



HUMAN PERFORMANCE

M6X00915

MODELS OF MEMORY AND PRACTICAL APPLICATION FOR EYEWITNESS TESTIMONY



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MEMORY

- Vital for performance:
- Why? How does it link to performance?
 - Being able to **remember** is one aspect of memory that can help us perform.
 - However, from a performance point we are also interested in mechanisms behind how/why we **Forget** & impact this has on performance.
 - It can be trivial – e.g., forgetting a phone number.
 - It can be critical – e.g., forgetting emergency procedure when noticing a faulty system in a nuclear power plant.

REAL-LIFE EXAMPLES OF MEMORY FAILURES

- 1915: railroad switchman in Scotland forgot train was moved to an active track - two trains travelled on same piece of track and crashed.
 - Over 200 people killed (Rolt, 1978; Reason 2008).
- 1996: mechanics forgot to put safety caps on oxygen generators loaded onto a flight.
 - Ramp agent also forgot to check content of the cargo.
 - During flight, a generator engaged, causing a fire.
 - The plane crashed, killing over 100 people (Langewiesche, 1998)

REAL-LIFE FAILURES OF MEMORY

- Success or failure of memory has major impact on safety.
- If we can understand mechanisms of memory and how it functions, we may identify ways to avoid disaster.
- To begin.....Can we develop a model of memory?
- Experimental & applied research, with evidence from brain damaged patients, suggests memory is multi-faceted.
- This makes designing a general model difficult.
 - It needs to be broken down into its constituent parts.

Memory Processes

```
graph TD; A[Memory Processes] --> B[Encoding]; A --> C[Storage]; A --> D[Retrieval]; B --> E["Code:  
e.g. visual, acoustic"]; C --> F["Internal representation  
or trace"]; D --> G["Recognition  
Recall"];
```

