MAR Neurology, Neurosurgery & Psychology (2025) 8:6

Research Article

The Neuropsychological Characteristics among Pregnant Women Compared with Non-Pregnant Women

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Received: 04 Jan 2025

Published: 17 Jan 2025

DOI: https://doi.org/10.5281/zenodo.14676621

Abstract

The study aims to reveal the neuropsychological characteristics of pregnant women compared to non-pregnant women and investigate if the number of pregnancies affects these characteristics. The sample included (86) women (46 pregnant women and 40 non-pregnant women) selected from the hospitals and health centres of Nazareth and northern Palestine. Tower of London test, Executive Functions index, Digit Span and Arithmetic tests of the Wechsler Adult Intelligence Scale were administered. The results showed that the non-pregnant women outperformed the pregnant women in problem-solving, executive functions, working memory, and short-term auditory memory. It also showed that first-pregnancy women outperformed second- and third-pregnancy women in terms of neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory).

Keywords: *Neuropsychological characteristics, pregnant women, non-pregnant women, number of pregnancies.*

Introduction

During pregnancy and after giving birth, many women experience cognitive changes called "pregnancy brain". The most common symptoms women experience during these times are oblivion, memory disorders, and poor concentration (Henry & Sherwin, 2012). Rendell and Henry (2008) pointed out that many changes in cognitive function occur throughout pregnancy and after giving birth, but it is unclear when they happen. For instance, it has been noted that pregnant women exhibit reduced cognitive function throughout pregnancy and after giving birth.

According to Basinger and Hogg (2021), a woman's brain changes faster throughout pregnancy and after giving birth than at any other period in her life, including adulthood. Additionally, Erickson and his colleagues (2010) noted that the morphological changes in a pregnant woman's brain are brought on by changes in hormone secretion in the endocrine glands. These morphological changes are caused by the lack of grey matter in the brain, as Hoekzema and his colleagues (2020) stated. Hoekzema and his colleagues (2017) also draw attention to the point that, regardless of the number of pregnancies, all pregnant women experience a decrease in brain size during pregnancy and an increase after giving birth and that these brain changes are consistent in all pregnant women despite the number of pregnancies, which return (may return) to normal after birth within

a specific period of time. Some researchers, such as Oatridg and his colleagues (2017), believe that while women lose some of the grey matter during pregnancy, their brains become more efficient, and their sense of attachment to their children strengthens during pregnancy.

The neuropsychological changes a pregnant woman experiences -especially in her first pregnancy- help her develop a new lifestyle that will enable her to provide love, protection, care, and support for her newborn child (Basinger & Hogg, 2021). As Erickson and his colleagues (2010) stated, these changes may enable the pregnant woman to succeed in the pregnancy journey and take care of her baby. While in the second pregnancy, there is no consistent consensus on whether the neuropsychological symptoms from the second pregnancy are different from those from the first because they may be the same, and the brain structure may be the same. Still, the emotions and anger differ between the experiences of multiple pregnancies (Martínez-García & Paternina, 2021). The body usually returns to normal a year after giving birth since the neuropsychological changes that occur during pregnancy are related to the time of pregnancy and childbirth (Oatridget al., 2017).

Based on the above, it is shown that pregnancy is associated with various neuropsychological characteristics that affect the woman's brain functions, memory, and changes in behaviour and temper. These characteristics could be similar between first-pregnancy and multiple-pregnancy women. However, their effect on the psychological state, daily behaviours and cognitive functions may differ depending on multiple pregnancy experiences. As stated earlier, some researchers pointed out that the neuropsychological characteristics of the pregnant woman end after the first year of birth. Thus, the current study complements researchers' works in revealing the neuropsychological characteristics of a sample of pregnant women in light of pregnancy order compared with non-pregnant women.

Neuropsychological Characteristics

Neuropsychological assessment is a more accurate and objective diagnosis method to evaluate the higher levels of brain function performance. Recent developments in neuropsychological assessment have emerged through a technique that combines traditional neurological observation with modern empiricism in neuropsychology. This led to developing and designing battery tests with extreme sensitivity to nervous disorders (Reitan & Wolfson, 2004).

