# Baddeley and Hitch's Multi-Component Model of Working Memory analytical study

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**Abstract**: The current article seeks to provide a broad and comprehensive view of Baddeley's model of working memory. Baddeley and recent studies consider working memory to be the active and effective part of memory and of great importance in storing, processing, and preparing information .Baddeley's model is one of the most important models developed in the field of working memory, and it has been widely accepted and successful. Baddeley and Hitch developed a model of working memory in 1973, which Baddeley revised and refined in 1986. Baddeley's first model in 1986 was a tripartite model consisting of a central executive system responsible for processing and storing information, with two subsystems under it. The first system is called the phonological loop, which is a system responsible for processing verbal information and consists of two components: the phonological loop and the verbal control process. The second system is called the visuospatial component, which deals with visuospatial information.

**Key Words :**Baddeley and Hitch model ,phonological loop; verbal information; visuospatial information.; working memory.

**الملخص بالعربية :**

هدفت الدراسة الحالية إلى تقديم نظرة واسعة وشاملة لنموذج بادلي للذاكرة العاملة والتي تعتبر حسب بادلي وحسب الدراسات الحديثة أنها الجزء النشط والفعال في الذاكرة وأنها ذات أهمية بالغة في تخزين ومعالجة وتجهيز المعلومات.ويعتبر نموذج بادلي من أهم النماذج التي أعدت في مجال الذاكرة العاملة، ومن النماذج التي لاقت رواجا ونجاحا كبيرين، حيث أعد بادلي وهيتش نموذجا للذاكرة العاملة سنة 1973، ثم قام بادلي بتعديله وتنقيحه سنة1986، حيث أعد بادلي نموذجه الأول سنة 1986 وهو نموذج ثلاثي يتكون من المنفذ المركزي وهو نظام مسؤول عن معالجة المعلومات وتخزينها، ويندرج تحته نظامان فرعيين، النظام الأول يسمى بالحلقة الفونولوجية وهو نظام مسؤول عن تجهيز المعلومات اللفظية، ويتكون من مكونين؛ الحلقة الفونولوجية، وعملية الضبط اللفظية. أم النظام الثاني يسمى بالمكون البصري المكاني، وهو مكون يتعامل مع المعلومات البصرية المكانية.

وفي سنة 2000 قام بادلي بإضافة مكون جديد إلى نموذج الذاكرة العاملة أطلق عليه اسم مصد الأحداث أو الحاجز العرضي أو الجسر المرحلي، وبالتالي أصبح نموذج بادلي للذاكرة العاملة نموذج رباعي المكونات.

**الكلمات المفتاحية:** نموذج بادلي وهيتش، الذاكرة العاملة

**Introduction**

Memory, in all its forms, especially working memory, is a necessary process in the life of an individual in general and in the learning process in particular. It is the part where the individual keeps the experiences and information that he acquires through his sensory interaction with the surrounding environment, in order to use it in his daily and school life. Therefore, any deficiency in working memory hinders the learning process at different stages of development.

New research trends and recent studies have considered working memory to be a fundamental component of human memory and that it plays an important role in the performance of cognitive tasks. This is due to the great progress that memory research and studies have made in recent years, which has extended from theories that focus on the structure and mechanisms of memory to research that deals with memory as processes and preparations (Al-Arishi et al., 2013, p. 93).

Due to the great importance of working memory, there have been many studies, researches, and models about it, such as the Daneman and Carpenter model (1980), the Hasher and Zacks model (1988), the Schneider model (1993), and the Baddeley model (1986). However, the Baddeley model is considered one of the most important and popular models, and we will discuss it in detail in this study.

**First: The General Framework of the Study**

## 1- Importance of the Study

The importance of the study lies in the importance of the topic being studied and analyzed, as the Baddeley model is one of the models that is credited with the expansion and spread of studies on working memory and highlighting its importance in the field of learning and teaching, and in the life of the individual in general.

- Providing a theoretical knowledge base that adds to the library of psychology.

## 2- Objectives of the Study

A- Draw the attention of researchers and scholars to conduct more studies on working memory due to its great importance in the field of education.

B- present a theoretical academic study that serves as a reference for scholars and researchers.

C- Highlight the components of working memory and the extent of its relationship to its great importance in storing, processing, and preparing information.

