# Memory Encoding

**http://www.human-memory.net/processes_encoding.html**

**Encoding** is the crucial first step to creating a new memory. It allows the perceived item of interest to be converted into a **construct** that can be stored within the brain, and then recalled later from short-term or long-term memory.

Encoding is a biological event beginning with **perception** through the senses. The process of laying down a memory begins with **attention** (regulated by the **thalamus** and the **frontal lobe**), in which a memorable event causes neurons to fire more frequently, making the experience more intense and increasing the likelihood that the event is encoded as a memory. **Emotion** tends to increase attention, and the emotional element of an event is processed on an unconscious pathway in the brain leading to the **amygdala**. Only then are the actual **sensations** derived from an event processed.

The perceived sensations are decoded in the various **sensory areas** of the cortex, and then combined in the brain's **hippocampus** into one single experience. The hippocampus is then responsible for analyzing these inputs and ultimately deciding if they will be committed to long-term memory. It acts as a kind of sorting centre where the new sensations are **compared** and **associated** with previously recorded ones. The various threads of information are then stored in various different parts of the brain, although the exact way in which these pieces are identified and recalled later remains largely unknown. The **key role that the hippocampus plays in memory encoding has been highlighted by examples** of individuals who have had their hippocampus damaged or removed and can no longer create new memories (see Anterograde Amnesia). It is also **one of the few areas of the brain where completely new neurons can grow.**

Although the exact mechanism is not completely understood, encoding occurs on different levels, the first step being the formation of short-term memory from the ultra-short term sensory memory, followed by the conversion to a long-term memory by a process of memory consolidation. The process begins with the creation of a **memory trace** or **engram** in response to the **external stimuli**. An engram is a hypothetical biophysical or biochemical change in the neurons of the brain, hypothetical in the respect that no-one has ever actually seen, or even proved the existence of, such a construct.

An organ called the **hippocampus**, deep within the **medial temporal lobe** of the brain, receives connections from the primary sensory areas of the cortex, as well as from **associative areas** and the **rhinal** and **entorhinal cortexes**. While these **anterograde** connections converge at the hippocampus, other **retrograde** pathways emerge from it, returning to the primary cortexes. A **neural network** of cortical **synapses** effectively records the various associations which are linked to the individual memory.

There are three or four **main types** of encoding:

- **Acoustic encoding** is the processing and encoding of sound, words and other auditory input for storage and later retrieval. This is aided by the concept of the **phonological loop**, which allows input within our **echoic memory** to be sub-vocally rehearsed in order to facilitate remembering.

- **Visual encoding** is the process of encoding images and visual sensory information. Visual sensory information is temporarily stored within the **iconic memory** before being encoded into long-term storage. The **amygdala** (within the **medial temporal lobe** of the

brain which has a primary role in the processing of **emotional** reactions) fulfills an important role in visual encoding, as it accepts visual input in addition to input from other systems and encodes the positive or negative values of **conditioned stimuli**.

- **Tactile encoding** is the encoding of how something feels, normally through the sense of touch. Physiologically, neurons in the primary **somatosensory cortex** of the brain react to vibrotactile stimuli caused by the feel of an object.

- **Semantic encoding** is the process of encoding sensory input that has particular **meaning** or can be applied to a particular **context**, rather than deriving from a particular sense.

It is believed that, in general, encoding for short-term memory storage in the brain relies primarily on **acoustic encoding**, while encoding for long-term storage is more reliant (although not exclusively) on **semantic encoding**.

Human **memory is fundamentally associative**, meaning that a new piece of information is remembered better if it can be associated with previously acquired knowledge that is already firmly anchored in memory. The more **personally meaningful the association, the more effective the encoding and consolidation**. Elaborate processing that emphasizes meaning and associations that are familiar tends to leads to improved recall. On the other hand, information that a person finds difficult to understand cannot be readily associated with already acquired knowledge, and so will usually be poorly remembered, and may even be remembered in a **distorted form** due to the effort to comprehend its meaning and associations. For example, given a list of words like "thread", "sewing", "haystack", "sharp", "point", "syringe", "pin", "pierce", "injection" and "knitting", people often also (incorrectly) remember the word "needle" through a process of association.

