Upper alpha-EEG/EMG training efficiency depends on menstrual cycle

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Background

Women's ability to regulate mood, emotions and cognitive activity depends on endogenous hormonal fluctuations, observed during the menstrual cycle (Sundström Poromaa, Gingnell, 2014). Our previous studies had demonstrated that upper alpha EEG activity, which associates with cognitive efficiency (Bazanova, Vernon, 2014) changes in dependence on the ovulatory related hormonal fluctuations also (Bazanova et al., 2014). Few studies had shown that individual upper alpha-EEG increasing neurofeedback training (NFT) is a prominent and useful technology for enhancing cognitive performance and improving behavior (Hanslmayr et al., 2005; Vernon et al., 2009; Bazanova, Aftanas, 2010). It is important to note that forehead muscle activity involves in emotional tension or mental stress (Cacioppo et al., 1988; Malmo, Malmo, 2000; Wijsman et al., 2011). So several researchers apply NFT techniques that simultaneously increase alpha-EEG and decrease forehead EMG (alpha-EEG/EMG) for potentiating training efficiency and improving cognitive performance (Peniston, Kulkosky, 1989; Bazanova, Aftanas, 2010; Bazanova, 2011).

Meanwhile, dependence of alpha-NFT on menstrual cycle in women remains unclear. Here we suggest that upper alpha-EEG/EMG NFT efficiency in women is modulated by the menstrual cycle.

Methods

Forty four healthy female subjects with regular menstrual cycle completed 10-11 simultaneous upper alpha-increasing and EMG-decreasing biofeedback training sessions (upper alpha-EEG/EMG NFT) every two-three days. Twenty two women were given real feedback based on the power of their individual upper alpha frequency range, while the remaining 22 were given sham feedback. Each menstrual cycle was divided into five phases, individually set (Walker, 1997): (1) menstrual (MP) – from the first up to the last day of menstruation; (2) follicular (FP) – from the next day after menstruation till increasing basal body temperature by 0.5-1 degrees; (3) ovulatory (OP) – from the first day of basal body temperature increase to the first day increasing the saliva progesterone level ≥ 20%; (4) luteal (LP) – from the first day when the level of saliva progesterone increased till the first day of its reduction ≥ 20%; (5) premenstrual phase (PMP) – from the first day of decline in the progesterone level by more than 20% till the first day of bleeding. Each woman's phase data were averaged before being used in group analyses. A counterbalanced, repeated-measurement design was used to avoid a novelty effect: 22 subjects started being monitored and trained at MP and another 22 at LP. So all participants were divided into 4 groups: (1) - 11 subjects started at MP and received real NFT (MP Real NFT); (2) - 11 subjects started at MP and received sham NFT (MP Sham NFT); (3) subjects started at LP and received real NFT (LP Real NFT) and (4) 11 subjects started at LP and received sham NFT (LP Sham NFT).

EEG and frontal muscle EMG were recorded before, during and after Real or Sham session. EEG recording provided with bandpass: 3–50 Hz, sampling rate: 720 Hz from Pz scalp electrode positioned according to an augmented 10–20 system. Electrical reference was located at right ear, and the ground electrode was located at the Fp1 site.

EMG was recorded by two 1.6-cm Ag/AgCl surface bipolar electrodes fixed about 3–5 cm apart and placed on the forehead. The EMG signals were acquired with a 720-Hz sampling rate, amplified and filtered with 5 Hz high pass and 350 Hz low pass filters. We applied the usual approach to average the integrated EMG power (IEMG) in the signal over 100 ms (Merletti, 1999). The IEMG was therefore the area under a voltage curve, measured in microvolts (μV^2)

Before and after every NFT session women asked to perform Kraepilin test. The biofeedback session was carried out in an eyes-closed condition.

NFT session began after initial individual upper alpha range assessment. The feedback signal took the form of bell sounds presented to participants. The upper alpha EEG and IEMG thresholds were set manually by the experimenter and updated so that alpha power was over and IEMG power was below these thresholds for approximately 60% of the time.

"Successful training periods" were defined as periods when the alpha power increase was accompanied by a simultaneous decrease in the EMG power. Training efficiency (TE) was calculated as the ratio of the sum-duration of the successful periods during the NFT compared to the whole length of the session.

Results

Between group comparison showed that first NFT session efficiency was lower in MP than in LP groups ($t=6.9$, $p=0.00$). Repeated measures ANOVA demonstrated that over 10 sessions TE increased in MP Real NFT group [$F(9, 71) = 5.6$, $p = 0.011$] and in LP real NFT group [$F(9, 71) = 4.2$, $p = 0.023$] but does not change in both Sham groups ($p>0.05$). However, TE increased consequently from MP to LP and decreased from LP to MP in both Sham groups. Fluency in cognitive task performance and TE positively correlated with salivary progesterone level.

Conclusion: Menstrual cycle modulates neurofeedback training efficiency. The menstrual cycle should be taken into account when planning biofeedback training in women.

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