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تشخيص ضعف الذاكرة العاملة في المرحلة ما قبل المدرسة

Diagnosing Working Memory Impairment in the Preschool Stage

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Abstract:

Memory, with its ability to store, process, and retrieve information, holds a central position among these functions. Among its various types- such as short-term memory, long-term memory, and semantic memory- working memory stands out as a crucial factor in the learning process. It represents the center of consciousness and the active processing point for information, playing a pivotal role in several complex mental processes such as comprehension, logical reasoning, and problem-solving.

Its scientific importance lies in distinguishing between typically developing children and those with specific learning difficulties, as the latter group shows a clear deficit in working memory. This deficiency negatively impacts their cognitive abilities, sustained attention, and acquisition of fundamental academic skills such as reading and arithmetic. Consequently, any impairment in working memory, as one of the key cognitive functions, can lead to evident learning disorders that directly and substantially affect a child's academic life and educational progress.

Key words: Working Memory Impairment, Preschool

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ملخص:

تحتل الذاكرة بقدرتها على تخزين المعلومات ومعالجتها واسترجاعها، مكانة محورية ضمن هذه الوظائف. ومن بين أنواعها المختلفة الذاكرة قصيرة المدى وطويلة المدى وذاكرة المعاني-تبرز الذاكرة العاملة كعامل حاسم في عملية التعلم. فهي تمثل مركز الوعي ونقطة المعالجة النشطة للمعلومات، وتلعب دوراً محورياً في عدد من العمليات العقلية المعقدة مثل الاستيعاب والتفكير المنطقي وحل المشكلات؛ وتمكن أهميتها العلمية من التمييز بين الأطفال العاديين وأولئك الذين يعانون من صعوبات تعلم محددة، حيث يظهر ضعف واضح في الذاكرة العاملة لديهم، مما ينعكس سلباً على قدراتهم في الإدراك والانتباه المستمر واكتساب المهارات الأكاديمية الأساسية مثل القراءة والحساب. وبالتالي، فإن أي خلل على مستوى الذاكرة العاملة، كأحد الوظائف المعرفية الرئيسية، قد يخلّف اضطرابات تعلمية واضحة تؤثر بشكل مباشر وجوهري على الحياة الأكاديمية للطفل وتقدمه الدراسي.

الكلمات المفتاحية: ضعف الذاكرة العاملة، مرحلة ما قبل المدرسة

1- Introduction:

Pre-academic skills refer to those behaviors that are crucial for a child before beginning formal education, such as recognizing letters, numbers, shapes, colors, and others. Typically developing children acquire these skills during early childhood. Numerous researchers have emphasized that cognitive processes, including attention, perception, memory, verbal language, thinking, and social interaction, are among the most fundamental requirements for the learning process. Any disruption in these processes undoubtedly impacts academic learning, as highlighted by many studies and research. These studies confirm that deficits and shortcomings in these skills result in lower academic achievement compared to children of the same age group. Many researchers have also noted that these deficiencies can be observed through noticeable gaps in their performance and behavior in kindergarten or at home when compared to their peers. Among the most prominent developmental difficulties that emerge during this stage—specifically early childhood or the preschool period (ages 3–5)—are deficits in memory. Children experiencing these difficulties struggle with reading words and are unable to name colors, pictures, numbers, and the like. Consequently, they require more practice and repetition to develop their learning abilities, unlike typically developing children, for whom processing

information requires less effort, allowing for easier reading and retention of information at a level surpassing that of children with learning difficulties (Al-Waqfi, 2012).

Moreover, they exhibit significant weaknesses in encoding and retrieving information, whether in long-term or short-term memory. They also face issues with motor memory, which affects learning skills such as dressing, undressing, tying shoelaces, rhythmic and writing movements, throwing a ball, using drawing tools, and others. Therefore, memory is a fundamental component of the learning process, and many children experience various memory-related problems. This is what our study will address, and its problem can be formulated as follows:

***How can weaknesses in working memory be détecte in Preschool children?**

2-Memory Definition

An individual's ability to record and recall an event is subject to multiple factors, with attention and alertness being the primary essential conditions. However, the storage or retrieval of information is closely linked to the accompanying psychological and emotional state. Thus, the processes of retaining and retrieving memories are significantly influenced by the deep-seated tendencies of the personality, along with conscious or unconscious motivations, which constitute the most prominent factor in shaping the mechanisms of remembering and forgetting (Cambier J. et al, 2008 , P 146)

3- Stages and Classifications of Memory :

3-1/Immediate Memory :

Also known as short-term memory, it results from temporary functional changes in neural circuits. It is studied through non-specific repetition of a series of numbers and letters (memory span) or by arranging objects according to a specific order (visual memory span).

