What does resting alpha oscillations teach us about anxiety ?

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11th FENS Forum of Neuroscience
7–11 July 2018 | Berlin, Germany
Organised by the Federation of European Neuroscience Societies (FENS)
Hosted by The German Neuroscience Society

Background & aims

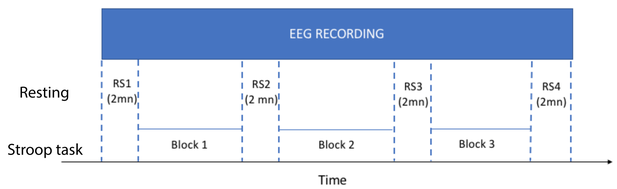
Numerous studies have shown that Alpha (8-13 Hz) oscillations were attenuated by attention and mental effort as well as affected transiently by other sensory stimuli and mental alerting activities (e.g., mental arithmetic) or by anxiety [1]. These oscillations occur during wakefulness and were best seen during physical relaxation and eyes closed over posterior regions of the head. Anxiety is thought be associated with increased attentional demand on threat cues involving a modulation of the alpha activity. Spontaneous self-referential thoughts were associated with enhanced alpha activity in the posterior default mode network (DMN) hub during resting state and the social game [2]. Further, it has been shown that neural activations during visual-sequence learning leave a trace in post-training spontaneous EEG [3]. However, few studies in humans have shown the link between alpha oscillations and anxiety using imaging and stimulation techniques. We thus examined the changes on two-minute periods eyes-open EEG resting state in young subjects to see the evolution of neural activations over time in alpha band before, during and following a forty-minute attentional-task (Stroop-task). We first established the topography and time course of oscillatory alpha activity changes in both low- and high-anxiety groups to investigate pre- and post-task effects on spontaneous EEG over right and left posterior brain sites in order to assess whether EEG alpha enhancement effectively reduces state anxiety (e.g., alpha oscillations as a correlate of trait anxiety).

Methods

Subjects

- 32 young adults (17 males, 15 females; mean age = 23 years, SD = 7, range 18 to 50 years)
- Participants completed the Spielberger State-Trait Anxiety Inventory (STAI-T) before the experimental session [4] .
- Eighteen participants with scores ranged from 25 to 38 were attributed to a low anxiety group (LA) (mean score =32.94, SD =9.016) and fourteen participants with scores ranged from 40 to 57 were attributed to a high anxiety group (HA) (mean score =47, SD =5.897).

Experimental setup



We recorded resting 2 minutes state EEG before and after a separate stroop task blocks (108 trials each) labeled (RS1, RS2, RS3 and RS4).

EEG

Data Recording. Continuous EEG was recorded from 64-channel ActiveTwo system (Biosemi) in addition to 2 x EOG. Data were sampling at 1024 Hz and Laplacian reference (CSD) was chosen for analysis.

Preprocessing. Band-pass filter between 0.05 and 120 Hz, notch 50 Hz. Bad channels replaced and interpolated. Independent component analysis (ICA) was used to identify vertical and ocular artifacts

Resting state analysis. EEG data for each block of resting state were segmented into 2 seconds epochs for each block (total of 60 epochs) then bad epochs were rejected visually for further analysis. The power spectrum for each clean data epoch was computed via the multitaper frequency transformation (FFT-"dpss" window) using Fieldtrip/Matlab toolbox (frequency range 0.5-60 Hz, frequency bin 0.5 Hz). Power was then averaged within the alpha band, thus obtaining a value for each subject in each of the four resting sessions (RS1, RS2, RS3 and RS4).

Statistical analysis. Statistical analyses on alpha power topographies were perfrormed using non-parametric statistical test by calculating Monte-Carlo estimates of the significance probabilities and/or critical values from the permutation (n=1000) distribution. Two ROI were created on the left parietal (LPO : CP1,CP3,CP5,P1,P3,P5,P7,P9,TP7,PO3,PO7) and the right parietal-occipital (RPO : CP2,CP4,CP6,P2,P4,P6,P8,P10,TP8,PO4,PO8) scalp sites on the basis of the electrodes showing significant differences (white sensors, $p < 0.05$) between LA and HA groups. Therefore, the alpha power was submitted to repeated ANOVAs with blocks (RS1,RS2, RS3, RS4) and side (LPO, RPO) as within-subject and anxiety (LA,HA) as between-subjects variables. Pairwise comparisons were used to assess significant interactions between the factors. Then, Pearson's correlation was assessed between each ROI and the anxiety score (STAI) of each subject.

Result 1. Alpha power attenuation for subjects with high anxiety over occipito-parietal regions

