Original article

Source localization of the visual C1 ERP component

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Abstract:

Background: Although some studies of the C1 ERP component have revealed perceptual variation in pregnant women, source localization has not yet been determined in this group. We aimed to investigate the source localization of the C1 component in pregnant women using the sLORETA tools in Net Station software. ***Method:*** A total of 36 participants were recruited and divided between the control (n=18) and pregnant group (n=18). ERP data were collected using 128 ERP nets during a visual oddball paradigm (standard: O and target: X). Grand average waveforms were entered into the Geosource system using sLORETA tools in Net Station software. MRI images were displayed automatically in sLORETA to show the source of the C1 ERP component for both groups. ***Results:*** The control group showed that standard stimuli activated Brodmann area 18 in the inferior occipital gyrus in the occipital lobe and target stimuli activated area 11 in the rectal gyrus in the frontal lobe. The pregnant group showed that standard stimuli activated Brodmann area 11, which consists of the medial frontal gyrus in the frontal lobe, and target stimuli activated area 10, which is in the medial frontal gyrus in the frontal lobe. ***Conclusion:*** The source of the C1 ERP component was in the frontal lobe for pregnant women during both standard and target stimuli as they used their encoding and executive function areas for attentional purposes.

Keywords: sLORETA; MRI; C1 component; deviant stimuli.

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Introduction:

Perception is the first stage of visual stimuli processing in the brain. Early perception and cognitive functional mechanisms can be biased during states of high arousal and in response to threat-related stimuli, as demonstrated in healthy subjects and also in patient groups[1,2,3]. An event-related potential study showed that patients with mild brain injury (MBI) have intact auditory perception[4] and pregnant women have reduced auditory perception in their mid trimesters[5]. However, another study found that pregnant women in their mid and third trimesters have enhanced auditory perception[6]. The visual perception of pregnant women has rarely been studied. Therefore, it is important to find out the neural source of visual perception in pregnant women as this information

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might help pregnant women manage their daily life activities.

Various brain areas activate depending on the type of stimuli. The primary visual cortex is activated more by emotional stimuli[7,8,9]. A past study showed that deviant stimuli are particularly effective at capturing attention[10]. Meta-analysis data from functional imaging studies[11] and an influential theoretical model[12] have proven that deviant stimuli are related to both bottom-up and top-down stimuli processing. Fronto-parietal networks—named the dorsal and ventral attention networks—are activated by deviant stimuli[11,12]. The ventral attentional network is more active than the dorsal attentional network in response to deviant stimuli. This probably allows the body to produce a suitable behavioural response when the main task is a deviant one[3]. During the oddball task, neural processing is engaged for object recognition and visual object perception[14,15]. In certain cases, parts of the occipital area (visual cortex) are involved[16]. Di Russo et al. (2003) showed that visual perception can be evoked as an early negative deflection of the peak in 60–90 ms is levelled as C1 event-related potential (ERP) component. These functional processes are mainly reflected in the primary visual cortex or Brodmann area 17[17]. However, there is still an argument among researchers about the neural generator of the C1 component[8,18].

To localize neural generators of brain activity, source imaging can be done using a Geosource tool with standardized low-resolution brain electromagnetic tomography (sLORETA) using EEG and ERP activities. Geosource can measure source localization in the brain using the inverse technique in Net station software. sLORETA is convenient as it allows for the use of MRI images in the system and helps avoid the expense of fMRI. It has a high temporal resolution. Besides this, it was confirmed that sLORETA is the number of combination of EEG and fMRI[19]. sLORETA can standardize the current density of the source equally from both superficial and deep sources, which allows for accurate source detection. Therefore, sLORETA is an effective tool for detecting neural source localization during the oddball paradigm in a fixed time course[19].

In this study, we used sLORETA from the Geosource tool in Net Station software to localize the source of the visual C1 ERP component in pregnant women.

Method and Materials:

After receiving human ethical approval from the ethical committee of Universiti Sains Malaysia (USM) (USM/JEPEM/15090294), 36 participants were recruited and divided between two groups: a control group and a pregnant group (n=18 in each group). All participants were matched for age, education, number of children, and corrected vision. Written informed consent was obtained from all participants before the experiment. The ERP experiment was done in the MEG and ERP study laboratory at Hospital Universiti Sains Malaysia (HUSM).

