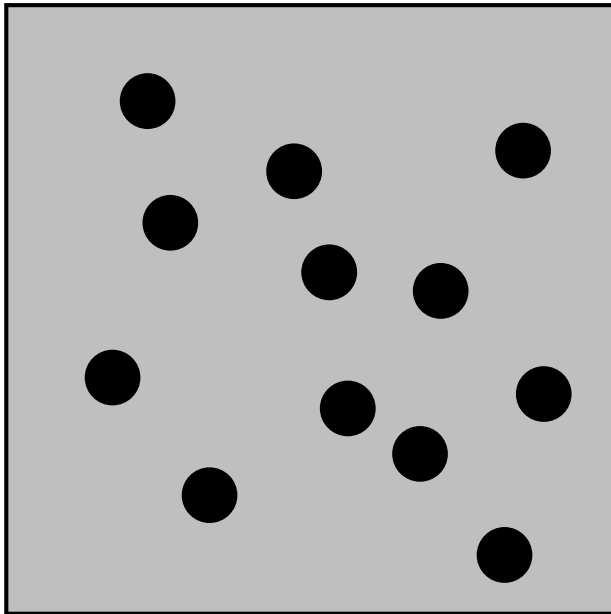
# How many dots?

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# How many dots?

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# How many dots?

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- For collections of items up to about three, most people are fast and accurate.
- For larger numbers, performance drops off.

# How about other animals?

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- Otto Koehler trained birds to distinguish numbers between 2 and 6
- Alex, Irene Pepperberg's parrot, could say the number of items on a tray.

Image removed to copyright issues.

Follow the link for more information on Alex

[http://en.wikipedia.org/wiki/Alex\\_the\\_parrot](http://en.wikipedia.org/wiki/Alex_the_parrot).

# Clever Hans

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- Early 1900s, Wilhelm von Osten claimed to have taught arithmetic to his horse.
- Was investigated by a committee of experts in 1904, concluded Hans was for real.
- Oskar Pfungst did further testing in 1907, showed that Hans may have been clever, but was not doing arithmetic.





# Babies and numbers

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- When do humans start to develop number sense?
- Jean Piaget (20th c. developmental psych guy) claimed around age 5.
- More recent (and more careful) studies using Piaget's framework show children as young as 2 have some sense of number and number permanence.

# Babies and number

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- Starkey studied babies between 16 and 30 weeks of age
- (How do you know what a non-verbal infant perceives? Clever experiment design!)
- Could distinguish between displays with two dots and three dots.
- 6-8 mo old babies could make connection between displays with two or three items, and soundtrack of two or three beats.

# Innate sense of smallish numbers

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- Some cases of adults without this sense:
- Frau Huber had an operation to remove a tumor in the left parietal lobe.
  - General intelligence, linguistic ability remained intact.
  - Numbers were no longer meaningful. Could not do arithmetic. Could recite the multiplication table, referred to it as a “nonsense poem”.
- Charles, young man, normal intelligence, with a college degree.
  - Born with no sense of number. Uses a calculator or his fingers. Cannot say which of two numbers is larger.

# Counting

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- A process for determining the number of items in a collection.
- Very young kids don't do this (or don't do it well).
- Some cultures do not have number words beyond two or three, therefore don't have counting.
- Counting (unlike innate number recognition) is a learned skill.

# Which is bigger?

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Which is bigger?

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7

9

# Which is bigger?

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# Which is bigger?

---

8

3



# Which is bigger?

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# Which is bigger?

---

2

1

# Which is bigger?

---

Which is bigger?

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26

27

# Counting is a skill

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- But it is a skill handled differently than many other things.
- We seem to have a “mental number line” that we consult to make judgements about number.

# Arabic numerals

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- Arabic numerals let humans use linguistic skills to manipulate numbers.
- Numerals are, in some ways, simply a written language for numbers.
- But, seem to be handled differently in the brain.
  - Patient with early Alzheimer's, could read words and word names for numbers (eg, one thousand two hundred forty-five, but not numerals or groups of numerals).
  - Woman who had frontal lobe surgery cannot read or write, but can name numerals and do arithmetic.

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