The goal behind neuropsychological diagnosis is to develop neuropsychological tests, batteries, and scales that measure the memory's different performances, cognitive and executive functions, and levels of thinking (Ryana, Umfleet, Kreinera, Fullera & Paoloc, 2018).

Wechsler Intelligence Scale is one of the most used tests in neuropsychological assessment. Some of Wechsler's scales were the basis of the Halstead-Reitan Battery. Moreover, the Wechsler Scales were employed in most research focused on neurocognitive performance, and they were the most used in neuropsychological assessment (Ceci & Williams, 2010). The most essential neuropsychological characteristics that can be examined in a pregnant woman are:

Problem- Solving

When Thorndike started his cat-based investigations, the interest in problem-solving in psychology began. Then, Kohler carried out his research on chimpanzees. These investigations led to the development of problem-solving based on the learning theory of "Trial and Error". After the cognitive theory was presented, the focus on problem-solving shifted to exploration, information processing, and problem-solving strategies. Then, the brainstorming approach emerged in problem-solving (Jarwan, 2007). Sternberg (2003) believes that problem-solving ability is a process the individual uses to overcome barriers to a goal or solution. Solso (2004) indicated that problem-solving involves thinking about a specific problem, including generating possible solutions and selecting one.

The "Tower of London" test is one of the most significant neuropsychological tests to measure the ability to problem-solve and plan, both of which are executive functions that indicate the ability to complete essential actions toward achieving a goal. The "Tower of London" test is an executive task used in the first place to assess the ability to plan to get to the right solution according to the time needed to find the right one. It was developed by Shallice (1982) as a modified version of "Hanoi Tower". The test involves five wooden rings and three columns of different lengths. The participant must move the rings on the columns from the initial to the final position using as few movements as possible. The test's rings, which are of different sizes, are arranged in a single column, starting with the largest size at the bottom and moving up to the smallest size at the top. The participant must move all the wooden rings from the first column to the third one according to a series of rules: Rings can only be moved one at a time; they must be moved in a sequence of size, with the larger ring moving before the smaller one. Two scores are chosen: the number of movements and the time (Güngor et al., 2020; Michalec et al., 2017; Macallistera et al., 2018).

Executive Functions

Executive functions help the individual self-regulate by organising and integrating the results of knowledge

processes over time, regulating the individual's behaviour, and delaying gratification to achieve long-term goals (Rose et al., 2012). Barkley (2012) defines executive functions as self-oriented actions by self-regulation used to select goals and direct the actions toward these goals with the participation of others or by using social and cultural means. It also refers to a group of general-purpose control mechanisms frequently associated with the brain's prefrontal cortex, which organises cognitive processes.

Furthermore, executive functions are allocated in the prefrontal cortex of the brain. They perform complex cognitive processes that require integration and organisation, which happens through the activity of the cerebral cortex of the prefrontal lobes, the limbic system, and the cerebellum (Ball, 2022).

Three domains are identified by Sullivan, Davis, and Koh (2022) for executive functions, namely:

- **Working memory**: this refers to the individual's ability to process information and data in the memory using a variety of strategies such as coding, replacing obsolete information with new and relevant information for the current task, mental calculation, translating instructions into action plans, and incorporating new information into current thinking (Benedek et al., 2014).
- **Shifting**, also known as switching or cognitive flexibility, refers to the individual's ability to shift between two or more cognitive tasks or mental groups. Shifting includes disengagement from mental activity that has become irrelevant to new mental activity. It helps individuals to think creatively and consider ideas from multiple points of view. Such things are necessary for the individual to handle unexpected conflicts and transition to new practices (Obeso et al., 2013).
- **Inhibition**, also known as "attention control, " refers to the deliberate and monitored suppression of unwanted responses. This enables individuals to selectively focus on their choices by suppressing attention to external stimuli or unwanted ideas (Diamond, 2013).

Besides, executive functions describe the procedures that interfere with some essential activities in the individual's life. It also includes a set of processes and subcomponents among them:

- Planning: This is a rational perception to complete a future goal, and the ability to develop a plan includes selecting the appropriate goals and sub-goals and executing them effectively (Pellicano, 2010).
- Working memory is a set of cognitive procedures responsible for saving and storing information until a complex cognitive function is performed (Myers & Derakshan, 2015).
- Mental flexibility: The ability to move and transform from one idea to another or another action in response to attitude changes (Oates & Grayson, 2004).