Encoding

Code:
e.g. visual, acoustic

Storage

Internal representation
or trace

Retrieval

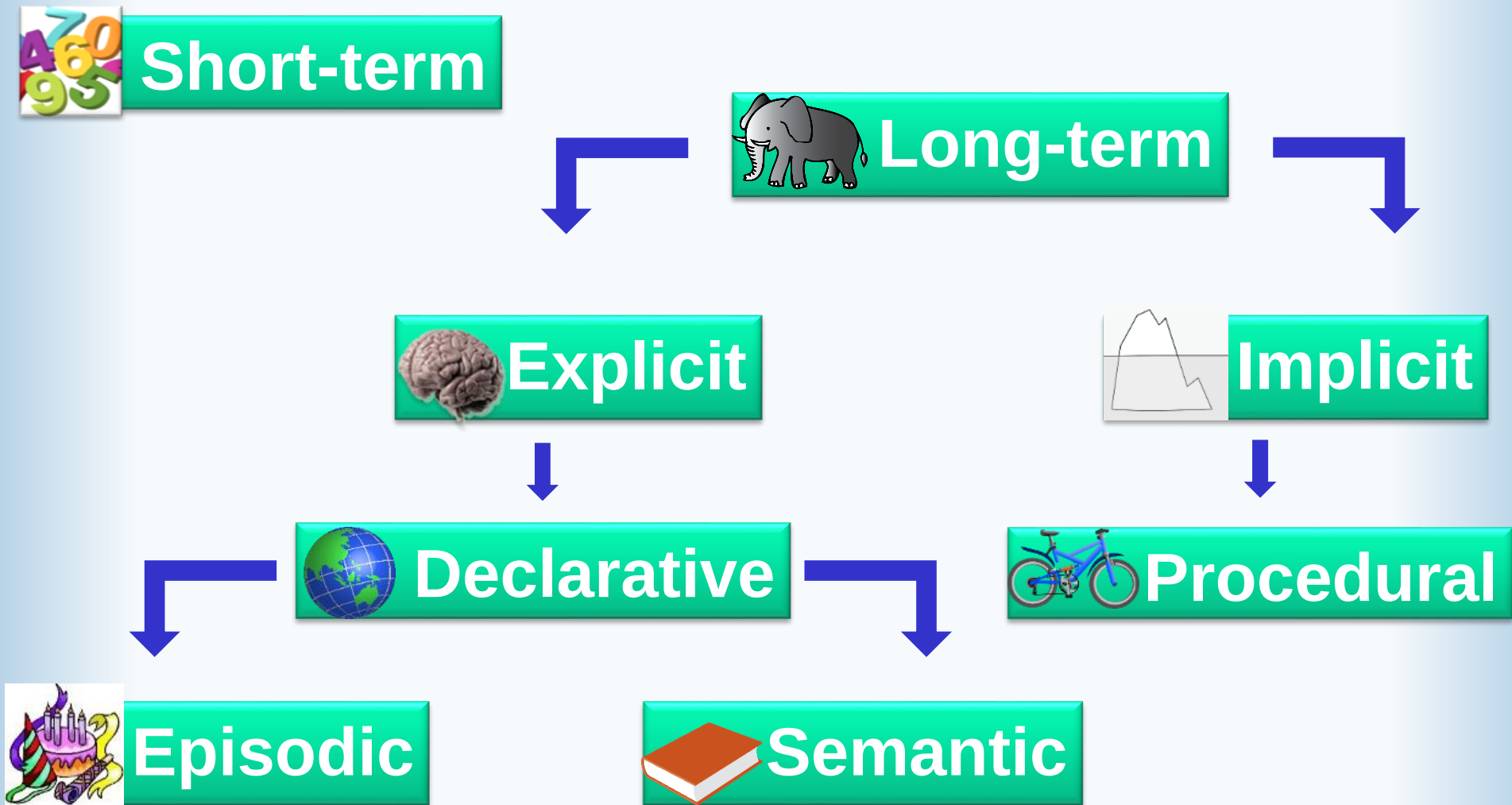
Recognition
Recall

- **Why are models of memory important?**
 - **Because performance depends on:**
 1. **Our memory for how a particular task should be done**
 2. **Our memory for the events of a particular episode**

TO ILLUSTRATE.....

- A pilot's memory should contain the representations of the various *skills required* to fly an aeroplane.
 - Memories for how a task should be done.
- But on a given flight the pilot also keeps an internal record of info related to *that particular flight*.
 - e.g., where aircraft is currently located, recent instructions from air traffic controller, next steps in flight plan, weather conditions, etc.

1. Categories/varieties of memory



Different aspects of performance depend on different aspects of memory.

1. Categories/varieties of memory

- Pilot example....
 - Would need LTM for flight procedures
 - E.g., standard take off/landing procedure
 - Would need STM for current flight operations
 - E.g., which runway they should take off from.



2. Memory for Skilled Performance

- Need to consider learning.
 - From learning a task we infer there has been a change in processing structures that represents that learning.
 - Even without verbal report of the learning
- How do you control a pushbike?
- For a memory model we need to be concerned with the type(s) of memory involved in performing different tasks.
- These are implicit and procedural memories.
 - They relate to unconscious memories.



3. WORKING MEMORY

- STM in conjunction with active processing of information.
- Seen as “workbench” of consciousness:
 - use it to evaluate, transform, & compare mental representations.
- Demanding tasks overload working memory:
 - E.g., during landing a pilot may be simultaneously implementing instructions from air traffic control, receiving new instructions, and converse with co-pilot.
 - Safety of passengers depends on pilots ability to combine various processing and short term storage operations involved.

