



Auditory Cognitive Function Assessment During Pregnancy

An Event-Related Potential
and Neuropsychological Study

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Abbreviations

ADHD	attention deficit hyperactivity disorder
ANOVA	analysis of variance
BDI	Beck Depression Inventory
BDI II	Beck Depression Inventory II
COWA/COWAT	Controlled Oral Word Association Test
CT scans	computed tomography scans
EEG	electroencephalography
ER	estrogen receptor
ERP	event-related potential
fMRI	functional MRI
ISI	interstimulus interval
LDST	Letter Digit Substitution Test
MRI	magnetic resonance imaging
RAVLT	Rey Auditory Verbal and Learning Test
RAVLT _{dr}	RAVLT for delayed recall
RAVLT _{im}	RAVLT for immediate recall
RAVLT _{ts}	RAVLT for total scores of tests
SD	standard deviation
SERP	somatosensory ERP
SNR	signal noise ratio
SPL	sound pressure level
SPM	Sijil Pelajaran Malaysia
TBI	traumatic brain injury
VERP	visual ERP
WCST	Wisconsin Card Sorting Test
ZCT	Zazzo's Cancellation Test

1 Introduction

1.1 Cognitive Function

The cognitive function is a mental performance that processes any received information by giving attention, thinking, memory, manipulation and retrieval of information. Any impairment in cognition limits the well-functioning in daily life and in worse cases can be seen in dementia or Alzheimer's diseases patients. In fact, the learning capabilities will also be affected by inability to retain memory or giving any attention. Cognitive function is enhanced by visual and auditory processing system. Both sensory processing systems are essential for the development of executive functions and attention skills. Audio-spatial ability functionally intersects with the visual attention ability (visuospatial) that created up the stability of executive function to properly function (Smith et al., 2010; Wu et al., 2017; Doty, 2012).

During pregnancy, a stable state of health and well performed cognition is needed to ensure a safe and proper pregnancy journey. However, hormonal fluctuations and disturbances during pregnancy gives some negative effects towards the expecting mothers including emotional disturbances (Schneider, 2017). In fact, some literature briefly described impaired performance in cognitive function especially in expecting mothers with no specific descriptions on different cognition across trimesters. Reduced memory and attention are also believed to be possible during pregnancy (Janes et al., 1999; Brett & Baxendale, 2001). Hormonal changes during pregnancy have

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the capability to increase the risk of getting depression and anxiety (Soares & Zitek, 2008; Henry & Rendell, 2007; Crawley, 2008), in which they may also negatively influence the cognitive functions such as learning, memory, attention and mood variations (Poser et al., 1986; Buckwalter et al., 1999). Even though these research findings suggest on cognitive performance in pregnancy, it was still lacking in evidence to clinically support the pregnant women in terms of proper rehabilitation while being pregnant.

In current normal clinical routines during maternal checkups, rarely the cognitive functions of expecting mothers were assessed and evaluated. This is because the cognitive impairment or emotional disturbances in pregnancy is lightly taken as normal biological changes and mildly effect on daily life functioning which expected to return to normal after delivery once the hormonal fluctuations are no longer persisted. However, it is essential to be reminded that the impairment of cognitive function which is known as maternal amnesia may somehow persist even after delivery (Mazor et al., 2019) signaling that cognitive impairment may be significantly impaired if it is not treated in the early stages of pregnancy. Considering that factor, it is a need for clinician to detect any deficit in cognitive function as early as possible to prevent any significant worsening of the cognition especially by determining the cognition at early pregnancy. To do so, a comparison of pregnancy trimesters and nonpregnant state is needed. Hence, this study is made as an initiation to determine the cognitive and executive state on pregnant women across trimesters of pregnancy by comparing them to nonpregnant women.

1.2 Cognitive Function and Pregnancy

Being a normal physiology among women (Soma-Pillay et al., 2016), pregnancy has three trimesters: first trimester (1-12 weeks), second trimester (13-26 weeks) and third trimester (27-40 weeks) (Jones, 2013). Pregnancy hormones like estrogen and progesterone are significant during pregnancy period in which they can also affect a woman's cognitive functions at that time (Bromberger et al., 2011; McEwen et al., 2012).