- Self-control: An individual's ability to monitor his thoughts and actions and self-correct these thoughts and actions (Drayer, 2008).
- Response inhibition is where individuals can desist and prevent inappropriate responses, information, and overlapping motives. Desisting is a value for keeping goals in mind and identifying action priorities.
- Shifting: For the individual to move flexibly and freely from one situation or activity to another in light of the situation's needs and solve the problems flexibly.

Henry and Sherwin (2012) stated that during pregnancy, in some cases, memory deficits and cognitive functions may be acquired, while Pieters and his colleagues (2021) did not find any differences between pregnant and non-pregnant women in the cognitive functions such as restoration, and working memory. Thus, there are no consistent results regarding the impact of pregnancy on executive functions.

Short-Term Auditory Memory

Short-term auditory memory is also called initial or active memory. It stores part of the information (Memory parts) for a relatively short period, reaching (30) seconds. This memory temporarily stores sensory, auditory, or visual information. The preservation process is done through a verbal, visual, or audio cognitive pattern without the imagination to select meaningful information (Akash, 2019). Usually, the duration of the information in this memory is a few seconds, and when it gets processed, it moves to the long-term memory (Baddeley, 2012). Al-Atoum (2004) pointed out that short-term memory is located between the sensory memory and long-term memory, where it receives the information through the sensory memory, noting that the data stays for very few seconds; for that reason, it is called short memory.

The distinctive feature of short-term memory is calling information and recognising it (Often sequentially) without any relative processing. On the other hand, working memory focuses on processing, which relies on the processes related to attention and goal implementation. Therefore, assessments designed to measure short-term and working memory share some features, such as temporary information processing. However, the tests of working memory include additional essential requirements, such as processing information while briefly retained (Murraya et al., 2018).

Working Memory

Working memory is one of the concepts of cognitive psychology, as it explains cognitive functions (Davis, 2011). It is the ability to retain information while processing it (Duff & Logie, 2001). Joidei and Nee (2006) cited that working memory is an important cognitive ability that contributes to higher cognitive functions since

it enters into some higher skills such as reading comprehension, reasoning training, and problem-solving. Working memory also describes an individual's capacity to analyse incoming information via senses, processing and reviewing it and replacing the old information with a new one related to the current task. Understanding events that take place over time necessitates working memory since it needs to relate what has already occurred to what will happen next, as well as mental calculations, ordering the elements mentally, translating instructions into action plans, and integrating the new information into the current thinking (Sullivan, Davis & Koh, 2022). Jarrold and Rowse (2006) also mentioned that working memory differs from short-term memory in that it uses information and integrates it to accomplish a particular cognitive goal.

According to Henry and Sherwin (2012), a woman's physiological and neurotic alterations during her first pregnancy differ from those she experiences during her second or third pregnancies. These differences are thought to be related to the number of pregnancies a woman has had. Compared to women who had numerous pregnancies, these changes were related to first-time moms having worse short-term memory.

The Baddeley model is considered one of the first developed models to measure the working memory capacity in 1974, and it was redeveloped in 2000. The model contains three memory systems (phonological awareness, spatial-visual memory, and main memory) and the core operational processes regulating attention and information processing (Baddeley, 2000). After that, a number of models were developed to assess individuals' working memory capacity, including the scale of Daneman and Carpenter (1980), which requires the individual to recall a group of sentences in the same order they were given to him and Turner and Engle (1989) scale which depends more on mathematical tasks than sentence-related tasks.

Previous Studies

Henry and Rendell (2007) analysed a group of articles and research (n = 14) on the subject from 1991 to 2007 to define the impact of pregnancy on memory functions. The findings demonstrated that pregnant women perform poorly on memory tests, particularly tests that significantly demand selective executive cognitive control. The same specific deficits associated with pregnancy are also observed postpartum.

