

# How do neuroscientists investigate memory?

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# Outline of today's talk

- What is memory?
- Testing memory
- Imaging memory

# What is memory?

## Memory:

- essential cognitive function
- not a single system
- a number of systems that have different purposes
- ageing affects some types of memory
- different brain disorders result in different types of memory problems

# Short term memory

## Working memory:

- very limited capacity, brief
- involves processing (working) and storage (memory)
- helps us keep track from moment to moment

## Examples

- adding up shopping items in your head & calculating change
- keeping track of what you are reading
- holding a phone number in your head

# Long term memory

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graph TD; A[Long term memory] --- B[Episodic memory]; A --- C[Semantic memory]; A --- D[Prospective memory]; A --- E[Procedural memory];
```

**Episodic  
memory**

**Semantic  
memory**

**Prospective  
memory**

**Procedural  
memory**

# Episodic memory

- memories of past events and experiences:
- personal experiences

## Examples:

- your wedding day
- your shopping trip yesterday
- where you put your keys
- conversation with your friend
- locking the front door

# Episodic memory

- Details recorded or encoded:
- What you heard or saw at the time, how you felt, smell, taste
- All these aspects collect together to form a memory
- These cues may prompt your recall at some later time.

# Semantic memory

- facts, concepts, words, symbols, signs that make up our knowledge of the world

## Examples:

- letters of the alphabet
- current Prime Minister's name
- word used to describe the striped animal that looks similar to a horse and can be found in Africa
- the sound of a trumpet

# Semantic memory

- vast store of knowledge
- no upper limit of capacity
- do not have to directly experience to know
- can know from inference based on related knowledge
- adult knows 20,000-50,000 words & their meanings

# Prospective memory

- remembering to remember

## Examples:

- remembering to tell your partner a telephone message
- remembering to pay a bill

# Procedural memory

- Skill memory, 'knowing how to'
  - Examples:
    - Driving a car
    - Playing tennis
- Not a conscious type of memory – do not need to remember when and how we learnt to do it
- Becomes automatic

# Three processes of memory

**encode** ⇒ **storage** ⇒ **recall**

# Encoding

- Taking in information through the senses
- How is this achieved:
  - Attention (selectively)
  - Binding/associating together aspects of the information
  - Understanding and incorporating the information into your knowledge base
  - Emotional value

# Storage

- Preserving the memory
- Not a conscious process
- Consolidates or strengthens if it is repeated or rehearsed or brought back to conscious recall
- Not all information we have learned or been exposed to will remain in storage
- Example:
  - Old vs new memories

# Recall

- Bring to conscious awareness what we have encoded and stored
- Involves a search process – may be almost automatic or effortful
- Cues that were associated with the information may bring back the memory