3-2/Working Memory :

This is a specific concept within short-term memory, where its duration extends based on the amount of attentional effort required, involving the prefrontal cortex. It is recognized by maintaining information in memory for the necessary period to accomplish a specific task. Like immediate memory, it is studied without a fixed time limit, but by increasing the complexity of the task to avoid simple automatic repetition. For example, the subject may be asked to repeat or arrange items in reverse order.

3-3/ Long-Term Memory :

It results from lasting modifications in neural network function. It requires good encoding of information, facilitated by attention (the role of the prefrontal cortex), whether accompanied or not by an emotional context (the role of the limbic cortex). Subsequently, the consolidation of the memory trace is secured. When forgetting relates to long-term memory, it may result from the erasure of traces that were not reactivated through use, or from interference with other traces that confuse the information and limit retrieval capabilities.

3-4/ Explicit Memory :

Explicit memory encompasses both episodic memory and semantic memory.

**** Episodic Memory :**

This type of memory relates to an individual's personal experiences (memories). Recording and retaining these events depends on the context in which the individual lived, especially their emotional dimensions. Recalling these events can occur either through voluntary retrieval or spontaneously. When there is damage to episodic memory, older memories often appear more resilient than more recent ones.

****Semantic Memory :**

Semantic memory pertains to an individual's cultural depth and general knowledge about the world, living organisms, and objects. It encompasses historical knowledge regardless of the context in which it was acquired. The cerebral cortex plays a significant role in semantic memory, while the hippocampus and related structures are crucial for episodic memory.

04/ Memory Functions :

4-1/ Encoding :

We encode or translate incoming information into neural codes that the brain can process. (Mohamed Shalaby, 2008, p. 33)

4-2/ Storage :

This is the process through which information is encoded and retained over time in our minds, acting as an informational bank. The storage process is generally influenced by the effort we invest in encoding and organizing what we store.

4-3/ Retrieval :

This is the final step. The more effort we invest in preparing information for storage, the more efficient our retrieval becomes. (Mohamed Shalaby, 2008, pp. 15-17)

5/ Information Processing Theory of Memory:

This theory was proposed by Waugh and Norman in 1965, and further developed by Atkinson and Shiffrin in 1968. It posits that memory is a system composed of interconnected components; each called a store, capable of processing specific types of cognitive codes. These codes can transfer from one store to another through control processes. These stores differ in their capacity, duration of retention, and procedural characteristics.

One of these stores is known as the sensory register, which performs feature detection and pattern recognition, thereby quickly generating a cognitive code that can be briefly stored. The generation of this code in the sensory store occurs automatically, meaning that an individual does not need to pay attention to incoming stimuli for a code to form in the sensory register. The sensory register retains sensory stimuli in a raw form, meaning there is no clear encoding of the stored material. The information stored in the sensory register gradually fades and decays.

Therefore, the cognitive code must transfer to another component of the memory system called short-term store, which is somewhat more durable. Codes stored in the short-term store can transfer to long-term store, which holds our permanent memories and can retain information indefinitely. The process that allows the transfer of encoded material between these two stores is called the control process for reinforcement and rehearsal, which maintains the vitality of the code in the short-term store. In short-term storage, cognitive codes are organized based on phonetic or verbal characteristics, while in long-term storage, they are organized based on meaning. (Al-Miliji Helmy, 2000, p. 75)

06/ The Emergence and Development of Working Memory :

6-1/ : Roots and Foundation (Pre-1974) :

The idea originated from studies on short-term memory in the 1950s and 1960s (Brown, Peterson, Atkinson, and Shiffrin). Memory was viewed as two separate systems : short-term (temporary storage) and long-term (permanent storage). The term "working memory" first appeared in 1960 (Miller and Galanter).

