Paradigms

There have been several approaches or paradigms during the history of research into memory. Ebbinghaus (1890) suggested that memories were simply associations of ideas. This associationist approach attempted to find out how new associations were made by presenting new, nonsense syllables (such as FAZ, CEF). His findings are still important today as he showed that the more the lists are repeated, the less time is needed to re-learn the items and if a delay is imposed then more is forgotten. Whereas associationists characterize memory as a passive process (we simply take in, store and recall), the constructivist approach (Bartlett 1932) sees memory as an active process, showing that meaningfulness and understanding are important in memory.

An alternative view characterises memory as a flow of information. This information processing has been the dominant paradigm since the 1950s and has resulted in many important research theories and models such as:

- Atkinson and Shiffrin's (1968, 1971) Multi-Store Model
- Craik and Lockhart's (1972) Depth Processing Model, and

We might try to understand a computer or a family by looking at the structure of the system and the processes operating within that structure. Similarly, theories of memory tend to consider structure and processes. This handout considers the structural approach of Atkinson and Shiffrin's model in detail. The Depth Processing Model and the Working Memory Model are considered on separate handouts.

A paradigm contrasting with the information processing view is Parallel Distributed Processing (PDP), a connectionist view which suggests that rather than there being one particular memory trace (or related structures), information is stored as several interconnected units.

Preliminary considerations

"Only that can be retrieved that has been stored, and ... how it can be retrieved depends on how it was stored." (Tulving and Thomson 1973)

This quotation has several merits to commend it for commitment to memory.
It points out that there are several stages in learning and memory. The first is the process of taking the information in or **encoding**. Some of this information is **stored** and then some may be **retrieved**. Though these stages are distinguishable, they are clearly inter-related. Whilst it is necessary for something to have been encoded in order for it to be stored and it has to have been stored for it to be retrieved, this does not guarantee that it will be stored or retrieved. Encoding is a necessary but not a sufficient condition for storage. Similarly, storage is a necessary but not a sufficient condition for retrieval. 

This points to the distinction between availability and accessibility. Just as I can have access to money from the cash point only if there's some available in my account (Okay, let's be honest, if I haven't exceeded my overdraft limit), so we can retrieve memories only if they have been stored in the first place. As Tulving and Thomson point out, "*only that can be retrieved that has been stored*..." We seem to be able to encode information in several formats, such as visual representation, acoustic or articulatory representation and semantic representation, to name a few. Tulving and Thomson again, "*how it can be retrieved depends on how it was stored.*"

"You bird-brain!" You may have been tempted to fling this insult at a particularly stupid friend but did you know that it comes from the ancient Greek philosopher Plato? He thought of the mind as analogous with an aviary, the flighty birds representing specific ideas and memories. This **spatial metaphor** suggests that memories are treated as objects stored in particular locations in the mind and that retrieval involves a search through the mental storehouse. There are several difficulties with this rather simplistic view of memory:

- it doesn't explain how we can very rapidly decide we don't know something
- the thorough searching implied does not seem to occur
- retrieval seems to make use of a flexible system, rather than a rigid placing of items

A model which employs the spatial metaphor is the multi-store model, dividing the memory system into different structures that correspond to the different stores, each of which is characterised by a typical form of coding.

### The Multi-Store Model

One of the most influential models within the **information processing paradigm** was outlined by Atkinson and Shiffrin in an article in *Scientific American* in 1971. They suggested three types of memory store:

1. sensory stores, a temporary buffer store holding information from the environment very briefly in a relatively raw, unprocessed state and is modality specific (i.e. information is held in the form in which it is received, be it visual, auditory, tactile or olfactory). Some of this information is attended to and is transferred to ...
2. a short term store (STS) with very limited capacity and duration but were the mode of storage is influenced by reference to additional information already held and so this store is not a simple repository but is a working memory, responsible for decision making and problem solving. During rehearsal some of this information is passed to...

3. a long term store (LTS) of unlimited capacity and duration, storing information in all modalities.

