



T.C.
ÜSKÜDAR UNIVERSITY
INSTITUTE OF HEALTH SCIENCES

HEALTH SCIENCES DEPARTMENT
NEUROSCIENCE MASTER'S THESIS PROGRAM
MASTER'S DEGREE THESIS

**INVESTIGATION OF NEUROPSYCHOLOGICAL CHANGES IN
PREGNANCY: A CROSS-SECTIONAL STUDY**

Beyza Nur EKŞİ

Thesis Advisor
Prof. Dr. Cumhuri TAŞ

İSTANBUL-2024

T.C.
ÜSKÜDAR UNIVERSITY
INSTITUTE OF HEALTH SCIENCES

HEALTH SCIENCES DEPARTMENT
NEUROSCIENCE MASTER'S THESIS PROGRAM
MASTER'S DEGREE THESIS

**INVESTIGATION OF NEUROPSYCHOLOGICAL CHANGES
DURING PREGNANCY: A CROSS-SECTIONAL STUDY**

Beyza Nur EKŞİ

Thesis Advisor
Prof. Dr. Cumhur TAŞ

İSTANBUL-2024

ÖZET

GEBELİK DÖNEMİNDE NÖROPSİKOLOJİK DEĞİŞİKLİKLERİN İNCELENMESİ: KESİTSEL ÇALIŞMA

Bu çalışma, hamilelik sırasında meydana gelen bilişsel değişiklikleri ve bunların annenin iyilik hali üzerindeki olası etkilerini incelemeyi amaçlamaktadır. Gönüllü katılımcılardan oluşan örneklem, İstanbul'da yaşayan 30 hamile kadın ve 30 hamile olmayan kadından oluşmaktadır. Katılımcılara çeşitli bilişsel testler uygulanmış ve sonuçlar karşılaştırılmıştır. Bulgular, hamile kadınların Stroop testinde daha yavaş işlem hızı ve daha az inhibisyon gösterdiğini, özellikle 3. trimesterde 2. trimestere kıyasla daha belirgin eksiklikler olduğunu, dikkat, bilişsel esneklik ve yürütücü işlevler açısından daha düşük skorlar aldıklarını ancak sözel bellek ya da İz Sürme Testi'nde gruplar arasında fark olmadığını ortaya koymuştur. Anksiyete düzeyleri ise benzerdir. Sonuç olarak, hamileliğin özellikle dikkat, hafıza ve yürütücü işlevler gibi alanlarda önemli bilişsel bozukluklarla ilişkili olduğu ve bu değişikliklerin erken teşhisinin annenin ruh sağlığı ve hem annenin hem de çocuğun genel iyi oluşu üzerinde etkileri olabileceği vurgulanmaktadır.

Anahtar Kelimeler: perinatal dönem, hamilelik, nörobilim

ABSTRACT

INVERTIGATION OF NEUROPSYCHOLOGICAL CHANGES DURING PREGNANCY: A CROSS-SECTIONAL STUDY

This study aims to examine the cognitive changes that occur during pregnancy and their possible effects on maternal well-being. The sample of volunteer participants consisted of 30 pregnant women and 30 non-pregnant women living in Istanbul. Participants were administered various cognitive tests and the results were compared. The findings revealed that pregnant women showed slower processing speed and less inhibition in the Stroop test, more pronounced deficits especially in the 3rd trimester compared to the 2nd trimester, lower scores in attention, cognitive flexibility and executive functions, but no difference between the groups in verbal memory or Trail Making Test. Anxiety levels were similar. In conclusion, it is emphasized that pregnancy is associated with significant cognitive impairments, especially in areas such as attention, memory and executive functions, and early diagnosis of these changes may have implications for the mental health of the mother and the general well-being of both mother and child.

Keywords: perinatal period, pregnancy, neuroscience

FORWARD

First of all, my first and greatest thanks, with the deepest feelings of respect and gratitude, to the Great Leader Mustafa Kemal Atatürk, who provide us independence and a bright future, and gave us the opportunity to progress on the path of science and knowledge.

I am grateful to my thesis advisor, Prof. Dr. Cumhur Taş, with whom I will always be honored to work, for his patience, guidance, and valuable suggestions throughout my research process. The study would not have been completed without his knowledge and support.

I would also like to thank my esteemed teacher, Prof. Dr. Türker Tekin Ergüzel, who always made me feel his support with patience and understanding from the beginning of the process, and the faculty members of Üsküdar University Institute of Health Sciences Department of Neuroscience who supported me in my research process. The academic environment they provided, as well as the various perspectives they offered me, enabled me to approach my study from a broader perspective.

I would like to thank my esteemed mentors Prof. Dr. Nazan Aydın and Uzm. Dr. Nalan Öztürk, who have contributed greatly to my professional path, who have always given me strength with their moral support, and who have generously shared their experience and knowledge. Their presence is always a tremendous strength for me.

I would like to thank my family, whose material and moral support I have always felt. I am especially grateful to my mother and father for patiently going through this journey with me. Knowing that they are always by my side has been a tremendous source of motivation in overcoming the difficulties I face.

I would also like to thank my friends and cousins, who have been with me throughout my research process and have always encouraged me. Their presence made this process easier and more enjoyable.

Finally, it is a great honor for me to express my gratitude to the valuable participants who voluntarily participated in my study, gave their time, and answered my questions sincerely and patiently.

Thank you very much,

Psy. Beyza Nur Ekşi

August, 2024

DECLARATION FORM

I have obtained all the information and documents in this study within the framework of academic rules, I have presented all visual, audio and written information and results in accordance with scientific ethics, I have not made any falsifications in the data I have used, I have referred to the sources I have used in accordance with scientific norms, I hereby declare that it is true, produced by me and written according to Üsküdar University Health Sciences Institute Thesis Writing Guide.

23.08.2024

Beyza Nur EKŞİ

Signature

TABLE OF CONTENTS

ÖZET	i
ABSTRACT.....	ii
FORWARD	iii
DECLARATION FORM	iv
TABLE OF CONTENTS	v
LIST OF TABLES	viii
LIST OF ABBREVIATIONS	ix
1. INTRODUCTION	1
1.1. Background of the Study	1
1.2. Importance and Purpose of the Study	3
1.3. Hypothesis of the Study	3
1.4. Assumptions of the Study	4
1.5. Limitations of the Study	4
2. GENERAL INFORMATION.....	5
2.1. Overview of Pregnancy	5
2.1. Neuroplasticity and Its Relevance to Pregnancy	6
2.1. Hormonal Influences on Neuropsychological Functioning in Pregnancy	7
2.4. Emotional and Psychological Adaptations During Pregnancy	9
2.5. Significance of Studying Neuropsychological Changes in Pregnancy	10
3. LITERATURE REVIEW	10
3.1. Cognitive Functioning in Pregnancy	11
3.1.1. Attention Capacity	11
3.1.2. Verbal Memory Skills.....	12
3.1.2. Executive Functions and Mental Flexibility	12
3.2. Comparison of Pregnant and non-Pregnant Women	12

3.3. Neurobiological Mechanisms Underlying Cognitive Changes.....	13
3.4. Previous Findings on Cognitive Changes Across Trimesters.....	13
4. METHODOLOGY	14
4.1. Research Design	14
4.2. Sample Selection and Characteristics	14
4.3. Data Collection Instruments	15
4.3.1. Sociodemographic Data Form	15
4.3.2. Beck Anxiety Scale.....	15
4.3.3. Öktem Verbal Memory Processes Test.....	16
4.3.4 Stroop Test.....	17
4.3.5. Extention Test.....	17
4.3.6. Wisconsin Card Sorting Test (WCST)	18
4.3.7. Continuous Performance Testing (CPT).....	18
4.3.8. Trail Making Test (TMT)	19
4.4 Data Collection	19
4.5. Statistical Analysis of the Data	23
5. FINDINGS.....	23
5.1. Descriptive Analysis	24
6.DISCUSSION and CONCLUSIONS	33
6.1 Discussion of Findings Consistent with the Literature.....	34
6.2 Discussion of Findings Inconsistent with the Literature	36
6.3 Mechanism of Possible Consequences	37
6.4 Limitations and Constraints of the Study	38
7. CONLUSIONS AND SUGGESTIONS	39
REFERENCES.....	41
APPENDIX.....	45
APPENDIX 1. Approval from Ethics Committee	45

APPENDIX 2. Voluntary Consent Form Used in the Study	46
APPENDIX 3. Sociodemographic Data Form	49
APPENDIX 4. Beck Anxiety Scale	52
APPENDIX 5. Öktem Verbal Memory Process Test	53
APPENDIX 6. Back Side of Öktem Verbal Memory Processes Test	54
APPENDIX 7. Stroop Test TBAG Form.....	55
APPENDIX 8. Extention Test	56
APPENDIX 9. Wisconsin Card Sorting Test	57
APPENDIX 10. Continuous Performance Testing.....	58
APPENDIX 11. Trail Making Test.....	59
APPENDIX 12. CV	60

LIST OF TABLES

Table 1. *Comparison of socio-demographic characteristics of pregnant women and control group*

Table 2. *Comparison of Beck Anxiety Scale scores of pregnant women and control group*

Table 3. *Comparison of Stroop test scores of pregnant women and control group*

Table 3.1 *Comparison of Stroop test scores of pregnant women according to trimesters*

Table 4. *Comparison of Öktem Verbal Memory Processes Test scores of pregnant women and control group*

Table 5. *Comparison of Extention Test scores of pregnant women and control group*

Table 6. *Comparison of Card Sorting Test scores of pregnant women and control group*

Table 7. *Comparison of Continuous Performance Test scores of pregnant women and control group*

Table 8. *Comparison of Trail Making Test scores of pregnant women and control group*

LIST OF ABBREVIATIONS

E2: Estradiol

P: Progesterone

CORT: Cortisol

PRL: Prolactin

BAS: Beck Anxiety Scale

SCWT: Stroop Color and Word Test

VMPT: Öktem Verbal Memory Processes Test

WCST : Wisconsin Card Sorting Test

CPT: Continuous Performance Test

TMT: Trail Making Test

1. INTRODUCTION

1.1. Background of the Study

As far as we know, since the time of Hippocrates, people have been curious about the relationship between the hormonal equilibrium of women and their mental health. Researchers in the field of medicine and the scientific community have been investigating the relationship between menstruation and behavioral changes ever since the 19th century (Haynes, 2022). There has been a growing focus on women's mental health in recent years, particularly on mental disorders related to the reproductive phase. The menstrual period becoming pregnant, giving birth, and menopause are pivotal stages in a woman's lifespan. Pregnancy is a common biological occurrence for women. Pregnancy is often seen as a joyous phase in woman's life. Pregnancy can elicit emotions of elation, satisfaction, individual development, self-exploration, and bliss. However, contrary to popular beliefs, it can also result in emotions such as anxiety, worry, and stress. Pregnancy encompasses more than simply positive emotions.

Women experience substantial physiological and psychological transformations during pregnancy. The hormonal, metabolic, and neurological changes that occur in women's bodies at this time can have a substantial impact on their physical and emotional health. For example, fluctuations in the secretion of estrogen, progesterone, and the stress hormone cortisol during pregnancy can lead to a range of mental disorders in women who are already susceptible to them. Women's cognitive functioning may be profoundly affected by some of these changes. Numerous cognitive abilities, including memory, attention, executive functioning, and cognitive flexibility, are included in cognitive functions. These changes in cognitive functions can also exert a significant influence on the daily functioning of both the mother and the baby. During case interviews, a study found that pregnant women who were presently or recently pregnant experienced a greater need to take notes in order to complete job and domestic duties. They also reported frequently forgetting plans, struggling with reading comprehension, and being unable to return to work owing to memory issues (Brett & Baxendale, 2001). In the literature, this condition is known by several names, including Baby Brain, Mommy Brain, Mom Brain or Momnesia (Pawluski, 2022). The terme Baby Brain is defined in the Cambridge

Dictionary online as “the state of forgetting things and not thinking clearly that pregnant women are often said to experience (Cambridge Dictionary, n.d.).

A woman's peripartum era is among her most neurobehaviorally malleable periods, comparable to other crucial hormonal-developmental stages like adolescence and menopause. Thus, this dynamic developmental stage—often called "matrescence"—offers a useful framework for comprehending the processes and applications of plasticity in the adult female brain (Pawluski, Hoekzema, Leuner, & Lonstein, 2022). The word was initially introduced by medical anthropologist Dana Raphael in 1973 to define the process of development that encompasses the period from before conception to after childbirth and beyond. Matrescence is frequently likened to adolescence because to shared characteristics such as hormonal fluctuations, physical alterations, transitions in identity, and a feeling of perplexity and mixed emotions. Researchers examined brain structural changes in pregnant first-time mothers and adolescent girls using MRI data. The study revealed that both pregnancy and adolescence result in comparable alterations in the brain, such as reductions in volume and decreases in cortical thickness, surface area, and other morphometric measurements. The alterations exhibited similar characteristics in both first-time mothers and teenage girls, indicating a common hormonal impact throughout these critical stages of neuroplasticity (Carmona et al., 2019).

Matrescence, although not classified as a clinical condition or mental illness, is a typical process that is frequently misinterpreted in modern society. Women may undergo a variety of emotions during the process of becoming a mother, including happiness and a sense of mourning for their previous life. It is crucial to acknowledge that these sentiments are a natural part of the matrescence journey.

In order to successfully manage the problems of matrescence, it is important for women to actively seek assistance from their loved ones, participate in communities of support, prioritize taking care of themselves, and engage in honest conversations about their experiences. Seeking assistance from psychologists or psychiatrists who specialize in perinatal mental health might offer useful strategies and resources for managing the shift.

