Original Article

Visual Perception in Pregnant Women: C1 Event-Related Component Analysis

Tahamina Begum[1] and Mohammed Faruque Reza[2]

ABSTRACT

Background

There is insufficient evidence regarding visual perception during pregnancy. Visual perception can be reflected by the C1 event-related potential (ERP) component. This study investigated visual perception in pregnant women by analyzing the C1 ERP component using visual oddball stimuli.

Method

Thirty-six participants were recruited and divided into a control group (n = 18) and a pregnant group (n = 18; 13-40 weeks of pregnancy). An ERP study used a 128-sensor net with a visual oddball task. In the oddball task, participants were asked to push either button '1' if they saw 'O' or button '2' if they saw 'X', as quickly and accurately as possible. The mean value of differences in standard and target stimuli was measured. Amplitudes and latencies of the C1 ERP component were analyzed in the parieto-occipital (P3, P4, O1, O2) and midline (Fz, Cz, Pz) areas using seven different electrodes.

Results

No significant differences in the amplitudes and latencies of the C1 ERP component were observed in the pregnant group compared to the controls.

Conclusion

The visual oddball-stimulated visual perception was intact in pregnant women, indicating that pregnancy-related hormones do not negatively impact visual perception during pregnancy.

Keywords

pregnancy; event-related potential; visual oddball;C1 component.

INTRODUCTION

Pregnancy hormones fluctuate during the three trimesters for proper fetal development. Although this change is normal during pregnancy, it significantly affects women's behavior and psychology due to alterations in cognitive-affective processing. The primary effects result from structural and neuronal changes in the brain due to a substantial increase in steroid hormones[1]. These hormonal changes directly influence pregnant women's perception, attention, and memory, disrupting the balance in their family, work, and social lives, ultimately impacting their overall quality of life. Research outcomes regarding attention and memory vary, with studies indicating both improved [2,3] and not improved [4] attention. Begum et al. (2021) studied second—and third-trimester pregnant women and revealed that auditory perception (reflected in P50 ERP component) and auditory attention (reflected in P300 ERP component) are enhanced during the second trimester of pregnancy. However, during the third trimester, this improvement diminishes[3]. Diminished visual attention was also observed in pregnant

1. Tahamina Begum, Dr. Sid E. Williams Center for Chiropractic Research, Life University, Marietta, Georgia 30060, USA.
2. Mohammed Faruque Reza, Dr. Sid E. Williams Center for Chiropractic Research, Life University, Marietta, Georgia 30060, USA.

Note: Both authors' previous affiliation is 'Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian 16150, Kota Bharu, Kelantan, Malaysia'.

Correspondence

Tahamina Begum, Dr. Sid E. Williams Center for Chiropractic Research, Life University, Marietta, Georgia, USA. E-mail: tahamina.begum@life.edu, tahamina676@gmail.com

Bangladesh Journal of Medical Science Vol. 24 No. 04 October'25

DOI: https://doi.org/10.3329/bjms.v24i4.84688

women, as reflected in the P300 ERP component [5]. Different experimental paradigms and types of stimuli can lead to inconsistent results. Target stimuli (oddball) differ perceptually from standard stimuli in both the auditory and visual oddball paradigms. Visual attention was examined using the visual oddball paradigm [6], but visual perception is rarely studied. Visual perception is reflected in the C1 ERP component. A recent study revealed that the source of the C1 ERP component is localized in the frontal lobe for both standard and target stimuli in pregnant women [7]. While there is a study on auditory perception and cognition assessment using ERP component analysis in pregnant women [2], a lack of studies remains to reveal the neuronal processing of visual perception in pregnant women through the visual oddball paradigm by analyzing amplitudes and latencies of the C1 ERP component.