MODELS OF MEMORY

- **Atkinson & Shiffrin (1968) Multi-store model**
- **Activation models: STM is just active part of LTM**
- **Blackboard models (e.g., Jones, 1993):**
 - Processing controlled by independent modules
 - Modules send info to central blackboard which registers the processing outputs.
 - Modules read info on blackboard & only process info relevant to their functions.
- **Working Memory Model (Baddeley, 1986; 2000; 2007; Baddeley & Hitch, 1974)**

WORKING MEMORY & PERFORMANCE

- Tasks to measure WM capacity:
 - **Reading span:**
 - Read/listen to series of 2-6 sentences & recall, in correct order, last word of each sentence.
 - **Operation span:**
 - Verify Math problem: Is $(4/2)-1=1$? & read a word after the operation (e.g., SNOW).
 - After series of problems & words, P recalls words.
 - No. of operation-word strings in a sequence is increased/decreased to measure operation span.
 - **Counting span**
 - Counting stimuli & remembering the **count totals** for later recall.

WORKING MEMORY & PERFORMANCE

- These tasks predict performance on:
 - Reading & listening comprehension
 - Academic performance
 - Multi-tasking
 - Language comprehension
 - Ability to follow directions
 - Vocabulary learning
 - Note taking
 - Writing
 - Reasoning
- **Taylor et al. (2005):** older pilots less accurate at remembering & executing air traffic control messages:
 - Suggests working memory span decreases with age.

References:

Miyake et al. (2000)

Engle (2001)

Kane & Engle (2002)

Logie (2011)

Causee et al. (2011)

WORKING MEMORY & PERFORMANCE

- Working Memory & Interference
- Code interference: Verbal-phonetic & visual-spatial code seem to function cooperatively rather than competitively.
 - E.g., both activated in parallel by pictures of objects.



BIKE

- Advantage of cooperation = the 2 codes do not compete for the same limited processing resources.
 - Verbal characteristics of verbal working memory task more disrupted by concurrent verbal task than by concurrent spatial task (Vergauwe et al., 2010).

WORKING MEMORY & INTERFERENCE

- Irrelevant input from general environment also produces disruptive influence on performance:
 - Salamé & Baddeley (1989): music with lyrics disrupts verbal working memory, while similar music without lyrics does not.
 - Tremblay & Jones (2001): To-be-ignored speech disrupted performance on verbal tasks.
- Suggests that to improve performance:
 - Irrelevant environmental info (e.g., sound) and
 - Concurrent tasks that amplify code interference should be minimised.
- While the visual-spatial sketch pad and the phonological loop are susceptible to code & resource interference.....

WORKING MEMORY & INTERFERENCE

- Central executive is disrupted by concurrent task activities performed by controlled (rather than automatic) processes with high demands.
- Baddeley: Four roles of the central executive:
 1. Temporarily hold & manipulate info stored in LTM
 2. Change retrieval strategies from LTM
 3. Coordinate performance on multiple tasks
 4. Attend selectively to stimuli
- A pure central executive task is a random generation task:
 - E.g., type a random sequence of letters – even after practice this task demands attention.

WORKING MEMORY & INTERFERENCE

- Tasks involving articulatory suppression (e.g., repeating 1-6) which involve phonological loop do not interfere with random generation tasks.
 - However, category generation tasks (e.g., list animals) do because they involve a semantic component.
- Bruyer & Scailquin (1998): random generation tasks interfere with mental rotation tasks but not on passive maintenance of an image task.
 - Can you think why?

WORKING MEMORY & INTERFERENCE

- The display format in which a code enters our system through different modalities also needs to be considered:

		Display Format Code	
Modality		Verbal	Spatial
	Auditory	Speech	Sound localization
	Visual	Print	Pictures

-  = optimum combination of code to modality.
- This has practical importance when considering for e.g., how instructions are provided.

WORKING MEMORY & INTERFERENCE

- Duration: Info that's not rehearsed decays from STM.
- Decay is not just a function of time
 - It relates to interference from other factors, including filler tasks & the stimuli (Lewandowsky et al., 2009).
- What could this mean for a pilot coming in to land?
- Capacity: Amount of info it can hold = limited.
 - Why? Faster decay when more items held in WM.