1.2. Importance and Purpose of the Study

Many studies show that women experience a temporary decrease in cognitive skills such as memory, abstract thinking, attention, concentration, planning and problem solving during pregnancy (Leuner & Sabihi, 2016). Cognitive impairments that occur during pregnancy can affect the general health of the expectant mother. These disorders can also trigger mental health problems such as stress, anxiety and depression. This situation reduces the quality of life of the expectant mother. Since the mental health of the expectant mother will have an impact on the health and development of the baby to be born, cognitive disorders in the expectant mother may also negatively affect the baby (Zhang et al., 2023). In addition, cognitive impairments may also affect postnatal outcomes. For example, depression or anxiety may increase the risk of postpartum depression. Early identification of cognitive impairments during pregnancy can enable appropriate treatment and support. For these reasons, it is thought that examining cognitive disorders during pregnancy may enable appropriate measures to be taken that can have positive effects on both mother and baby's health and minimize negative outcomes with early intervention and support.

1.3. Hypothesis of the Study

- H1: Pregnant women have lower attention capacity than healthy controls
- H2: Pregnant women in the third trimester have significantly impaired attention compared to pregnant women in the first and second trimester groups.
- H3: Non-pregnant women have higher verbal memory skills than pregnant women.
- H4: Non-pregnant women have higher response inhibition than pregnant women.
- H5: Non-pregnant women have higher attention, mental flexibility and psychomotor skills than pregnant women.
- H6: Non-pregnant women have higher executive functions, conceptualization and abstract thinking skills than pregnant women.

1.4. Assumptions of the Study

1. It is assumed that the sample selected for the study is representative of the target population in terms of demographic, clinical and socioeconomic characteristics.
2. It is assumed that the neuropsychological tests and scales used accurately and reliably measure neuropsychological changes during pregnancy.
3. It is assumed that the answers given by the pregnant women participating in the study during the application are valid and reliable.
4. The sample group of pregnant women in Istanbul is assumed to be representative of the general pregnant population.
5. It is assumed that external factors (e.g., participants' mood, environmental factors) are minimally influential during data collection.
6. It is assumed that the statistical data analysis methods used to reach the findings on the variables in the research are adequate, valid and reliable methods to determine the findings.

1.5. Limitations of the Study

The cross-sectional study design allows data to be collected only over a specific time period. Therefore, it can be difficult to assess the dynamics and causal relationships of neuropsychological changes over time. Conducting research at a single time point may make it difficult to observe changes at different stages of pregnancy. There may be differences between neuropsychological changes in the first, second and third trimesters of pregnancy. A cross-sectional study cannot examine the long-term effects of neuropsychological changes in the post-pregnancy period. This may limit understanding the lasting effects of pregnancy on neuropsychological health. The most important limitation of the study is that it is limited to the information obtained from pregnant women in Istanbul. The research data is limited to the information obtained from 30 healthy controls and 30 pregnant women. These limitations point to areas that could be considered for future studies.

2. GENERAL INFORMATION

2.1. Overview of Pregnancy

Pregnancy is an intricate physiological process characterized by notable bodily, emotional, and psychological transformations that prime the body for giving birth and becoming a mother. The process usually spans 40 weeks and entails significant alterations in multiple organ systems to facilitate the growth of the fetus (Brunton & Russell, 2020).

Significant physiological changes take place across various systems: the cardiovascular system experiences an increase in blood volume and cardiac output, the respiratory system sees a rise in oxygen consumption, the endocrine system undergoes elevated hormone levels, and the musculoskeletal system faces alterations in posture and joint flexibility. Pregnancy encompasses emotional and psychological dimensions as well, with women encountering a spectrum of emotions, from happiness to anxiety, and navigating psychological changes as they prepare for motherhood (Brunton & Russell, 2020).

The 40-week period is divided into 3 trimesters. Each trimester is associated with distinct developmental milestones for the fetus and particular physiological changes for the mother.

First Trimester (Weeks 1-12): During this stage, there is rapid cell division, leading to the formation of vital organs and systems. It is also the period when the risk of miscarriage is at its peak (Cleveland Clinic, 2021; StatPearls, 2021).

Second Trimester (Weeks 13-26): In this period, the fetus continues its growth, and many women notice a reduction in early pregnancy symptoms. This trimester is commonly characterized by a boost in energy and the onset of the first detectable fetal movements (Britannica, 2021; LibreTexts, 2021).

Third Trimester (Weeks 27-40): During this period, the fetus experiences substantial growth and development in preparation for birth. For the mother, this stage can be physically demanding, marked by increased discomfort and the beginning of labor preparation (StatPearls, 2021).

2.1. Neuroplasticity and Its Relevance to Pregnancy

Neuroplasticity is a comprehensive concept that encompasses the capacity of the nervous system to undergo diverse forms of change. Half a century ago, the concept that the adult brain might undergo any type of alteration was seen as revolutionary. Researchers recognized the malleability of the growing brain, but they hypothesized that as a kid grew older, it would solidify into a rigid and unchangeable framework, much to plaster solidifying in a mold (Costandi, 2017). However, this was not true. The brain of an adult is not only able to change, but it is also constantly evolving during the course of our lives as a result of everything that we do and all the experiences that we have. Through the process of evolution, the nervous system has developed to enable us to adjust to our surroundings and determine the most appropriate course of action in specific circumstances by drawing on the knowledge that we have gained from our previous experiences. To put it another way, neural systems have developed over time to be alterable, and as a result, neuroplasticity is an essential characteristic of neurological systems. Another innate occurrence that promotes neuroplasticity is the act of becoming a parent.

Pregnancy induces significant anatomical and functional changes in the mother's brain, known as neuroplasticity. These modifications are believed to have significant implications for the health and welfare of both the mother and her kid.

Pregnancy results in enduring alterations in brain structure, especially in regions associated with maternal caregiving, motivation, somatosensory processing, and executive functions (Hoekzema et al., 2017; Barba-Müller, Craddock, Carmona, & Hoekzema, 2019). Research indicates that these alterations are driven by hormone-induced plasticity during pregnancy, and are further influenced by experience-dependent plasticity in the postpartum period (Duarte-Guterman, Leuner, & Galea, 2019; Servin-Barthet, Martínez, Vilarroya, & Carmona, 2022)

Researchers have explored the neurobiological changes occurring during pregnancy and the postpartum period, revealing significant brain adaptations and shifts in maternal behavior. It is believed that hormonal fluctuations, particularly those involving estrogens, drive brain plasticity during these times (Servin-Barthet, Martínez, Vilarroya, &

Carmona, 2022). Pregnancy induces alterations in maternal brain morphology, notably a decrease in gray matter in areas associated with social interactions, with these changes persisting for at least two years after childbirth. Estrogens are regarded as the primary hormones driving these brain changes (Servin-Barthet, Martínez, Vilarroya, & Carmona, 2022; Leuner & Sabihi, 2016).

A growing body of evidence shows that reproduction is linked to significant and distinctive brain plasticity across various non-human animal species, resulting in notable alterations in both the mammalian brain and behavior. These findings indicate that pregnancy-related neuroplasticity contributes to psychological and physiological processes during gestation, aiding a woman in preparing for the arrival of her baby and in establishing the new mother-infant bond (Hoekzema et al., 2017; Barba-Müller, Craddock, Carmona, & Hoekzema, 2019).

However, fully grasping the intricate interplay between hormones, brain adaptations, and resulting maternal behavior necessitates further investigation. The emotional and cognitive processes shaping the developing mother-child relationship—especially during pregnancy and the postpartum period—are among the least understood aspects and are what differentiate human mothers from those in other animal species (Servin-Barthet, Martínez, Vilarroya, & Carmona, 2022).

2.1. Hormonal Influences on Neuropsychological Functioning in Pregnancy

Pregnancy is marked by significant elevations in many hormones, such as estradiol (E2), progesterone (P), cortisol (CORT), and prolactin (PRL). These hormones have the dual role of promoting prenatal development and affecting cognitive performance by crossing the blood-brain barrier. Increased concentrations of estrogen and progesterone have been found to have neuroprotective properties and can improve specific cognitive processes. Conversely, cortisol, which is frequently connected with stress, can have negative effects on memory and attention (Barda et al., 2021; Henry & Sherwin, 2012). Studies suggest that hormonal changes during pregnancy can result in both cognitive impairments and improvements. A longitudinal study revealed that pregnant women exhibited diminished performance in tests assessing vocabulary memory and processing speed when compared to non-pregnant controls. This suggests that cognitive abilities may degrade during the

late stages of pregnancy and the early postpartum period. More precisely, elevated cortisol levels were linked to decreased verbal recall and spatial ability, suggesting an intricate connection between stress hormones and cognitive functioning (Henry & Sherwin, 2012). Studies on humans frequently indicate impairments in memory, attention, and executive function during pregnancy, leading to instances of forgetfulness and challenges with concentration for many women (Logan et al., 2014; Barda et al., 2021).

Pregnancy induces not just cognitive but also emotional and psychological neuropsychological alterations. The cognitive functioning can be further complicated by shifts in mood, anxiety, and stress that are connected with approaching childbirth. For example, pregnant women have been found to perceive more memory issues, despite objective neuropsychological evaluations showing no significant changes compared to controls. This disparity underscores the need of taking into account both individual perceptions and quantifiable indicators of cognitive performance (Logan et al., 2014; Miranda & Sousa, 2018).

Oxytocin, often referred to as the "love hormone," is another critical hormone that influences maternal behavior. It is involved in promoting bonding and attachment between mother and child and is released during childbirth and breastfeeding (Uvnäs-Moberg, 1998). Research has shown that oxytocin not only facilitates social bonding but also modulates stress responses, which can be beneficial during the postpartum period (Neumann, 2008).

The interplay between these hormones and neuropsychological functioning is complex and multifaceted. While hormonal changes are essential for supporting the physiological aspects of pregnancy, they also significantly impact cognitive and emotional processes. Understanding this interplay can provide insights into the challenges faced by pregnant women and new mothers, as well as inform interventions aimed at supporting maternal mental health.

2.4. Emotional and Psychological Adaptations During Pregnancy

Pregnancy entails substantial emotional and psychological adjustments, often leading to increased emotional sensitivity, fluctuations in mood, and heightened anxiety in many women (Barba-Müller, Craddock, Carmona, & Hoekzema, 2019; Cárdenas, Kujawa, & Humphreys, 2020). The observed alterations can be ascribed to hormonal variations and the psychological adaptations linked to the approaching state of becoming a mother (Cárdenas, Kujawa, & Humphreys, 2020).

Pregnancy can cause alterations in the brain regions responsible for emotional regulation, including the amygdala and prefrontal cortex. These changes have the potential to affect how women perceive and react to emotional inputs (Barba-Müller, Craddock, Carmona, & Hoekzema, 2019).

During this period, the pregnant mother establishes a conducive atmosphere not just for her own but also for the growth and development of her unborn child. This stage is marked by the process of getting ready to form a strong emotional connection with the baby and adjusting to the changing responsibilities and duties of becoming a mother.

A woman's life, including her personal history, relationships with her mother and partner, living conditions, and societal expectations regarding motherhood collectively shape the emotional landscape during pregnancy, influencing how a woman experiences this transition (Barnes, 2014).

Studies suggest that pregnancy is characterized by significant emotional changes. During the initial trimester, women commonly undergo a combination of favorable emotions, such as enthusiasm and happiness, combined with adverse sentiments like unease and concern. Various factors can influence these emotional states, such as physical indicators like nausea, the intended or unintended nature of the childbirth, financial anxieties, and the extent of support from loved ones (Deave, Johnson, & Ingram, 2008).

During the second trimester of pregnancy, women often experience a decrease in negative emotions, which may be due to less physical discomfort and a better understanding of pregnancy-related care. Emotional swings may continue during this period, but mental health disorders such as anxiety and sadness are less common than in the first and last trimesters (Chrisler&Johnson-Robledo, 2000).

During the third trimester, heightened bodily pain and the expectation of giving birth can lead to the reemergence of unpleasant feelings. This stage is crucial for the development of maternal-fetal bond, which usually becomes stronger as the pregnancy progresses. Psychological adaptations during this period are crucial for cultivating a stable connection between mother and infant, as well as getting ready for the duties of parenthood (Cameron & McGowan, 2010; Gouilhers et al., 2019).

In essence, pregnancy is not solely a biological phenomenon; it is a complex voyage that necessitates substantial emotional and psychological adjustments. Comprehending these alterations is crucial for delivering suitable assistance to pregnant women, guaranteeing a more seamless shift into motherhood, and fostering the welfare of both the mother and the infant (Deave, Johnson, & Ingram, 2008).

2.5. Significance of Studying Neuropsychological Changes in Pregnancy

Studying the neuropsychological changes that occur during pregnancy is essential for comprehending the adjustments that the maternal brain undergoes and the potential effects on the health of both the mother and the child (Martínez García, 2021; Cárdenas, Kujawa, & Humphreys, 2020).

Although there is a substantial amount of literature on this subject, there are still important areas where our comprehension is lacking. These include identifying the precise cognitive domains that are impacted, understanding the underlying mechanisms behind these changes, and determining the long-term consequences (Cárdenas, Kujawa, & Humphreys, 2020). Conducting thorough study to address these gaps can yield useful insights into the neuropsychological elements of pregnancy and the transition to parenting.

3. LITERATURE REVIEW

In recent years, there has been a considerable increase in the research on neuropsychological changes that occur during pregnancy. This has uncovered a range of

cognitive modifications and their potential impact on the health of both the mother and the child. This chapter will investigate cognitive functioning during pregnancy, compare pregnant women to non-pregnant women, analyze the neurobiological mechanisms that cause cognitive changes, and provide a summary of prior research on cognitive changes across the trimesters.

