Human Working Memory

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There are various, more or less similar definitions of the working memory, like[1]:

- "*short-term memory applied to cognitive tasks*",
- "*multi-component system that holds and manipulates information in short-term memory*", or
- "*use of attention to manage short-term memory*".

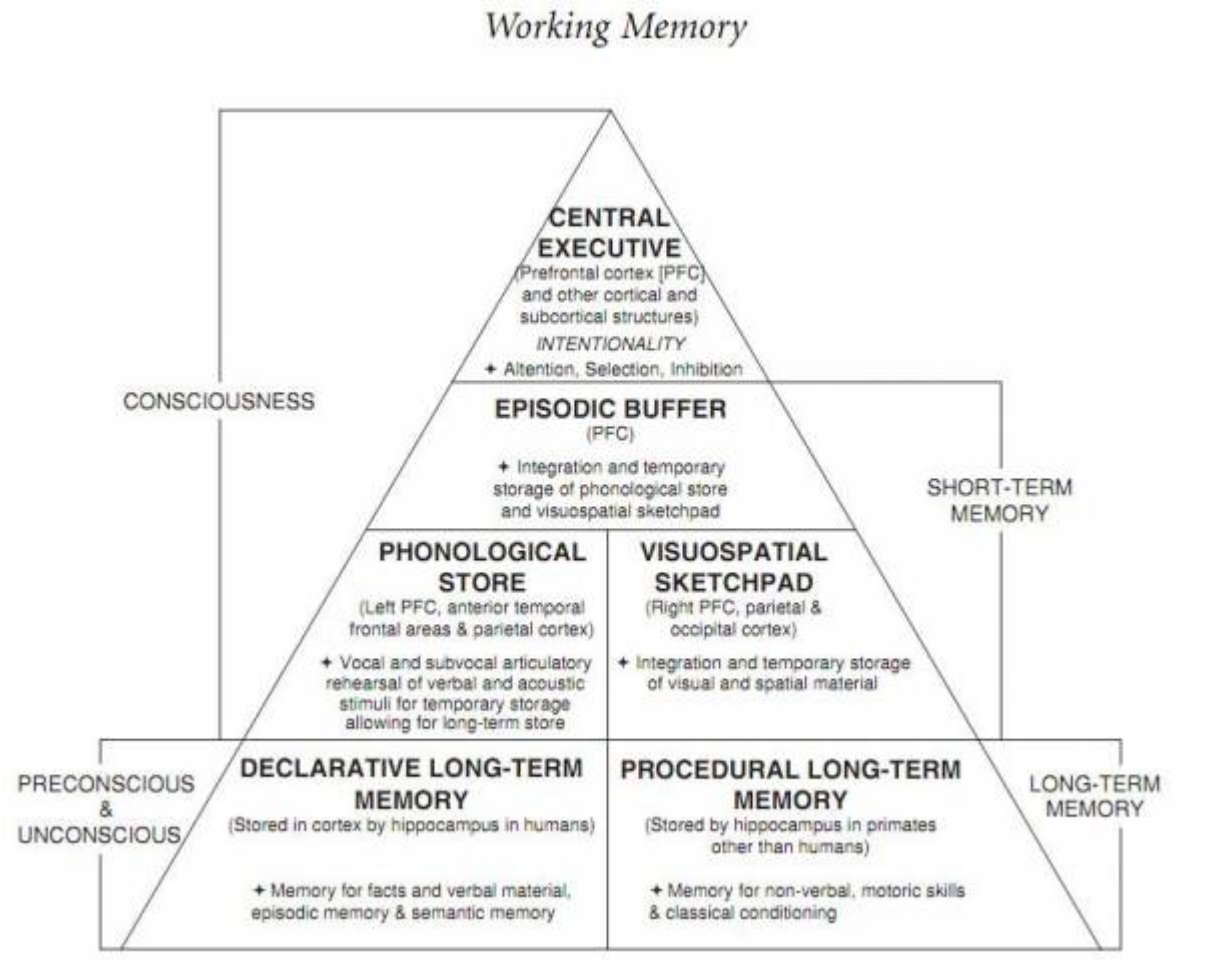
What is mostly common to them is that they address working memory as the system which manipulates information from STM, and sometimes even LTM. As this system is one of the key components in the process of knowledge acquisition, the most commonly discussed working memory models of Baddeley and Cowan will be briefly discussed here.

Baddeley's model of working memory

Alan Baddeley and **Graham Hitch** proposed a multi-component working memory model in **1974**[2]. This model was very well accepted and later adjusted to new findings. In their experiments Baddeley and Hitch examined subjects' retention of series of numbers which were memorized before they had to judge simple logical statements. The results have shown that although both tasks required working memory capacity, the ability of remembering the number sequence wasn't strongly affected by judging logical statements. This led to an assumption that working memory is composed out of more than one component.

Baddeley and Hitch suggested working memory is composed of three parts: the **central executive**, a system that controls the **phonological loop** (a subsystem for remembering phonological information such as language by constant refreshing through repetition in the loop), and the **visuospatial sketch pad** (a subsystem for storing visual information).