## 3-Literature Review

## 3.1. Working Memory

**The term "working memory" was first proposed by Miller and Gallanter (1960) in their book "Plans and the Structure of Behavior."** The term began to be used in computer science and in animal learning studies, and eventually it was adopted by

cognitive psychology to refer to the system of temporarily storing information in an active state while performing a cognitive task.

**Atkinson and Shiffrin (1968) then used the same term for the short-term store, which they called the unitary store.** They considered working memory to be a unitary system, meaning that it does not contain any other subsystems. In contrast, Baddeley and Hitch (1974) proposed that working memory is a multi-component model and that it is not a single component (Abdul-Hafiz, 2016, p. 104).

## 1.1. Definition of Working Memory

The concept of working memory is one of the concepts introduced by the assumptions of cognitive theory, due to the importance of this memory in cognitive mental activities, and at the forefront of these activities is problem solving. Baddeley (1974) believes that working memory includes abstract representations of meanings and interpretations of the current situation, on which attention is focused. He also believes that working memory is part of direct memory (Immediate Memory) in which the majority of cognitive activities take place (Abdul-Baqi; Muhammad Issa, 2010, p. 82).

The term "working memory" is one of the terms that emerged in the field of cognitive psychology in 1974 in the work of Baddeley and Hitch (1974**).** Baddeley and Hitch considered it a more modern alternative to the term "short-term memory" (Al-Arishi et al., 2013, p. 94).

Working memory is the element of memory in which information is processed.It identifies information in the sensory register that needs attention, stores information for a longer period of time, and then processes it. It also requires the retrieval of some information from long-term memory to help interpret new information received from the environment (Abu Alam, 2012, p. 54).

Logie (1996) states that working memory is the active or constantly active part of short-term memory, as well as the part that processes and classifies information according to its type (Abu Al-Diyar, 2012, p. 26).

Alloway and Alloway (2015) point out that working memory is a system responsible for temporarily storing and processing information during an individual's practice of daily cognitive activities that require the storage and processing of this information. It is characterized by a limited capacity.

From the above, we can conclude that working memory plays an important and effective role in preparing, storing, and processing information and keeping it active in human memory for a limited period of time. One of the most prominent researchers in the field of working memory is Baddeley and Hitch.

Based on the previous definitions, we can provide a comprehensive definition of working memory. It is considered the cognitive component and the active system responsible for temporarily storing, classifying, interpreting, and processing information. Some, such as Logie (1996), consider it a part of short-term memory, while others, such as Baddeley and Hitch, consider it a more modern alternative to short-term memory.

## Characteristics of Working Memory

The working memory includes many features, including the following:

- Working memory only receives information that is paid attention to. Information that is not paid attention to in sensory memory does not undergo any processing in working memory.
- The capacity of working memory is very limited, as it cannot hold a huge amount of information as is the case with sensory memory or long-term memory. The results of studies known as memory span indicate that its capacity ranges between "5-9" units of knowledge; i.e., with an average of (7) units.
- Working memory represents the conscious aspect of the cognitive system. We are often fully aware of what is happening in it, and it forms the link that connects humans to the external world around them.
- Working memory can retain information for a short period of time, not exceeding "30 seconds". The duration of information retention in this memory depends on the nature of the information received and the level of activation of the required cognitive processes.
- Working memory forms the link between sensory memory and long-term memory: Working memory forms the link between sensory memory and long-term memory. It receives sensory impressions in sensory memory and works to retrieve the experiences associated with them from long-term memory to encode them and extract their meanings. It also determines the appropriate behavioral procedures for external stimuli and situations. Stimuli are encoded differently in working memory than they are in external reality
- Stimuli are encoded differently in working memory than they are in external reality. Stimuli can take on multiple forms of representation in this memory depending on the purpose of their processing and the nature of the cognitive control processes that the individual adopts in a given situation. Stimuli may be represented verbally, visually, auditorily, semantically,etc.

Temporary storage of information, and the ability to store different types of information due to the presence of many components.

- Working memory is a temporary storage system for information. It is a limited-capacity system that stores and processes information for a short period of time.

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- The capacity of working memory varies depending on the information presented to the individual. The capacity of working memory varies depending on the information presented to the individual. The capacity of working memory is not a fixed entity.
- The relationship between the storage and processing functions within working memory is governed by a specific organizational plan. This organization is most evident when the activation process reaches its maximum level.