To compare neuropsychological characteristics among pregnant women who continue smoking, quit smoking and never smoke, Güngor, Budak, Güngor and Taymur (2020) selected a sample of (15) pregnant women who quit smoking, (28) pregnant women who never smoked, and (18) non-pregnant women. They were asked to respond to the Barratt Impulsivity Scale, Tower of London Task, and Executive Function Tests. Then, the severity of nicotine addiction was assessed using the Fagerstrom Test. Non-planning impulsiveness was higher among pregnant women who smoke and quit smoking than non-pregnant women who smoke and non-

pregnant women. The percentage of the variance explained by non-planning impulsivity in quitting smoking was 10%. Pregnant women who never smoke performed better on the problem-solving test (Tower of London Task) than pregnant women who smoke, and non-pregnant women performed better than pregnant women who smoke and non-smoking pregnant women on the Tower of London Task.

In the Netherlands, Pieters and her colleagues (2021) examined the changes in the working memory of pregnant women during pregnancy and after pregnancy compared with their husbands. Seventy-five pregnant women and forty-four husbands were selected. Kirchner's working memory scale (1958) was employed for data collection. No changes were found in the levels of the working memory of women during pregnancy and after pregnancy; this indicates the constant level of working memory in both cases and that there are no statistically significant differences in the working memory test results between males and females.

Begum and Reza (2021) attempted to investigate executive and auditory cognitive functions among pregnant and non-pregnant women. The study sample consisted of (15) non-pregnant women, (12) pregnant women in the 2nd trimester of pregnancy, and (12) pregnant women in the 3rd trimester of pregnancy. They use the Wisconsin test for executive functions, Zazzo's Cancellation Test (visuospatial perception test including selective attention and response speed to particular tasks), the Ravlt test for working memory, and the Beck Depression Inventory. The results found that the pregnancy groups performed better in attention, memory, working memory, and executive functions. The pregnant women in the 2nd trimester of pregnancy had better auditory cognitive function than pregnant women in the 3rd trimester of pregnancy due to hormonal changes, which may have a positive effect during pregnancy. Even though pregnant women in the 3rd trimester of pregnancy have mild cognitive weakness, it does not affect their daily life.

By reviewing the previous studies, it can be noted that they had different goals and addressed some of the neuropsychological characteristics of pregnant and non-pregnant women. It seems no research addresses the neuropsychological characteristics that the current study covered (problem-solving, executive functions, short-term auditory memory, working memory) among pregnant women compared with non-pregnant women and comparing these characteristics according to pregnancy order.

The Problem of the Study

Pregnancy-related physical and hormonal changes may result in many changes in the central nervous system, impacting the brain's executive functions (Hoepfiner et al., 2019). It also affects working memory (Pieters et al., 2021). This is because pregnancy is associated with morphological brain changes and neuropsychological characteristics, as pointed out by Hoepfiner (2015). The current study aims to identify pregnant women who

exhibit this.

By examining the previous studies, the pregnancy order was not considered in studies that addressed neuropsychological characteristics among pregnant women. Therefore, the current study sought to explore some of the neuropsychological characteristics, including problem-solving, executive functions, working memory, and short-term auditory memory among pregnant women, pregnancy order (first, second, third) compared to non-pregnant women by answering the following questions:

1. Are there any significant differences in the level of neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) of pregnant women compared to non-pregnant women?
2. Are there any significant differences in the level of neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) of pregnant women related to pregnancy order (first, second and third)?

Significance of the Study

In addition to hormonal changes that impact the central nervous system, the experience of pregnancy causes changes in the size and function of the brain, making this study of great importance. The study's theoretical significance is derived from the academic information it offers related to the neuropsychological characteristics of pregnant women and pregnancy order compared to non-pregnant women. Researchers and clinical psychologists will benefit from this addition to the Clinical Psychology Library.

As for the practical significance, it offers descriptive results regarding the neuropsychological characteristics of pregnant women and pregnancy order compared to non-pregnant women. This provides objective descriptive indications of the study population, which helps researchers and those interested in the field in assisting this group of women in dealing with the neuropsychological characteristics and changes during pregnancy.

Definitions

Problem-solving: A focused way of thinking to solve a specific problem. It entails creating alternatives and selecting possible alternatives (Solso, 2004). This study defines it as the score on the Tower of London Test (a problem-solving test).

