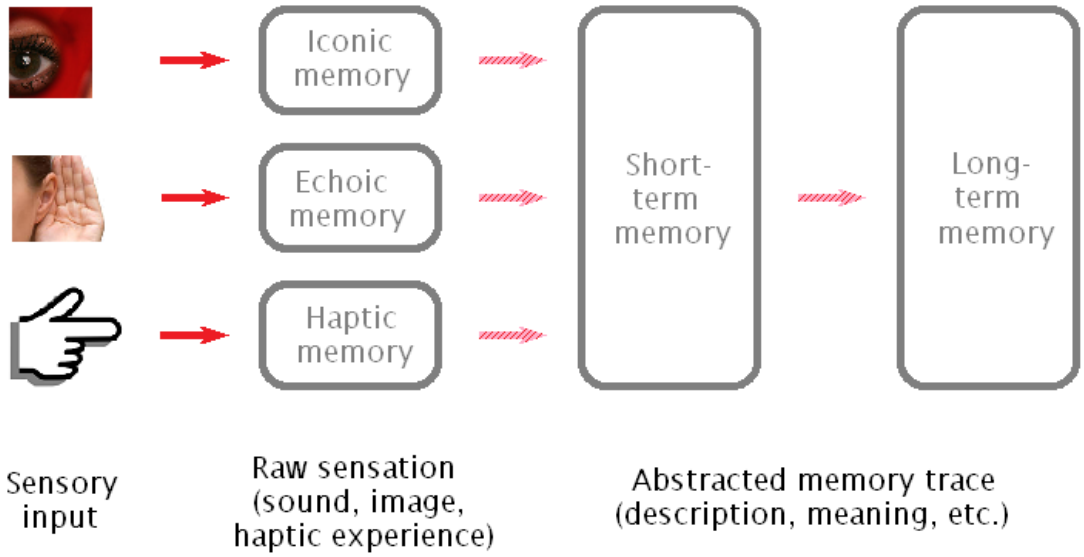
Human Memory

The human memory system has three distinct stages. Information is:

1. received through one or more of the *sensory memories* e.g.:
    - *Iconic* (visual) memory
    - *Echoic* (auditory) memory
    - *Haptic* memory
2. selectively held in *short-term memory* while it is analysed, after which it may be either discarded or...
3. stored permanently in *long-term memory*



Sensory Memory

The sensory memories store visual, auditory and haptic experiences:

- in their raw form
    - e.g., images, sounds, etc.
- for very short periods of time
    - typically just a few seconds
    - sometimes longer in the absence of new stimuli

In short, sensory memory behaves rather like a *tape-loop*:

- It can store sounds for a short period (around a second)
- Incoming sound is recorded over the existing sound, so it always holds the last second of incoming sound
- However, if no new sound is recorded, it can retain the existing sound for longer.

Short-term Memory

Short-term memory involves largely *conscious* recall of information.

Information held in the sensory memories *may* be passed to the short-term memory for analysis and processing.

However, the capacity of STM is limited and hence only some sensory information receives attention.

Information held in short-term memory can be accessed in around 70ms.

The short-term memory can hold around *seven* items of information ("Seven plus or minus two" - Miller, 1956).

However, it is not easy to define an 'item of information'. An item might be:

- a single digit or character or word, or....
- a long number or entire phrase, if that number or phrase is already known to the person.

For example, if you hear an unfamiliar place-name you may initially store it as a sequence of syllables.

Once you become familiar with the name, it can be stored as a single item in short-term memory.

To use a computing analogy:

- Short-term memory can be viewed as an array with 7 elements.
- Each element can hold either an *integer*, a *char*, a *string* or a *pointer*.
- If an item is already held in *main memory*, the array need only store a pointer to the relevant address in main memory. Thus only one element is used for storage.
- If an item is not already held in main memory, each character, word or digit must be stored in a separate element in the array. Thus many elements are used for storage.

Storing information in STM involves mental effort.