6-2/ The Revolution : The Baddeley and Hitch Model (1974) :

Baddeley and Hitch introduced the pivotal model that completely changed the concept.They rejected the idea of a single store and proposed that working memory is an active, multicomponent processing system. The system consists of three components :

1. **The Central Exécutive** : A primary control device that directs attention and focus.

2**. The Phonological Loop** : Specialized in verbal and auditory information.
3. **The Visuo-Spatial Sketchpad** : Specialized in visual and spatial information.
*** They validated the model through dual-task experiments** :
The ability to perform two different tasks (verbal + visual) simultaneously, indicating the existence of independent subsystems.

6-3/ Subsequent Development and Expansion (Post-1974) :

The concept became more comprehensive to include :
Information processing (not Just storage).
- Organization of sequential information. · Retrieval of information from long-term memory.
- In the Work of Martina (1997), the dynamic nature of the system was emphasized.
- The term "working memory" replaced "short-term memory" to reflect the modern perspective.

Conclusion :
The Transition from the Old to the Modern Concept.
***The Old Concept** : Short-term memory = a passive, temporary store for information. ·
***The Modern Concept** : Working memory = an active, central cognitive system with multiple components that processes and temporarily stores information to support complex mental processes such as comprehension, reasoning, and problem-solving. (Mosaad Abu Al-Diyar, 2012, pp. 12-14)

07/ Concept of Working Memory :

Baddeley (1986) defines it as a limited-capacity processing resource that involves holding information while simultaneously processing other information, meaning maintaining some information while processing other information. (Amani Khafaji, 2005, p. 62)

08/ Features of Working Memory :

8-1/ Storage Capacity or Encoding Speed :

In 1975, researchers Buchanan, Thomson, and Baddeley found a strong correlation between memory span and the speed of reading visual units. Meanwhile, Nicolson (1982) observed that memory span increases with age but remains constant relative to reading pace. Thus, it is believed that the variation in memory span with age is due to the speed of encoding units into their verbal form. Memory span increases as stimuli take longer to recognize.

8-2/ Flexibility of Information in Working Memory :

The decay of stimuli does not vary by individual ; rather, what varies is the ability of rehearsal strategies to review information through mental repetition on one hand, and on the other hand, the nature of the encoding that occurred during the presentation of stimuli.

8-3/ Retrieval of Information from Working Memory :

****Sternberg's Experiment (1966):**

Tested the speed of recognizing a number within à list of numbers. He found that response time increased linearly with the number of items in the list, at a rate of 38 milliseconds per additional item. The comparison time remained constant regardless of the type of response (positive or negative), indicating that working memory scans all items at the same speed.

(Richard JF, 1990, pp. 37–38)

****Cavanaugh's Study (1972):**

Contradicted Sternberg's findings. It found that the scanning rate of items (which was constant at 38 milliseconds in Sternberg's study) varies depending on the type and characteristics of the information stored in memory.

Conclusion : **Sternberg's** experiment suggested a constant and rapid scanning process for information in working memory, while **Cavanaugh's** study indicated that this process may be more flexible and dependent on the nature of the information It self. (Anwar Muhammad Sharif, 1992, p. 51)

09/Baddeley's Revised Working Memory Model:

Among the most important models is Baddeley's revised model (2000), which consists of:

9-1/ The Visuospatial Sketchpad:

Baddeley(2000) defined it as a system with the capacity for the temporary retention and processing of visuospatial information, playing an important role in spatial orientation and in solving visuospatial problems, whether through perception or via long-term memory.

9-2/ The Phonological Loop:

This is a fundamental component of working memory,responsible for processing, storing, and retrieving verbal and auditory information. It consists of two main parts:

· The Articulatory Rehearsal Process: Recycles information to maintain it temporarily.

