Ovarian hormones and the brain signals

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ABSTRACT

Many clinical studies of biological signals reveal correlation between the effect of estrogen, progesterone and brain signals captured in the form of Alpha, Beta, Theta and Delta by Electro Encephalography (EEG) recordings. It is known that there is significant and sustained changes in the levels of sex hormones that may have profound effect on brain functioning leading to changes in mood, memory and learning in women. The theta oscillations are involved with the memory encoding processes and anxiety; the alpha oscillations are associated with memory processing, whereas beta and delta pertain to attention. The release of the estrogen and progesterone hormones is divided into three phases that is premenstrual, menstrual and postmenstrual states. The frequency patterns of the brain signal and hormones are reported to be correlated. We have reviewed the use of EEG recordings in interpreting the variations in estrogen and progesterone level with the purpose of highlighting the area for further research. This technique can also be applied to study other biological signals, their frequencies and relative phases.

KEY WORDS : Alpha, Beta, Theta, Delta, EEG, Estrogen and Progesterone.

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Introduction

The electroencephalogram (EEG) is a recording of the electrical activity of the brain. The first recordings were made by Hans Berger in 1929 although similar studies had been carried out in animals as early as 1870. The waveforms recorded are thought to reflect the activity of the surface of the brain, the cortex. This activity is influenced by the electrical activity from the brain structures underneath the cortex.

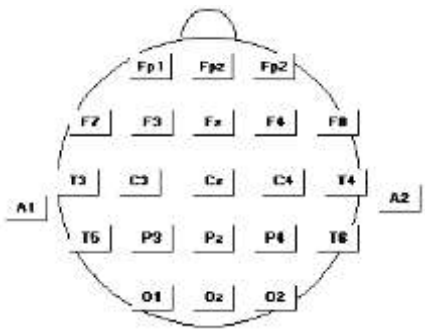

Figure 1 : 10/20 System of electrode placement

Small electrodes are placed on the scalp in special positions. These positions are identified by the International 10/20 System. Each electrode site is labeled with a letter and a number. The letter refers to the area of brain underlying the electrode e.g. F - Frontal lobe and T - Temporal lobe. Even numbers denote the right side of the head and odd numbers the left side of the head[1]. 10/20 system of electrode is shown in figure 1.

Physiological Effects of Estrogen and Progesterone

In order to understand the role of estrogens and progesterone it is important to remember that hormones are vital chemical substances often referred to as "chemical messengers,"; which carry instructions from one group of cells to another. Hormones regulate the growth, development, sexual function and moods. Estrogen and progesterone are such hormones. In women, estrogen is circulated through the bloodstream and it is binds to estrogen receptors on cells in targeted tissues, that affects the breast, uterus, bone, liver, heart, and brain. Progesterone hormone is secreted by the ovaries. It stimulates and regulates various functions. It plays a very important function in maintaining pregnancy and helps prepare the body for pregnancy by regulating the monthly menstrual cycle. The pituitary gland in the brain generates hormones follicle-stimulating hormone [FSH] and luteinizing hormone [LH]. In reproductive years, the release of these hormones causes the new egg to mature and be released from its ovarian follicle each month. As the follicle develops, it produces the sex hormones called estrogen and progesterone. The physiological effects of the estrogen leads to various symptoms like increased body fat, weight gain, depression, anxiety, headaches where as progesterone leads to sleepiness, depression and prevents cyclical migraines respectively[2].

Effect of estrogen and progesterone on brain

Several studies indicate that there is a relationship between ovarian hormones and functioning of central nervous system. The amount of these hormones produced by the body can vary from month to month and year to year depending on many factors including stress, nutrition and exercise. Ovarian steroid hormones affect neurotransmission in the brain. Recently, paired Tran cranial magnetic stimulation (TMS) was used to measure the effects of the menstrual cycle in normal women[3]. The effect of ovarian hormones during the menstrual cycle has been reported to influence several aspects of cognitive and motor functions in women including spatial and verbal abilities, visual memory, and motor performance. Menstrual phase-dependent changes in emotional processing as well as in mood and anxiety have also been reported. Indeed, while everyone thinks of hormones as the chemicals that drive our reproductive system, in truth, there are receptors for both estrogen and progesterone throughout our body. When these hormone levels begin to decline, as they do in the months and years leading up to menopause, every system that has these hormone receptors registers the change including brain. A disruption in an entire chain of biochemical activity, which in turn affects the production of mood-regulating chemi-

cals, includes serotonin and endorphins. The result of these changes are mood swings and depression.