Al-Zoghoul, Al-Zoghoul (Dr. S); Al-Arishi (2013); Al-Sayyid (2014); Abu Al-Diyar (2012)

## Baddeley and Hitch's Model of Working Memory

## Some Models of Working Memory

The human mind is a remarkable tool, and working memory plays a critical role in its everyday functioning. However, there's no single, universally accepted explanation of how it works. Psychologists have proposed various theories, each offering a unique perspective on this complex system. These competing ideas have fueled a vibrant field of research, leading to the development of numerous models that dissect the components and capabilities of working memory.

**Malim's Model of Working Memory (1994).**

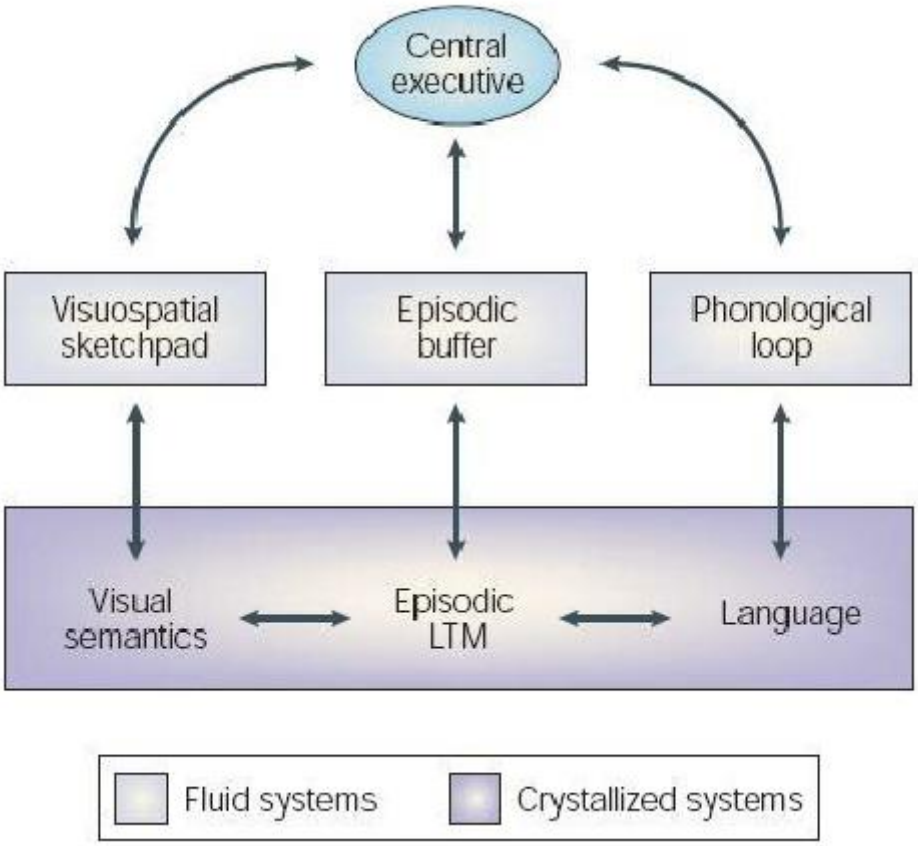


**Figure. 1. Malim's Model of Working Memory (1994)**

**Malim (1994) proposed a model to illustrate the components of working memory.** He suggests that the central processor receives input and works through interaction with other components.

Through the auditory store, which stores auditory or non-verbal information, information is selected and classified through the work of the verbal and non-verbal components together, through the reciprocal relationship between them and the central executive (Abdul Hafiz, 2016, p. 128).

In brief, Malim's Model of Working Memory is a cognitive model that provides a framework for understanding how working memory functions. It, thus, involves the interplay of different components to process and store information temporarily.