3.1. Cognitive Functioning in Pregnancy

The study of cognitive performance during pregnancy is a complicated field of research. There is evidence to suggest that hormonal shifts and physiological adaptations can contribute to changes in a variety of cognitive domains.

3.1.1. Attention Capacity

Research suggests that attention capacity may be affected during pregnancy, particularly in the later stages. A meta-analysis found that pregnant women exhibited significantly lower attention performance compared to non-pregnant women, especially in the third trimester (Davies et al., 2019). According to some study women have experienced heightened absent-mindedness, diminished concentration, and challenges in accomplishing tasks, which can have an impact on their daily activities and work productivity (Davies et al., 2017; de Groot et al., 2006). One study objectively measured directed attention, the ability to focus or concentrate, in pregnant women during the 3rd trimester and postpartum. They found the greatest difficulty focusing occurred during the 3rd trimester, with some individuals showing limitations in directed attention capacity at all three time points tested (enrollment, 37 weeks gestation, 1st postpartum week) (Stark, 2000). Another study using a complex cognitive battery found that after adjusting for education and age, performance on attention tasks like the Digit Span Forward test was similar between pregnant and non-pregnant women. This suggests attention capacity may be maintained in pregnancy. Pregnancy is associated with structural brain changes, including reductions in gray matter volume in areas related to attention and cognitive control. However, the brain may undergo a "cognitive reorganization" to prioritize functions essential for maternal caregiving and bonding with the baby. (Barda et al., 2021

In summary, while some studies report declines in attention capacity during pregnancy, particularly in the 3rd trimester, the findings are mixed. Attention may be maintained in some domains, possibly due to adaptive changes in brain structure and function to support maternal caregiving. More research is needed to fully understand the impact of pregnancy on different aspects of attention.

3.1.2. Verbal Memory Skills

Pregnancy also impacts verbal memory skills, which are part of the cognitive domain. Research has indicated that pregnant women experience decreases in verbal memory ability, specifically in tasks that involve the encoding and retrieval of information from memory (Glynn, 2018). A study revealed that pregnant women exhibited worse performance on verbal memory tests in comparison to non-pregnant women, indicating that hormonal alterations can hinder the process of memory consolidation (Glynn, 2018; Onyper et al., 2010).

3.1.2. Executive Functions and Mental Flexibility

During pregnancy, it is commonly observed that executive functions, which involve many cognitive activities including as planning, mental flexibility, and problem-solving, tend to decrease. In a study conducted by de Groot et al. (2006), it was discovered that pregnant women demonstrated reduced performance on tasks that evaluated executive functions in comparison to women who were not pregnant, especially during the third trimester. The observed changes can be ascribed to hormonal fluctuations, namely the impact of heightened levels of progesterone and estrogen, which have been demonstrated to affect cognitive processes (Glynn, 2018).

3.2. Comparison of Pregnant and non-Pregnant Women

Comparative studies indicate that pregnant women typically exhibit lower cognitive performance compared to women who are not pregnant. A meta-analysis revealed that pregnant women display substantial impairments in memory, attention, and executive functioning (Davies et al., 2017). Nevertheless, the extent of cognitive impairment differs

among investigations, with several studies indicating only negligible alterations (Henry & Rendell, 2007). This discrepancy underscores the necessity for additional investigation to elucidate the cognitive disparities between women who are pregnant and those who are not. Furthermore, the diversity in results could be affected with variables such as the number of participants, the structure of the study, and the particular cognitive tasks used (Glynn, 2018).

3.3. Neurobiological Mechanisms Underlying Cognitive Changes

The neural mechanisms behind changes in cognition during pregnancy are intricate and influenced by multiple factors. Fluctuations in hormones, namely elevated levels of progesterone as well as estrogen, are thought to have a significant impact on cognitive performance (Glynn, 2018). These hormones have the ability to affect neurotransmitter systems and facilitate neuroplasticity, resulting in alterations in both the structure and function of the brain (Hoekzema et al., 2017). Pregnancy has been found to cause changes in the volume of gray matter in the brain, namely in areas that are responsible for mental balance and social cognition. These changes may be indicative of adaptations that occur to facilitate mother caring (Hoekzema et al., 2017). The elevated amounts of hormones, for example oxytocin and cortisol, that occur during pregnancy can also influence cognitive alterations, as these hormones are recognized for their impact on memory and learning mechanisms (Glynn, 2018).

3.4. Previous Findings on Cognitive Changes Across Trimesters

Studies have shown that cognitive alterations during pregnancy can differ between trimesters. Research indicates that memory function has a decrease in performance during the initial trimester, but stabilizes or shows improvement in the second trimester. However, there is a subsequent decline in memory function throughout the third trimester (Davies et al., 2017; Glynn, 2018). This pattern suggests that the precise timing of cognitive alterations is crucial for comprehending the influence of pregnancy on cognitive performance. Longitudinal studies are necessary to thoroughly investigate these alterations and evaluate their long-term effects on the health of both mothers and children. Moreover, the results indicate that certain cognitive processes may experience a decrease,

while others may maintain stability or even enhance, demonstrating an intricate interaction of elements that affect cognitive performance during pregnancy (Glynn, 2018).

4. METHODOLOGY

This chapter focuses on the research model, population and sample, data collection instruments, data collection process, and analysis of the gathered data.

4.1. Research Design

The study utilized a cross-sectional research approach to investigate neuropsychological changes in pregnant women in comparison to non-pregnant controls. The selection of this design was made to enable the evaluation of cognitive ability at a particular moment, hence facilitating comparisons between different groups. The research sought to assess multiple cognitive areas, such as attention ability, verbal memory abilities, reaction inhibition, and executive functions. The participants were selected from obstetric clinics and community centers, guaranteeing a varied sample that accurately reflects the overall population. The study employed a quantitative methodology, using standardized cognitive exams to measure disparities in cognitive functioning between pregnant and non-pregnant women. Statistical studies were performed to ascertain the significance of the findings and evaluate the magnitude of the observed discrepancies.

4.2. Sample Selection and Characteristics

The sample consisted of 60 women, divided into two groups: 30 pregnant women and 30 non-pregnant women. The pregnant participants were recruited from obstetric clinics and community centers, while the control group was composed of women who had not been pregnant in the past year. Participants were matched for age, educational background, and family type to minimize confounding variables.

Participants were selected on a voluntary basis. Consent was obtained from the participants using the Informed Voluntary Consent Form.

4.3. Data Collection Instruments

The data were gathered through a combination of standardized cognitive testing and self-report questionnaires. Scales were applied to pregnant and non-pregnant individuals who participated in the study. Firstly, “Sociodemographic Data Form” was applied to the participants. Then, “Beck Anxiety Scale”, “Öktem Verbal Memory Processes Test”, “Stroop Test”, “Spatial Test”, “Wisconsin Card Matching Test”, “Continuous Performance Test” and “Trail Making” tests were applied in a room where only the participant and the practitioner were present. During the application, the participants were informed about the purpose of the study and the principle of confidentiality, and consent was obtained by signing the Informed Voluntary Consent Form.

4.3.1. Sociodemographic Data Form

The purpose of this form is to contribute to the questionnaires and to obtain detailed information about the individuals. Questions were created to reinforce the questionnaires and certain forms and to complete the desired data. Information such as age, pregnancy status, education, family type, etc. can be accessed in this way.

4.3.2. Beck Anxiety Scale

The Beck Anxiety Inventory (BAI) is a highly regarded self-report assessment instrument specifically developed to quantify the intensity of anxiety symptoms. The BAI, initially created by Aaron T. Beck in 1988, is composed of 21 items that evaluate a range of both psychological and physical signs associated with anxiety that occurred within the previous week. The Turkish form of the BAI has been modified and confirmed to be suitable for use with Turkish populations, guaranteeing its dependability and suitability in evaluating anxiety levels among individuals who speak Turkish.

The respondents rank each item on a 4-point Likert scale, indicating the extent to which they have been disturbed by each symptom. The ratings range from 0 (not at all) to 3 (severely). The overall score can vary from 0 to 63, with higher numbers suggesting a more pronounced level of anxiety. The score categories are as outlined below:

0 to 7: Minimal anxiety

8 to 15: Mild anxiety

16 to 25: Moderate anxiety

26 to 63: Severe anxiety

This score system enables clinicians to assess the intensity of anxiety in people and can guide therapy choices (Healthline, 2023; Wikipedia, 2023).

The Turkish form of the BAI received thorough testing to determine its psychometric qualities. Research has demonstrated that the Turkish version of the measure consistently produces reliable results, as indicated by a Cronbach's alpha coefficient frequently exceeding 0.85. This suggests that the questions effectively assess the same underlying concept (Tunay & Soygüt, 2009). The test-retest reliability has been found to be satisfactory, indicating stability over time. The Turkish BAI has demonstrated strong correlation with other well-established anxiety measures, including the State-Trait Anxiety Inventory (STAI) and the Hamilton Anxiety Rating Scale. This confirms the construct validity of the Turkish BAI, as reported by Tunay and Soygüt (2009).

4.3.3. Öktem Verbal Memory Processes Test

The Öktem Verbal Memory Processes Test is a cognitive evaluation test specifically created to assess the verbal memory and learning capabilities of individuals. Measuring the ability of individuals to encode, store, and retrieve verbal information is very valuable in clinical and research environments. This assessment is crucial for comprehending cognitive performance in diverse demographics, encompassing children, adults, and specific clinical groups, such as individuals with cognitive disabilities.

During the administration of the test, participants are provided with a list of words to memorize. The list often consists of a fixed number of words, such as 15-20 terms, which are carefully chosen to encompass various levels of difficulty and semantic categories. Following the presentation of the word list, participants are instructed to recollect the words in an unordered manner. This procedure may need conducting several iterations to evaluate both the ability to remember information immediately and the ability to remember information after a delay. Typically, each subject goes through approximately 10 trials, which enables a thorough assessment of their verbal memory performance. The test performance is evaluated by the number of words accurately remembered in each

trial. The overall score can offer valuable information about the participant's verbal memory capacity and aptitude for learning.

Multiple studies have assessed the reliability and validity of the Öktem Verbal Memory Processes Test. Research suggests that the exam exhibits strong internal consistency and test-retest reliability, making it a reliable instrument for evaluating verbal memory. The test has demonstrated its ability to accurately distinguish between persons with different levels of cognitive functioning, including those with and without cognitive impairments (Şahin-Sadık et al., 2022).

4.3.4 Stroop Test

The Stroop Test, also referred to as the Stroop Color and Word Test (SCWT), is a commonly employed neuropsychological evaluation instrument that aims to examine cognitive flexibility, attention, and the capacity to suppress cognitive interference. The test, created by John Ridley Stroop in 1935, has gained widespread recognition as a fundamental tool in psychological study and clinical practice.

In the test participants are given a series of color names (such as "red," "blue," "green") written in black ink and are instructed to pronounce the words as fast as they can. During this task, individuals are presented with a sequence of colored squares (such as red, blue, and green) and are required to rapidly identify and state the colors of the squares. The most crucial condition in the test involves participants being presented with color names that are printed in hues that are incongruent with the words (e.g., the word "red" printed in blue ink). Participants are directed to identify the hue of the ink instead than reading the actual word.

4.3.5. Extention Test

The Extension Test is a neuropsychological evaluation specifically created to examine the cognitive abilities of individuals in terms of working memory and attention. The system is comprised of two primary elements: Forward Memory Extension and Backward Memory Extension. The Forward Memory Extension assesses participants' immediate recall and working memory by requiring them to accurately repeat a sequence of items in the exact order in which they were presented. In contrast, the Backward Memory Extension requires participants to remember the same sequence but in reverse order, which evaluates more advanced cognitive processes such as the capacity to manipulate

information in working memory. The test also assesses the Number of Correct Answers, yielding a numeric score that accurately represents memory performance.

4.3.6. Wisconsin Card Sorting Test (WCST)

The Wisconsin Card Sorting Test (WCST) is a commonly employed neuropsychological assessment tool that measures executive functions, specifically cognitive flexibility and the capacity to adapt cognitive strategies in reaction to changing environmental circumstances (Heaton et al., 1993; Strauss et al., 2006). It has undergone thorough examination and use in several clinical and scientific environments.

The WCST comprises four stimulus cards illustrating a red triangle, two green stars, three yellow crosses, and four blue circles. Each participant is provided with a set of 64 or 128 answer cards, which they can use to match with the stimulus cards based on their color, shape, or number. The activity necessitates participants to associate each response card with one of the stimulus cards without receiving explicit instructions regarding the sorting criterion. After each trial, they are provided with feedback indicating whether their match was accurate or inaccurate. The rule changes intermittently and unexpectedly, necessitating participants to adapt their cognitive framework in reaction to the feedback (Heaton et al., 1993).

The Turkish iteration of the Wisconsin Card Sorting Test underwent standardization to assure its suitability for Turkish populations. The adaption process entailed the translation of the test materials and the establishment of normative data using a sample of Turkish participants. Wisconsin Kart Sıralama Testi'nin (WCST) Türkçe uyarlaması sağlam psikometrik özellikler sergilemektedir. Araştırmalar, bu ölçeğin güçlü iç tutarlılık ve test-tekrar test güvenilirliği sergilediğini ve klinik ortamlarda yürütme işlevinin değerlendirilmesinde faydalı olduğunu göstermiştir. Geçerlilik çalışmaları, Türkçe WCST'deki performansın, yürütme işlevinin diğer köklü ölçümleriyle güçlü bir korelasyon sergilediğini ve dolayısıyla yapı geçerliliğini doğruladığını göstermektedir (Yeniceri & Altan-Atalay, 2011).