Label the stores in the following diagram:

![Diagram](env_input_attention_rehearsal)

What are the characteristics of these stores?

**Sensory stores**

The theory suggests that these stores are modality-specific having a separate store for each of the sensory modalities (vision, hearing, touch etc.). Most research has concentrated on visual and auditory modalities, the iconic and echoic stores respectively. Sperling (1960) showed that more information is available in iconic store immediately after visual stimulation and that the information decays very rapidly. He presented a visual array of three rows each with four letters for 50 milliseconds, finding that subjects could recall only four or five letters on average, though they said they'd seen more. However, if they were instructed to report the letters in a row selected at random as indicated by a particular tone (high, medium, low) then they were able to report 3.04 letters per row, an average of just over 9 letters from the 12 letter array. If the instructional tone was delayed too much, recall dropped dramatically, suggested that iconic storage decays after about 0.5 seconds. As our visual perception seems to operate on the icon within this store rather than on the visible environment, it seems this store is an essential part of visual perception and memory. Treisman (1964) showed that subjects can shadow (repeat aloud) a message in one ear when another but identical message is played in the other ear only if the second message is more than 2 seconds behind the first message. This suggests that information is stored in echoic storage for a duration of approximately 2 seconds. Morton (1970) suggests we process the message only on the basis of gross physical characteristics such as volume, pitch, gender of voice but not for meaning, a similar point being made by Broadbent (1958) concerning iconic storage (see selective attention handout).
Short-term store

STS has three key aspects:

1. **limited capacity** (only about 7 items can be stored at a time)
2. **limited duration** (storage is very fragile and information can be lost with distraction or passage of time)
3. **encoding** (primarily acoustic, even translating visual information into sounds).