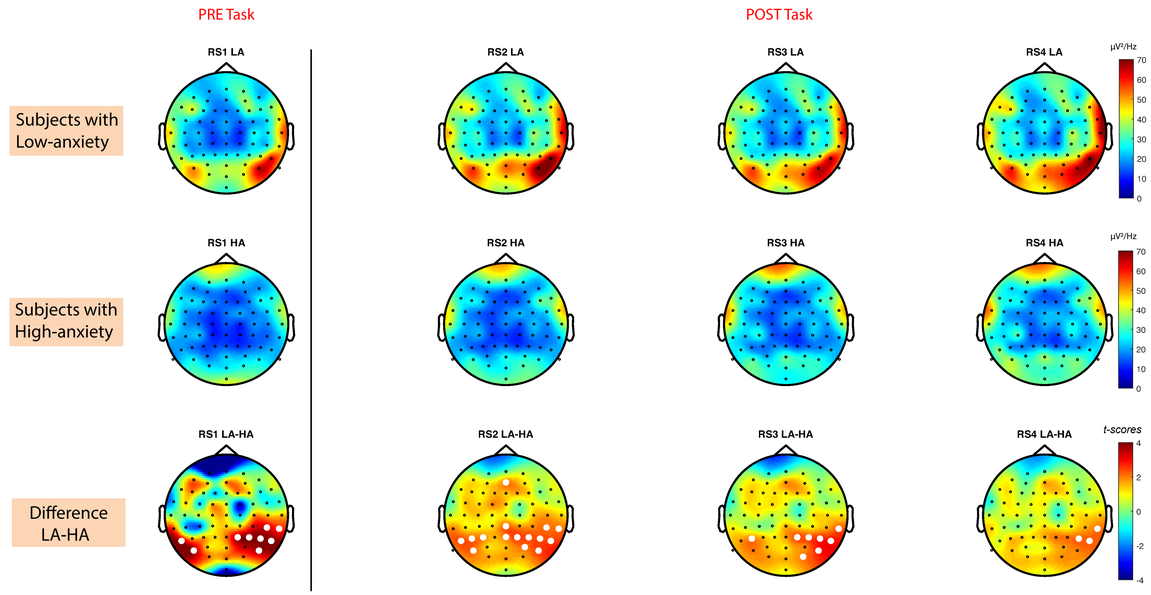
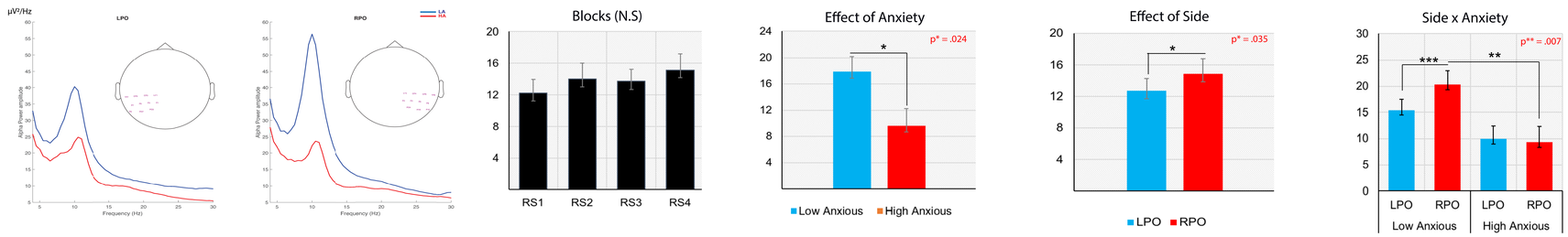
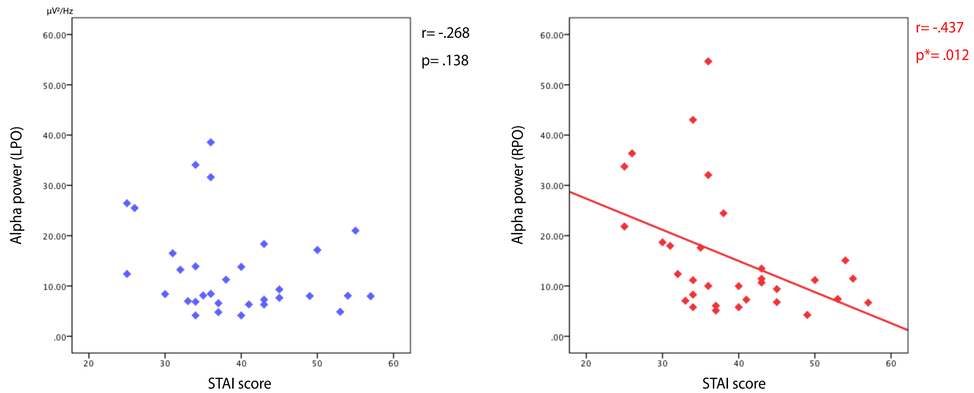


Figure 1. We compared the resting state EEG during eyes open during 2 minutes before, during and after Stroop-task. We found a higher alpha power (electrodes marked in white) over right-and left- occipito-parietal areas (RPO and LPO) in subjects with low anxiety score (LA) compared to HA, the areas showing spectral changes during the RS blocks. Importantly, significant changes were observed only in the RPO region at the end of task (RS4). In addition, a significant asymmetry was observed between RPO and LPO regions showing higher alpha activity over the right hemisphere ($p < 0.05$). We then correlated the alpha power in the resting state EEG (RS1,RS2, RS3 and RS4) in the occipital-parietal sensors for each ROI with the level of anxiety for each subject.

Result 2. Significant asymmetry in alpha band manifested by a higher activation over the right hemisphere (RPO > LPO)



Result 3. Alpha oscillations on RPO region as a correlate of trait anxiety (STAI)



We computed the correlation between the STAI score of anxiety and the EEG alpha power changes the average resting-state (RS) blocks over the LPO and RPO regionsof the brains across subjects.

We found significant correlations ($p < .05$) only for right parietal-occipital region of the brain (RPO).

Conclusions

- The resting state alpha rhythm is attenuated by anxiety over occipito-parietal regions of the brain.
- The comparison of right and left ROIs showed that the alpha power was higher in the right ROI compared to the left possibly because this is the nondominant hemisphere.
- These findings on lateralization in alpha band suggest that they may well represent a trace of learning and a hallmark of use-dependent plasticity.
- A significant negative correlation indicated that the higher the anxiety score, the lower the alpha power is. These findings suggest that resting alpha rhythm is sensitive to emotional state and might be a marker of a higher vigilance.

References

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