4.3.7. Continuous Performance Testing (CPT)

CPT primarily aims to evaluate sustained attention, which is the ability to sustain focus on a task or stimuli for an extended period. The capacity to perform everyday tasks is essential and can be influenced by different circumstances, including hormone fluctuations, exhaustion, and psychological strain (Conners, 2014).

CPT often entails the display of a sequence of stimuli on a computer monitor, such as letters, numbers, or shapes. Participants are directed to react to particular target stimuli (such as pressing a button) while refraining from reacting to non-target stimuli. The duration of the test typically ranges from 10 to 20 minutes, during which the participant is required to sustain concentration and provide precise responses (Conners, 2014).

4.3.8. Trail Making Test (TMT)

The Trail Making Test (TMT) is a commonly used neuropsychological evaluation that aims to test several cognitive skills, namely executive functions like cognitive flexibility, visual attention, and processing speed.

4.4 Data Collection

Participants were informed about the purpose of the study before the application and consent was obtained by signing the “Informed Voluntary Consent Form”. Data collection was carried out between January and May 2024, and the number of participants included in the evaluation was 60 women in total, 30 pregnant women and 30 controls.

At the beginning of the application, the patient was taken into the room. While filling out the sociodemography form, information about the patient's age, gender, marital status, educational status, history of chronic diseases, history of psychiatry, neurological diagnoses, alcohol-smoking history, and social life were obtained.

The participants were explained in detail what the Beck Anxiety Scale was, how to fill it out and how the answers would be evaluated. Participants were made to feel comfortable and encouraged to answer the questions honestly. Participants were asked to fill in each item according to the symptoms they had experienced in the last week. After the questionnaire was completed, the data were collected by the researcher.

The participants were explained in detail what the Beck Anxiety Scale was, how to fill it out and how the answers would be evaluated. Participants were made to feel comfortable and encouraged to answer the questions honestly. Participants were asked to fill in each item according to the symptoms they had experienced in the last week. After the questionnaire was completed, the data were collected by the researcher.

Then, the Öktem Verbal Memory Processes Test was started. The test consists of fifteen unrelated words. These words were read aloud to the subject at one second intervals. The subject was asked to keep these words in mind. Then the recall phase was started. In the word recall phase, the number of words recalled in the first trial was recorded as immediate memory and the total number of words recalled by the subject at the end of 10 trials was recorded as learning score. These applications took approximately 35-40 minutes. After that, the participant was given a 5-minute rest period and then the Stroop test was started.

Prior to receiving the initial card, which contained color names written in black, the participant was instructed to read it swiftly and precisely, adhering to a sequential order similar to reading a book. Once the first card was completed, the participant received a card containing color names written in different colors. They were instructed to read it swiftly and precisely, following the order as if reading a book. Following the submission of the application, an additional card featuring various colored shapes was provided. The participants were instructed to verbally state the names of the colors in a specific sequence, with speed and precision. Following the completion of this card, another card was provided containing words printed in color, but without any color names. The participants were instructed to identify the hue of the ink used to write the words. Subsequently, the participants were once again provided with a card containing color names written in corresponding colors. Similar to the preceding card, participants were instructed to identify the color of ink used to write the words. Throughout each phase, the participant's performance was closely observed through the use of timing and meticulous documentation of their mistakes and subsequent fixes. The elapsed time and the number of errors and adjustments were recorded for each card. This application required roughly 5 minutes to complete.

Then, the Card Sorting Test was started. This test was administered to the participants on a computer. Before the application, the test was explained to the participants and technical details were shown. Before starting the application, the participants were asked to read the instructions written on the screen. The instruction is as follows;

“In this task, you need to categorize the pictures on the cards according to their different characteristics. At the beginning, you will see four cue cards at the top of the screen. Each card has a different number, color and shape. If you think that the card in the center of the

screen has the same characteristics as a cue card, you have to click on it with the mouse. The categorization will take place according to a certain rule, you need to find the rule first. The rule may change during the mission. You will get feedback on whether the card you placed is in the right category or not. Try to answer as accurately as possible according to the feedback you receive.” After reading the instructions, the participant was assured that she understood the task and was told that she could start when she was ready.

Afterwards, the Trail Making Test was started. The test was administered to the participants via computer. Before the application, the test was explained to the participants and technical details were shown. Before starting the application, the participants were asked to read the instructions written on the screen. The instruction is as follows;

“In this test, you will see numbers and/or letters on the screen. The test has three parts.

In the first part, your task is to mark the numbers on the screen from small to large (1,2,3...). In the second part your task is to mark the letters on the screen in alphabetical order (A,B,C...). In the last part your task is to mark the numbers on the screen from small to large and the letters in alphabetical order, one number one letter (1, A, 2, B, 3, C...).

If you click on the correct circle, it will become clear and a line will be drawn between it and the previous circle. If you click on the wrong circle, there will be no line between the circles.”

After reading the instructions, the participant was assured that she understood the task and was told that she could start when she was ready.

After the Trail Making Test was completed, the Spatial Test was started. This test consists of two stages. Both phases of the test were administered to the participants via computer. Before the application, the test was explained to the participants and technical details were shown. Before starting the application, the participants were asked to read the instructions written on the screen. The instruction is as follows;

“You are participating in a test that measures your ability to remember the sequence of locations on the screen. You will see touch blue squares on the screen. On each trial, the squares will light up one by one in sequence and you will be expected to remember the sequence. When the squares stop flashing, you have to click on them in the same order.

If you can't remember the order, you can click in the order you guess closest to the original order.

When finished, you can press the 'OK' button to proceed to the next stage.

At first you will start with two squares, then the number of squares will gradually increase and you will be expected to respond to two trials each time the number increases. When you answer at least one of the two trials correctly, the number of lit squares will increase.”

After the instruction was read, the participant was assured that she understood the task and was told that she could start when she was ready and the first phase of the test was started. After this phase was completed, the second phase was started. Before starting the second phase, the participants were asked to read the instructions written on the screen. The instruction is as follows;

“You are participating in a test that measures your ability to remember the positions on the screen sequentially. You will see nine blue squares on the screen. On each trial, the squares will light up one by one in sequence and you will be expected to remember the sequence. When the squares stop blinking, you have to click on them in the reverse order in which they were lit. That is, you should click on the last lit square first and the first lit square last. If you can't remember the order, you can click in the order you think is closest to the original order. When done, you can press the 'OK' button to move on to the next stage.

At first you will start with two squares, then the number of squares will gradually increase and you will be expected to answer two trials each time the number increases. When you answer at least one of the two trials correctly, the number of lit squares will increase.”

After reading the instructions, the participant was assured that she understood the task and was told that she could start when she was ready.

Finally, after the completion of the Spatial Test, the Continuous Performance Test was started. The test was administered to the participants via computer. Before the application, the test was explained to the participants and technical details were shown. Before starting the application, the participants were asked to read the instructions written on the screen. The instruction is as follows;

“You will see various letters in the center of the screen. When you see the letter 'Z' after the letter 'A', you need to respond by pressing the space bar. However, your answer will be considered correct only if the letter immediately after the letter 'A' is 'Z'.

For example;

A ... A ... Z -> Correct

A ... B ... Z -> False

Z ... A -> False

Click here to start when you are ready.”

After reading the instruction, the participant was assured that she understood the task and was told that she could start when ready.

These four computerized tests took 45-50 minutes in total.

4.5. Statistical Analysis of the Data

For statistical analysis of the research data

Chi-square test was used to compare the socio-demographic characteristics of the control group and pregnant women in the study.

The compatibility of the research data with the normal distribution was examined with the Shapiro-Wilk test and skewness and kurtosis values and it was determined that it showed normal distribution. In this context, parametric tests were used in the study. Independent sample t test was used to compare the Beck Anxiety Scale, Stroop test, Öktem Verbal Memory Processes Test, Spatial Test, Card Sorting Test, Continuous Performance Test and Trail Making Test scores of the control group and pregnant women included in the study. In addition, independent sample t test was used to compare the Stroop test scores of pregnant women according to trimesters.

5. FINDINGS

5.1. Descriptive Analysis

Table 1.

Comparison of socio-demographic characteristics of pregnant women and control group

	Control		Pregnant		Total		t/X²	p
	n	%	n	%	n	%		
Age	31,47±4,53		30,90±4,07		31,47±4,55		0,510	0,612
Educational Background								
High School	6	20,0	3	10,0	9	15,0	1,176	0,278
Undergraduate and higher	24	80,0	27	90,0	51	85,0		
Family Type								
Nuclear Family	27	90,0	26	86,7	53	88,3	0,162	0,688
Extended Family	3	10,0	4	13,3	7	11,7		
Psychiatric Drug Use								
None	30	100,0	30	100,0	60	100,0	-	-
Pregnancy Period								
2nd Trimester	-	-	12	40,0	-	-		
3rd Trimester	-	-	18	60,0	-	-		

(t: independent sample t test, X2: chi-square test)

Table 1 shows the findings related to the comparison of socio-demographic characteristics of the control group and pregnant women in the study.

When Table 1 was examined, it was determined that the mean age of the control group women in the study was 31.47±4.53, 20.0% were high school graduates, 80.0% were university graduates, 90.0% had nuclear families, and none of them used psychiatric drugs. The mean age of the pregnant women who participated in the study was 30.90±4.07, 10.0% were high school graduates and 90.0% were university graduates; 86.7% had nuclear families and 13.3% had a nuclear family; none of them used psychiatric drugs; 40.0% were in the second trimester of pregnancy; and 60.0% were in the third trimester.

Table 2.*Comparison of Beck Anxiety Scale scores of pregnant women and control group*

	Group	n	$\bar{x}$	s	t	p
Beck Anxiety Scale	Control	30	4,87	1,68	-0,964	0,339
	Pregnant	30	5,30	1,80		

(Independent sample t test)

Table 2 shows the results of the independent sample t test for the comparison of the Beck Anxiety Scale scores of the control group and pregnant women included in the study, and it was found that there was no difference between the Beck Anxiety Scale scores of the control group and pregnant women ($p>0.05$).

Table 3.*Comparison of Stroop test scores of pregnant women and control group*

	Group	n	$\bar{x}$	s	t	p
Stroop I Duration	Control	30	9,33	1,66	-5,468	0,000*
	Pregnant	30	12,90	3,17		
Stroop I Error	Control	30	0,00	0,00	-	-
	Pregnant	30	0,00	0,00		
Stroop I Correction	Control	30	0,00	0,00	-	-
	Pregnant	30	0,00	0,00		
Stroop II Duration	Control	30	9,41	1,44	-5,819	0,000*
	Pregnant	30	12,15	2,14		
Stroop II Error	Control	30	0,00	0,00	-	-
	Pregnant	30	0,00	0,00		
Stroop II Correction	Control	30	0,30	0,47	2,918	0,005*
	Pregnant	30	0,03	0,18		
Stroop III Duration	Control	30	12,61	1,66	-2,782	0,007*
	Pregnant	30	14,19	2,62		
Stroop III Error	Control	30	0,00	0,00	-	-
	Pregnant	30	0,00	0,00		
Stroop III Correction	Control	30	0,80	0,89	3,471	0,001*
	Pregnant	30	0,17	0,46		
Stroop IV Duration	Control	30	14,28	1,69	-2,374	0,021*
	Pregnant	30	15,81	3,08		
	Control	30	0,00	0,00		

Stroop IV Error	Pregnant	30	0,00	0,00	-	-
Stroop IV Correction	Control	30	0,30	0,47	0,885	0,380
	Pregnant	30	0,20	0,41		
Stroop V Duration	Control	30	16,69	2,79	-2,421	0,019*
	Pregnant	30	19,13	4,76		
Stroop V Error	Control	30	0,63	0,93	-1,010	0,317
	Pregnant	30	0,87	0,86		
Stroop V Correction	Control	30	1,00	0,79	2,454	0,017*
	Pregnant	30	0,53	0,68		

* $p < 0.05$ (Independent sample t test)

Table 3 shows the results of the independent sample t test for the comparison of the Stroop test scores of the control group and pregnant women in the study.

When Table 3. was examined, it was determined that there were statistically significant differences between the Stroop I Duration, Stroop II Duration, Stroop II Correction, Stroop III Duration, Stroop III Correction, Stroop IV Duration, Stroop V Duration and Stroop V Correction values of the control group and pregnant women ($p < 0.05$). It was determined that the Stroop I Duration, Stroop II Duration, Stroop III Duration, Stroop IV Duration and Stroop V Duration values of the women in the control group were lower than the pregnant women. Stroop II Correction and Stroop III Correction values of the control group participants were found to be higher than pregnant women.

It was determined that there were no statistically significant differences between the Stroop IV Correction and Stroop V Error values of the control group and pregnant women included in the study ($p > 0.05$).