· The Phonological Store: Holds the acoustic characteristics of words. (Musa'ad Abu Al-Diyar, 2012, p. 37)

This component plays a crucial role in learning to read and write at an early age, as well as in language production and comprehension. Alongside the

visuospatial sketchpad, it forms a servant system that supports the operation of the central executive in working memory. (Dalia Badawi, 2005, p. 73)

9-3/ The Central Executive:

According to the model by Baddeley and Hitch,the central executive is a limited-capacity executive unit that acts as a "mental workshop" for the immediate processing and temporary storage of information. It performs the following core functions: selective focus on tasks and suppression of distractions, continuous updating of information in working memory, coordination of the activities of other components (like the phonological loop and visuospatial sketchpad), retrieval of information from long-term memory, and resource management during the execution of multiple simultaneous tasks.

In 2000, a new component was added to this model known as the Episodic Buffer.

9-4/ The Episodic Buffer Component:

According to (Baddeley, 2004), it is a limited-capacity system that integrates related events or scenes. It binds information from different sources (such as long-term memory and the slave systems), helping to form a clear and coherent picture of a situation for processing, then breaks it down into smaller units compatible with working memory capacity (Abu Al-Diyar, 2012, p. 40).

10/ The Basic Processes of Working Memory:

There are three stages of representation within working memory:

10-1/ The Encoding Stage:

This describes the process of inputting information into the memory system. There are two main types of encoding within working memory:

****Phonological Encoding**: Concerns the encoding of verbal information (numbers, letters, words) and keeping it active through rehearsal (repeating the item several times). The left hemisphere of the brain is primarily involved in encoding this verbal information.

Visual Encoding: Allows for the retention of verbal items in a visual form and is also used for non-verbal items (like pictures) that are difficult to describe and therefore difficult to rehearse phonologically. This type of encoding fades quickly. The right hemisphere of the brain is primarily involved in encoding spatial information.

10-2/ The Storage Stage:

This refers to the way information is represented in the memory systems.Storage capacity in working memory is very limited, averaging about 7 items, with a minimum of 5 and a maximum of 9 items.

10-3/ The Retrieval Stage:

This stage represents our ability to successfully recall information from memory. (Khafaji, 2005, p. 79)

It is the individual's ability to retrieve the information they have retained when needed, correctly and without any difficulties or errors.

11/ The Neural Basis of Working Memory:

Cognitive psychology scientists have faced few problems more enigmatic than the nature of the brain's memory structure. The study of human memory was initially subjected to a simplistic dualistic idea of structure and process. Many cognitive psychologists accepted the idea of a dual-natured memory structure, arguing for the existence of short-term memory and long-term memory. This view, consistent with the information processing perspective, gained widespread acceptance.

However, in recent years, opposing ideas about the nature of human memory have led many cognitive psychologists to doubt the validity of the dual-store memory model. Meanwhile, brain science research has focused for over a century on the necessity of finding specific brain regions associated with and corresponding to particular behavioral patterns. The significant results they reached ended up supporting the view of the brain's processes or partial functions.

After conducting experiments, researchers began to better understand the neural foundations that form the basis of working memory—the limited, short-term store for current relevant information we rely on when understanding a sentence, following a predetermined plan of action, or remembering a phone number. For example, when we recall the name of the Arab League's Secretary-General to our mind, this information is temporarily copied (retrieved) from long-term (remote) memory into working memory.

Psychological studies have shown that working memory is essential for human capacity for thinking, persuasion, judgment, and problem-solving. It is believed that schizophrenia, one of the most devastating mental illnesses, stems partly from a defect in the working memory system.

There are three areas in the brain that play an important role in memory function: the temporal lobe, the mammillary bodies, and the region around the third ventricle and the limbic system. These areas are interconnected and help imprint events in the mind for later recall. However, they are not the sole stores of memory, as evidenced by a person retaining memories of distant events even when these areas are damaged.

Modern scientific studies indicate that chemical changes occur in brain cells, helping to consolidate and imprint memory in the imagination. This leads us to mention what is known as the memory trace or engram, referring to the change that occurs within brain cells as a result of learning a new experience or acquiring a skill, enabling its subsequent recall.