WORKING MEMORY & INTERFERENCE

- More items to rehearse in phonological store = longer delay between successive rehearsals of each item.
- Delay increases chance of decay.
- Length of time to say different items influences capacity:
 - E.g., difference in time to rehearse Chinese & Welsh spoken words for digits compared to English words causes increase in span for Chinese (shorter) words (9.9 digits; Hoosain & Salili, 1988) & decrease in span for Welsh (longer) words (5.8 digits; Ellis & Hennelly, 1980).

4

ENGLISH

FOUR

CHINESE

SI

WELSH

PEDWAR

WORKING MEMORY & INTERFERENCE

- Evidence = Miller (1956): Digit span technique.
- BUT: Cowan (2000) suggests “magic” number is inflated:
- Thus: when presenting auditory or visual info, need to be mindful of this capacity limit.
- E.g., for our pilot, the length of navigational info from air traffic control would need to be concise.
- “Chunking”: Capacity overcome by organisation & rules.
- Loftus et al. (1979): pilots’ memory of air traffic control info was better when parsed in to 2 chunks (27 84) than when presented as 4 separate digits (2 7 8 4).

INTERFERENCE

- One of the primary functions of the executive control within WM is to deal with interference (Anderson, 2003).
- However, interference can impact on both STM and LTM.

PROACTIVE: Prior info interferes with new info.

- Effects are pronounced when little time between series of memory tasks (Hopkin, 1980); when engaged in another task & for Ps with low WM capacity (Kane & Engle, 2000).
- Loftus et al. (1979): need at least 10 second delay in-between verbal material being presented in exchange between pilots & air-traffic controllers to avoid subsequent material from disrupting memory for previous info.

INTERFERENCE

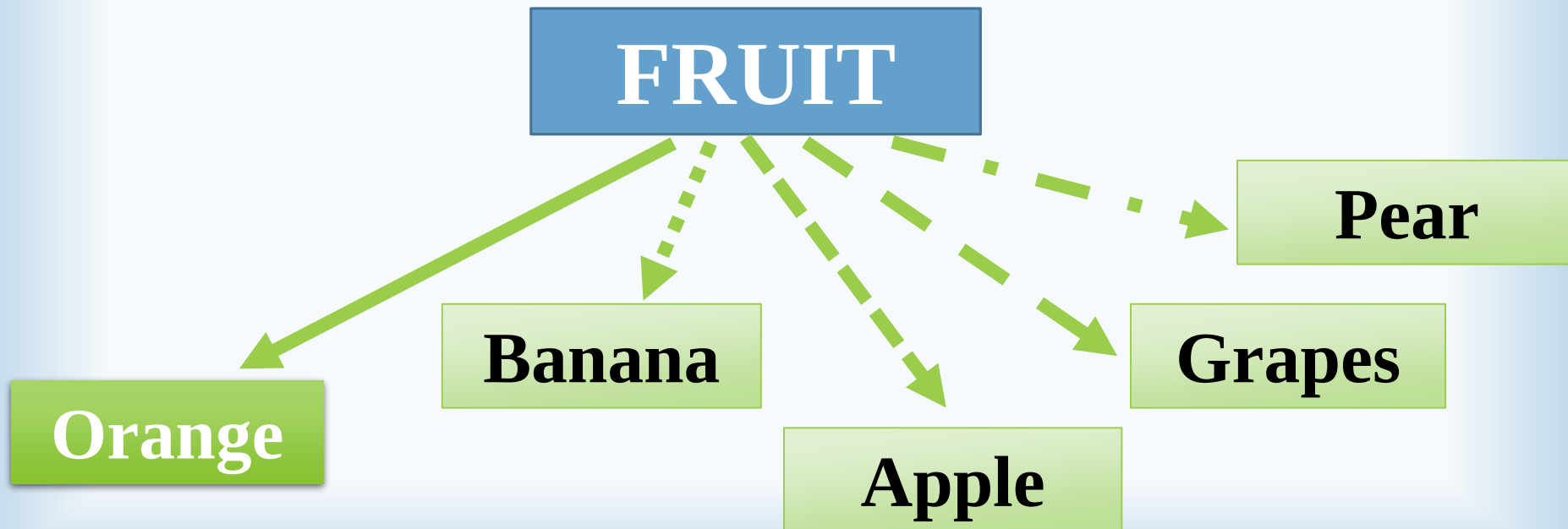
RETROACTIVE: New info interferes with old info.