In the study, carried out by Jen-Chuen Hsieh and colleagues, they identified the region of the brain used for coping with stress, flips to the opposite side of the brain during a woman's menstrual cycle from an area linked to negative emotion to one that usually deals with positive thoughts. The researchers studied 14 women using a magneto encephalograph -a machine that measures magnetic waves created by brain activity.

All the subjects were right-handed, to ensure that the left-right orientation of their brains matched. When the subjects were shown frightening images, there was activity in the right half of the subject's brains. This side of the brain tends to process negative feelings, such as anxiety. However, during the women's menstrual periods, the images activated areas in the left half of their brains, which handles positive emotions. The switch in brain dominance during menstruation could help women cope with stress linked to hormone changes[4].

The other study used *invivo*- functional neuroimaging providing the means to probe brain activity in a noninvasive manner and is well suited to monitor changes in emotional brain activity as a function of menstrual cycle status. Studies that used positron emission tomography (PET) have provided evidence that the menstrual cycle influences resting brain glucose metabolism and patterns of brain activity during cognitive and emotional processing. The experiment was carried out by showing the printed words with negative, neutral or positive pictures. The blood oxygen level is recorded in their brains, which corresponded to increased brain region usage. The data was segregated between premenstrual and postmenstrual situations. Premenstrual patterns help to control the emotion where as reciprocal effect is seen in postmenstrual phase[5].

For the first time, scientists have pinpointed an area of the brain involved in a woman's menstrual cycle. The research, reported online by the *Proceedings of the National Academy of Sciences,* shows contrasts in activity over the course of a month and provides a baseline for understanding the emotional and behavioral changes that 75 percent of all women report experiencing before, during and after their period. Protopopescu and his team used functional magnetic resonance imaging (FMRI) to monitor the activity of the orbital frontal cortex, which is known to be associated with regulating emotion and controlling behavior. To capture the activity, 12 healthy women in the age group of 22 to 35 were considered. The subjects were experimented with a series of negative, neutral and positive words meant to illicit emotional responses. The subjects were tested before and after their menstrual cycle. They result of experiment is reported during the one to five days before menses and the subjects showed greater activity in the middle front part of the brain region and less activity on the sides. After menses, more activity occurred on the sides than the middle front area.

According to the report, the reallocation of activity from one part of the brain region to another may reflect the organ's ability to compensate for hormonal changes and help a woman maintain a consistent emotional state. The scientists are now working to compare these results with imaging work on subjects that experience more severe premenstrual mood symptoms[6].

Sex hormone levels and brain waves are biological signals of interest in many areas of science. Research is been carried out using FFt and EEG profiles to get the correlation between the brain signals – Delta, Theta, Alpha, Beta and estrogen and progesterone in women. There is evidence that in healthy young women these signals and other ones are correlated[7-10]. The absolute power of EEG profile of women with normal menstrual cycle[11, 12] and variation in estrogen and progesterone have also been previously studied. Some of these studies included brain waves that were sampled twice in each period corresponding to the following days of menstrual cycle. The progesterone and estrogen levels were consequently sampled. The absolute power of the brain signal was then noted. The study showed the following observation:

- In premenstrual period progesterone is relatively higher as compared to estrogen and alpha signal seems to be dominant followed by the delta and yheta.
- In menstrual period the progesterone is considerably high and Delta seems to be dominant followed by Alpha and Theta.
- In Post menstrual, the progesterone goes high and estrogen is relatively low and Alpha is prominent followed by Delta and Theta.

Brain signals have been extensively studied and associated in literature, with functional abilities[13-15]. Theta oscillations in human beings are involved with perceptual and memory encoding processing, verbal and nonverbal task[16] and it is also related to women anxiety[17]. Alpha oscillations have been observed in memory processes[18] and Delta and Beta oscillations is observed in attention[19]. Several studies have also reported the possible relation of the different brain signal with the sex hormones.

Conclusion

The working of brain is a function of the status of ovarian hormones. The disturbances, lack of sleep and many symptoms of menopause and various other emotional state modify women's behavior making it difficult to analyse.

Competing interests – None
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