Table 3.1

Comparison of Stroop test scores of pregnant women according to trimesters

	Group	n	$\bar{x}$	s	t	p
Stroop I Duration	2nd trimester	12	10,41	1,69	-4,554	0,000*
	3rd trimester	18	14,56	2,83		
Stroop I Error	2nd trimester	12	0,00	0,00	-	-
	3rd trimester	18	0,00	0,00		
Stroop I Correction	2nd trimester	12	0,00	0,00	-	-
	3rd trimester	18	0,00	0,00		
	2nd trimester	12	10,66	1,57		

Stroop II Duration	3rd trimester	18	13,14	1,90	-3,730	0,001*
Stroop II Error	2nd trimester	12	0,00	0,00	-	-
	3rd trimester	18	0,00	0,00		
Stroop II Correction	2nd trimester	12	0,08	0,29	1,236	0,227
	3rd trimester	18	0,00	0,00		
Stroop III Duration	2nd trimester	12	13,02	2,49	-2,111	0,044*
	3rd trimester	18	14,97	2,48		
Stroop III Error	2nd trimester	12	0,00	0,00	-	-
	3rd trimester	18	0,00	0,00		
Stroop III Correction	2nd trimester	12	0,42	0,67	2,668	0,013*
	3rd trimester	18	0,00	0,00		
Stroop IV Duration	2nd trimester	12	15,53	2,59	-0,396	0,695
	3rd trimester	18	15,99	3,43		
Stroop IV Error	2nd trimester	12	0,00	0,00	-	-
	3rd trimester	18	0,00	0,00		
Stroop IV Correction	2nd trimester	12	0,33	0,49	1,497	0,146
	3rd trimester	18	0,11	0,32		
Stroop V Duration	2nd trimester	12	19,50	3,41	0,339	0,737
	3rd trimester	18	18,89	5,56		
Stroop V Error	2nd trimester	12	0,75	1,06	-0,600	0,554
	3rd trimester	18	0,94	0,73		
Stroop V Correction	2nd trimester	12	0,92	0,79	2,796	0,009*
	3rd trimester	18	0,28	0,46		

* $p < 0.05$ (Independent sample *t* test)

Table 3.1. shows the independent sample *t* test results for the comparison of Stroop test scores of pregnant women according to trimesters

It was determined that there were statistically significant differences between the Stroop I Duration, Stroop II Duration, Stroop III Duration, Stroop III Correction and Stroop V Correction values of pregnant women in the study according to trimesters ($p < 0.05$).

Stroop I Duration, Stroop II Duration, Stroop III Duration of women in the III trimester of pregnancy were found to be higher than those in the II trimester. Stroop III Correction and Stroop V Correction values of women in the III trimester of pregnancy were lower than those in the II trimester.

It was found that there were no statistically significant differences between Stroop II Correction, Stroop IV Duration, Stroop IV Correction, Stroop V Duration and Stroop V Error values of pregnant women in the study according to trimesters ($p>0.05$).

Table 4.

Comparison of Öktem Verbal Memory Processes Test scores of pregnant women and control group

	Group	n	$\bar{x}$	s	t	p
Immediate Memory	Control	30	6,20	2,41	-0,060	0,953
	Pregnant	30	6,23	1,89		
Learning Score	Control	30	128,37	9,31	0,252	0,802
	Pregnant	30	127,77	9,16		
Reaching Criterion	Control	30	5,03	1,16	0,761	0,450
	Pregnant	30	4,80	1,21		
Learning Error Score	Control	30	1,40	1,71	-1,301	0,198
	Pregnant	30	2,03	2,04		
Perseveration	Control	4	2,50	0,58	0,658	0,527
	Pregnant	7	2,29	0,49		
Recognition	Control	30	13,83	1,64	-1,707	0,093
	Pregnant	30	14,43	1,01		
False Recognition	Control	30	0,40	0,50	1,654	0,110
	Pregnant	30	0,41	0,31		

(Independent sample t test)

Table 4 shows the results of the independent sample t test for the comparison of the Öktem Verbal Memory Processes Test scores of the control group and pregnant women included in the study sample.

When Table 4. is examined, it was determined that there was no statistically significant difference between the scores of the Öktem Verbal Memory Processes Test of the control group and pregnant women included in the study ($p>0.05$). It was determined that the Öktem Verbal Memory Processes Test scores of the control group and pregnant women were similar.

Table 5.

Comparison of Extention Test scores of pregnant women and control group

	Group	n	$\bar{x}$	s	t	p
Extention Test -	Control	30	5,13	1,28	3,044	0,004*
Forward Memory Extention	Pregnant	30	4,08	1,39		
Extention Test -	Control	30	8,17	2,74	2,811	0,007*
Number of Correct Answers	Pregnant	30	6,17	2,77		
Extention Test -	Control	30	2,47	1,97	2,645	0,010*
Backward Memory Extention	Pregnant	30	1,37	1,14		
Extention Test -	Control	30	2,93	3,95	2,645	0,010*
Number of Correct Test	Pregnant	30	0,73	2,27		

** $p<0.05$ (Independent sample t test)*

The results of the independent sample t test conducted to compare the Extention Test scores of the control group and pregnant women included in the study are shown in Table 5.

According to Table 5, it was determined that there were statistically significant differences between the values of forward memory span, number of lines, backward memory span and number of lines in the Extention Test of the control group and pregnant women ($p<0.05$). The values of forward memory span, number of lines, backward memory span and number of lines in the Extention Test of pregnant women were found to be lower than those of the control group women.

Table 6.*Comparison of Card Sorting Test scores of pregnant women and control group*

	Group	n	$\bar{x}$	s	t	p
Card Sorting Test -	Control	30	0,80	0,02	3,639	0,001*
Number of Completed Categories	Pregnant	30	0,74	0,08		
Card Sorting Test -	Control	30	49,33	3,55	3,448	0,001*
Number of Correct Answers	Pregnant	30	45,27	5,40		
Card Sorting Test -	Control	30	14,60	3,50	-3,451	0,001*
Number of Errors	Pregnant	30	18,67	5,42		
Card Sorting Test -	Control	30	4,33	2,29	-3,486	0,001*
Perseverative Error	Pregnant	30	7,23	3,94		
Card Sorting Test -	Control	30	15,60	4,13	0,204	0,839
Number of Trials for the First Category	Pregnant	30	15,37	4,71		

* $p < 0.05$ (Independent sample *t* test)

Table 6. shows the results of the independent sample *t* test for the comparison of the Card Sorting Test scores of the control group and pregnant women in the study.

According to Table 6, it was determined that there were statistically significant differences between the Number of Completed Categories, Number of Correct, Number of Errors and Perseverative Error values in the Card Sorting Test of the control group and pregnant women ($p < 0.05$). The values of the Number of Completed Categories and Number of Corrections in the Card Sorting Test of the pregnant women in the study were lower than those of the women in the control group. In addition, the Number of Errors and Perseverative Error values of pregnant women were higher than the control group.

It was determined that there was no statistically significant difference between the values of the Number of First Category Attempts in the Card Sorting Test of the control group and pregnant women participating in the study ($p > 0.05$).

Table 7.

Comparison of Continuous Performance Test scores of pregnant women and control group

	Group	n	$\bar{x}$	s	t	p
Comparison of Continuous Performance - Commission Error Score	Control	30	0,57	0,57	-4,570	0,000*
	Pregnancy	30	1,90	1,49		
Comparison of Continuous Performance - Omission Error Score	Control	30	0,03	0,18	-5,849	0,000*
	Pregnancy	30	0,60	0,50		

**p<0.05 (Independent sample t test)*

Table 7. shows the results of the independent sample t test for the comparison of the Continuous Performance Test scores of the control group and pregnant women included in the study.

When Table 7. was examined, it was determined that there was a statistically significant difference between the number of errors and number of misses in the Continuous Performance Test of the control group and pregnant women ($p<0.05$). The values of the number of errors and number of misses in the Continuous Performance Test of pregnant women were higher than those of the control group.

Table 8.

Comparison of Trail Making Test scores of pregnant women and control group

	Group	n	$\bar{x}$	s	t	p
Trail Making Test - (Number Condition)	Control	30	17,00	0,00	1,795	0,078
Number of Clicks	Pregnant	30	16,90	0,31		
Trail Making Test - (Number Condition)	Control	30	1,00	0,00	1,795	0,078
	Pregnant	30	0,99	0,03		

Accuracy Rate						
Trail Making Test - (Number Condition)	Control	30	0,71	0,13	-1,585	0,112
	Pregnant	30	0,80	0,12		
Average Reaction Time						
Trail Making Test - (Letter Condition)	Control	30	17,17	0,38	0,850	0,399
	Pregnant	30	17,07	0,52		
Number of Clicks						
Trail Making Test - (Letter Condition)	Control	30	0,97	0,05	0,266	0,791
	Pregnant	30	0,96	0,05		
Accuracy Rate						
Trail Making Test - (Letter Condition)	Control	30	0,76	0,11	-1,786	0,079
	Pregnant	30	0,83	0,17		
Average Reaction Time						
Trail Making Test - (Number-Letter Condition)	Control	30	17,10	0,31	0,460	0,647
	Pregnant	30	17,07	0,25		
Number of Clicks						
Trail Making Test - (Number-Letter Condition)	Control	30	0,99	0,03	-0,460	0,647
	Pregnant	30	0,99	0,03		
Accuracy Rate						
Trail Making Test - (Number-Letter Condition)	Control	30	0,87	0,14	-0,913	0,365
	Pregnant	30	0,92	0,22		
Average Reaction Time						

**p<0.05 (Independent sample t test)*

Table 8 shows the results of the independent sample t test used to compare the Trail Making Test scores of the control group and pregnant women.

According to Table 8, it was determined that there was no statistically significant difference between the Number of Number Clicks, Number Correct Ratio, Number Reaction Time, Number of Letter Clicks, Letter Correct Ratio, Letter Reaction Time, Number-Letter Clicks, Number-Letter Correct Ratio, Number-Letter Reaction Time values of the Trail Making Test of the control group and pregnant women ($p>0.05$).

6. DISCUSSION and CONCLUSIONS

The study aimed to compare cognitive performance between pregnant women and a control group of non-pregnant women across various cognitive tasks. The socio-demographic characteristics revealed that the control group had a mean age of 31.47 years, with 20% being high school graduates and 80% university graduates, while the pregnant women had a mean age of 30.90 years, with 10% high school graduates and 90% university graduates. None of the participants in either group used psychiatric drugs, and the pregnant women were divided into 40% in the second trimester and 60% in the third trimester. The Beck Anxiety Scale scores indicated no significant differences between the two groups. In the Stroop test, significant differences were found, with pregnant women exhibiting longer durations and lower correction scores across various Stroop measures, indicating impaired cognitive flexibility and attention. Specifically, the third trimester pregnant women showed higher durations and lower correction scores than those in the second trimester, highlighting a decline in cognitive performance as pregnancy progressed. The Öktem Verbal Memory Processes Test revealed no significant differences between the groups. However, significant impairments were observed in the Extension Test, where pregnant women scored lower on forward and backward memory spans compared to the control group, indicating reduced working memory capacity. The Card Sorting Test results showed that pregnant women completed fewer categories and made more errors, reflecting decreased cognitive flexibility and executive function. Similarly, the Continuous Performance Test indicated that pregnant women made more errors and misses, suggesting impairments in sustained attention and vigilance. In contrast, the Trail Making Test showed no significant differences between the two groups, indicating that visual attention and task-switching abilities may not be significantly affected by pregnancy. Overall, the study found that while pregnant women exhibited impairments in attention, cognitive flexibility, and working memory compared to healthy

controls, verbal memory remained stable. These findings underscore the cognitive challenges faced during pregnancy and highlight the need for further research to explore the underlying mechanisms and potential interventions to support cognitive health in pregnant women.

6.1 Discussion of Findings Consistent with the Literature

In keeping with the findings of previous studies, the current study discovered that pregnant women had decreased cognitive flexibility and attention on a variety of activities. This finding is consistent with the findings of that study. According to the findings of a study that was carried out by Kinsella et al. (2014), for example, it was discovered that pregnant women typically have difficulties when attempting to accomplish activities that need selective attention. This conclusion is comparable to the significantly longer durations that were reported in the Stroop test among participants who were pregnant. Multiple studies have shown that pregnant women have declines in their cognitive flexibility and attentiveness throughout pregnancy. In their study, Ciesielski et al. (2016) conducted a meta-analysis of 25 research studies. They found that pregnant women consistently exhibited lower performance on tests of executive function, such as the Stroop test, compared to non-pregnant individuals. Researchers attribute these impairments to the hormonal alterations and increased cognitive demands that accompany pregnancy. Longitudinal studies have also been done to examine the development of cognitive flexibility during pregnancy. The study conducted by Rendell and Henry (2008) found that cognitive flexibility, as measured by the Wisconsin Card Sorting Test, declined as pregnancy progressed. The researchers examined pregnant women from the first trimester to the third trimester of their pregnancy. The results of the present study align with the findings that pregnant women exhibited a notable decline in performance on the Card Sorting Test in comparison to the control group. Pregnant women commonly experience a decrease in their ability to retain and process information, known as working memory, as well documented in scientific literature. Based on the results of the present study, pregnant women exhibit lower scores on the Extension Test. The results align with a study undertaken by Murray et al. (2016), which also observed comparable decreases in working memory in pregnant women. These impairments may be attributed to the cognitive burden associated with pregnancy, which encompasses hormonal changes. Henry and Rendell (2007) conducted a comprehensive evaluation of 14 research that investigated the effects of pregnancy on working memory. They discovered consistent

evidence of deficits, particularly in activities that required the active manipulation of information throughout the pregnancy. It was hypothesized by the authors that a pregnant woman's ability to multitask and retain concentrate on difficult tasks could be negatively impacted by a diminished capacity for working memory capacity. Several studies have found that deficits in working memory are more noticeable during specific trimesters of pregnancy. Jang et al. (2018) found that the working memory performance of pregnant women was at its lowest during the third trimester of pregnancy. The researchers assessed pregnant women at different stages of their pregnancy to reach this conclusion. Considering this, the results of the present study, which revealed that pregnant women exhibited lower Extension Test scores in general when compared to the control group, are corroborated. Based on the results of the present study, pregnant women exhibited reduced performance in terms of completing categories and showed an increased number of errors on the Card Sorting Test. This indicates that their ability to adapt their thinking and switch between different mental frameworks is reduced. Consequently, this aligns with the conclusions of a study conducted by Huang et al. (2018), which also found that pregnant women often have less cognitive flexibility. Hormonal changes during pregnancy have been associated with declines in cognitive flexibility and set-shifting abilities. In a study conducted by Gaab et al. (2003), it was discovered that pregnant women with elevated cortisol levels had lower performance on cognitive flexibility tests. This indicates that stress and hormonal factors may play a role in these impairments. Several studies have found that specific subgroups of pregnant women are more prone to cognitive inflexibility compared to pregnant women without any abnormalities. Keenan et al. (1998) found that pregnant women with depression displayed greater cognitive inflexibility compared to pregnant women without depression. It is crucial to acknowledge that this emphasizes the possible influence that concurrent illnesses have on amplifying cognitive alterations during pregnancy. Pregnancy has been linked to deficits in sustained attention and attentiveness in various studies. The present study's results, which indicate a higher occurrence of errors and missed responses on the Continuous Performance Test among pregnant women, are consistent with the findings of Gonzalez et al. (2015). Their study indicated that pregnancy can have a detrimental effect on sustained attention and alertness. Crawley et al. (2003) conducted a meta-analysis where they analyzed thirteen research on attention during pregnancy. They found that pregnant women consistently had lower performance on measures of sustained attention compared to non-pregnant controls. The researchers arrived at this conclusion. According to the

authors, these shortcomings could potentially impact a pregnant woman's ability to maintain focus on tasks for prolonged durations during her pregnancy. Longitudinal studies have also investigated the course of attention shifts during pregnancy. Jang et al. (2018) discovered that as pregnancy advanced, there was a drop in performance on tests measuring sustained attention, with the most significant impairments occurring during the third trimester. This is consistent with the current study's discovery of a higher occurrence of mistakes and omissions on the Continuous Performance Test among pregnant women.