- E.g., after using a new number we cannot remember our old one.
- Has an impact on verbal info (Anderson, 2003); visual info (Davies et al., 1979); & spatial info (Hole, 1996).

- Items in WM can be forgotten due to their *similarity* with other items being held.
 - E.g., if air-traffic controller needs to deal with fleet of aircrafts having similar identification codes, interference caused by similarity makes it difficult to keep each separately in WM (Fowler, 1980).
- Similarity also increases the degree of PI & RI.

INVESTIGATING MEMORY

- Even if representation in memory exists, may be difficult to retrieve specific memory as retrieval is dependent on **cues** that facilitate access to the correct item in memory.
- E.g., in spreading activation model, activation of cue may spread from the cue representation to the representation of the memory the person is trying to retrieve.



INVESTIGATING MEMORY

- Traditional method of investigating retrieval = comparing:
 - Recognition
 - Recall
- Assumed that recall involves process of retrieval/search through LTM
- Whereas recognition short cuts this & depends only on quality of memory trace.

Study Phase

DOG, TABLE, CAR, RAIN, PEN, KITCHEN, METAL...

Test Phase

Recall

List as many words from the study phase as you can

Recognition

RAIN
Was this in the study phase?

INVESTIGATING MEMORY

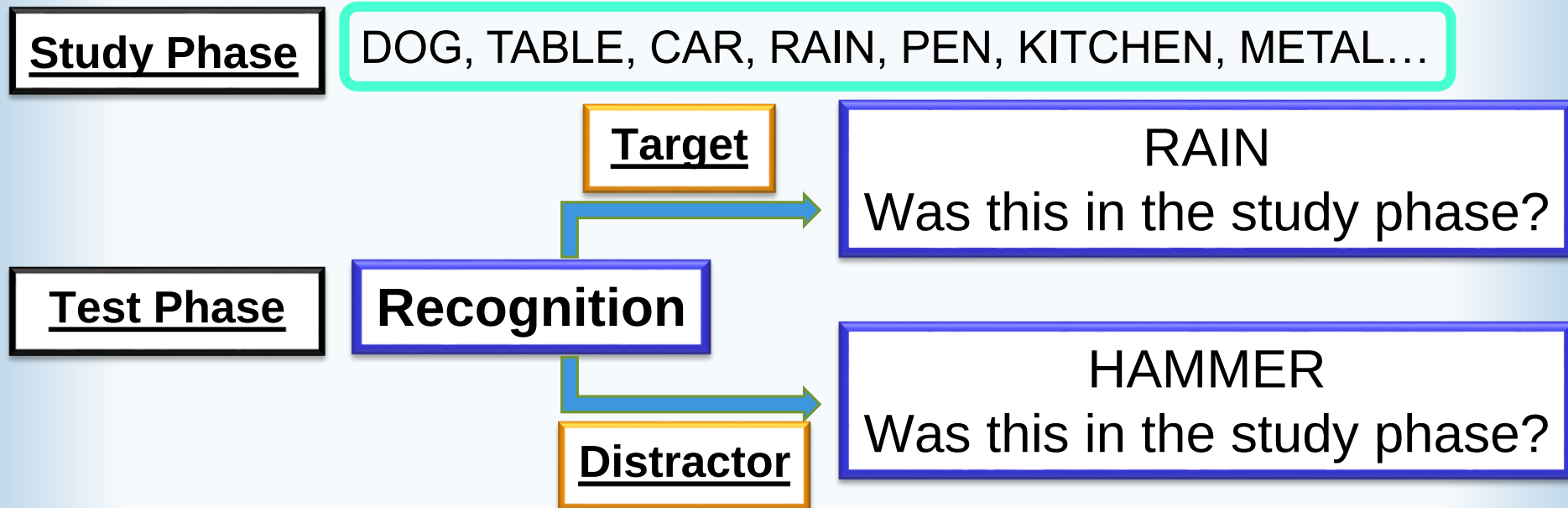
- Memory models also highlighted distinction of memories by processing codes.
- Conrad (1964): errors made in short term recall were based on acoustic confusion:
 - e.g., B recalled instead of V as they sounded similar.
 - Implied STM based on acoustic phonological code,
 - LTM based on a semantic meaning based code
- But these models were oversimplified and failed in various aspects of experimental tests.
 - E.g., Baddeley & Hitch (1977): recency effect demonstrated in LTM, so this called into question the evidence for another separate short term store.