To understand the neuronal processing of auditory, visual, or somatosensory stimuli, event-related potentials (ERPs) are the best method because they are inexpensive, non-invasive, and safe [8]. Different ERP components can reflect perception, memory, and attention based on various types of stimuli [9]. Sensory and cognitive information have been investigated as early and later ERP components, respectively [8]. Perception is a significant aspect of the sensory system. The C1 ERP component represents the early negative deflection evoked during visual perception and is generated in the primary visual cortex (V1). The C1 component's early onset occurs at approximately 55 ms, with its peak around 90-92 ms [10]. Some studies indicate that the C1 component can exhibit both positive and negative deflections depending on the visual field [10,11]. These deflections of the C1 ERP component signify the essential role of early perceptual encoding, serving as the initial stage of feed-forward processing within the visual system [12]. Therefore, understanding the characteristics and neuronal processes of the C1 ERP component is crucial for assessing sensory processing dynamics, particularly under certain physiological conditions like pregnancy, which involve substantial neurobiological changes.

The neuronal processes of visual perception have not yet been investigated using the visual oddball paradigm in pregnant women. This study aims to reveal the neural mechanisms of visual perception by analyzing the amplitude and latency of the C1 ERP component through a visual oddball paradigm in pregnant women.

METHODOLOGY

Study design

The Ethical Committee of Universiti Sains Malaysia (USM) (USM/JEPEM/15090294) provided human ethical approval for human research before initiating the experiment.

The power and sample size (PS) software v3.1.6 (Vanderbilt University, Nashville, TN, USA) calculated the sample size. Participants were divided into two groups: a control group (n=18) and a pregnant group (n=18, 13-40 weeks of pregnancy). Participants in both groups were recruited through personal communication, the Internet, or noticeboard advertisements. Both groups were matched based on age, education, and number of children, and participants were not under treatment and had no primary conditions such as hypertension, diabetes, kidney disease, obesity, or drug addiction, as these criteria may affect cognitive function, which influences attention in daily life.

All participants provided written informed consent before the initiation of the experiment. ERP measurements were conducted in the Laboratory for Magnetoencephalography (MEG) and ERP studies at the Hospital Universiti Sains Malaysia (HUSM).

Experimental procedure

ERP experiment

E-prime software v2 (Psychology Software Tools, Inc., Sharpsburg, Pennsylvania, USA) was utilized for the presentation of visual oddball stimuli, and all data were recorded using the Net Station software v5.2 (Electrical Geodesics, Inc., Eugene, OR, USA). The ERP component of C1 was captured with a 128 ERP net. All participants sat comfortably in a dimly lit, sound-treated room, positioned 80 cm from a liquid-crystal display (LCD) screen that presented all stimuli.

A visual oddball task was conducted. Participants were instructed to press button '1' if they saw 'O' (standard stimuli) or press '2' if they saw 'X' (target stimuli). All stimuli were displayed for 1 second, followed by a 1.4-second interstimulus interval (ISI). During the recording, electrode impedances remained below 50 kΩ.

Data analysis

The ERP raw data were analyzed using Net Station software to obtain the values of amplitudes and latencies

for C1. All raw data were filtered between 0.3 and 30 Hz at a sampling rate of 250 Hz. Artifacts from eye blinks and body movements were removed using artifact removal tools. The data were segmented from -100 ms to 600 ms. A baseline correction was applied 100 ms before the stimuli. The mean differences in amplitudes and latencies of the standard and target stimuli for the C1 component were collected across seven electrode channels in the parieto-occipital [13] and midline areas using the same software. We utilized the Social Package for Social Sciences version 24.0 (SPSS v24.0) software and the non-parametric Mann-Whitney test to examine group differences. Significance was established at a p-value ≤ 0.05.

RESULTS

Participants from both groups were matched by age and education. The mean age (SD) in the control group was 31.88 (3.67) years, while in the pregnant group, it was 28.07 (3.92) years. The mean years of education (SD) for the control and pregnant groups were 15.94 (1.80) years and 16.40 (3.40) years, respectively.