### 2.1.2. Caplan and Waters Model (1999).

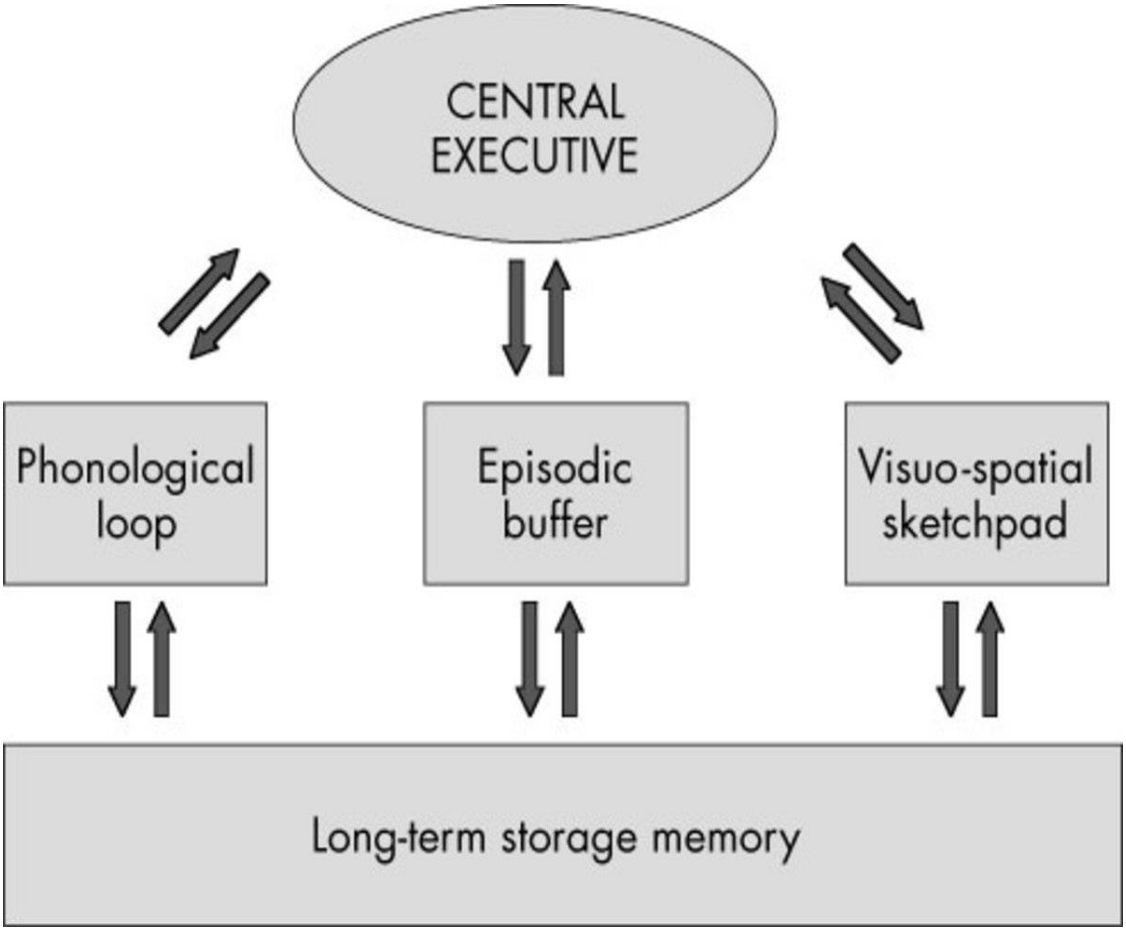


**Figure. 2.Caplan and Waters Model (1999)**

Caplan and Waters (1999) discussed in another theory of working memory the previous theories that do not take into account the specific knowledge necessary to process language, and that there are two types of separate sub-processes within this distinctive system:

- The first process is the unconscious understanding of the first meaning of speech.
- The second process is a conscious act that is controlled by the individual.

An example of this is when the second process is necessary to understand a sentence in the passive voice, for example, "The cat was chased."
The second process will be used to understand that the verb "chased" refers to the subject/agent (the dog) and not the object (the cat) (Abu Al-Diyar, 2012, p. 33).

**3.1.2. Daneman and Carpenter Model (1980).**

This model was based on what Baddeley presented in his first model in 1974 and was concerned with the extent of Working Memory Span (WMS) in order to test working memory.This type of test was used extensively in studies on working memory.This concept is based on the theory that working memory is a limited resource, and its role must be divided between processing and storage.This model was developed by having participants read sentences aloud, and remember the last word in each sentence.The longer and larger the sentence, the more difficult the task became (Zaid Al-Khair, 2014, p. 73).