INVESTIGATING MEMORY

- Exp. research showed that simple rehearsal did not automatically lead to better long-term memory, instead active/elaborate processing does.
- Recall and recognition more complex than once thought.
 - Also, with cued recall somewhere in the middle.
- Plausible that recall is more dependent than recognition for assessing memory search.
- Some researchers think recall is a better way to test memory because it is actually testing what people can remember instead of providing the answer and asking Ps to confirm (which is the case in recognition studies).

INVESTIGATING MEMORY

- Other issue with recognition studies =
 - Have to also present distractor items to test memory.
 - This raises additional issues for examining memory.
 - Why would someone say they have seen something in the study when in fact it was not there?



- Link here to Signal detection theory:
 - Can you explain how???.

INVESTIGATING MEMORY

- Application of SDT to recognition memory:
 - Instead of assessing whether a signal is present or not,
 - Ps required to decide whether or not stimulus was seen or heard at earlier time point.
 - Usually signal detection tasks are referred to as “Yes/No” recognition tasks.
 - When investigating signal detection of memory they are referred to as “Old/New” recognition tasks.

Wixted (2007)

INVESTIGATING MEMORY

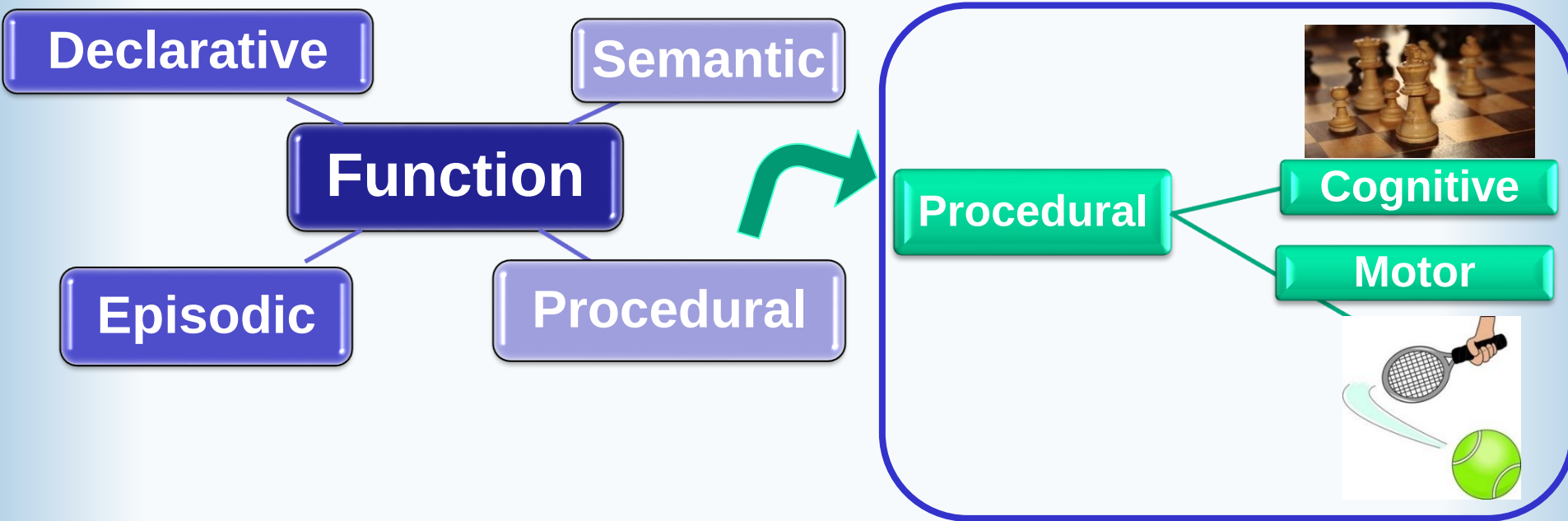
- Traditional view of memory:
 - Organised as record keeper with records allocated to different stores like filing cabinets/archives in an office.
- Current focus: **functions of memory.**
 - Examine memory by type of processing problem for which they are needed:
 - E.g., distinction between memories for abstract info & those required for action & response.
 - Remembering facts is different to remembering how to do something
 - Distinction between:
 - Declarative: subconsciously reportable items of info
 - Procedural: skills for interacting with the outside world.