C1 ERP source localization procedure:

The experiment was conducted by using E-Prime software to present visual oddball stimuli to the participants, who had 128 ERP nets fitted on their heads. Participants were seated in a dimly lit sound-treated room, 80 cm away from a 22-inch LCD monitor on which standard (O) and target stimuli (X) were presented. All ERP raw data were recorded, and data were analysed using Net Station software. Data were filtered in 0.03–30 Hz with a 250 Hz sampling rate, segmented with -100–600 ms. Artefact removal tools were used to correct and remove eye blinking, eye movements, and body movement artefacts. Baseline was corrected as -100 ms. Finally, all baseline-corrected data were entered into the grand average tool. We used grand average data for both control and pregnant groups, obtained using the EGI Geosource tool, to detect brain source localization using sLORETA. In this procedure, the source of the C1 ERP component was selected as 77 ms after stimuli, which is the within the timeframe of C1 component. It was displayed automatically, overlaid on 3D MRI slices.

Results:

Grand average waveforms were shown in the butterfly system in the control (Figure 1a) and pregnant (Figure 1c) groups, where we marked the estimated time as 77 ms after stimulation to localize the source of the C1 ERP component. The sagittal, coronal, and axial MRI slices were presented separately for standard (Figure 1b, 1d) and target (Figure 2a, b) stimuli in both groups. Standard stimuli activated Brodmann area 18, which is over the inferior occipital gyrus in the occipital lobe, for the control group (Figure 1b). In the pregnant group, standard stimuli activated Brodmann area 11, which is over the medial frontal gyrus in the frontal lobe (Figure 1d). In the case of target stimuli, we found that Brodmann areas 11 and 10 were activated in the control (Figure 2a) and

