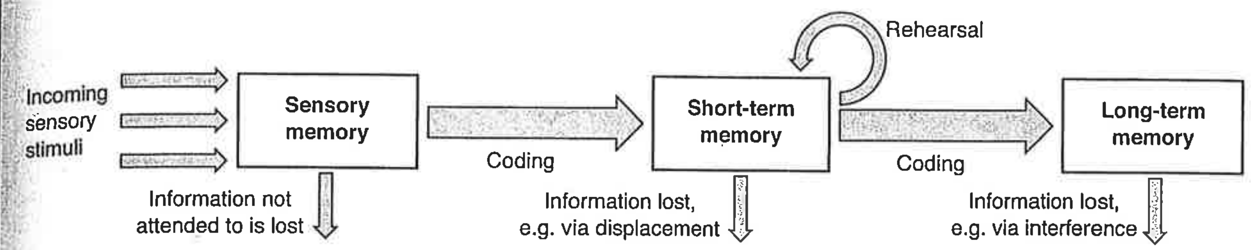
10.3 Multi-store model of memory

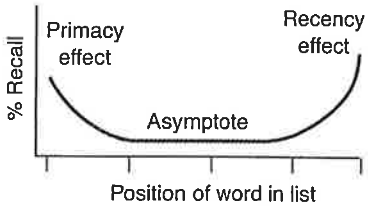
- Much research was devoted to identifying the properties of sensory, short-term, and long-term memory, and cognitive psychologists such as Atkinson and Shiffrin (1968) began to regard them as **stores** – hypothetical holding structures.
- Atkinson and Shiffrin proposed the two-process model of memory, which showed how information flowed through the two stores of short-term and long-term memory, but like many of the models, they assumed the existence of a sensory memory that precedes the short-term memory, and so it is sometimes termed the multi-store model.



- Atkinson and Shiffrin regarded the stores as the **structural components** of the model, but also proposed a number of **control processes,** such as attention, coding and rehearsal, which operate in conjunction with the stores.

In addition to the research on the differing durations, capacities, etc. of the memory stores there are two main lines of evidence that support the model's assumptions about the way information flows through the system and the distinct existence of short-term and long-term memory stores – free recall experiments and studies of brain damaged patients.

FREE RECALL EXPERIMENTS



- In free recall experiments, subjects are given a number of words (for example 20) in succession to remember and are then asked to recall them in any order ('free recall'). The results reliably fall into a pattern known as the **serial position curve.** This curve consists of
  - a a **primacy effect** – Subjects tend to recall the first words of the list well, which indicates that the first words entered short-term memory and had time to be rehearsed and passed on to long-term memory before the STM capacity was reached. The primacy effect, therefore, involves recall from long-term memory.
  - b an **asymptote** – The middle portion items of the list are remembered far less well than those at the beginning and the end. This is probably because the increasing number of items fills the limited capacity of the STM and these later items are unable to be properly rehearsed and transferred to LTM before they are displaced.
  - c a **recency effect** – Subjects usually recall those items from the end of the list first, and tend to get more of these correct on average than all the earlier items. This effect persists even if the list is lengthened (Murdock, 1962), and is thought to be due to recall from the short-term memory store – since the items at the end of the list were the last to enter STM and were not displaced by further items.
- Further evidence for the primacy/recency effects comes from two other findings:
  - a Slower rates of presentation can improve the primacy effect perhaps due to more rehearsal time, but have little or no influence on the recency effect.
  - b The recency effect disappears if the last words are not recalled straight away. Glanzer and Cunitz (1966) gave subjects an interference task immediately after the last word of the list and found a primacy but no recency effect.

STUDIES OF BRAIN DAMAGED PATIENTS

Cases of **anterograde amnesia** such as H.M. (Milner *et al.*, 1978) or Clive Wearing (reported in Blakemore, 1988) provide strong evidence for the distinction between STM and LTM. Anterograde amnesia is often caused by brain damage to the hippocampus and those suffering from it seem incapable of transferring new factual information between STM and LTM. With this inability, they are essentially trapped in a world of experience that only lasts as long as their short-term memory does. Patients afflicted by anterograde amnesia often retain most of their long term memory for events up until the moment of brain damage and maintain their procedural memories. While they seem incapable of gaining new long-term declarative memory for semantic or episodic information most are able to learn new procedural skills (like playing table-tennis).

