



# A Review on Investigating the Blurring Thought to be Experienced in Cognitive Functions During Pregnancy

## Hamilelik Sırasında Zihinsel İşlevlerde Yaşandığı Düşünülen Bulanıklığın Araştırılması Üzerine Bir Derleme

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### Abstract

There is a common experience of forgetfulness and mental fogginess among pregnant, often referred to as "pregnancy brain." However, the question of whether this phenomenon is genuine remains unclear. Pregnancy is a unique physiological process that involves significant hormonal and physiological changes in a woman's body. While the physical transformations during pregnancy are well-documented, there has been growing interest in investigating potential cognitive changes that may occur during this period. This review aims to explore the existing literature on pregnancy-related cognitive impairment and provide an overview of the current understanding in this field.

**Keywords:** pregnancy, neuropsychology, cognitive functions, review

### Öz

Hamile bireyler arasında genellikle "hamilelik beyni" olarak adlandırılan unutkanlık ve zihinsel bulanıklık gibi yaygın bir deneyim vardır. Ancak, bu olgunun gerçek olup olmadığı sorusu belirsizliğini koruyor. Hamilelik, bir kadının vücudunda önemli hormonal ve fizyolojik değişiklikleri içeren benzersiz bir fizyolojik süreçtir. Hamilelik sırasındaki fiziksel dönüşümler iyi belgelenmiş olsa da, bu dönemde meydana gelebilecek olası bilişsel değişiklikleri araştırmaya ilgi artmaktadır. Bu çalışma, gebeliğe bağlı bilişsel bozulma ile ilgili mevcut literatürü keşfetmeyi ve bu alandaki mevcut anlayışa genel bir bakış sunmayı amaçlamaktadır.

**Anahtar Kelimeler:** hamilelik, nöropsikoloji, bilişsel işlevler, derleme

### Introduction

The duration of pregnancy is associated with significant transformations in a woman's life. Pregnancy brings about biological, psychological, hormonal, sociological, and many other changes together. As multiple dimensions change during pregnancy, cognitive functions also exhibit differences. Due to variations in influences on the pregnancy period, it is plausible that there would be individual differences in cognitive alterations.

Cognitive changes among pregnant women have been extensively documented in the literature (1). A study found 81% of pregnant women reported experiencing cognitive decline (2). The literature reports various regressions, including memory problems, reading difficulties, confusion, orientation problems, poor concentration, increased absent-mindedness, and decreased motor coordination (1). Additionally, there is a general

observation of slowed cognition, with forgetfulness being the most frequently mentioned change. The broader cognitive domain has noted similar changes in executive functions and attention. Investigating and understanding these deficiencies and regressions holds significant importance for daily life (1).

Cognitive researchers have long been intrigued by the common instances during pregnancy, like forgetting the whereabouts of specific items, misplacing them, and scheduling appointments in everyday life. Despite the growing number of studies on these deficiencies, a definitive conclusion regarding the various cognitive deficits occurring during pregnancy has not yet been realized. This is primarily due to the influence of numerous potential confounding variables, including hormonal changes and fluctuations in emotion regulation. Furthermore, previous literature suggests that pregnant women have a tendency to overestimate



their cognitive deficits (3).

The prevailing focus of general pregnancy literature revolves around hormonal changes, which are known to contribute to mood alterations worldwide. In a broader sense, there is agreement on the impact of these hormonal fluctuations on cognitive functions. However, it is crucial to consider the findings of controlled studies to gain a more accurate understanding. Interestingly, the literature on pregnancy appears to be inconsistent. While some studies have observed changes in cognitive functions during or after pregnancy (3, 4, 5, 6), other studies have not found any significant differences (3, 7, 8). This divergence in results may be attributed to the use of distinct measures, various inclusion criteria, and individual differences among the studies.

The purpose of this literature review is to assess experimental and quasi-experimental studies that examine the effectiveness of different cognitive deficits in pregnant women. While cognitive processes encompass a wide area, this study specifically focuses on memory and attention processes in healthy pregnant women, as these areas are commonly studied in the existing literature. Initially, memory, the most prominent complaint by pregnant women regarding altered cognition, was evaluated through self-reports. Subsequently, various memory subsystems were examined objectively and subjectively to establish a general consensus. Although there may be inconsistencies across studies, this review aims to present studies that have employed different methodologies to investigate memory systems and attention processes.

It is important to note that this article excludes studies involving pregnant women with alcohol, cigarette, and substance abuse, as well as studies involving pregnant women with a history of neurological or psychiatric conditions.