ERP components

Figures 1a and 1b display the grand average waveforms of standard and target stimuli for control and pregnant groups, respectively. Seven channels were selected for analysis: P3, P4, O1, O2, Fz, Cz, and Pz, as the C1 component is typically reflected in these areas. The mean value of the differences between standard and target stimuli was calculated for both components in both groups.

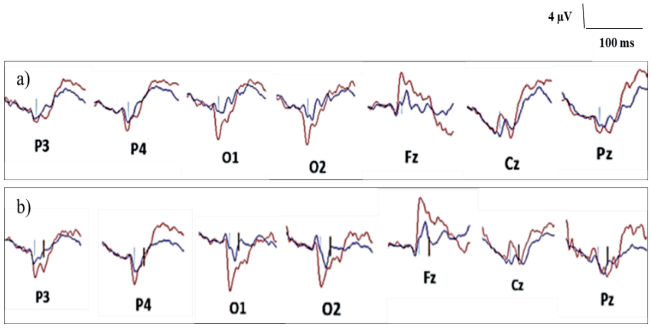

Figure 1: The grand average waveforms of the C1 ERP component are presented for the control (a) and pregnant (b) groups across seven electrode sites. The blue traces represent standard stimuli, while the red traces depict target stimuli.

DISCUSSION

We investigated the neural processing of visual perception in pregnant women by analyzing the amplitudes and latencies of the C1 ERP component using a visual oddball task. Compared to the control group, the pregnant group did not exhibit significant differences in the amplitudes or latencies of the C1 component at any electrode location in the parieto-occipital areas.

A stronger V1 neural response corresponds to a higher amplitude of the C1 ERP component. Changes in the C1 ERP component relate to various factors, including spatial and selective attention, attentional load, stimulus presentation, and other motivational or learning influences. Attention enhances behavioral performance, as reflected in ERP components when administering auditory oddball stimuli [2]. The relationship between spatial attention and modulation of the C1 ERP component in response to visual stimuli remains debatable. Depending on the complexity of the image and contrast, attention can either amplify or suppress visual neuronal responses in certain situations. This bidirectional modulation of the C1 ERP component is also influenced by visual fields [10, 11]. Research indicates that spatial attention can induce a more robust C1 amplitude during exogenous cuing with stimuli in the upper visual field compared to endogenous cuing with stimuli in the lower visual field [14]. Selective attention can increase C1 amplitude [12]. Results regarding the impact of spatial attention on C1 amplitude are contradictory [15–17]. Spatial attention is essential during extensive perceptual training. A decrease in the amplitude of the C1 ERP component was observed following extensive training on the texture discrimination task (TDT) [15, 17]. Bao et al. (2010) found enhanced C1 amplitude after extensive training on the detection task. This study explained that increased electrical activity in the V1 area during training can boost C1 amplitude [16]. Some studies suggested that spatial or feature-based neutral stimuli may not elevate C1 amplitude, as these stimuli are insufficient to induce neural plasticity in the V1 area [11,18]. One study documented unchanged C1 amplitude during visuospatial attention in a normal population [19]. An unchanged C1 amplitude was noted in the attentional load (complex) experiment, where researchers anticipated at least a reduced C1 amplitude due to attentional load. Additionally, this study found a larger C1 amplitude during bilateral stimulus presentation

Table 1: Amplitudes and latencies of the C1 event-related potential (ERP) component in the control and pregnant groups:

Sites		P3	P4	O1	O2	Fz	Cz	Pz
Amplitudes of C1 component (in µV)	Control group. mean (SD)	1.46 (1.48)	2.57 (1.78)	1.23 (1.58)	2.11 (2.39)	4.00 (1.40)	3.16 (1.82)	3.14 (2.20)
	Pregnant group. mean (SD)	1.92 (1.89) (p=0.730)	1.62 (1.29) (p=0.129)	1.91 (2.38) (p=0.512)	1.95 (1.64) (p=0.972)	4.07 (1.80) (p=1.000)	2.82 (2.46) (p=0.581)	3.35 (3.95) (p=0.836)
Latencies of C1 component (in ms)	Control group. mean (SD)	71.33 (14.73)	74.22 (17.37)	73.11 (18.45)	73.78 (17.69)	77.11 (21.81)	75.78 (18.43)	74.67 (17.25)
	Pregnant group. (mean (SD)	75.75 (18.62) (p=0.521)	72.00 (16.72) (p=0.688)	79.00 (19.02) (p=0.475)	68.25 (17.31) (p=0.307)	85.50 (13.05) (p=0.379)	82.00 (14.61) (p=0.305)	66.00 (13.06) (p=0.135)