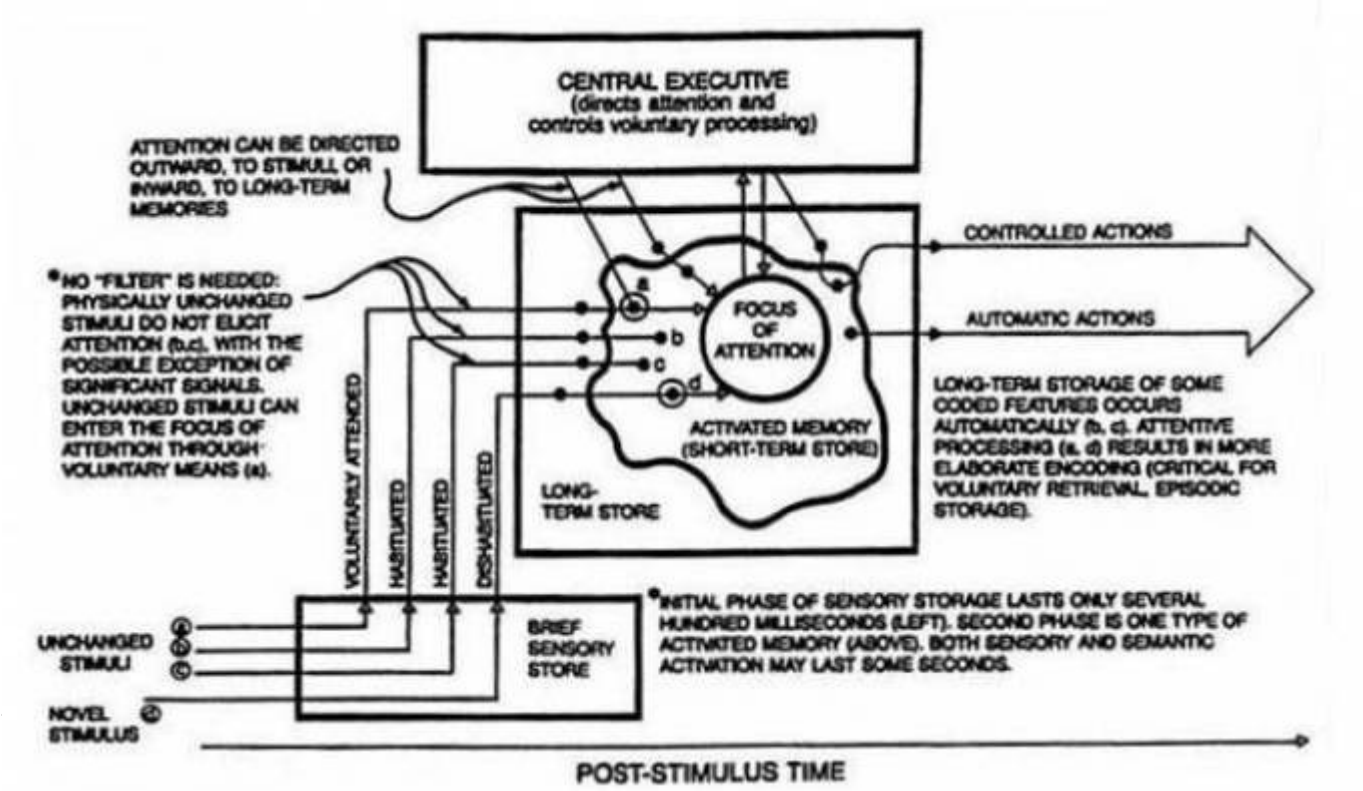
This model was later revised and improved by Baddeley[3][4] but also contributed by other authors[5], which resulted in additional component of **episodic buffer**[6] in year **2000** and more detailed functions and analysis of other components, as described in table below.



Central executive	It is still unclear weather it is a single system or more systems working together. Central executive's functions include **attention** and focusing, **active inhibition** of stimuli, planing and decision-making, sequencing, **updating**, **maintenance** and **integration of information** from phonological loop and visuospatial sketchpad. These functions also include communication with long-term memory and connections to language understanding and production centers.
Episodic buffer	Episodic buffer has the role of **integrating the information** from phonological loop and visuospatial sketchpad, but also from long-term memory. It serves as the **storage component of central executive**, or otherwise information integration wouldn't be possible.
Phonological loop	According to Baddeley, phonological loop consists of **two components**: a sound **storage** which lasts just a few seconds and an **articulatory processor** which maintains sound information in the storage by **vocal or subvocal repetition**. Verbal information seems to be automatically processed by phonological loop and it also plays an important, maybe even key role in language learning and speech production. It can also help in memorizing information from the visuospatial sketchpad. (For example, repeating “A red car is on the lawn.”)
Visuospatial sketchpad	This construct according to Baddeley enables temporary storing, maintaining and manipulating of visuospatial information. It is important in **spatial orientation** and solving **visuospatial problems**. Studies have indicated that visuospatial sketchpad might actually be containing two different systems: one for spatial information and processes and the other for visual information and processes.

Cowan's embeded-process model of working memory

Nelson Cowan proposed a different model of working memory in **1988**[7], the ***embeded-process model of working memory***. Unlike Baddeley's model, which is concerned with modularity and components of the working memory, Cowan offered a view oriented mostly on **underlying cognitive processes** which occur when solving a task like language comprehension or production, problem-solving, decision-making and other.



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f four elements:

- **central executive** (the top rectangle in the picture),
- **long-term memory** (the large rectangle),
- **activated memory**, which refers to a subset of long-term memory in state of temporal activation (the irregular shape in the long-term memory rectangle), and
- the **focus of attention**.

The active memory consists of parts of long-term memory needed to preform a cognitive task. Elements can be activated also voluntarily or involuntarily. The amount of simultaneously active elements is still an issue of debate, but without rehearsing, evidence show these elements remain active for about 10 - 20 seconds. Working memory holds all of these activated elements, but only about 4±1 of them can be in focus, what is decided by voluntarily or involuntarily attention switching using the central executive.

Just like in Atkinson and Shiffrin model, the ingoing information is first stored in the sensory memory. Sensory information then activates certain elements inside the long-term memory. In his model, Cowan does not address the issue of processing information of different modality like Baddeley.

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