6.2 Discussion of Findings Inconsistent with the Literature

The findings of the current study indicated that there were no significant differences in the scores on the Öktem Verbal Memory Processes Test between the group of pregnant women and the control group. The findings of this study suggest that the mechanisms responsible for verbal memory exhibit a relatively consistent state during pregnancy. However, this conclusion directly contradicts the results of several studies that have shown verbal memory difficulties in pregnant women. For instance, Henry and Rendell (2007) performed a meta-analysis in which they scrutinized 14 studies on cognitive functioning during pregnancy. They found consistent evidence of deficiencies in various cognitive areas, including verbal memory. Although there is a chance that some elements of memory may be retained, the authors noted that tasks involving the active manipulation of linguistic information often exhibit significant declines. This contradiction raises doubts about the durability of verbal memory during pregnancy and suggests that the findings of the current study may not capture the full extent of cognitive changes that occur during pregnancy. Furthermore, Keenan et al. (1998) discovered that pregnant women demonstrated significant impairments in verbal memory tests, particularly when compared to non-pregnant controls. This was the case when the study was conducted using a control group. These deficiencies could be made worse by factors such as stress and hormone fluctuations, both of which are common during pregnancy, according to the authors' hypothesis. Due to the fact that the current study did not find any significant changes, it is possible that there is a requirement for additional research into the particular circumstances through which verbal memory is impacted. According to the findings of the current study, there were no significant changes in the performance of pregnant women and controls on the Trail Making Test. This suggests that visual attention and task-switching abilities may stay relatively unchanged during pregnancy. However, this

conclusion contradicts other studies that have documented impairments in these cognitive domains. This finding is generally consistent with some of the written literature; however, it contradicts other research. Rendell & Henry (2008) discovered that pregnant women exhibited impairments in their ability to switch between tasks on the Trail Making Test, when compared to non-pregnant individuals. According to their research, the cognitive demands related to pregnancy may impede a woman's capacity to efficiently transition between tasks. The present study's discovery of no disparities contradicts this, indicating that the cognitive load may not have as negative an impact on visual attention and task-switching as previously believed. In contrast, a study conducted by Jang et al. (2018) did not observe any notable disparities in visual attention and task-switching abilities between pregnant women and the control group, which aligns with the findings of the present investigation. Nevertheless, the inconsistent results observed in several studies underscore the diversity in cognitive abilities throughout pregnancy. This indicates that factors such as the characteristics of the participants, the conditions under which the tests were conducted, and the specific cognitive tasks used could impact the results.

6.3 Mechanism of Possible Consequences

The mechanisms underlying the possible outcomes observed in the study on cognitive performance among pregnant women compared to healthy controls can be attributed to several interrelated factors, as supported by existing literature. An essential process is the influence of hormonal fluctuations that occur during pregnancy. Pregnant women have substantial hormonal variations, including changes in estrogen and progesterone levels, which can impact brain function and cognitive processes. Studies have demonstrated that these hormonal changes can impact neurotransmitter systems, including those related to executive function and cognitive control. Another crucial factor is the heightened cognitive burden that comes with pregnancy. Pregnant women may face increased cognitive demands as their bodies undergo physical changes and prepare for childbirth. The cognitive burden can result in challenges in maintaining focus and carrying out activities that necessitate cognitive adaptability. Murray et al. (2016) emphasized that the cognitive requirements of pregnancy can put pressure on the capacity of working memory, which is consistent with the results of lower scores on the Extension Test in the present study. The study's findings highlight the difficulties that pregnant women encounter when engaging in tasks that demand cognitive flexibility and executive function, as seen by their lower performance on the Stroop test and Card Sorting Test.

Henry and Rendell (2007) have consistently demonstrated that pregnancy can have a detrimental effect on executive functions, which further supports the present findings. The reduced number of completed categories and elevated error rates observed in the Card Sorting Test among pregnant women suggest that these cognitive difficulties are substantial and may be compounded by the stress and exhaustion often encountered during pregnancy. Moreover, the results of the Continuous Performance Test indicate that pregnant women had a higher number of errors and misses, indicating deficiencies in their ability to sustain attention and remain vigilant. In their study, Crawley et al. (2003) conducted a meta-analysis which revealed that pregnant women consistently exhibited lower performance on tests measuring sustained attention, in comparison to non-pregnant individuals used as controls. This finding supports the idea that the cognitive requirements of pregnancy can have a detrimental effect on activities connected to attention. Interestingly, the study found no significant differences in verbal memory skills between pregnant women and the control group, which contrasts with some literature that reports verbal memory deficits during pregnancy. For instance, Keenan et al. (1998) documented impairments in verbal memory tasks among pregnant women, suggesting that the current study's findings may not capture the full extent of cognitive changes associated with pregnancy. This discrepancy may indicate that while certain cognitive functions decline, others, such as verbal memory, may remain stable or be less affected. Finally, the lack of significant differences in visual attention and task-switching abilities, as indicated by the Trail Making Test results, suggests that these cognitive functions may not be significantly impacted by pregnancy. This finding contrasts with other cognitive areas where impairments were noted, indicating that specific cognitive functions may remain intact during pregnancy. Jang et al. (2018) also reported mixed results regarding visual attention, suggesting that more research is needed to understand the nuances of cognitive performance during pregnancy.

6.4 Limitations and Constraints of the Study

The study has several limitations and constraints that should be acknowledged to provide a comprehensive understanding of its findings and implications. One significant limitation is the sample size and demographic homogeneity. The control group and pregnant women were relatively similar in terms of age and educational background, which may limit the generalizability of the findings. A more diverse sample that includes a wider range of ages, educational levels, and socio-economic backgrounds could provide

a more comprehensive view of cognitive performance during pregnancy. Additionally, the study did not account for potential confounding variables such as pre-existing mental health conditions, lifestyle factors, or social support systems, which could influence cognitive outcomes. Another constraint is the reliance on specific cognitive tests to measure various domains of cognitive function. While the Stroop test, Card Sorting Test, and Continuous Performance Test are established measures, they may not capture the full spectrum of cognitive abilities affected by pregnancy. The timing of cognitive examinations during pregnancy is an important factor to take into account. The study specifically targeted women in the second and third trimesters, however, cognitive ability may exhibit considerable variation during various phases of pregnancy. Conducting longitudinal studies that evaluate cognitive ability at various intervals during pregnancy and postpartum could offer a more comprehensive understanding of the temporal changes in cognitive capacities. The study's cross-sectional design limits the ability to draw causal inferences about the relationship between pregnancy and cognitive performance. Longitudinal designs would be more effective in establishing causal relationships and understanding the mechanisms underlying cognitive changes during pregnancy. Furthermore, the study did not investigate the potential influence of environmental variables such as stress, weariness, and physical well-being on cognitive functioning. These variables have the potential to exert a substantial impact on cognitive outcomes and should be taken into account in future studies to acquire a more intricate comprehension of cognitive function throughout pregnancy.

7. CONCLUSIONS AND SUGGESTIONS

This study concludes that pregnancy is associated with significant cognitive impairments in areas such as attention, memory, and executive function. The results emphasize the need for awareness among healthcare providers regarding the potential cognitive challenges faced by pregnant women. Early identification of these cognitive changes is crucial, as they can have implications for maternal mental health and the overall well-being of both mother and child.

The findings also suggest that cognitive impairments during pregnancy may contribute to increased risks of mental health issues such as postpartum depression and anxiety, highlighting the importance of providing appropriate support and interventions for expectant mothers.

Based on the findings of this study, the following recommendations are proposed:

Routine Cognitive Assessments: to implement cognitive screening as part of prenatal care to identify pregnant women who may be experiencing cognitive impairments. Early detection can facilitate timely interventions.

Psychological Support: to provide psychological support and counseling for pregnant women to address cognitive challenges and promote mental well-being. This may include stress management techniques and coping strategies.

Education and Awareness: to increase awareness among healthcare professionals about the cognitive changes that can occur during pregnancy. Training programs can help providers recognize and address these issues effectively.

Further Research: to conduct longitudinal studies to explore the long-term effects of cognitive impairments during pregnancy on maternal and child outcomes. Investigating the underlying mechanisms of these cognitive changes will also be beneficial.

Supportive Interventions: to develop targeted interventions aimed at enhancing cognitive functioning during pregnancy, such as cognitive training programs or mindfulness practices, to help mitigate the observed impairments.

By addressing these recommendations, healthcare providers can better support pregnant women, ultimately improving health outcomes for both mothers and their infants.

REFERENCES

- Barba-Müller, E., Craddock, S., Carmona, S., & Hoekzema, E. (2019). Brain plasticity in pregnancy and the postpartum period: Links to maternal caregiving and mental health. *Archives of Women's Mental Health*, 22(2), 289-299. <https://doi.org/10.1007/s00737-018-0888-7>
- Barda, G., Mizrachi, Y., Borokchovich, I., Lampl, Y., Paleacu Kertesz, D., & Dabby, R. (2021). The effect of pregnancy on maternal cognition. *Scientific Reports*, 11, 12187. <https://doi.org/10.1038/s41598-021-91504-9>
- Brett, M., & Baxendale, S. (2001). Motherhood and memory: A review. *Psychoneuroendocrinology*, 26(4), 339-362. [https://doi.org/10.1016/S0306-4530\(01\)00019-5](https://doi.org/10.1016/S0306-4530(01)00019-5)
- Britannica. (2021). *Pregnancy - Duration, development, trimesters*. Retrieved from <https://www.britannica.com/topic/pregnancy>
- Brunton, P. J., & Russell, J. A. (2020). Neurobiological changes during the peripartum period: Implications for health and behavior. *Social Cognitive and Affective Neuroscience*, 15(10), 1097–1110. <https://doi.org/10.1093/scan/nsz091>
- Buckwalter, J. G., Stanczyk, F. Z., McCleary, C. A., Bluestein, B. W., Buckwalter, D. K., Rankin, K. P., ... & Goodwin, T. M. (1999). Pregnancy, the postpartum, and steroid hormones: effects on cognition and mood. *Psychoneuroendocrinology*, 24(1), 69-84. [https://doi.org/10.1016/S0306-4530\(98\)00044-4](https://doi.org/10.1016/S0306-4530(98)00044-4)
- Cambridge Dictionary. (n.d.). *Baby Brain*. In *Cambridge Dictionary*. Cambridge University Press. Retrieved August 15, 2024, from <https://dictionary.cambridge.org>
- Cameron, J. L., & McGowan, J. (2010). Psychological and psychophysiological considerations regarding the maternal-fetal relationship. *Infant and Child Development*, 19(1), 27–38. <https://doi.org/10.1002/icd.651>
- Cárdenas, E. F., Kujawa, A., & Humphreys, K. L. (2020). Neurobiological changes during the peripartum period: Implications for health and behavior. *Social Cognitive and Affective Neuroscience*, 15(10), 1097–1110. <https://doi.org/10.1093/scan/nsz091>
- Carmona, S., Martínez-García, M., Paternina-Die, M., Barba-Müller, E., Wierenga, L. M., Alemán-Gómez, Y., Pretus, C., Marcos-Vidal, L., Beumala, L., Cortizo, R., Pozzobon, C., Picado, M., Lucco, F., García-García, D., Soliva, J. C., Tobeña, A., Peper, J. S., Crone, E. A., Ballesteros, A., Vilarroya, O., Desco, M., & Hoekzema, E. (2019). Pregnancy and adolescence entail similar neuroanatomical adaptations: A comparative analysis of cerebral morphometric changes. *Human Brain Mapping*, 40(11), 3243-3255. <https://doi.org/10.1002/hbm.24513>
- Chrisler, J. C., & Johnston-Robledo, I. (2000). Motherhood and reproductive issues. In M. Biaggio & M. Hersen (Eds.), *Issues in the psychology of women* (1st ed., Vol. 1, pp. 199-226). Kluwer Academic Publishers.