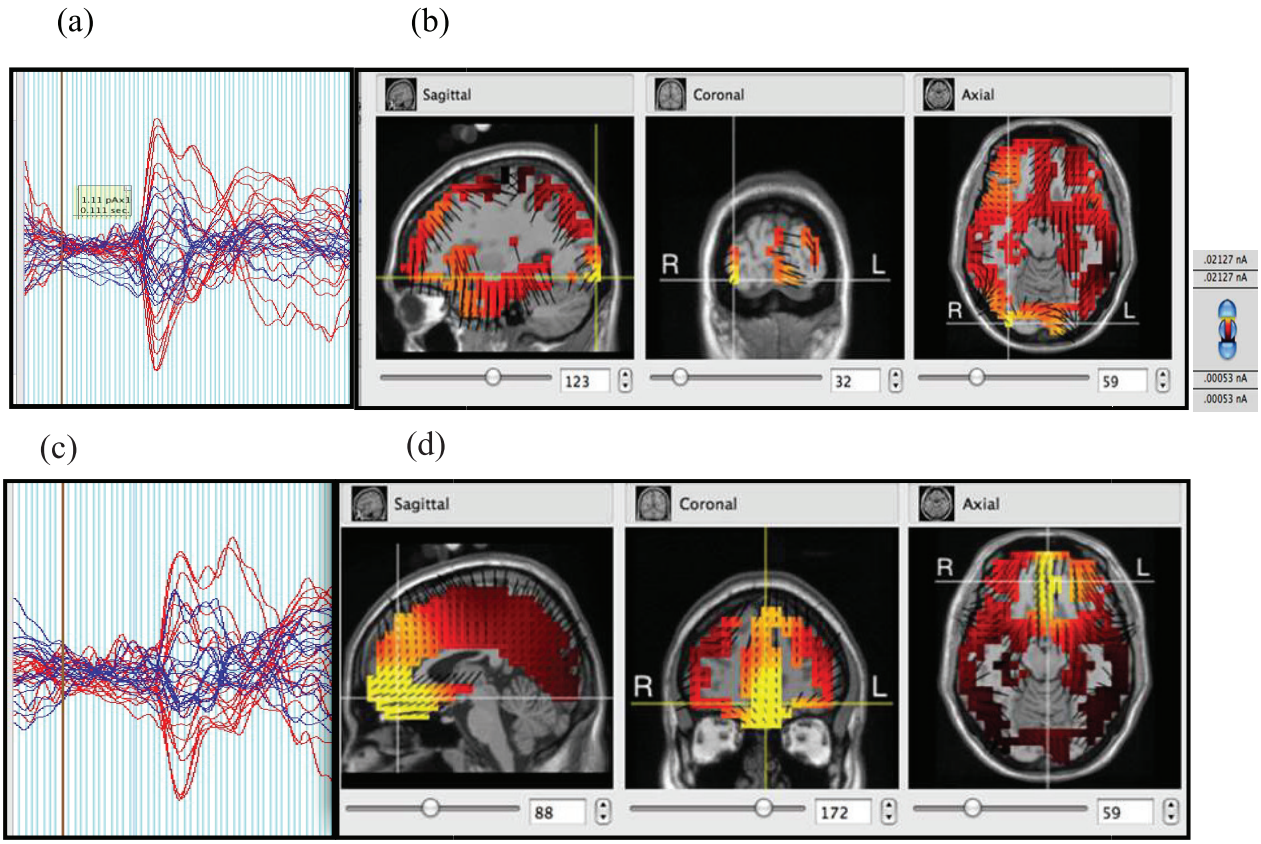

Figure 1: Grand average ERP waveform in the butterfly system for the control group (a) and pregnant group (c). Blue traces are standard, and red traces are indicated as target stimuli. C1 ERP component source localization was shown in sLORETA images during standard stimuli in the visual oddball task, over time, 77 ms after stimuli for control (b) and pregnant (d) groups. The brighter yellow colour indicates the activated source area.

pregnant (Figure 2b) groups, respectively. In this case, Brodmann area 11 was in the rectal gyrus in the frontal lobe, and 10 was in the medial frontal gyrus in the frontal lobe.

Discussion:

We studied sLORETA source localization of the visual C1 ERP component in pregnant women, which is reflected as the source of perception. We found that in the control group, standard stimuli activated Brodmann area 18 in the inferior occipital gyrus in the occipital lobe. Target stimuli activated area 11, which is in the rectal gyrus in the frontal lobe. On the other hand, in the pregnant group, standard stimuli activated Brodmann area 11, which is the medial frontal gyrus in the frontal lobe, and target stimuli activated area 10 which is in medial frontal gyrus in the frontal lobe.

There is controversial evidence about the source of the C1 ERP component. It was suggested that the C1 source is in Brodmann areas 17 (V1 or the striate cortex)[20,21,22], 18[23], and 19[24]. Brain electrical source analysis (BESA), including fMRI, revealed that the source of the C1 component is in Brodmann area 17 when using circular checkerboards[25] and the black-white checkerboards circle[17]. In our study, women in the control group received the visual perception of standard stimuli in Brodmann area 18, which indicated a visual association area or V2, and a part of the occipital lobe. This result is consistent with that of a study by Lesevre et al. (1982). Brodmann area 11 activation means that the rectal gyrus in the frontal lobe was activated more in controls when their attention was directed toward deviant or target stimuli. However, when we compared the activated areas of pregnant women for standard and target stimuli, we found that the areas were different. Specifically, the frontal lobe was activated more for both standard (area 11) and target stimuli (area 10). Brodmann area 10 acts as a memory retrieval area and executive function center[26]. However, Brodmann area 11 may also encode new information into long-