INVESTIGATING MEMORY

- Procedural memory is unconscious: e.g., cannot say exactly how to ride a bicycle or solve a complex problem.
- Declarative memory subdivided into:
 - Episodic: recall of specific events
 - Semantic: general knowledge of the world.
- If you had breakfast this morning, what did you have?
 - Type of memory needed?
- What are typical breakfast foods?
 - Type of memory needed?

CURRENT FOCUS



- Procedural memory can be subdivided into:
 - Cognitive: skills – e.g., playing chess
 - Motor: action/movement – e.g., playing tennis
 - Likely to be represented differently in memory.
- Other action orientated memory function is **prospective** memory: remembering to do something in the future

MODELS OF MEMORY: ISSUES TO CONSIDER

Modularity

Separate representation systems for different types of memory?

Anderson: Semantic & episodic info presented in a single parallel process.

Tulving: Separate systems

Evidence?: Amnesiacs

Mental Imagery:

Paivio – Dual-coding: info represented as separate visual & verbal codes.

Pylyshyn: we use language

Organisation

Connectionist model:
A lifetime of connected concepts.

But what structure?

- Schema:
- Use scripts to describe action oriented towards generic information.
- e.g., how to behave in a restaurant.

But schemas & scripts can themselves end up guiding the encoding of info

- E.g., Bartlett: War of the ghosts

Voluntary control

Are we always in control of our memories?

- Schemas also play a role here

Intention to remember may not be sufficient:

- Levels of processing: Craik & Lockhart, 1972

But: quality of processing rather than depth more important.

Role of elaboration.

INVESTIGATING MEMORY

Conscious

VS.

Unconscious

- To build a model of memory we need to consider what is involved when we try to remember.
- In traditional lab studies Ps are asked to respond by reporting their conscious awareness of a memory item.
 - Can also examine memory (lab or real life) by inferred memory from behaviour even in absence of conscious awareness.
- Unconscious memories make an important contribution to skill acquisition and procedural knowledge
 - Such effects may also be demonstrated in experiments using simple stimulus materials.
 - Dramatic examples come from studies with brain damaged patients.

