Intro to Cognitive Neuroscience

Numbers and Math
But first some review

• 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

- 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

• 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

- 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?
How many dots?
How many dots?
How many dots?
How many dots?

• For collections of items up to about three, most people are fast and accurate.

• For larger numbers, performance drops off.
How about other animals?

- 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.

Follow the link for more information on Alex

http://en.wikipedia.org/wiki/Alex_the_parrot.
Clever Hans

• 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

- 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

• 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

• 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

• 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?
Which is bigger?

7

9
Which is bigger?
Which is bigger?

8   3
Which is bigger?
Which is bigger?

2

1
Which is bigger?
Which is bigger?

26

27
Counting is a skill

• 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

• 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.