Executive functions are maintaining a proper problem-solving orientation to define a future goal. This orientation involves strategic planning, controlling emotions, structured search, thinking resilience, and

changing actions. These cognitive components describe oriented actions toward the goal and future (Welsh et al., 1991). This study defines it as the score on the Executive Functions index developed by Spinella (2005).

Working memory: The ability to retain information while processing it (Duff & Logie, 2001). Baddeley (2003) defines it as a comprehensive system for data and information processing that works on unifying long-term and short-term memory functions. This study defines working memory as the score on the Arithmetic test of the Wechsler Adult Intelligence Scale (Wechsler, 1955).

Short-term auditory memory: A temporary station to store sensory, auditory, or visual information. The preservation process is done through a verbal, visual, or audio cognitive pattern without the imagination to select meaningful information (Akash, 2019). This study defines it as the Digit Span score of the Wechsler Adult Intelligence Scale (Wechsler, 1955).

Methods and Procedures

Design of the Study

This study adapts the descriptive comparative approach to reveal the neuropsychological characteristics among pregnant women compared with non-pregnant women.

Sample of the Study

The sample included (86) women selected using a convenient sampling method; among them (46) pregnant women from the hospitals of Nazareth (Nazareth Hospital EMMS, French Hospital, Holy Family Hospital and health centres of northern Palestine, and (40) non-pregnant women from Nazareth and north Palestine in 2022. Table (1) shows the variables of the study sample.

Table 1: The distribution of the study sample in light of pregnancy status and pregnancy order

Variable	Category	Number	%
Pregnancy Status	Pregnant	46	53.5%
	Non-Pregnant	40	46.5%
Pregnancy Order	First Pregnancy	15	32.6%
	Second Pregnancy	14	30.4%
	Third Pregnancy	17	37.0%
Sum		46	100%

Instruments of the Study

First: Tower of London

The Tower of London test assessed problem-solving, planning and changing strategies (Korkman, Kirk & Kemp, 2003). It is part of a neuropsychological assessment battery that involves five wooden rings (disks) and three columns of the same length. The examen person is asked to move the five disks from the first rod to the third one according to the following rules: Only one disk can be moved at a time, larger disks cannot be placed on top of smaller disks, only one hand is allowed to be used, only the top disk can be moved to another stack or an empty rod.

Each participant has two scores: the number of movements the participant performs to reach the right solution and the time needed to get the right solution.

Second, the Executive Function Index (EFI) was developed by Spinella (2005). The EFI is used to assess the brain's prefrontal cortex functions. It is self-rated and includes (27) items, and this index has five factors: Empathy (six items), which measures the ability to engage in positive social behaviours and care for and assist others; Strategic Planning (seven items), which measures the ability to forecast, plan, and employ thinking strategies; Organisation (five items) which measures the ability to plan multi-tasking behaviours to achieve a specific goal; Impulse Control (five items) which measures one's capacity for self-control or restraint when engaging in risky social behaviours; and Motivational Drive (four items) which measures one's motivation level to engage in any behavioural task. The EFI was translated into Arabic by Zaynoun and Shoqeirat (2019).

Validity and Reliability

The correlation coefficient between the item, its factor and overall score range (0.69-0.75), and test-retest reliability was (0.57) (Zaynoun and Shoqeirat, 2019).

Scoring

The index items are scored on a Likert scale of 1 to 5, with five being strongly agreed, four being agreed, three being neutral, two being disagreed, and one being strongly disagreed; these values were reversed for the negatively formed items. The higher the score on the index, the better the executive functions. The index's overall score range (27-135).

Wechsler Adult Intelligence Scale: Digit Span and Arithmetic Subtests

Auditory short-term and working memory were assessed using the Digit Span and Arthmet tests of the Wechsler Adult Intelligence Scale. These tests were chosen based on the theoretical and conceptual basis and

reviewed literature. The two subtests were administered according to the scale's manual (Wechsler, 1955).

Results of the Study

Results of the first question: "Are there significant differences in neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) of pregnant women compared to non-pregnant women?"

A t-test was used to reveal the significant differences in the neuropsychological characteristics of pregnant women compared to non-pregnant women. Table (2) shows the results.