If these people are given free recall experiments, they show good recency effects but extremely poor primacy effects (Baddeley and Warrington, 1970).

CRITICISMS OF THE MULTI-STORE MODEL

It is too simplistic, in that:

a It under-emphasises interaction between the stores, for example the way information from LTM influences what is regarded as important and relevant to show attention to in sensory memory and helps the meaningful chunking of information in STM.

b STM and LTM are more complex and less unitary than the model assumes. This criticism is dealt with by the Working Memory model of STM by Baddeley and Hitch (1974) and by research into the semantic, episodic, imagery and procedural encoding of LTM.

c Mere rehearsal is too simple a process to account for the transfer of information from STM to LTM – the model ignores factors such as the effort and strategy subjects may use when learning (**elaborative** rehearsal leads to better recall than just maintenance rehearsal) and the model does not account for the type of information taken into memory (some items, e.g. distinctive ones, seem to flow into LTM far more readily than others). These criticisms are dealt with by the Levels of Processing approach of Craik and Lockhart (1972).

10.2 Research on sensory memory, short-term and long-term memory

SENSORY MEMORY

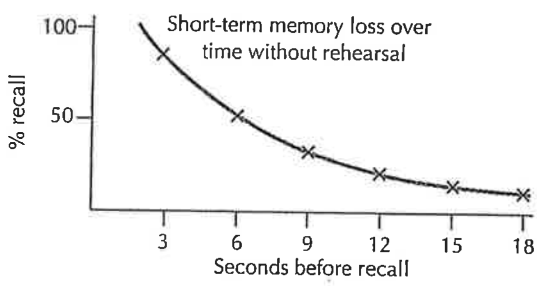
- Since sensory memory lasts less than a second, most of the material in it will have been forgotten before it can be reported! ***Sperling*** studied the sensory memory for vision (the iconic store) by using a ***tachistoscope*** – a device that can flash pictoral stimuli onto a blank screen for very brief instances. Using this device, Sperling was able to ask subjects to remember as many letters as they could from a ***grid of 12 symbols*** that he was going to display for just ***one twentieth of a second***, and found that while they could only recall around ***four*** of the symbols before the grid faded from their sensory memory, they typically reported seeing a lot more than they had time to report.
- **Capacity** – Sperling presented the 12 symbol grid for 1/20th of a second, followed immediately by a ***high, medium*** or ***low tone,*** which indicated which of the three rows of four symbols the subject had to attend to from their iconic memory of the grid. In this partial report condition, recall was on average just over 3 out of the 4 symbols from any row they attended to, suggesting that the iconic store can retain ***approximately 76%*** of all the data received.

Step 1 Show grid	Step 2 Ring tone	Step 3 Recall letters
7 1 V F		? ? ? ?
X L 5 3	Medium tone	X L 5 3
B 4 W 7		? ? ? ?

- **Duration** – If there was a delay between the presentation of the grid and the sounding of the tone, Sperling found that more and more information was lost (only 50% was available after a 0.3 second delay and only 33% was available after a 1 second delay).

SHORT-TERM MEMORY

- **Duration** – Peterson and Peterson (1959) investigated the duration of short-term memory with their ***trigram experiment.*** They achieved this by
  1. asking subjects to remember a single nonsense syllable of three consonants (a *trigram* of letters such as FJT or KPD).
  2. giving them an *interpolated task* to stop them rehearsing the trigram (such as counting backwards in threes from one hundred).
  3. testing their *recall after* 3, 6, 9, 12, 15 or 18 seconds (recall had to be perfect and in the correct order to count). While average recall was very good (about 80%) after 3 seconds, this average dropped dramatically to around 10% after 18 seconds.