There are two ways in which capacity is tested, one being span, the other being recency effect. Miller (1956) showed that the span of information held within STS is 7 items but that through combining items into larger times in a process called *chunking* the capacity can be increased. For example, the following array of 25 items can be chunked into four items, making it much easier to recall.

```
E G N R N
L A L E E
L M A B V
I S C M E
M R I U S
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How? Start at the bottom left hand corner (M) and go up the column, to the bottom of the next column and up it again and so on. What does it say? Once you have worked this out, it will be very easy to recall. However, Simon (1974) discovered that span is less with larger chunks (such as eight-word phrases) so it's no good trying to get an essay to be one chunk! Chunking shows that long-term memory feeds into STS to do the chunking, so the notion of discrete stores is a theoretical convenience more than an empirical reality.

Glanzer and Cunitz (1966) used free recall (recalling the to-be-remembered items in any order) of a list of 20 items combined with an interference task to show that there are two processes involved in retrieving information. They showed lists of 20 words one at a time and had subjects recall the words under one of three conditions. With 0 seconds delay the first 5 and last three words were recalled best but with a 10 or 30 second delay during which the subject counted backwards there was little effect on the early words but poor recall of later items. This suggests that the later words were held in short term storage and were lost due to interference whereas the earlier words had been passed to long-term storage.

Duration seems to be between 15 and 30 seconds, according to Atkinson and Shiffrin (1971). Items can be kept in STS by repeating them verbally (acoustic encoding), a process known as **rehearsal**.
**Long-Term Store**

Theoretically, the **capacity** of LTS could be unlimited, the main constraint on recall being accessibility rather than availability. **Duration** might be a few minutes or a lifetime. Suggested **encoding** modes are **semantic** (meaning) and **visual** (pictorial) in the main but can be **acoustic** also.

*The multi-store model of memory*

![Diagram of multi-store model of memory]

**The evidence**

The Glanzer and Cunitz (1966) study above is cited most often to illustrate the operation of two separate processes.

*A typical serial position curve, based on Glanzer and Cunitz 1966*

![Graph of serial position curve]

The shape of this curve implies that the primacy effect reflects information being stored in and retrieved from a long-term store and the recency effect reflects information being stored in and retrieved from a short-term store. Using a technique called the **Brown-Peterson technique** which prevents the possibility of retrieval by having subjects count backwards in 3s, Brown and Peterson (1959) showed that the longer the delay, the less information is recalled. The rapid loss of information from memory when rehearsal is prevented is taken as an indication of the existence of short-term memory and the fact that some information can be recalled suggests that it has been transferred into a longer-term store. Gruneberg (1970), however, points out that...
this is not evidence that there are two processes or stores, just that there is some memory system.

The study of brain-damaged patients, particularly amnesiacs, provides considerable evidence for Atkinson and Shiffrin's model. In anterograde amnesia patients seem unable to learn from novel situations and so their STM seems to be impaired to the extent that they might not remember just having read a sentence or what time of day it is, unless they had looked at a clock in the last 15 seconds. The problem could be interpreted as having difficulty transferring information from STS to LTS. Of course, the problem may be one of retrieval and not one of transfer at all. If so, this is not valid evidence for the existence of the two processes.

Differences in coding suggest the existence of discrete stores. Material that is encoded for meaning (semantic coding) seems to be better remembered than the phonemic features of material. Research by Conrad (1964) suggests that when we make retrieval errors they tend to be similar in sound to the target items (e.g. retrieving b instead of d, m instead of n). Similarly, Wickelgren (1965) presented subjects with four letters followed by another eight letters before asking them to recall the first four. He found that this was more difficult if the second eight letters sounded similar to the first four. Baddeley (1966) found that immediate recall of the order of unrelated but similar sounding words (e.g. caught/short/taut/nought) was relatively poor but not if they were unrelated words (e.g. huge/great/big/wide). However, if a delay was introduced, the opposite effect occurred, suggesting that information recalled after a delay (i.e. from LTS) is encoded in a different way from that recalled immediately (i.e. from STS).

There does seem to be evidence that semantic encoding occurs in STS too, however. Consider Miller's idea of chunking to increase STM recall. The chunking can occur only on the basis of meaning, so it must operate in STS too, perhaps by the items activating information in LTM. In another study, Posner (1970) used response time as an indicator of differences in processing. He presented subjects with pairs of letters (e.g. Aa, Bb, AA, BB, aa, bb) and subjects had to say whether they were the same or not. It takes longer to decide this if the pair is Aa compared with AA, arguably because the structural difference in the letters (A compared with a) need to be overlooked and the stimuli compared in terms of their meaning/semantics. It seems clear therefore, that semantic encoding has a role in STS as well as acoustic encoding and that, since we can remember voices and tunes over long periods of time, acoustic encoding operates in LTM.

One of the main lines of evidence for a distinction between STS and LTS lies in different types of forgetting. Counting backwards can cause forgetting from STM (see Glanzer and Cunitz 1966), suggesting either interference between counting and the rehearsal activities of STM or a diversion of attention (Reitman 1974). Forgetting from LTM may occur because the memory trace itself has deteriorated (Tulving's 1974 trace-dependent forgetting) or because the person is not exposed to the appropriate cues to recall but when they are exposed to cues by, for example, revisiting a childhood home, retrieval is improved (Tulving's cue-dependent forgetting).
### Evaluation of the Multi-Store Model

The distinction between short and long term memory makes a lot of sense and has entered the public domain in much the same way as has a distinction between unconscious and conscious. The memory stores differ in at least these ways:

- Duration
- Capacity
- Effects of Brain Damage
- Encoding
- Forgetting Mechanisms

The multi-store model is over-simplified (Eysenck and Keane 1995), assuming that the stores operate as a unit and in a single, uniform fashion. Evidence from Shallice and Warrington (1974) suggests that it is possible to suffer impairment of verbal information but without affecting other auditory information (such as the ringing of a telephone). Furthermore, it is unlikely that all the information in LTM is stored in the same form or that it is retrieved by an active searching of shelves in a linear fashion. Also, the multi-store theorists suggested that information was transferred from STS to LTS by rehearsal but it is evident that little rehearsal is needed on many occasions and that increased attempts at rehearsal are no guarantee that information will be stored in LTS.