### 4.1.2. Engle and Cantor Model (1992).

This model explains individual differences in working memory**.**It assumes that there is a single capacity for active memory, unlike the trend that sees working memory as having two capacities.This model demonstrates this property through work that has shown that working memory capacity is effective in tasks (phonological verbal, numerical, and visual spatial) and is a good predictor of learning in different subjects.Previous models suggest that the content of working memory is the sum of the information stored in long-term memory that is activated at a certain threshold.The central idea of this model is that the content of working memory only concerns the part that is in the focus of the individual's attention and that can be explicitly remembered, but for the set of information that can be processed directly.Concepts also have varying levels of activation in long-term memory and can have a certain number of concepts in an active state (Daif, 2017).

## 5.1.2. Comments on Working Memory Models.

Malim's model of working memory (1994) proposes that the central processor interacts with other components and consists of two components: the verbal component and the non-verbal component together.

Caplan & Waters' model of working memory (1999) proposes that there are two types of processes in working memory:

- **Unconscious understanding of meaning:** This is the process of automatically and unconsciously understanding the meaning of a sentence.
- **Conscious action to understand the sentence:** This is the process of consciously and deliberately understanding the meaning of a sentence.

The unconscious understanding of meaning is thought to be a fast and automatic process that does not require any attention or effort. The conscious action to understand the sentence is thought to be a slower and more deliberate process that requires attention and effort.

Daneman & Carpenter's model of working memory (1980) proposes that working memory has a limited role in language comprehension. They argue that the main function of working memory is to store and manipulate information, and that this function is not essential for language comprehension.

Engle & Cantor's model of working memory (1992) proposes that the more concepts that are associated with each other, the less likely it is that any one of them will be activated. This translates into a long and difficult retrieval and processing process.The model is based on the idea that working memory is a limited-capacity system that can only store and process a small amount of information at a time. When there are a large number of concepts associated with each other, it becomes more difficult for the system to activate any one of them. This is because the system has to divide its attention between all of the concepts, which makes it more difficult to focus on any one concept.

**Baddeley & Hitch's Model of Working Memory**

Baddeley & Hitch (1974) proposed a model of working memory that went beyond the traditional view of short-term memory as a store. Their model emphasized the role of mental processes in working memory, and it has been very successful in explaining the role of short-term memory and its properties.

One of the reasons for the success of Baddeley & Hitch's model is that it differs from earlier theories, such as those of Waugh & Norman (1965) and Atkinson & Shiffrin (1968). These earlier theories proposed that short-term memory only stores verbal

information. They also offered static views of short-term memory**(Al-Arishi et al., 2013, p. 105)**

**Components of Working Memory according to Baddeley and Hitch**

Baddeley divided the components of working memory according to a proposed model (Baddeley, 1982, 1999) that consists of a main component, the central executive or executive control system, and the phonological loop, the visuospatial sketchpad (Al-Zagoul; Al-Zagoul, Dr. S: 171).

**Executive Control System or Central Executive:**

The central executive is considered the most complex component of working memory. Morris and Gruneberg (1994) note that Baddeley and Hitch (1974) were the first to introduce the concept of the central executive. Since then, many different functions have been ascribed to this component, which is considered one of the most important components of working memory.It is believed that the central executive plays an important and critical role in organizational and control activities, including attention and action. The central executive organizes the flow of information through the other components of the working memory system, and it also retrieves information from long-term memory.In general, the central executive is thought to be the seat of consciousness, and it is believed to control both storage and processing capabilities, which are supported by limited-capacity processing and preparation resources (Al-Arishi et al., 2013, p. 110).

Baddeley points out that the central executive is responsible for coordinating activities in the cognitive system and for integrating information in the first two subsystems. Not only that, but it also allocates part of its resources to increasing the amount of information carried in these two systems. For Baddeley, the central executive is working memory. A study by Swanson (1994) points to the important role of this component in the reading comprehension process, as the central executive performs two operations during initial reading comprehension: first, filtering out non-task-related information, and second, updating task-related information (Abdul-Baqi, Muhammad Issa, 2010, p. 84).