- **Capacity** – Many early researchers in the area of memory, including Ebbinghaus, noted that short term memory appears to have a limited storage capacity. *Miller* (1956) investigated this limited capacity experimentally, refering to it as ***'The magical number seven, plus or minus two'.*** Miller found that the amount of information retained could be increased by ***chunking*** the information – packaging it into larger items or units, although the STM can still only retain 7 + or – 2 of these chunks. Chunking is greatly improved if the chunks already have ***meaning*** from LTM.

Unchunked items

0 1 0 3 3 8 9 8 2 1 8 6 5 7
M P I B M I T V A A F B I R A F

Chunked items

010 33 898 21 8657
MP IBM ITV AA FBI RAF

- **Encoding** – It has been argued that the main way information is encoded or retained in STM is through sound – an ***acoustic code.*** Regardless of whether we see or hear material, we tend to find ourselves repeating the information verbally to ourselves to keep it in mind (STM), and hopefully pass it on to long term storage. Conrad (1964) demonstrated acoustic STM encoding, finding that rhyming letters were significantly harder to recall properly than non rhyming letters, mostly due to acoustic confusion errors, e.g. recalling 'B' instead of 'P'. Baddeley found similar effects for rhyming vs. non-rhyming words.
  Den Heyer and Barrett (1971) showed that STM stores visual information too.

1) **B T C P G E D**
2) **F T Z Q W R N**
3) **MAT, CAT, SAT, BAT, HAT, RAT, FAT**
4) **PIE, SIX, TRY, BIG, GUN, HEN, MAN**

Acoustic confusion errors are made when recalling lists 1 & 3, even though the letters are visually presented. This shows the material is retained acoustically in STM.

LONG-TERM MEMORY

- **Duration** – Ebbinghaus tested his memory using nonsense syllables after delays ranging from 20 minutes to 31 days later and found that a large proportion of information in LTM was lost comparatively quickly (within the first hour) and thereafter stabilised to a much slower rate of loss.
  Linton used a diary to record at least 2 'every day' events from her life each day over 6 years, and randomly tested her later recall of them. She found a much more even and gradual loss of data over time (approx. 6 % per year).
- **Capacity** – Enormous but impossible to measure.
- **Encoding** – Baddeley (1966) showed that LTM stores information in terms of meaning (semantic memory), by giving subjects four lists to remember.
  If recall was given immediately, list A was recalled worse than list B, but there was little difference between the recall of lists C and D, indicating acoustic STM encoding. After 20 minutes, however, it was list C that was recalled worse than D since words with similar meanings were confused, indicating semantic LTM encoding.

Baddeley's (1966) lists:

List A – Similar sounding words e.g. man, map, can, cap.

List B – Non similar sounding words e.g. try, pig, hut, pen.

List C – Similar meaning words e.g. great, big, huge, wide.

List D – Non similar meaning words e.g. run, easy, bright.

10.4 Levels of processing and working memory

LEVELS OF PROCESSING APPROACH TO MEMORY – CRAIK AND LOCKHART (1972)

THE APPROACH

- Craik and Lockhart's important article countered the predominant view of fixed memory **stores**, arguing that it is what the person **does** with information when it is received, i.e. how much attention is paid to it or how deeply it is considered, that determines how long the memory lasts.
- They suggested that information is more readily transferred to LTM if it is *considered, understood* and related to past memories to gain *meaning* than if it is merely *repeated* (maintenance rehearsal). This degree of consideration was termed the **'depth of processing'** – the deeper information was processed, the longer the ***memory trace*** would last.
- Craik and Lockhart gave three examples of **levels** at which verbal information could be processed:
  1. **Structural** level – e.g. merely paying attention to what the words *look* like (very shallow processing).
  2. **Phonetic** level – processing the *sound* of the words.
  3. **Semantic** level – considering the **meaning** of words (deep processing).

EVIDENCE

- Craik and Tulving (1975) tested the effect of depth of processing on memory by giving subjects words with questions that required different levels of processing, e.g.