EVIDENCE FROM PRIMING STUDIES

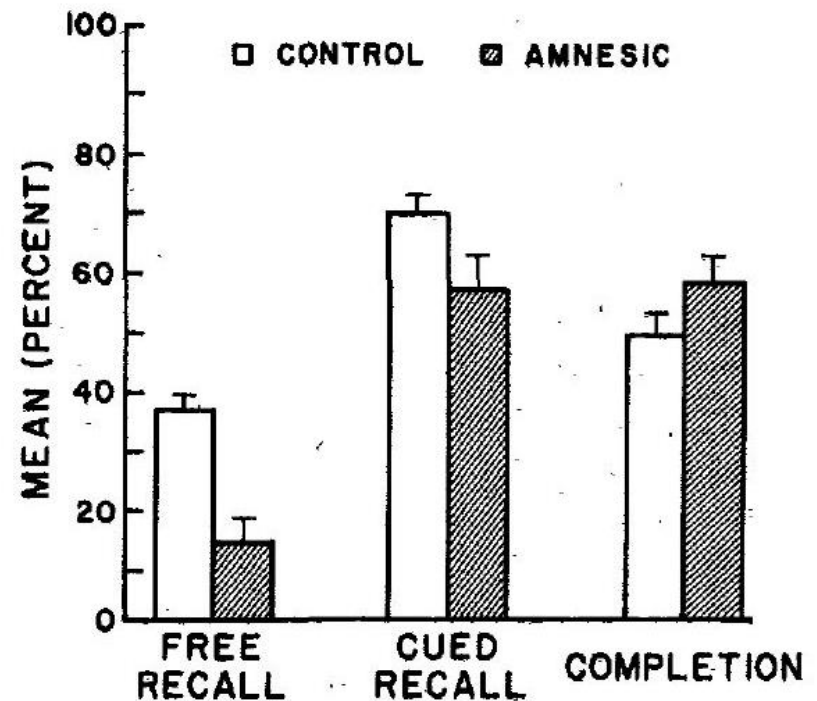
- E.g., Graf et al. (1984): gave amnesiacs word lists to learn.
- As expected performance was very poor.
- Also asked to complete letter stem to form complete word

Study: JACKET

Stem-completion: JAC_ _ _

Word-stem completion spared in amnesiacs

- Patients performed just as well as healthy controls.
- This suggests they had memories for some of the words previously seen even when they were unable to access them consciously.



INVESTIGATING MEMORY

- 3 features distinguish implicit from explicit learning (Berry, 1997):
 1. Limited transfer of knowledge to related tasks - implicit knowledge transfers less tasks with a similar logical structure than explicit knowledge does.
 2. Learning is associated with focus on particular items rather than on underlying rules:
 - Implicit knowledge related to memory for specific items are sequences of info, not an insight into general principles of memory
 3. Difference in robustness of learning and knowledge
 - Implicit learning is resistant to psychological & organic disorders, & ageing.
 - Storage & retrieval of implicit knowledge is insensitive to attentional demands of secondary tasks: but evidence is mixed.
 - Implicit learning may be attentionally demanding in some circumstances.

INVESTIGATING MEMORY

- Should we try to compare/distinguish between implicit & explicit memory?
- Also, debate over what constitutes implicit learning and implicit memory, which tends to come from technical issues related to specific paradigms being used.
- Difficulties using consciousness (a non-computational construct) to distinguish between 2 types of processing.
- In connectionist models, explicit & implicit learning may be expressed as changes in connection strength or resisting levels of activation
 - So, it is irrelevant to the model whether or not there is conscious awareness of changes in these network properties.

INVESTIGATING MEMORY

- It may be the case that implicit knowledge is simply too difficult to bring into consciousness rather than it being qualitatively different from explicit knowledge.
- However, we could say that explicit rather than implicit knowledge raises conceptual difficulties.
 - To overcome this we could express the difference between explicit and implicit memories in terms of the cognitive architecture.
 - However, it is a large assumption to suppose that either implicit or explicit memory related to a distinct system because it could be that different instances of implicit memory may relate to different systems.

NEXT WEEK

- Lecture: Expert Memory, Learning, and Considerations for Education
- Seminar: Skilled performance and Expertise
- **ESSENTIAL READING: See module handbook**