### **Intact and Enhanced Cognitive Functions**

The self-reports of pregnant women regarding their cognitive abilities during pregnancy present mixed results. Studies aiming to uncover the truth have yielded conflicting outcomes. A longitudinal study that examined cognitive functions during the third trimester of pregnancy and three months postpartum found no differences in several cognitive domains, including executive function, memory, learning, and attention (7).

Interestingly, pregnant women reported more memory difficulties and poor mood than non-pregnant participants. However, these self-reports only affected attention and verbal fluency performance, while general cognitive function did not differ between the groups. The key finding here is the impact of belief, as the belief about cognitive functions during pregnancy did not influence actual cognitive performance. This discrepancy is remarkable.

De Groot *et al.* (2003) found no significant difference between the pregnant group (second trimester) and the control group in tasks involving concept shifting and the Stroop test (3). Additionally, Anderson *et al.* (2012) argued that as more studies were included in the meta-analysis and the inclusion criteria became stricter, the effect of pregnancy on working memory performance became smaller (9).

An EEG study using an auditory oddball paradigm compared pregnant women in the second and third trimesters to a control group. The results showed that the second-trimester group performed worse than the third-trimester group, and both pregnant groups performed better than the control group (10). Another EEG study by Ali *et al.* (2012) found improvements in auditory attention, memory, and executive function during pregnancy, although they observed a superiority in the second trimester over the third trimester (11).

As mentioned earlier, Anderson *et al.* (2012) reported impairments in certain cognitive functions in pregnant women. However, they also noted a slight advantage for pregnant women in recognition tasks. Furthermore, it was found that a few months after delivery, there was an increase in gray matter volume in areas essential for parenting. Pregnancy presents a variety of stressors, and previous findings have indicated that stress positively affects spatial cognitive functions. In the context of pregnancy, this effect acts as a buffer, suggesting that stress during pregnancy can have a positive impact (9).

The debate regarding cognitive changes during pregnancy continues, with contradictory findings on the revival of cognitive impairments in pregnant women. Henry and Rendell (2007) claimed that memory impairments improve within two days postpartum, whereas others suggest that these impairments persist for up to two months (4).



## Pregnancy and Memory

In the earliest studies on pregnancy and cognition, Janes *et al.* (1999) found that approximately half of the women reported experiencing more forgetfulness during pregnancy and the postpartum period compared to before pregnancy (12). Similarly, Sharp and Brindle (1993) assessed memory in 48 women and found no difference between first-time pregnant women and those who had been pregnant before, but both groups differed significantly from non-pregnant controls (13).

In a subsequent study, Glynn (2010) investigated the impact of pregnancy on human memory using a sample of 254 women from a university medical center. The inclusion criteria were singleton pregnancy, age over 18, being a native English speaker, non-smoking status, and absence of neuroendocrine conditions. The study also included 48 non-pregnant participants who met the same criteria and served as a control group to account for memory changes associated with the passage of time. Working memory was measured using the digit span task, recognition memory using the face recognition paradigm, and verbal recall memory using the paired-associates learning tasks. Materials were counterbalanced across participants, and all assessments took place in the same laboratory setting. Blood samples were collected to measure endocrine levels. The findings revealed that verbal recall memory declined during pregnancy, while there were no recognition or working memory differences. This memory decline can be attributed to prenatal glucocorticoids and estrogen. The researchers also noted that altered memory performance is a consequence of adaptation to pregnancy and the brain's remodeling concerning it. Considering that memory is the most prominent aspect of cognitive changes during pregnancy and that memory consists of multiple systems. Besides, it is crucial to investigate other subsystems (14).

In line with this, McDowall and Moriarty (2010) conducted a study examining implicit and explicit memory using data-driven and conceptually driven processes (15). Their study aimed to replicate the findings of Brindle *et al.* (2), which indicated impaired implicit memory and intact explicit memory in pregnant women. The study included 32 pregnant and 32 non-pregnant participants, with pregnant women divided into two groups based on their pregnancy status (primigravid: first pregnancy, multigravid: subsequent pregnancy). Data-driven tests utilized word fragment completion and graphemic cued

recall, while conceptually driven tests involved semantic cued recall and category generation. Priming and recall were assessed using a set of 96 words divided into List A and List B, with three blocks per list containing 16 words each. The allocation of reading and generating tasks was counterbalanced among participants. During the test phase, participants completed a word-fragment test as an implicit memory task, where they had to complete words based on their initial thoughts without reference to the study phase. An explicit memory task using semantic cues was also administered during the test phase. Despite primigravid participants reporting recent declines in memory performance compared to their usual abilities, objective results showed no differences between pregnant and non-pregnant participants to address the concerns raised by other researchers regarding the applicability of implicit and explicit memory tasks to real-life experiences of pregnant women. Rendell and Henry (6) conducted a study focusing on prospective memory functioning during pregnancy and postpartum. This study aimed to shed light on prospective memory, in addition to previous studies that primarily examined retrospective memory during pregnancy. The study included 20 pregnant subjects in their third trimester and 20 non-pregnant controls. Both laboratory-based and naturalistic prospective memory tasks were employed.