Normal cognitive functioning is needed for human beings to perform daily routine tasks which involve mental capabilities including reading a book, baking a chocolate cake, and even walking to the office, and all these require intact cognitive function. All those daily routines can be done with good cognitive performance in paying attention, good working memory and intact executive function. Unfortunately, cognitive and executive functions processes were reported to be impaired during pregnancy (Davies et al., 2018).

There is a phenomenon known as 'baby brain' phenomenon subjectively reported to be experienced by pregnant women. Frequent forgetfulness, lack of focus and attention to poor thinking skills were commonly reported. There is no exact scientific explanation for this phenomenon, but most findings relate it to hormonal effects. Try to imagine what happen to pregnant women who may be affected if they tend to forget things easily, cannot pay attention to their surroundings or even slow in make decisions. They may experience emotional stress for not being able to function as they used to while not being pregnant. The impact of cognitive impairment may be significant depending on the perception of expecting mothers, while some claimed that they lose the ability to organize work and even the inability to return to work because of severe memory problems (Sharp et al., 1993). Some also reported non-significantly affecting their daily life. These perceived cognitive deficits,

however, are inconsistent in findings (Christensen et al., 2010; Davies et al., 2018). Due to that factor, more studies on cognitive function during pregnancy are needed.

1.3 Problem Statement

Limited findings of cognitive and executive functions in pregnant women have been investigated, specifically in the study of neuronal mechanism. Among the studies of cognition in pregnancy was performed by Raj (2014), focusing on visual cognitive function using emotional and non-emotional visual oddball tasks as stimuli. Raj hypothesized that different event-related potential (ERP) findings alteration in N170 and P300 ERP components during pregnancy suggest a modulation of cognitive-affective function. This study has covered areas of the visual attentional network during pregnancy. Then, in 2016, Begum et al. made a further ERP study on cognitive function of pregnant women using auditory oddball task as a stimulus. Both Raj (2014) and Begum et al. (2016) have covered the auditory and visual cognitive functions, respectively, but their studies did not represent a comprehensive neural network in cognitive processes in all trimesters of pregnancy.

Besides, comparison of cognitive and executive function across trimesters using ERP and neuropsychological tests have never been reported. As we know, pregnancy stages or trimesters may have different hormonal influences and according to some studies different trimesters may have different states of cognition. Also, a few studies have attempted to investigate cognitive function during pregnancy and presented separate findings of electrophysiological and neuropsychological (Davies et al., 2018), but no attempt has yet been made to integrate both techniques in one study. In fact, no studies have been done on investigating cognitive studies between trimesters of pregnancy

that combine ERP and neuropsychological tests. So, this current study intends to fill in the gap of the studies in cognitive and executive functions between trimesters of pregnancy comparing it to nonpregnant women.

1.4 Study Objective

A cognitive study related to pregnancy is needed to serve as a baseline in detecting any deficit in cognition at an early stage. Besides, early stage detection allows for expecting mothers to receive proper neuro-rehabilitation to prevent any worsening of cognition deficits throughout pregnancy, which can negatively persist until postpartum. The general objective of this study is to investigate the cognitive and executive functions of pregnant women during second and third trimesters of pregnancy. This can be achieved by assessing the neuronal mechanisms of auditory cognitive function with auditory oddball stimulation and by evaluating executive function using five different neuropsychological tests and comparing them with nonpregnant women.

1.5 Event-Related Potential

One of the prominent electrophysiological tools used to assess neural resources in cognitive studies is ERP test in which neural activity is time-locked throughout the test session. It also provides a wide range of amplitudes and latencies reading as test output. ERP is a safe and non-invasive tool that can capture any neural activities in millisecond, which is also characterized as a high temporal electrophysiological tool and perfectly suitable for cognitive studies (Key et al., 2005; Sur & Sinha, 2009). It can be evoked by different types of stimuli such as auditory, visual and somatosensory. Auditory stimulus was used in this