Baddeley's Four Roles of the Central Executive

- It is responsible for supporting performance on two separate tasks through separable executive capacity and distributing attention to two tasks at once.
- Expanding the transformation and changing recall strategies as in random generation.
- Expand the focus or concentration of available attentional capacity on a selective stimulus and suppress the effect of distracting stimuli for this stimulus, especially in complex tasks that depend on this capacity.
- It retrieves information from long-term memory and reprocesses it with the current task by the subsystems, then returns to long-term memory again in the form of a new event (Abdul-Hafiz, 2016: 134).

**The phonological loop (the phonological component):**

The phonological loop is a system that specializes in the temporary storage of verbal information in an organized manner for a limited period of time. This system is similar to a voice recorder in that it can store information for about 1.5 seconds. It consists of a phonological store and self-rehearsal or repetition processes so that the processed information can later be used in the phonological storet receives verbal information

presented audibly, i.e., the person receives it through hearing, which is stored in the form of a phonological code. The information stored in this store is for a short period of time, from 1 to 2 seconds, but it can be extended through phonetic repetition (Dhayf, 2017, p. 31).

The phonological component is divided into two subsystems, which are:

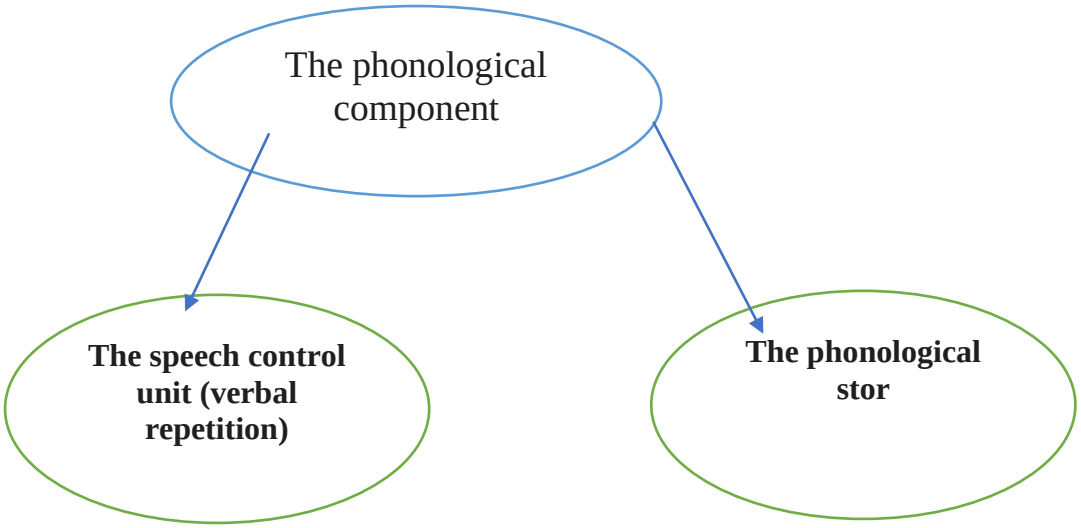


**Figure. 3.** Phonological components

**The speech Control Unit (verbal repetition).**

This system can store information by reciting it internally, and this component organizes the information in a temporal sequence, and it can be considered the inner voice.

Baddeley (1975) pointed out two phenomena that are essentially associated with the repetition component of the phonological loop, namely:

- ✓ The phenomenon of the verbal suppression effect, where current memory performance is impaired when subjects are asked to verbalize an element that is unrelated to the topic while performing a memory test.
- ✓ The effect of word length, where it was found that the ability to recall lists containing large-syllable words is impaired (Abdul-Wahid, 2001, p. 257).

**Phonological store**

And it stores information that depends on speech, where it receives the verbal information presented audibly and stores it in a morphological form, and the information is not stored except for a very limited period (1.5 seconds - 2 seconds). It can enter again and continuously through the mechanism of verbal repetition (Abdul-Wahid, 2001, p. 256).

- ❖ The visual-spatial component:

The visual-spatial system has received a lot of attention in recent years; because it plays a fundamental role in learning verbal material. Visual-verbal aids are one of the most effective ways to remember word lists, and words that can be imagined are easier

to remember than others. There has been some debate about whether the image is stored directly in the brain or whether it is created from abstractions. Proponents of the first view - who support the direct storage of the image in the brain - tend to look at the similarity between the process of perception and the process of reading information, and they have been largely successful (Al-Sayyid, 2014, p. 116).