For the naturalistic prospective memory task, participants engaged in a board game on its circuits that represented different days of the week. Each day involved 10 prospective memory tasks, consisting of 4 regular tasks (routine duties), 4 irregular tasks (occasional tasks), and 2 time-check tasks (monitoring the real-time). The regular and irregular tasks included both time-based and event-based tasks. Participants were required to make choices regarding these events and remember them. The task spanned seven days, and a "correct" score was assigned if participants remembered the target event at the correct time.

Additionally, participants were asked to log the time indicated before the task over the course of seven days for the naturalistic prospective memory task. After 13 months, 15 of the pregnant participants were retested following childbirth. The results indicated no difference in laboratory-based prospective memory and naturalistic memory measurements within the same individuals (pregnancy versus postpartum). However, a statistically



significant impairment was observed in the naturalistic measure compared to both pregnant and non-pregnant subjects. As a result, this study provided experimental evidence of the challenges pregnant women face in daily life experiences when implementing delayed intentions.

### Pregnancy and Attention

Although it has long been known that hormonal changes and various factors during pregnancy lead to cognitive changes—particularly, studies in the literature have primarily focused on memory deficits (16). In addition to impaired memory, attention deficits and concentration problems are common during pregnancy. Many studies investigating attention processes have employed precuing techniques to enhance motor processes, where the benefits of precuing, guided by selective attention, expedite the recognition of target stimuli (17). De Groot *et al.* (3) conducted a study using the finger precuing task to explore whether selective attention is affected in pregnant women. This task assesses the ability to differentiate between two fingers on the same hand, using either the right or left hand, among four possible positions on a computer screen, with the aid of cues.

The study included 48 pregnant women (in their 14<sup>th</sup>, 17<sup>th</sup>, 29<sup>th</sup>, and 36<sup>th</sup> weeks of pregnancy) with an average age of 29 and 48 non-pregnant women (mean age: 30) in the control group. The pregnant and non-pregnant participants were matched for age and education. All participants in the study performed the finger precuing task, responding by pressing the appropriate response button based on the location when the target pre-stimulus cue was presented. The results revealed that the pregnant group, particularly in the 36<sup>th</sup> week of pregnancy, exhibited decreased accuracy in response processes and precuing compared to the control group, especially when compared to the early stages of pregnancy. However, it was reported that these significant decreases in attention processes disappeared after 32 weeks postpartum. These findings are significant considering the limited number of studies investigating attentional processes during pregnancy. Although determining the exact nature of attention deficit is challenging due to potential confounding variables during pregnancy, impaired selective attention is attributed to the “fatty acid hypothesis.” According to this hypothesis, fatty acids, crucial components of cell membranes, decrease in the latter stages of pregnancy

and return to normal levels around 32 weeks after delivery. Additionally, fluctuating levels of hormones such as estrogen, progesterone, and oxytocin during pregnancy are believed to be associated with attention and memory impairments.

During the preparation for childbirth and parenthood, attention and concentration skills play a crucial role in activities such as learning new information, acquiring skills, and engaging in various practices. However, numerous literature studies have reported significant difficulties pregnant women face in tasks requiring concentration compared to non-pregnant women (16, 13). Directed attention involves intentionally allocating attention to specific information (18), and it requires significant mental effort to avoid distractions and maintain focus on the target task (19). Several studies have confirmed the performance-enhancing effect of spending time in natural environments and engaging in outdoor activities as a restorative intervention for directed attention (20). Based on this information, Stark (2003) investigated whether spending time in the natural environment and participating in various activities during the last three months of pregnancy would improve directed attention in pregnant women (21). For this quasi-experimental study, 57 pregnant women with a mean age of 29—most of whom had university degrees—were included. They were randomly assigned, with 29 women allocated to the treatment group and 28 women to the control group. Pre- and post-tests were conducted for all participants, consisting of digit span tests, tracing tests, and category-matching tasks. The researchers calculated an “error scale” by tallying the errors that participants failed to notice or correct. Additionally, the Profile of Mood States Short Form (22) was administered to control for potential confounding variables related to intense emotional changes during pregnancy. The pretest measurements were carried out in the third month of pregnancy. Subsequently, the experimental group received an intervention involving the natural environment, while the control group engaged in a discussion session about the discomforts of pregnancy with a researcher as an alternative activity conducted during a similar timeframe. In the experimental group, participants were provided with both verbal and written information regarding the importance of directed attention in daily life, the increased concentration challenges during pregnancy, and the role and content of reparative activities for voluntary and involuntary attention.