The Mann-Whitney test showed that the pregnant group did not demonstrate any significant differences in amplitudes or latencies of the C1 ERP component across all seven electrode locations compared to the control group (Table 1).

compared to unilateral presentation [20]. Furthermore, motivational and learning- related visual stimuli can enhance C1 amplitude [21]. Moreover, C1 latency is not modulated by attention [20], which aligns with the results of this study.

In this study, pregnant women did not differ significantly in amplitudes and latencies of the C1 ERP component in any of the examined areas compared to controls. Our results did not indicate an increase or a decrease in C1 amplitude. Firstly, we assume that our experimental paradigm differs from other studies [12,14–17]. These studies employed an experimental paradigm that focused on selective or spatial attention. In contrast, our experimental paradigm is a simple visual oddball ("X" and "O") paradigm presented for a brief duration, which may not be sufficient to enhance neuronal electrical stimulation, thereby impacting neuronal plasticity in the V1 area. Secondly, this study did not undertake extensive perceptual training to maximize neuronal plasticity. Thirdly, participants were pregnant women who experienced a surge of pregnancy hormones, which did not boost V1 neuronal plasticity but did not inhibit it either. Therefore, this study found no significant change in C1 amplitude among pregnant women, consistent with other studies [11,18–20]. Considering the findings of Fu et al. (2005)[18] and Di Russo et al (2003)[10], we propose that visual perception in pregnant women remains intact because the visual oddball stimuli were spatial or feature-based neutral stimuli, which do not enhance V1 neuronal plasticity. Pregnancy hormones did not amplify the V1 neuron response.

CONCLUSION

Visual perception in pregnant women remains intact when using visual oddball stimuli in the C1 ERP component analysis. This suggests that pregnancy-related hormones do not affect the visual perception of pregnant women.

Limitation

1. Small sample size. We need a larger sample size for more reliable information.
2. Collect data from different trimester groups.

Conflict of interest: None.

Authorship Contribution

Data gathering and idea owner of this study: Begum T, Reza F.

Study design: Reza F, Begum T.

Data gathering, writing, and submitting manuscript: Begum T, Reza F.

Editing and approval of final draft: Begum T, Reza F.

Acknowledgment

This study was supported by the Universiti Sains Malaysia (USM) short-term grant (304/PPSP/61313160) for TB.