  'table'

  Structural – 'Is the word in capital letters?'
  Phonetic – 'Does it rhyme with "able"?'
  Semantic – 'Does it fit in the sentence "the man sat at the ____"?'
- Subjects thought that they were just being tested on reaction speed to answer yes or no to each question, but when they were given an unexpected test of recognition words processed at the semantic level were recognised more often than those processed phonetically and structurally.

MODIFICATIONS

Many researchers became interested in exactly what produced **deep** processing:

- **Elaboration** – Craik and Tulving (1975) found complex semantic processing (e.g. 'The great bird swooped down and carried off the struggling __') produced better cued recall than simple semantic processing (e.g. 'She cooked the ___').
- **Distinctiveness** – Eysenck and Eysenck (1980) found even words processed phonetically were better recalled if they were distinctive or unusual.
- **Effort** – Tyler *et al.* (1979) found better recall for words presented as difficult anagrams (e.g. 'OCDTRO') than simple anagrams (e.g. 'DOCTRO').
- **Personal relevance** – Rogers *et al.* (1977) found better recall for personal relevance questions (e.g. 'Describes you?') than general semantic ones (e.g. 'Means?').

EVALUATION

- **Strengths** – good contribution to understanding the processes that take place at the time of learning.
- **Weaknesses** – There are many problems with defining 'deep' processing and why it is effective.
- Semantic processing does not always lead to better retrieval (Morris *et al.*, 1977).
- It describes rather than explains.

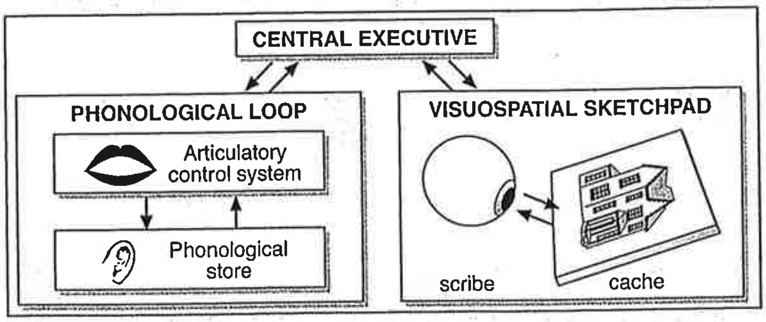
THE WORKING MEMORY MODEL – BADDELEY AND HITCH (1974)

THE MODEL (AS OF 1999)

The working memory model challenged the unitary and passive view of the multi-store model's short-term memory store.

Working memory is an **active** store to hold and manipulate information that is currently being consciously thought about. It consists of 3 separate **components:**

- **The central executive** – a modality-free controlling attentional mechanism with a limited capacity, which monitors and co-ordinates the operation of the other two components or slave systems.
- **The phonological loop** – which itself consists of two subsystems,
  - a The ***articulatory control system*** or 'inner voice' which is a verbal rehearsal system with a time-based capacity. It holds information by articulating sub-vocally material we want to maintain or are preparing to speak.
  - b The ***phonological store*** or 'inner ear' which holds speech in a phonological memory trace that lasts 1.5 to 2 seconds if it does not refresh itself via the articulatory control system. It can also receive information directly from the sensory register (echoic) or from long-term memory.
- **The visuospatial sketchpad** – a visual cache that holds visual and spatial information from the sensory register (iconic) or LTM and an inner scribe.



EVIDENCE

- The existence of separate systems in working memory has been shown experimentally by using concurrent tasks (performing two tasks at the same time) – if one task interferes with the other, then they are probably using the same component.
- Thus, if articulatory suppression (continually repeating a word) uses up the phonological loop, another task involving reading and checking a difficult text would be interfered with, but not a spatial task.

EVALUATION

- Working memory provides a more thorough explanation of storage and processing than the multi-store model's STM.
- It can be applied to reading, mental arithmetic and verbal reasoning.
- It explains many STM deficits shown by brain-damaged patients.
- However, the nature and role of the central executive is still unclear.