Written consent and signatures were obtained from the participants in the experimental group, allowing them to engage in natural environmental activities suitable for them, participate in reparative environmental activities for a minimum of 120 minutes per week, and keep records of these activities to submit to the researchers at the second measurement time (post-test). As a post-test, digit span tests, tracing tests, and category-matching tasks were administered to all participants at 36 and 37 weeks. Considering the study's results, it is important to note that participants in both groups were unaware of the extent of their natural environmental activities outside the scope of the experiment. Despite several potential confounding factors and the small number of women who completed the entire intervention (n=18), the women in the experimental group exhibited a lower error rate than the control group. These findings highlight the significance of natural environmental activities for improving directed attention, even though various confounding factors must be considered. It is worth noting that participants in the control group did not show any significant differences in pre-/post-testing, further emphasizing the importance of engaging in natural environmental activities for directed attention.

### Cognitive Functions and the Stage of Pregnancy

Previous research has suggested that cognitive functions could be influenced by the trimester of pregnancy (4). However, there is inconsistency among studies regarding the specific trimester that shows cognitive impairments. Some studies indicate impairments during the second and third trimesters, and others suggest impairments across all trimesters. The majority of articles reviewed focused on pregnant women in the third trimester (6; 7).

Notably, most studies did not examine developmental changes during this period and primarily included women in the third trimester and postpartum. Some studies included pregnant women from various trimesters—which could contribute to the diverse conclusions. Furthermore, hormonal changes play a crucial role in cognitive functions, and since pregnant women experience fluctuations in hormonal balance, studies need to control and measure hormonal levels through specific restrictions or measurements.

Considering all these studies, drawing inferences about the extent and timing of cognitive impairments during

pregnancy is challenging (21). This difficulty arises from various confounding factors such as hormonal changes during pregnancy, limitations in tracking the daily activities of pregnant participants, and the decrease in fatty acid levels in late pregnancy (3). Two common findings from studies examining cognitive processes in healthy pregnant women are that overall cognition does not deteriorate during pregnancy, and any impairments or reductions generally resolve after approximately 32 weeks postpartum (1, 3, 23). Sleep problems have also been identified as contributing to perceptual slowing during pregnancy.

### Discussion

This literature review examines the findings of various studies on memory and attention deficits in pregnant women in light of the existing literature. Memory studies within the pregnancy brain and cognition field play a crucial role (14). At the same time, it appears that memory impairment occurs during pregnancy and the postpartum period. There is inconsistency in the results between objective and subjective assessments and across different memory systems (6). These inconsistencies can be attributed to a variety of confounding factors, as indicated by the memory literature. Factors such as the alignment of pregnancy, stage of pregnancy, age, and other memory-related conditions may contribute to these discrepancies (15). On the other hand, although many types of attention show deterioration during pregnancy, the limited number of studies on attention is noteworthy. Future memory studies should take these factors into consideration. Moreover, longitudinal studies may provide valuable insights into the period preceding pregnancy.

Regarding studies on memory processes in pregnant women, attention has been drawn to the tendency of pregnant women to underestimate their memory and cognitive abilities, which negatively impacts their performance compared to control groups (1). Similarly, some studies indicate that pregnant women self-report more forgetting due to underestimation, but objective tests do not necessarily reflect the same level of impairment (1). Despite various hypotheses, the root cause of cognitive impairment during pregnancy remains unclear. Given the high levels of anxiety and cognitive load experienced by pregnant women, especially first-time



mothers, future studies should explore cognitive factors in more detail and develop non-pharmacological treatment methods such as music therapy to support pregnant women during this process.

In conclusion, the pregnancy literature exhibits variations, and this review suggests that these variations may arise from differences in study controls. Pregnancy is a sensitive period influenced by environmental factors and individual differences. Therefore, it is crucial to control for all the aforementioned factors in studies involving pregnant women to arrive at clear and accurate conclusions.

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