- Cleveland Clinic. (2021). Pregnancy: Gestation, trimesters & what to expect. Cleveland Clinic. Retrieved from <https://www.clevelandclinic.org>
- Conners, C. K. (2014). *Conners Continuous Performance Test (Conners CPT 3) & Conners Continuous Auditory Test of Attention (Conners CATA): Technical Manual*. Multi-Health Systems Inc.
- Davies, S. J., Lum, J. A. G., Skouteris, H., Byrne, L. K., & Hayden, M. J. (2017). Cognitive impairment during pregnancy: A meta-analysis. *The Medical Journal of Australia*, 208(1), 10-15.
https://www.mja.com.au/system/files/issues/208_01/10.5694mja17.00131
- Davies, S. J., Lum, J. A. G., Skouteris, H., Byrne, L. K., & Hayden, M. J. (2019). Cognitive impairment during pregnancy: A meta-analysis. *The Medical Journal of Australia*, 208(1), 10-15. <https://doi.org/10.5694/mja17.00131>
- de Groot, R. H., Vuurman, E. F., Hornstra, G., & Jolles, J. (2006). Differences in cognitive performance during pregnancy and early motherhood. *Psychological Medicine*, 36(7), 1023-1032. <https://doi.org/10.1017/S0033291706007391>
- Deave, T., Johnson, D., & Ingram, J. (2008). Transition to parenthood: the needs of parents in pregnancy and early parenthood. *BMC Pregnancy and Childbirth*, 8, 30. <https://doi.org/10.1186/1471-2393-8-30>
- Duarte-Guterman, P., Leuner, B., & Galea, L. A. (2019). The long and short term effects of motherhood on the brain. *Hormones and Behavior*, 111, 69-82.
<https://doi.org/10.1016/j.yhbeh.2018.11.002>
- Glynn, L. M. (2018). The impact of pregnancy on maternal cognition: A review of the literature. *Psychoneuroendocrinology*, 95, 1-10.
<https://doi.org/10.1016/j.psyneuen.2018.05.013>
- Gouilhers, S., Meyer, Y., Inglin, S., Pfister Boulenaz, S., Schnegg, C., & Hammer, R. (2019). Pregnancy as a transition: First-time expectant couples' experience with alcohol consumption. *Drug and Alcohol Review*, 38(7), 758–765.
<https://doi.org/10.1111/dar.12973>
- Haynes, E. (2022). *Historical aspects of maternal mental illness*. Routledge.
https://doi.org/10.1007/978-3-030-41716-1_1
- Healthline. (2023). Beck Anxiety Inventory (BAI): Benefits, cost, and more. Retrieved from <https://www.healthline.com/health/anxiety/beck-anxiety-inventory>
- Heaton, R. K., Chelune, G. J., Talley, J. L., Kay, G. G., & Curtiss, G. (1993). Wisconsin Card Sorting Test manual: Revised and expanded. Odessa, FL: Psychological Assessment Resources.
- Henry, J. D., & Rendell, P. G. (2007). A review of the impact of pregnancy on memory function. *Journal of Clinical and Experimental Neuropsychology*, 29(7), 793-803.
<https://doi.org/10.1080/13803390601185374>

- Henry, J. F., & Sherwin, B. B. (2012). Hormones and cognitive functioning during late pregnancy and postpartum: A longitudinal study. *Behavioral Neuroscience*, 126(1), 73–85. <https://doi.org/10.1037/a0025540>
- Hoekzema, E., Barba-Müller, E., Pozzobon, C., Picado, M., Lucco, F., García-García, D., ... & Vilarroya, O. (2017). Pregnancy leads to long-lasting changes in human brain structure. *Nature Neuroscience*, 20(2), 287-296. <https://doi.org/10.1038/nn.4458>
- Leuner, B., & Sabihi, S. (2016). The birth of new neurons in the maternal brain: Hormonal regulation and functional implications. *Frontiers in Neuroendocrinology*, 41, 99-113. <https://doi.org/10.1016/j.yfrne.2016.01.001>
- LibreTexts. (2021). *Overview of pregnancy and human development*. Retrieved from [https://chem.libretexts.org/Bookshelves/Developmental_Biology/Developmental_Biology_\(LibreTexts\)](https://chem.libretexts.org/Bookshelves/Developmental_Biology/Developmental_Biology_(LibreTexts))
- Logan, D. M., Hill, K. R., Jones, R., Holt-Lunstad, J., & Larson, M. J. (2014). How do memory and attention change with pregnancy and childbirth? A controlled longitudinal examination of neuropsychological functioning in pregnant and postpartum women. *Journal of Clinical and Experimental Neuropsychology*, 36(5), 528–539. <https://doi.org/10.1080/13803395.2014.912614>
- Martínez García, M. T. (2021). *Characterization of gestational brain remodeling in human mothers* [Doctoral dissertation, Universidad Carlos III de Madrid]. e-Archivo. <https://e-archivo.uc3m.es/rest/api/core/bitstreams/38a646e1-5d56-45fe-a4cc-a1177fdee76b/content>
- Miranda, A., & Sousa, N. (2018). Maternal hormonal milieu influence on fetal brain development. *Brain and Behavior*, 8(2), e00920. <https://doi.org/10.1002/brb3.920>
- Neumann, I. D. (2008). Brain mechanisms underlying emotional regulation of social behavior. *Journal of Neuroendocrinology*, 20(5), 703-712. <https://doi.org/10.1111/j.1365-2826.2008.01748.x>
- Onyper, S. V., Searleman, A., Thacher, P. V., Maine, E. E., & Johnson, A. G. (2010). Executive functioning and general cognitive ability in pregnant women and matched controls. *Journal of Clinical and Experimental Neuropsychology*, 32(9), 986-995. <https://doi.org/10.1080/13803390903067080>
- Pawluski, J. L., Hoekzema, E., Leuner, B., & Lonstein, J. S. (2022). *Less can be more: Fine tuning the maternal brain*. *Journal of Neuroendocrinology*, 34(6), e13165. <https://doi.org/10.1111/jne.13165>
- Rendell, P. G., & Henry, J. D. (2008). Prospective-memory functioning is affected during pregnancy and postpartum. *Journal of Clinical and Experimental Neuropsychology*, 30(8), 913-919. <https://doi.org/10.1080/13803390701874379>
- Servin-Barthet, C., Martínez, M., Vilarroya, O., & Carmona, S. (2022). Motherhood's brain blueprint: How pregnancy rewires us. *Nature Reviews Neuroscience*, 23(10), 605-620. <https://doi.org/10.1038/s41583-022-00650-5>

Stark, M. A. (2000). Is it difficult to concentrate during the 3rd trimester and postpartum? *Journal of Obstetric, Gynecologic, and Neonatal Nursing*, 29(4), 378-389. <https://doi.org/10.1111/j.1552-6909.2000.tb02060.x>

StatPearls. (2021). *Physiology, pregnancy*. Retrieved from NCBI Bookshelf: <https://www.ncbi.nlm.nih.gov/books/NBK567773/>

Strauss, E., Sherman, E. M., & Spreen, O. (2006). A compendium of neuropsychological tests: Administration, norms, and commentary. American Chemical Society.

Şahin-Sadık, S., & et al. (2022). Neuropsychological assessment of cognitive functions. *Journal of Scientific Reports-A*, 51, 240-252. Retrieved from <https://dergipark.org.tr/en/download/article-file/2602963>

Torres, M., & Ngun, T. (2019). Hormonal influences on cognitive function: A review. *Hormones and Behavior*, 111, 69-82. <https://doi.org/10.1016/j.yhbeh.2019.03.002>

Tunay, Ş., & Soygüt, G. (2009). The reliability and validity of Turkish Brief Measure of Worry Severity based on Turkish university students. *Turkish Journal of Psychiatry*, 20(1), 68-74. Retrieved from <https://www.turkpsikiyatri.com/PDF/C20S1/en/68-74.pdf>

Uvnäs-Moberg, K. (1998). Oxytocin and the establishment of maternal behavior. *Journal of Neuroendocrinology*, 10(9), 765-770. <https://doi.org/10.1046/j.1365-2826.1998.00306.x>

Wikipedia. (2023). Beck Anxiety Inventory. Retrieved from https://en.wikipedia.org/wiki/Beck_Anxiety_Inventory

Yeniceri, N., & Altan-Atalay, A. (2011). Age-Related Changes in the Wisconsin Card Sorting Test Performances of 8- to 11-Year-Old Turkish Children. *Clinical Neuropsychologist*, 25(6), 1179-1192. DOI: [10.1080/13854046.2011.613855](https://doi.org/10.1080/13854046.2011.613855).

Zhang, Y., Cui, Y., Jiang, Y., Wang, Y., Zhang, X., & Tao, F. (2023). Associations between cognitive impairment during pregnancy and postpartum depression: A prospective cohort study. *Journal of Affective Disorders*, 321, 1-8. <https://doi.org/10.1016/j.jad.2022.10.084>

APPENDIX

APPENDIX 1. Approval from Ethics Committee



APPENDIX 2. Voluntary Consent Form Used in the Study

INFORMED VOLUNTARY CONSENT FORM (IVCF)

TITLE OF THE STUDY:

Investigation of Neuropsychological Changes during Pregnancy: A Cross Sectional Study

*You are asked to participate in a research study, the details of which are given below. The decision whether or not to participate in the study is entirely yours. Before deciding whether or not to take part, it is important that you understand why the study is being done, how your information will be used, what the study involves, the possible benefits and risks, and any aspects that may cause discomfort. Please take time to read the following information carefully. If you decide to participate in the study, please sign the **Consent to Participate Form**. You are free to leave the study at any time. You will not be paid for participating in the study or asked for any financial contribution/material contribution. / All materials to be used in the study and all expenses to be incurred will be covered by the researcher (can be one of two sentences)*

SUBJECT AND PURPOSE OF THE STUDY:

This study, which is planned as Üsküdar University Neuroscience (English) Master's Thesis, is carried out by Psychologist Beyza Nur Ekşi under the supervision of Prof. Dr. Cumhuri Taş. The aim of the study is to examine the neuropsychological differences that occur during pregnancy and the responses of these differences in the brain. The study aims to provide information on this subject and contribute to the literature.

STUDY PROCEDURES:

This study will be conducted in an interview. You will be asked to fill in the form prepared by the researchers inquiring about your socio-demographic characteristics and to participate in the neuropsychological tests to be applied in line with the instructions given by the researcher.

You have the right not to participate in the research and to leave at any time. There is no financial benefit to you for participating in the study. If you request additional information, it will be provided verbally. The data we receive from you will not be used for any purpose other than research and your private data will be kept confidential.

WHAT ARE THE POSSIBLE BENEFITS OF PARTICIPATING IN THE STUDY?

To contribute to science and literature.

HOW WILL MY PERSONAL INFORMATION BE USED?

The data we receive from you will not be used for any purpose other than research and your private data will be kept confidential.

PERSONS TO CONTACT FOR QUESTIONS AND PROBLEMS:

Psychologist Beyza Nur EKŞİ

Prof. Dr. Cumhur TAŞ

CONSENT TO PARTICIPATE

I have discussed the above information in detail with the researcher and he answered all my questions. I have read and understood this informed consent document. I agree to participate in this study and sign this consent document of my own free will. This consent does not override any relevant laws and regulations. The researcher has given me a copy of this document for my safe-keeping, including the points to be considered during the study.

<i>Voluntary Name And Surname:</i>		<i>Date and Signature:</i>
<i>Phone Number:</i>		

<i>Guardian (If any) Name and Surname:</i>		<i>Date and Signature:</i>
<i>Phone Number:</i>		

<i>Researcher² Name and Surname:</i>		<i>Date and Signature:</i>
<i>Address and Phone Number:</i>		

1: The person who witnessed the volunteer's information process from beginning to end

2: The person who informs the volunteer about the research



APPENDIX 3. Sociodemographic Data Form

QUESTIONS ON DEMOGRAPHIC INFORMATION

1. Age:

2. Education

- ☐ Reader-literate
- ☐ Primary School
- ☐ Middle School
- ☐ High School
- ☐ University or higher

3. Family Type

- ☐ Nuclear family
- ☐ Extended Family

4. Duration of marriage:

____ year/month

5. Province and district

QUESTIONS ON GENERAL HEALTH AND PSYCHOSOCIAL FACTORS

6. Do you have any existing chronic diseases? If yes, please specify the disease.

- ☐ Yes _____
- ☐ No

7. Do you have existing habits? Please indicate if your answer is drug/other

- ☐ No
- ☐ Smoking
- ☐ Alcohol
- ☐ Drug/Other _____

8. Do you have any history of psychiatric illness (depression, psychosis, etc.)? If yes, please specify it.

- ☐ Yes _____

- ☐ No

9. Do you use psychiatric medication during pregnancy? If yes, please specify.

- ☐ Yes _____
- ☐ No

10. Do you have a first-degree relative with a history of psychiatric illness? If yes, please specify.

- ☐ Yes _____
- ☐ No

11. Do your partner support you during pregnancy?

- ☐ Always
- ☐ Sometimes
- ☐ Never

12. How is your romantic relationship with your partner during pregnancy?

- ☐ Good
- ☐ Not bad
- ☐ Bad

13. How is your communication/emotional bonding with your baby during your pregnancy?

- ☐ Good
- ☐ Not bad
- ☐ Bad

PREGNANCY-RELATED QUESTION

14. What gestational period are you in?

- ☐ 1st trimester
- ☐ 2nd trimester
- ☐ 3rd trimester

15. Number of pregnancies

- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four and higher

16. Number of living children

- ☐ None
- ☐ One
- ☐ Two
- ☐ Three
- ☐ Four and higher

17. Do you have a history of miscarriage or stillbirth?

- ☐ Yes
- ☐ No

18. Your first gestational age:

- ☐ _____

19. How did you conceive?

- ☐ Natural pregnancy
- ☐ Pregnancy with reproductive techniques

20. Did you get pregnant willingly?

- ☐ Planned pregnancy
- ☐ Unplanned pregnancy

21. Did you have any health problems during your pregnancy? If yes explain, please.

- ☐ Yes _____
- ☐ No

22. Do you regularly attend your check-ups during pregnancy?

- ☐ Yes
- ☐ No

APPENDIX 4. Beck Anxiety Scale

Beck Anxiety Inventory

Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past month, including today, by circling the number in the corresponding space in the column next to each symptom.