REFERENCES

1. Blakemore SJ, Burnett S, Dahl RE. The role of puberty in the developing adolescent brain. *Hum Brain Mapp*. 2010;**31**(6):926-933. doi:10.1002/hbm.21052
2. Ali A, Begum T, Reza F, Wan Rosli WR, Wan Mohamad WNA. Neuro Cognitive Improvement During Pregnancy: An Auditory Event Related Potential (ERP) and Neuropsychological Study. *J Neurol Neurosci*. 2018;**09**(02). doi:10.21767/2171-6625.1000254
3. Begum T, Reza F. Auditory cognitive function assessment during pregnancy: An event-related potential and neuropsychological study. *Bangladesh Journal of Medical Science*. 2021;**20**(3):608-617. doi:10.3329/bjms.v20i3.52803
4. Christensen H, Leach LS, Mackinnon A. Cognition in pregnancy and motherhood: Prospective cohort study. *British Journal of Psychiatry*. 2010;**196**(2):126-132. doi:10.1192/bjp.bp.109.068635
5. Raz S. Behavioral and neural correlates of cognitive-affective function during late pregnancy: An Event-Related Potentials Study. *Behavioural Brain Research*. 2014;**267**:17-25. doi:10.1016/j.bbr.2014.03.021
6. Ferrari V, Bradley MM, Codispoti M, Lang PJ. Detecting novelty and significance. *J Cogn Neurosci*. 2010;**22**(2):404-411. doi:10.1162/jocn.2009.21244
7. Raid MF, Begum T, Reza MF. Source localization of the visual C1 ERP component. *Bangladesh Journal of Medical Science*. 2023;**22**(2):398-402. doi:10.3329/bjms.v22i2.65002
8. Sur S, Sinha V. Event-related potential: An overview. *Ind Psychiatry J*. 2009;**18**(1):70. doi:10.4103/0972-6748.57865
9. Rugg MD. Event-related/Evoked Potentials. International Encyclopedia of the Social & Behavioral Sciences 2001; 4962–4966. https://doi.org/10.1016/B0-08-043076-7/03410-0.
10. Di Russo F, Martinez A & Hillyard SA. Source analysis of event-related cortical activity during visuo-spatial attention. Cerebral Cortex 2003;**13**(5):486-99. https://doi.org/10.1093/cercor/13.5.486.
11. Kropotov JD. Event-Related Potentials. In: *Functional Neuromarkers for Psychiatry*. Elsevier; 2016:59-78. doi:10.1016/B978-0-12-410513-3.00006-1
12. Qin N, Wiens S, Rauss K, Pourtois G. Effects of selective attention on the C1 ERP component: A systematic review and meta-analysis. *Psychophysiology*. 2022;**59**(12). doi:10.1111/psyp.14123
13. Slotnick SD. The experimental parameters that affect attentional modulation of the ERP C1 component. *Cogn Neurosci*. 2018;**9**(1-2):53-62. doi:10.1080/17588928.2017.1369021
14. Pitts MA, Hillyard SA. Still wanted: a reproducible demonstration of a genuine C1 attention effect. *Cogn Neurosci*. 2018;**9**(1-2):68-70. doi:10.1080/17588928.2017.1388226
15. Pourtois G, Rauss KS, Vuilleumier P, Schwartz S. Effects of perceptual learning on primary visual cortex activity in humans. *Vision Res*. 2008;**48**(1):55-62. doi:10.1016/j.visres.2007.10.027
16. Bao M, Yang L, Rios C, He B, Engel SA. Perceptual learning increases the strength of the earliest signals in visual cortex. *Journal of Neuroscience*. 2010;**30**(45):15080-15084. doi:10.1523/JNEUROSCI.5703-09.2010
17. Ahmadi M, McDevitt EA, Silver MA, Mednick SC. Perceptual learning induces changes in early and late visual evoked potentials. *Vision Res*. 2018;**152**:101-109. doi:10.1016/j.visres.2017.08.008
18. Fu S, Greenwood PM, Parasuraman R. Brain mechanisms of involuntary visuospatial attention: An event-related potential study. *Hum Brain Mapp*. 2005;**25**(4):378-390. doi:10.1002/hbm.20108
19. Martínez A, Dirusso F, Anllo-Vento L, Sereno MI, Buxton RB, Hillyard SA. *Putting Spatial Attention on the Map: Timing and Localization of Stimulus Selection Processes in Striate and Extrastriate Visual Areas*. 2001; **41**: www.elsevier.com
20. Fu S, Fedota JR, Greenwood PM, Parasuraman R. Dissociation of visual C1 and P1 components as a function of attentional load: An event-related potential study. *Biol Psychol*. 2010;**85**(1):171-178. doi:10.1016/j.biopsycho.2010.06.008
21. Stolarova M, Keil A, Moratti S. Modulation of the C1 visual event-related component by conditioned stimuli: Evidence for sensory plasticity in early affective perception. *Cerebral Cortex*. 2006;**16**(6):876-887. doi:10.1093/cercor/bhj031