Because of this, information held in STM is easily lost:

- an interruption may demand our attention, forcing other information out of STM
- it's difficult to maintain information in STM for more than very short periods, so a long delay may result in items being lost.
- information is discarded when it no longer appears useful, so (e.g.) completing a task may cause us to 'flush' all associated information from STM.

Short-Term Memory is the gateway to Long-Term Memory.

Information is held in STM while it is being learned (i.e., stored in LTM).

Long-term Memory

Long-term memory provides permanent storage of information.

Information held in long-term memory can be accessed in around 100ms.

The capacity of long-term memory is huge, apparently unlimited.

Forgetting takes place slowly, if at all.

Recall after a few hours or days is usually no different from recall after a few minutes.

There are three main processes associated with long-term memory (LTM):

- Storage/remembering.
- Information Retrieval
- Forgetting

LTM: Storage/Remembering

Information passes into long-term memory via the short-term memory.

However, not everything that is held in short-term memory is eventually stored in long-term memory.

The main factors determining what is stored are:

- Rehearsal
- Meaning

Rehearsal, i.e., repeated exposure to data, or consideration of it, increases the likelihood that it will be stored in LTM.

- Ebbinghaus found that the likelihood of long-term recall is directly proportional to the total period of exposure to the material.
- This is known as the *total time hypothesis*.
- Baddeley found that the likelihood of long-term recall varied according to the pattern of exposure rather than the total period of exposure.
- Brief but regular exposure produced long-term recall more effectively than infrequent, prolonged exposure
- This is known as the *distribution of practice* effect.

Meaningful information is more likely to be stored in LTM than meaningless data.

- Bartlett found that subjects who were asked to learn a story about an unfamiliar culture tended to recast the story within their own culture, and that this aided recall.
- He coined the phrase *effort after meaning* to describe the way in which people organise information to make it easier to recall.

These two factors, rehearsal and meaning, interact: through rehearsal it is possible to learn even meaningless material, but learning-time is much shorter for meaningful material.

Learning may be improved by reinforcement through several senses:

- Baddeley notes that performing any kind of action while reading or listening to material increases the likelihood that it will be recalled.

  Thus using key-clicks to cycle through a list promotes learning more than merely pressing once to access the entire list.
- Research has also shown that reading material and hearing it spoken at the same time improves recall.

  It doesn't seem to make much difference whether the spoken version is produced by another voice, or by the reader's own voice.

  This may be why people often read aloud when trying to memorise something: reading aloud - or even mouthing the words silently (sub-vocalisation) - improves recall.

LTM: Information Retrieval

There are two types of information retrieval from LTM:

- *Recall*: the recovery of information as a result of a conscious search.
- *Recognition*: the automatic recovery of information as a result of an external stimulus.

Recognition is the less complex cognitive activity.

For this reason, modern computer interfaces rely heavily on recognition rather than recall.

Instead of having to recall commands - as in a command-line system - users merely have to recognise commands from menus.

During recall, we access long-term memory either *episodically* or *semantically*.

- *Episodic Memory* represents our memory of events and experiences.

  It allows us to access items in serial form, reconstructing sequences of events and experiences from earlier points in our lives.
- *Semantic Memory* is structured so that it represents relationships between information.

  It allows us to access information without regard to the order in which it was acquired or the sense through which it was acquired.

Semantic memory is assumed to be arranged as a *semantic network*.

Items are arranged in classes, and may inherit attributes from parent classes.

Researchers have shown that the delays which occur in recall can be modelled accurately as a network.

The greater the number of levels in the hierarchy that have to be traversed, the longer the recall time.

LTM: Forgetting

There are two main theories to explain the loss of information from long-term memory: decay and interference.

- *Decay*: Ebbinghaus concluded that information is lost through natural decay.

  His experiments suggested that the decay is exponential, i.e., information is lost rapidly at first but then more slowly.

- *Interference*: new information may replace or corrupt older information.

Many psychologists believe that we never really forget anything - we just lose access to certain parts of the stored information.

This is almost impossible to prove since losing access to data has the same effect as losing the data.