Table (2)

Results of the t-test for the differences in the level of neuropsychological characteristics of pregnant women compared to non-pregnant women

Neuropsychological characteristics	Test	Pregnancy Status	No.	Mean	Std. Devi.	t	df	Sig.
Problem-Solving	Number of Movements	Pregnant	46	132.30	34.295	2.528	84	0.013 *
		Non-Pregnant	40	114.15	31.919			
	Time	Pregnant	46	11.0298	3.14775	60.076	84	0.000 *
		Non-Pregnant	40	7.2213	2.58310			
Executive Functions	Executive Functions Index	Pregnant	46	87.07	11.887	-2.606	84	0.011 *
		Non-Pregnant	40	94.00	12.782			
Short-Term Auditory Memory	Digit Span test	Pregnant	46	4.96	0.788	-5.410	84	0.000 *
		Non-Pregnant	40	5.85	0.736			
Working Memory	Arithmetic test	Pregnant	46	10.20	1.572	-.0728	84	0.000 *
		Non-Pregnant	40	11.55	1.797			

*** Significant at (α = 0.05)**

The results from Table (2) showed the following results:

- Significant differences exist in problem-solving test (Tower of London), the number of moves to reach the right solution, and the time needed to get the right solution in favour of non-pregnant women.
- Significant differences exist in executive functions (Total score) favouring non-pregnant women.
- There are statistically significant differences in the short-term auditory memory (Digit Span test) favouring non-pregnant women.
- There are statistically significant differences in the working memory (Arithmetic test) favouring non-pregnant women.

According to the results, pregnant women have lower problem-solving abilities than non-pregnant women. Pregnant women need more moves and a longer time to come up with the proper solution. During pregnancy, a different stage in the woman's cognitive and physical life can lead to changes in her body and brain, affecting many of her mental processes and executive functions. Therefore, the morphological changes in the pregnant woman's brain decrease her problem-solving ability. Different studies, including those by Buckwalter and his colleagues (1999) and De Groot and his colleagues (2006), indicated the existence of a persistent weakness in the verbal memory of pregnant women during pregnancy and for over 32 weeks after giving birth.

Additionally, the results of some studies (e.g. Silber et al., 2019; Glynn, 2010) found a decrease in the levels of learning, the proper learning methods, problem-solving, and memory tests during pregnancy and in the postpartum period. When women were asked to remember pairs of syllables, they performed poorly during pregnancy and for over 12 weeks postpartum. However, this is no longer the case after 12 months after childbirth, where improvement in learning and problem-solving has emerged. This indicates a disparity between pregnant and non-pregnant women regarding cognitive functions, proper learning methods, and memory tests. This explanation is confirmed by Brunton and Russell (2008), who pointed out that pregnancy affects the brain. Erickson and his colleagues (2010) mentioned that hormone secretion changes in the endocrine glands lead to morphological changes in the pregnant woman's brain. Moreover, Hoekzema and his colleagues (2020) stated that morphological changes appear in the lack of grey matter in the brain.

The findings agree with Güngor and his colleagues (2020), who found that non-pregnant women performed better on the Tower of London Test than pregnant women who smoke and those who don't. Gupta (2021) also found that first-time mothers had little grey matter in their cerebral cortex, which impacted brain functions for at least two years.

The results found that pregnant women have low levels of executive functions compared with non-pregnant

women, meaning that pregnancy affects the executive functions of the pregnant woman. Ben-Jonathan and Hnasko (2001) claim that hormonal levels fall during pregnancy, which may impact pregnant women's brain's executive functions. According to Güngor and his colleagues (2020), there are no consistent results regarding the effect of pregnancy on executive functions, where some studies indicated the absence of differences between pregnant and non-pregnant women on the tests of memory, cognitive functions, and executive functions. The results differ from the one provided by Begum and Reza (2021), which showed a better performance among pregnant women on working memory and executive functions than non-pregnant women. Results also pointed out that the performance of non-pregnant women on the test of short-term auditory memory was better than that of pregnant women, meaning that pregnant women have difficulties with short-term auditory memory compared to non-pregnant women. This may suggest that frontal lobe functions in pregnant women may have been affected (See the fourth point below). This supports the explanation provided by Basinger and Hogg (2021), who claimed that a woman's brain changes faster during pregnancy and in the postpartum period than at any other time in her life, which has an impact on the various brain functions, including attention and memory (long-term memory, short-term memory). Some studies, including the studies of Crawley and his colleagues (2003), Harris and his colleagues (1996), and Keenan and his colleagues (1998), indicated that pregnant women face difficulties in coding and recalling verbal information. The results suggest that pregnant women have lower attention than non-pregnant women since the short-term auditory memory test depends on attention.