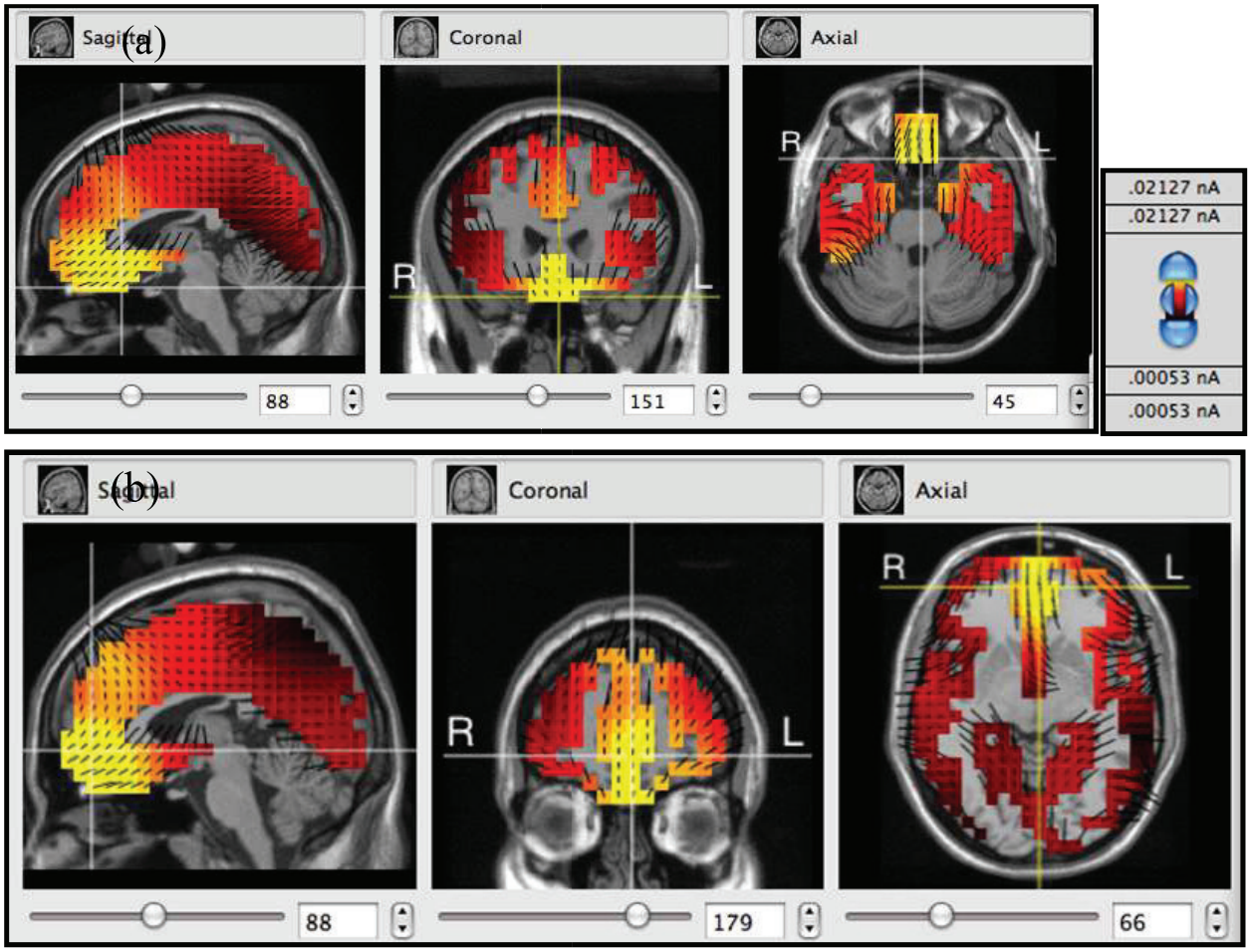

Figure 2: sLORETA images for C1 ERP component source localization during target stimuli in the control (a) and pregnant (b) groups over 77 ms. The brighter yellow colour indicates an activated source area.

term memory[27]. Considering this information[26,27], we can say that pregnant women responded to standard stimuli using Brodmann area 11 and had increased memory retrieval and executive function, given that area 10 was activated in response to the target stimuli. This might be due to the effects of pregnancy hormones, which divert the source of visual perception for pregnant women. Moreover, target stimuli activation was in the frontal lobe for both groups. This supports the idea that the ventral attentional network is activated—for both groups—in response to target stimuli[13]. Therefore, this result increases our understanding of the source of visual perception in pregnant women.

Conclusion:

We investigated the source of visual perception through the source localization of C1 ERP component using sLORETA in pregnant women. We concluded that the source of the C1 ERP component was the frontal lobe for pregnant women during both standard and target stimuli as they used their encoding and executive function areas for attentional purposes.

Conflict of interest: None.

Authorship Contribution

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

Study design: Reza F, Begum T.

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

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

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