As the name of the visual-spatial component suggests, it deals with visual-spatial information and can receive inputs either directly from the sense of sight or from retrieving information from long-term memory in the form of images. We use this component in our daily lives, for example when driving on an unfamiliar road and approaching a turn, and thinking about the shape of the road at this turn (Abu Al-Diyar, 2012: 35).

Another definition provided by Baddeley (2002). He defined the visual-spatial component as a system that has the ability to temporarily retain and process visual-spatial information and play an important role in spatial orientation and solving visual-spatial problems, either through sensation or through long-term memory (Abu Al-Diyar, 2012, p. 36).

The Visuospatial sketchpad (Visuospatial Skechpad) is the part responsible for storing visual information and spatial information for a short period of time, and it plays a major role in producing and processing mental imagery (Abdul Baqi, Muhammad Issa, 2010, p. 83).

**Baddeley's Updated Model (Baddeley2000)**

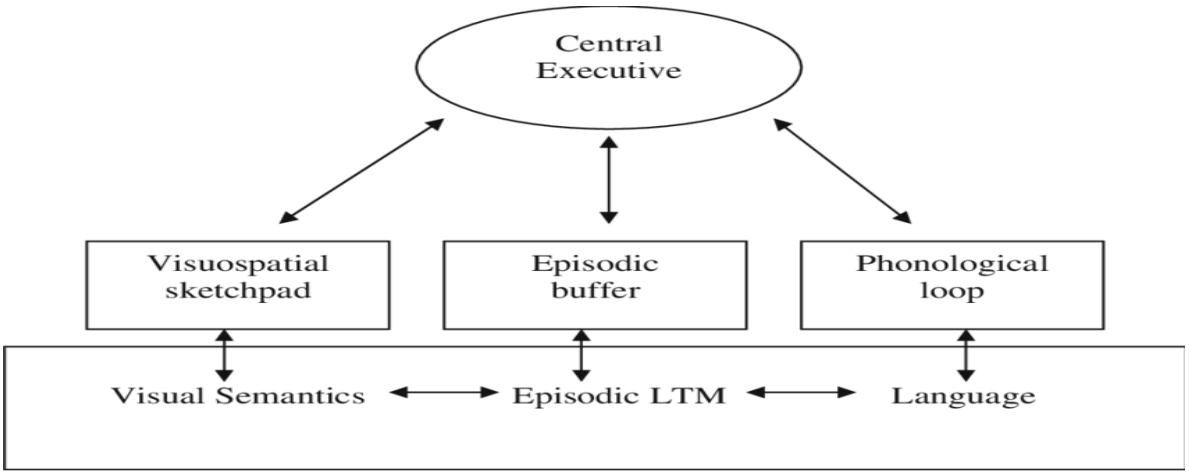


**Figure.4.**Baddely's Updated Model (Baddely' 2000)

In 2000, after the research conducted by Baddeley, he developed his previous model of working memory, which he had prepared in 1986 and consisted of the visual-spatial component, the verbal component, and the central executive, by adding a fourth component to the model called: the episodic buffer or the event buffer or the staging bridge.

Episodic buffer or event buffer:

The origins of this component go back to what Ericsson and Kintsch (1995) hypothesized as the need to add another mechanism that, from their point of view, contributes to explaining the enormous capacity of working memory in skilled

individuals. They found that some pianists can sing while reading sheet music without any interference, and that some individuals can perform spatial tracking tasks while performing mental or arithmetic operations. This led them to believe that there is a type of long-term working memory in addition to the well-known short-term working memory.

The episodic buffer is a multi-component coded storage system that assembles related events or scenes. It is both broad and limited, and it intervenes and links between multiple systems that use different codes. "Buffer" means that it activates multiple sources of information at once, which helps to create a clear model of the task and then process it. It also processes information from the twosubsystems and long-term memory (Wasif, 2017, p. 220).

Perhaps it is this function that led Baddeley to propose it as a fourth subcomponent of working memory, transforming the old three-component model into a new four-component model.

It is worth of noting that the new component differs from the old component in two ways:

The first difference is the existence of clear links between the two subsystems and long-term verbal and visual memory. There is a link between the phonological loop and language, i.e. the verbal aspect, and there is a similar link between the visuospatial sketchpad and visual meanings. The latter resulted from the periodic accumulation of non-verbal information with meaning, such as the color patterns of objects, or how a certain animal moves (Abu al-Diyar, 2012, p. 40).