- Familiarity vs precise recall
- Example:
  - Filing system

# Measuring memory function

## Neuropsychological assessment

- Identify strengths & weaknesses & possible abnormality
- Look for risk factors or indicators of possible disease or disorder
- Problem with memory is the classic first clinical feature of Alzheimer's disease

# Measuring memory function

- How?
  - Psychometric tests – standardised, reliable, established validity
  - Assessment of memory and wide range of cognitive abilities can take 2-3 hours
  - Learning & memory
  - Attention & concentration
  - Language skills
  - Spatial skills
  - Problem-solving, planning & organisation

# Measuring memory function

## Neuropsychological assessment

### Episodic memory

- Verbal & visual information
- Providing context/structure or no structure
- Encoding: one exposure or repeated learning
- Storage: immediate or delayed
- Recall: spontaneous, cued or recognition

# Measuring memory function

## Neuropsychological assessment

- Semantic memory
  - General knowledge
  - Vocabulary
  - Concepts & categories
- Prospective memory
  - Difficult to test

# Measuring memory function

## Test results

- How do we know what is normal or abnormal?
  - Comparison of scores to peer groups:
    - Must be healthy
    - Same age
    - Similar education

# Measuring memory function

## Test results

- Example: comparison of 20 year old and 70 year old on different tests
  - Vocabulary
  - General knowledge
  - Recall of a word list
  - Recognition of words from the list

# Measuring memory function

## Test results

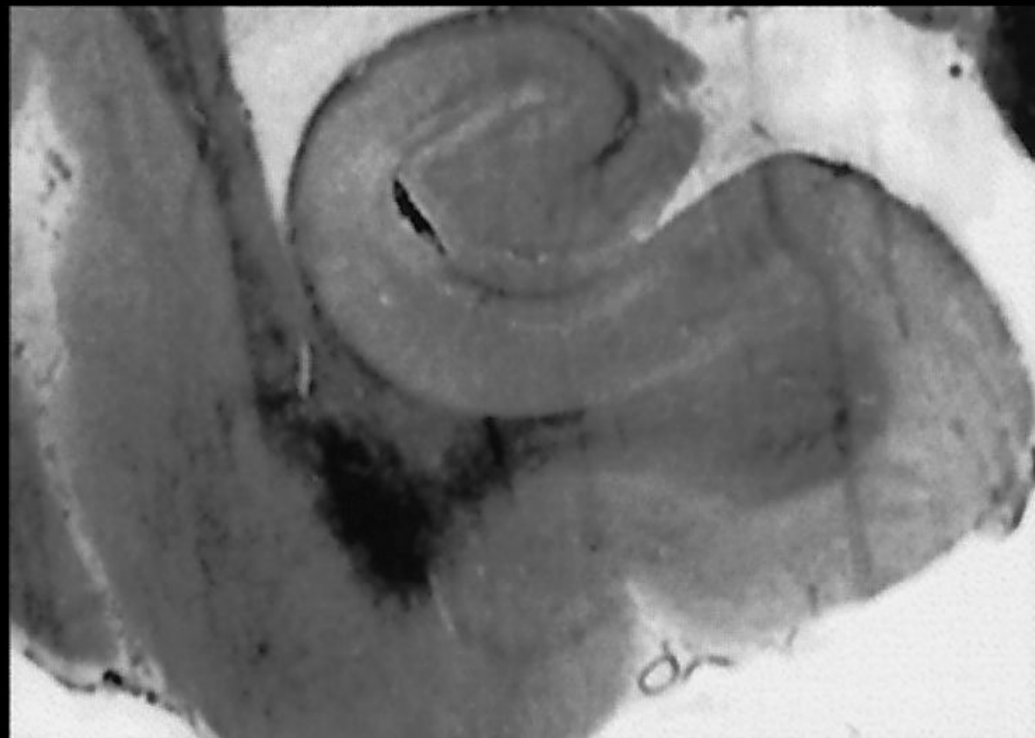
- What is abnormal?
  - Compared to expected previous level of functioning
  - Cut-offs
  - Consideration of other factors:
    - Non-English speaking background
    - Educational opportunities
    - Physical/sensory difficulties
- Implications of abnormal test results
  - needs to be put in context (history of decline, pattern of test scores, affects everyday functions).

# Imaging memory

## Structural Imaging

- MRI and CT can be used to look at the brain structures that support memory
- Hippocampus plays a crucial role in memory
- People with damage to this structure will have profound memory problems

# “Hippocampus”



# Imaging memory

## Structural Imaging

- atrophy (shrinkage) of the hippocampus is a risk factor for Alzheimer's disease
- but no direct relationship between atrophy and disease on an individual basis (false positives & false negatives)
- cannot be used as a diagnostic marker

# Imaging memory

## Functional Imaging

### Functional MRI (fMRI)

- **Allows measurement of brain activity via alterations in blood flow & blood oxygenation while a person is doing a memory task in the MRI scanner**
- **Can provide activation maps that highlight which parts of the brain are responding to the given task**

# Imaging memory

## Functional Imaging

- **Can map the activation changes according to the different processes involved in a task; encoding, storage, recall**
- **Can map the activation changes in response to different task demands eg task difficulty, visual vs verbal material**





# Memory & Ageing Study fMRI task activation results