Furthermore, it was found that pregnant women's working memory is less functional than that of non-pregnant women. Pregnant women perform less well than non-pregnant women in working memory tests since their memories may process information more slowly. De Groot and his colleagues (2006) believe there is a clear difference between the memory performance of pregnant and non-pregnant women. This can be attributed to the complex hormonal changes, as Brett and Baxendale (2001) indicated, which occur during pregnancy and childbirth. According to Shetty and Pathak (2002), the reasons behind the changes can be attributed to the plasma neurotransmitters of pregnant women, while Lurie and his colleagues (2005) contend that the changes in the life span of red blood cells in pregnant women are the cause. Rendell and Henry (2008) and Crawley and his colleagues (2003) postulate that the pregnant woman's mood swings and lifestyle are the reasons behind that. This aligns with Pieters and his colleagues' (2021) explanation, who noted that pregnancy is associated with a decline in working memory, which can be related to the intense hormonal changes during pregnancy. These declines extend to the postpartum period and may be exacerbated by night insomnia and hormonal changes.

Results of question two: "Are there significant differences in the level of neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) between pregnancy orders (first, second, third)?"

One-way ANOVA was used to reveal if there are significant differences in the neuropsychological characteristics between pregnancy orders. The results are shown in Table (3).

Table 3: Results of One-Way ANOVA for the level of Neuropsychological characteristics of Pregnancy order

Neuropsychological characteristics	Test	Change Level	Sum of Squares	df	Mean of Squares	F	Sig.
Problem-Solving	Number of Movements	Between groups	8671.821	2	4335.910	4.213	0.021*
		Within groups	44253.918	43	1029.161		
		Sum	52925.739	45			
	Time	Between groups	68.027	2	34.013	3.871	0.028*
		Within groups	377.848	43	8.787		
		Sum	445.875	45			
Executive Functions	Executive Functions Index	Between groups	4382.740	2	2191.370	47.685	0.000*
		Within groups	1976.064	43	45.955		
		Sum	6358.804	45			
Short-Term Auditory Memory	Numbers Recall	Between groups	15.050	2	7.525	25.156	0.000*
		Within groups	12.863	43	0.299		
		Sum	27.913	45			

Working Memory	Arithmetic Test	Between groups	70.654	2	35.327	37.429	0.000*
		Within groups	40.585	43	0.944		
		Sum	111.239	45			

*** Significant at (α = 0.05)**

It can be noted from Table (3) that there are significant differences at (α = 0.05) in the neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) of pregnant women between pregnancy orders (First, second and third). The Scheffe test was used to decide the direction of the differences between pregnancy orders. The results are presented in Table (4).

Table 4: Results of Scheffe test of the differences in Neuropsychological characteristics between pregnancy order

Neuropsychological characteristics	**Test**	**Change Level**	**Mean**	**First Pregnancy**	**Second Pregnancy**	**Third Pregnancy**
Problem-Solving	Number of Movements	First Pregnancy	118.47			
		Second Pregnancy	125.86	7.390		
		Third Pregnancy	149.82	31.357*	23.966	
	Time	First Pregnancy	9.3927			
		Second Pregnancy	11.2493	1.85662		
		Third Pregnancy	12.2935	2.90086*	1.4424	
Executive Functions	Executive Functions	First Pregnancy	98.80			

	Index	Second Pregnancy	88.57	10.229*	
		Third Pregnancy	75.47	23.329*	13.101*
Short-Term Auditory Memory	Digit Span test	First Pregnancy	5.67		
		Second Pregnancy	5.00	1.310*	
		Third Pregnancy	4.29	2.314*	1.004*
Working Memory	Arithmetic Test	First Pregnancy	11.80		
		Second Pregnancy	10.14	0.667*	
		Third Pregnancy	8.82	1.373*	0.706*