The second difference is the episodic buffer. Baddeley added a fourth component to his tripartite model, and defined it as the staging bridge, temporary memory, or episodic memory.

The episodic buffer is considered to be the link between the subsystems and the central executive. Its task is to integrate information in working memory, whether from its verbal or visual component, and from information retrieved from long-term memory, into a coherent whole.Thus, the working memory model consists of four components that work together in integration and consistency (Baddeley, 2000).

## Criticisms of Baddeley's Model

The Baddeley and Hitch model of working memory has been influential in the field of psychology. And the sources of working memory were not only those identified by Baddeley and Hitch, but there are other sources that they did not address.

In their commentary on the Baddeley and Hitch model of working memory, Eysenck and Cohen argue that the model has rightly added to our understanding of memory. They argue that it is realistic to assume that working memory consists of a number of independent mechanisms for operation, rather than being a single short-term storage system. They also argue that it is more useful to treat attentional processes as part of the same system, as they are used together most of the time in everyday life.

Haberlandt (1997) points out that there is a body of research and studies that have been conducted on working memory other than the sources identified by Baddeley's "three components". **Procedural knowledge** is knowledge about how to do something. It is often stored in long-term memory, but it can be accessed by working memory when needed. For example, procedural knowledge would be used to ride a bike, play a piano, or type on a keyboard.**Abstract semantic information** is information about the meaning of words and concepts. It is stored in long-term memory, but it can be accessed by working memory when needed. For example, abstract semantic information would be used to understand a text, solve a math problem, or have a conversation.**Auditory**

**memory** is the ability to remember and recall sounds. For example, auditory memory would be used to remember a phone number, listen to music, or understand a conversation in a noisy environment(Abu Al-Diyar, 2012, p.33)

Despite the contributions of Baddeley and Hitch's original model in 1974, and despite the research and studies that Baddeley continued to conduct on the development and refinement of the original model, some reservations remain about this model. These reservations include the lack of information about the workings of working memory, as more research and study is needed to complete the picture of how working memory works, especially the central executive. However, this has not prevented many researchers from relying on the Baddeley and Hitch model in their research and studies.

As Richardson (1984) pointed out another issue, particularly regarding the executive system in the Baddeley model, where he mentioned that the way the executive system carries out various tasks bears a strong resemblance to the concept of short-term memory as a single system, thus this system did not offer anything new to the working memory. Moreover, Baddeley responded to Port's (1980) suggestion of renaming this part as the Central Allocation of Attention by stating that he had developed a strategy to understand working memory, based on identifying a larger number of specialized mechanisms for task execution (Saeed, 2014, p. 121).

This means that what is known about working memory in general and the executive system in particular still lacks a lot of analysis, investigation, and research to clarify the picture of the functions of working memory and its functions. Therefore, Eysenck described it as "the part called the executive system may represent the remaining unknown area, despite the fact that this main executive system has an effective and dangerous role in control activities, including attention, in addition to its control over storage and processing capabilities, and therefore its existence is necessary and important, otherwise things will turn into chaos and inability and deficiency in some cognitive processes and abilities.

## Conclusion

From all of the above, it can be claimed that working memory, with all of its components, still needs a lot of research and study to make it clearer in terms of its components: the auditory system, the visual-spatial system, and the relationship of working memory to other mental abilities.There is no doubt that through experimental studies, research, diagnostics, and comparison, we may be able to make progress in the field of improving the efficiency of working memory.Despite all of the criticisms of the Baddeley and Hitch model of working memory, we cannot deny the valuable contributions that have added much to the field of research and study in the field of cognitive psychology and neuropsychology with regard to working memory, and have opened the door for many scientists and researchers to research the field of memory.The Baddeley and Hitch model is also one of the models that differs from other models in that it has modified its vision of how working memory works. They conducted many studies and experiments to investigate the efficiency of activating, retaining, and processing information as a function of working memory before concluding that it is necessary to consider the short-term memory system as a separate system from the system and work of working memory.

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14- Baddeley went on to propose a number of other models, in an attempt to overcome some of the difficulties in understanding the original model**1986 (Anderson, 2000).**