Because of the associative nature of memory, **encoding can be improved by a strategy of organization of memory called elaboration**, in which new pieces of information are associated with other information already recorded in long-term memory, thus incorporating them into a broader, coherent narrative which is already familiar. An example of this kind of elaboration is the use of **mnemonics**, which are verbal, visual or auditory associations with other, easy-to-remember constructs, which can then be related back to the data that is to be remembered. Rhymes, acronymns, acrostics and codes can all be used in this way. Common examples are “Roy G. Biv” to remember the order of the colours of the rainbow, or “Every Good Boy Deserves Favour” for the musical notes on the lines of the treble clef, which most people find easier to remember than the original list of colours or letters. **When we use mnemonic devices, we are effectively passing facts through the hippocampus several times**, so that it can keep strengthening the associations, and therefore improve the likelihood of subsequent memory recall.

In the same way, **associating words with images** is another commonly used mnemonic device, providing two alternative methods of remembering, and creating additional associations in the mind. Taking this to a higher level, another method of improving memory encoding and consolidation is the use of a so-called **memory palace** (also known as the **method of loci**), a mnemonic techniques that **relies on memorized spatial relationships** to establish, order and recollect other memories. The method is to assign objects or facts to different rooms in an imaginary house or palace, so that recall of the facts can be cued by mentally “walking though” the palace until it is found. Many top memorizers today use the memory palace method to a greater or lesser degree. Similar techniques involve placing the items at different landmarks on a favourite hike or trip (known as the **journey method**), or weaving them into a story.

The old and popular notion of the brain as a kind of “muscle” which strengthens with repeated use (also known as **faculty theory**) is now largely discredited. Research, dating back to **William James** towards the end of the 19th Century, shows that long hours spent memorizing does not

build up the powers of memory at all, and, on the contrary, may even diminish it. This is not to say that **individual memories** cannot be strengthened by repetition, but that, as James found, daily training in the memorization of a poetry of one author, for example, does not improves a person's ability to learn the poetry of another author, or poetry in general.

Many studies have shown that the **most vivid autobiographical memories tend to be of emotional events,** which are likely to be recalled more often and with more clarity and detail than neutral events. One theory suggests that high levels of emotional arousal lead to **attention narrowing**, where the range of sensitive cues from the stimulus and its environment is decreased, so that information central to the source of the emotional arousal is strongly encoded while peripheral details are not (e.g. the so-called **"weapon focus effect"**, in which witnesses to a crime tend to remember the gun or knife in great detail, but not other more peripheral details such as the perpetrator's clothing or vehicle).

## ??? Did You Know ???

When presented with a **visual stimulus**, the part of the brain which is activated the most depends on the nature of the image. A blurred image, for example, activates the **visual cortex** at the back of the brain most. An image of an unknown face activates the **associative** and **frontal** regions most. An image of a face which is already in working memory activates the **frontal regions** most, while the visual areas are scarcely stimulated at all.

## ??? Did You Know ???

In a positive example of **disfluency** (the subjective feeling of difficulty associated with any mental task), a recent study at Princeton University has shown that students learning new material printed in a **difficult-to-read font** or typeface were able to recall significantly more than those learning the same material in a font considered **easy to read**. It is believed that presenting information in a way that is hard to digest means that a person has to concentrate more, leading to **deeper processing** and therefore better retrieval afterwards.

## ??? Did You Know ???

Studies suggest that **characteristics of the environment** are encoded as part of the **memory trace**, and can be used to enhance retrieval of the other information in the trace.
In other words, you can recall more when the environments are **similar** in both the learning (encoding) and recall phases.Thus, deep-sea divers tend to remember their training more effectively when trained underwater rather than on land, and students perform better on exams by studying in silence, because exams are usually done in silence.

## ??? Did You Know ???

It has been shown that using **two separate study sessions**, with time between the sessions, can result in twice the learning as a **single study session** of the same total time length.
This is known as **spaced learning** (the oppposite of cramming), and is designed to avoid the situation where the synapses become "maxed out" or lose their ability to learn new information (also known as the **long-term depression** or weakening of a synapse connection).