	Not At All 0	Mildly but it didn't bother me much. 1	Moderately - it wasn't pleasant at times 2	Severely – it bothered me a lot 3
Numbness or tingling				
Feeling hot				
Wobbliness in legs				
Unable to relax				
Fear of worst happening				
Dizzy or lightheaded				
Heart pounding/racing				
Unsteady				
Terrified or afraid				
Nervous				
Feeling of choking				
Hands trembling				
Shaky / unsteady				
Fear of losing control				
Difficulty in breathing				
Fear of dying				
Scared				
Indigestion				
Faint / lightheaded				
Face flushed				
Hot/cold sweats				
Column Sum				

Scoring - Sum each column. Then sum the column totals to achieve a grand score.

Write grand score here _____.

APPENDIX 5. Öktem Verbal Memory Process Test

ÖKTEM VERBAL MEMORY PROCESS TEST (ÖKTEM VMPT)
(LIST A)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Score
	Drum	Curtain	Bell	Coffee	School	Mom	Garden	Hat	Moon	Farmer	Nose	Turkey	Colour	Home	River	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
U																
S																
B																
T																

Tot. Rec.

F. R.

APPENDIX 6. Back Side of Öktem Verbal Memory Processes Test

WALL
 DRUM
 ZURNA
 WINDOW
 CURTAIN
 PITA
 BELL
 CHAIN
 DOOR
 TEA
 COFFEE
 BREAKFAST
 GAME
 SCHOOL
 TEACHER
 SISTER
 MOM
 DAD
 TREE
 FLOWER
 GARDEN
 SCARF
 HAT
 CAP
 MOON
 QUINCE
 SUN
 FIELD
 FARMER
 FARM
 THROAT
 NOSE
 MOUTH
 TURKEY
 COOK
 DITCH
 PICTURE
 COLOUR
 AD
 ROOM
 HAND
 HOME
 SEA
 RIVER
 STREAM

VMPT Scores	
Immediate Memory	
Learning Score	
Reaching the Criterion	
Highest Learning	
Learning Misuse Score	
Persistence	
Inconsistency Score	
Delayed Spontaneous Recall	
Recognition	
TOTAL Recall	
False Recall Score	
False Recognition	

APPENDIX 7. Stroop Test TBAG Form

Section I: Reading Color Name Printed in Black Name

B	Y	R	G
G	B	Y	R
G	R	B	Y
R	G	Y	B
Y	R	G	B
R	B	Y	G

Section III: Saying Shape Color Name

G	B	Y	R
Y	R	G	B
B	G	Y	R
B	Y	R	G
R	G	B	Y
Y	G	B	R

Section II: Reading Color Printed Color

B	Y	R	G
G	B	Y	R
G	R	B	Y
R	G	Y	B
Y	R	G	B
R	B	Y	G

Section IV: Word Color without a Color

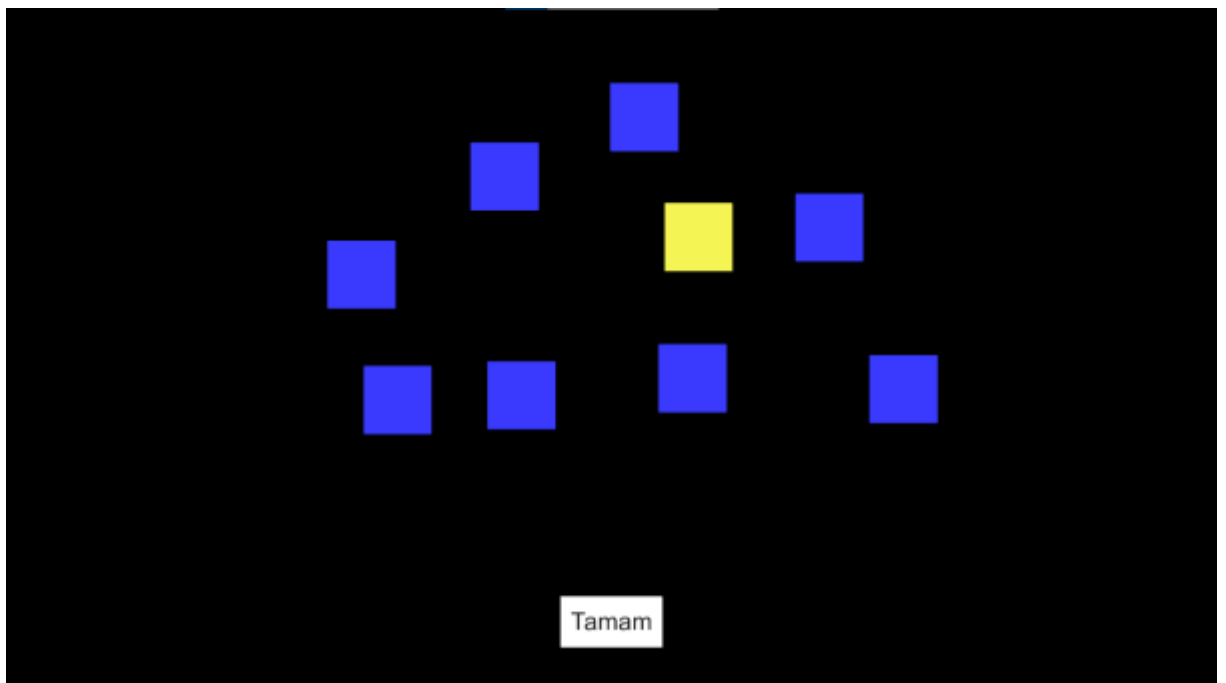
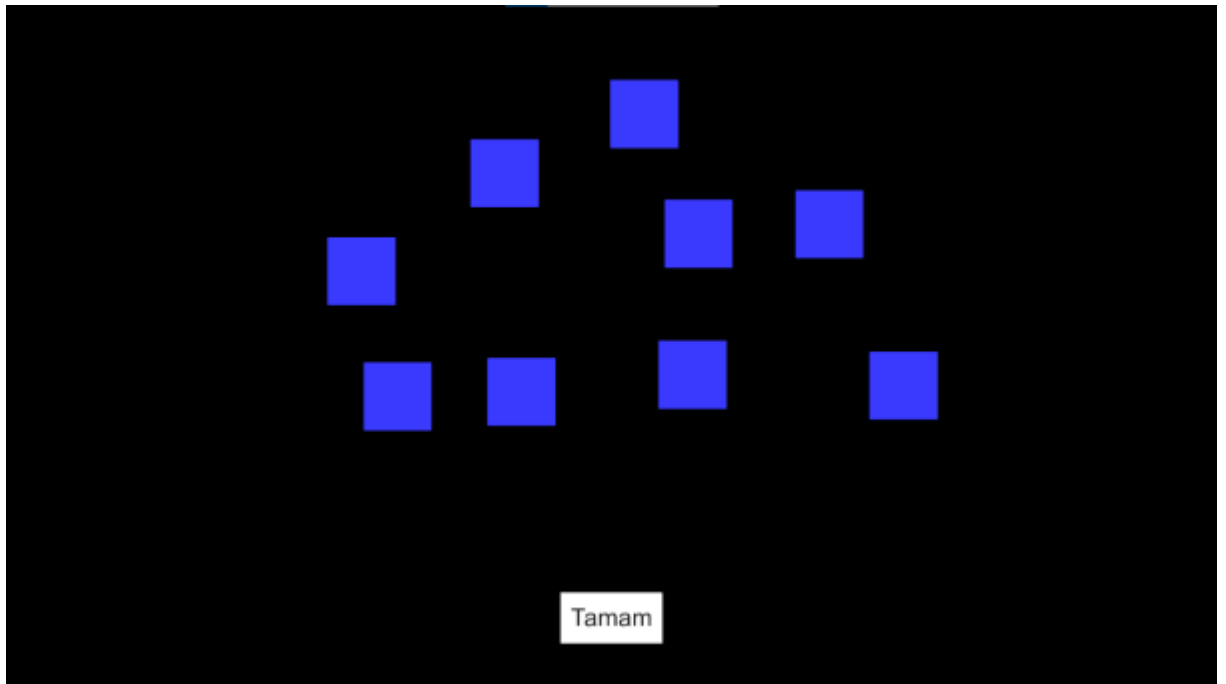
G	B	Y	R
Y	R	G	B
B	G	Y	R
B	Y	R	G
R	G	B	Y
Y	G	B	R

Section V: Word Color with Color Name

G	B	Y	R
Y	R	G	B
B	G	Y	R
B	Y	R	G
R	G	B	V
Y	G	B	R

(B = BLUE, G = GREEN, R = RED, Y = YELLOW)

APPENDIX 8. Extention Test



APPENDIX 9. Wisconsin Card Sorting Test

The stimulus consists of a 2x4 grid of cards. The top row contains four cards: a red triangle, two green stars, three yellow plus signs, and four blue circles. The bottom row contains four empty white cards. Below the grid is a comparison card with three blue triangles. Below the comparison card is the text "Kartı yerleřtirmek iin bir deste sein."

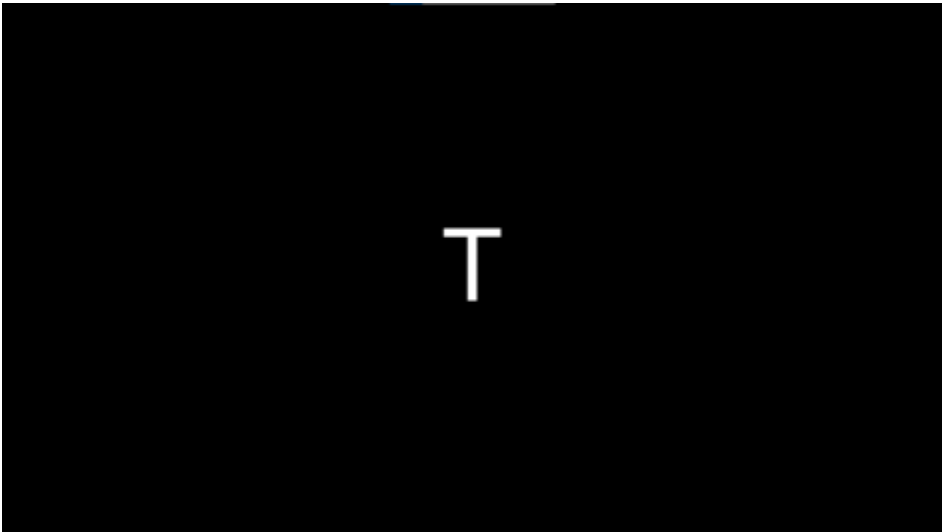
Kartı yerleřtirmek iin bir deste sein.

The stimulus consists of a 2x4 grid of cards. The top row contains four cards: a red triangle, two green stars, three yellow plus signs, and four blue circles. The bottom row contains four cards: a red star, two green circles, one yellow plus sign, and three blue stars. Below the grid is the text "Doğru" in green. Below the text is a comparison card with one green plus sign. Below the comparison card is the text "Kartı yerleřtirmek iin bir deste sein."

Doğru

Kartı yerleřtirmek iin bir deste sein.

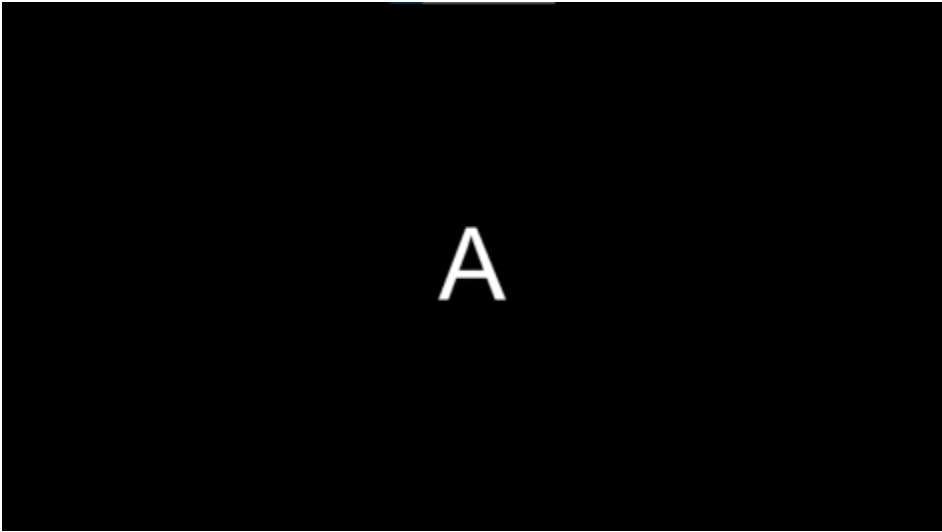
APPENDIX 10. Continuous Performance Testing



T



Z



A

APPENDIX 11. Trail Making Test