*** Significant at (α = 0.05)**

Table (4) shows that there are significant differences at (α = 0.05) between pregnancy orders, as follows:

- Significant differences were found at (α = 0.05) in favour of the first pregnancy in the number of movements and the time needed to find the right solution compared with the third pregnancy in the Tower of London test. This suggests that women in their first pregnancy are better at problem-solving than women in their third pregnancy, as they need fewer movements and less time to solve the problem.
- Significant differences were found at (α = 0.05) between pregnancy orders in the EFI, in favour of the first pregnancy compared with the third pregnancy and in turn of the second pregnancy compared with the third pregnancy. This suggests that women in their first and second pregnancies have better executive functions than women in their third pregnancies.
- Regarding short-term auditory memory (Digit Span test), significant differences were found at (α = 0.05) in favour of the first pregnancy compared with the third pregnancy and the second pregnancy compared with the third pregnancy, suggesting that women in their first and second pregnancies have a better level of short-term auditory memory than women in their third pregnancy.

- Significant differences were found at ($\alpha = 0.05$) between pregnancy orders in the working memory (Arithmetic test), in favour of the first pregnancy compared with the third pregnancy, and in turn of the second pregnancy compared with the third pregnancy. They show that women in their first and second pregnancies have better working memory than women in their third pregnancy.

The results showed that first-pregnancy women's problem-solving performance was better than second- and third-pregnancy women's, who needed more moves and a longer time to get to the right solution. The reason behind that could be attributed to the nature of a pregnant woman's first experience, which motivates her to focus on and pay attention to everything around her. Neuropsychological changes help her to adjust to her new life and to focus on a new lifestyle. Basinger and Hogg (2021) pointed out that the neuropsychological changes faced by the pregnant woman, especially in her first pregnancy experience, help her to create a new lifestyle that enables her to provide love, protection, care, and support for her new baby later on.

The results also pointed out that the performance of the pregnant woman in the first and second pregnancy regarding executive functions was better than that of third-pregnancy women. This suggests that the more pregnancies a woman has, her executive functions may be negatively affected, as cognitive processes are as affected in her first pregnancy as they are during her second. As the number of pregnancies increases, memory deficits and cognitive dysfunctions are acquired during the third pregnancy. This result differs from the one presented by Parsons and his colleagues (2004), which revealed that the cognitive deficit reported during pregnancy has no relation with the number of pregnancies.

Additionally, a pregnant woman's brain experiences quick changes. Her body also undergoes many morphological changes that affect the secretion of various hormones in her body, affecting brain function and executive functions because of the change made to the grey matter in the cerebral cortex of the pregnant women's brains, and these changes continue throughout pregnancy. This differs from the results provided by some researchers, as Hoekzema and his colleagues (2017) pointed out that there is a decrease in brain size during pregnancy and an increase in size after birth, and that these changes are consistent among all pregnant women with different pregnancies numbers, which return (possibly) to normal after-birth within a certain period.

Regarding short-term auditory memory, the results found that first and second-pregnancy women performed better than third-pregnancy women. This implies that the higher the number of pregnancies, the more short-term auditory memory may be negatively affected. This can be attributed to the pregnant woman's distraction during her third pregnancy and inability to concentrate on events around her since her mind is busy thinking of her first and second child and those related to the fetus, pregnancy, and childbirth. This lowers the capacity

of short-term memory, especially since this memory can only hold information for up to 30 seconds at a time. The results also indicated that first and second-pregnancy women performed better than third-pregnancy women in terms of working memory. This suggests that more pregnancies may negatively impact working memory. The neuropsychological symptoms in the second pregnancy are not significantly different from those in the first pregnancy, and the brain structure may also be the same. However, emotions and anger vary between multiple pregnancy experiences, affecting brain functions, including working memory and attention.

Recommendations

The study suggests conducting longitudinal studies to reveal the neuropsychological characteristics (problem-solving, executive functions, working memory, and short-term auditory memory) of women before and after pregnancy, as well as in the case of pregnancy (one baby, twins, or triplets).

Conflict of Interest: The author declares that the study holds no conflicts of interest.

Consent to Participate: Participants provided informed consent to participate in this study.

Ethics approval: This study was performed per the principles of the Committee on Publication Ethics (COPE).

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