There are three mechanisms that contribute to memory formation: one serves the immediate memory for events of the present moment, another serves memory for events that occurred minutes or hours ago, and a third serves memory for the distant past. Memory for recent events is often weakened or completely lost in people with neurological diseases, but memory for distant events resists these diseases and remains intact even in the presence of severe brain damage. It has been observed that stimulating certain parts of the temporal lobe in patients with temporal lobe epilepsy leads to the detailed recall of events from the distant past, surpassing the capacity of voluntary recall.

Scientific studies and experiments have proven that memory is stored within brain cells in the form of biochemical changes accompanied by molecular changes in the proteins of those cells. (Musa'ad Abu Al-Diyar, 2012, pp. 102-104)

12/ Methods of Measuring Working Memory:

Recall in working memory is studied with the help of the Brown-Peterson task. In this task, the subject must either recall as many items as they can in any order they wish—this is called a free recall task—or recall the items in the same order in which they were presented—this is called a serial recall task, which is considered the most difficult type.

12-1/ Free Recall:

In an experiment,a series of words is presented (about one word per second). Upon hearing the last word in the series, the person must repeat all the words they can remember in any order they wish. The examiner then calculates the percentage of words recalled by the subject relative to each word's position in the presented list. This yields a U-shaped curve known as the serial position curve. Through this curve, two important effects become apparent: the Recency Effect and the Primacy Effect, as follows:

*** The Recency Effect:**

The right leg of the U-shaped curve results from the good retention of the last words presented. This is called the Recency Effect. It is characterized by high sensitivity, as it disappears completely after a short delay. Typically, recall of the last word is 100% and 90% for the one before it, but after a few

minutes, recall drops to only about 10%. This effect is usually large when stimuli are presented auditorily.

***The Primacy Effect:**

The left leg of the serial position curve is incomplete, resulting from the retention of the first words. Usually, the middle items in the series are remembered less well than items at the beginning or end of the series. Also, beginning items are remembered less well than ending items. This explains that subjects do not store the items in the same type of memory. The beginning items are transferred to long-term memory and then retrieved at the time of recall, while the items at the end of the series are retrieved from working memory. (Ben Safia Amal, 2002, p. 61)

12-2/ Recall in a Dual-Task Situation:

ResearcherLetterman conducted an experiment based on presenting three similar letters either visually, auditorily, or both. The subject is asked to continuously repeat the numbers from 1 to 9 without stopping and in the same order (the subject performs two tasks simultaneously). The subject cannot engage in the automatic vocal rehearsal of the letters (because they are continuously counting). Therefore, any difference observed in recall between auditory and visual presentation reveals the effective difference between retaining auditory and visual information without the interference of the rehearsal effect.

Initially, the effect of auditory memory is more effective, but it disappears completely after a short period. This leads us to say that a surplus of information (about 20%) goes to short-term memory in an auditory form that fades quickly (3 to 11 seconds). However, despite 11 seconds passing, the person still retains some information (50%), which is explained by its transfer to long-term memory. (Ben Safia Amal, 2002, p. 62)

Conclusion:

Memory is considered one of the crucial cognitive functions responsible for a significant portion of the knowledge and skills an individual retains through their experiences. It has multiple types, each with its own unique characteristics. Among these, working memory is specifically highlighted, as it is responsible for holding, processing, and retrieving information over short periods. This ability is instrumental in helping an individual acquire foundational educational skills such as reading, writing, and arithmetic. Accordingly, we can derive a set of guidelines and solutions to assist families and educators in supporting the group of children who experience weaknesses or impairments in working memory, specifically kindergarten-

aged children. These recommendations are outlined in the following points :

Parental Engagement :

Parents should focus on their child from an early age by encouraging speech through baby talk, imitation, describing and naming objects while pointing to them, and using various symbolic gestures and signs. This approach helps the child build à broad range of concepts, develop their receptive language skills, and accumulate a linguistic repertoire that enables them to form sentences and short narratives.

***Family Involvement in Thérapies :**

It is essential to involve the family in the therapeutic process through family counseling sessions. This ensures coordination between the speech therapist, psychologist, educator, and the institution where the child is enrolled regarding the treatment plan. Such alignment between home-based interventions and the therapeutic setting facilitates a more streamlined, effective, and faster recovery process.

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