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Association between Emotional Intelligence and Hemispheric Activity Asymmetry

Olga Razumnikova[1,2], Ekaterina Khoroshavtseva[1], and Anna Yashanina[1,2]

[1]Novosibirsk State Technical University (RUSSIA, Novosibirsk)
[2]Scientific Research Institute of Physiology and Basic Medicine (RUSSIA, Novosibirsk)

Abstract

The relations between the asymmetry of hemispheric activity using the EEG rhythms in resting and both trait emotional intelligence (EI-IPIP) and self-assessment of emotional reactivity on IAPS stimuli were studied in university students. The obtained EEG patterns of power asymmetry in both low-frequency and high-frequency indicate different variants of the hemispheric dominance in the anterior and posterior regions of the brain, depending not only on the valence of induced emotions, but also on self-assessment of perception or expression of emotional states. Total EI was associated with relatively greater left frontal activation on low frequency delta oscillations and on higher beta2 oscillations in posterior cortex. Using EEG mapping positive relations were found between the right hemispheric delta rhythm and emotional reactivity to negative emotive stimuli and between the left hemispheric delta and positive affect. Self-rating of positive to negative emotion during both EI and IAPS stimuli-induced affect testing was more pronounced in the relationships to asymmetry of hemispheric activity than separate traits EI.

Keywords: Emotional intelligence traits, self-assessment of emotional reactivity, EEG, hemispheric asymmetry, frequency bands

Corresponding Author:
Olga Razumnikova
azoum@mail.ru

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1. Introduction

Emotional intelligence (EI) is defined as a set of individual's capacities to accurate perception, expression, understanding, and regulation of emotions that can explain effectiveness of cognition and behavior. It is known two different approaches to the EI testing: (i) based on the representation of EI as personality traits or (ii) as mental abilities. Emotion regulation involves changes in positive or negative emotional state and variable responding on emotional stimuli along fundamental dimensions such as valence, arousal, and approach/avoidance [9, 16]. These characteristics are also reflected in individual emotional traits.

Neuroimaging and electrophysiological data suggest that different subregions of prefrontal cortex generally considered to be involved in elaborating upon and regulating the basic emotional processes [2, 5]. For example, the lateral orbitofrontal cortex can be used to assess multidimensional representation of the internal and external environment whereas its medial region may supply episodic memories and imagined future events based on current needs and goals. Anterior cingulate cortex plays appraisal role in subjective feeling states of pleasure and displeasure. Left superior and lateral frontal regions are implicated in regulation of both positive and negative emotions [12].

Summarizing the research on frontal lateralization, the integral theory of emotion suggested the asymmetric involvement of prefrontal cortical regions in positive affect (or approach motivation) and negative affect (or withdrawal motivation). Support for a frontal asymmetry in relation to the level of trait EI it is shown an association between EI scores greater relative left-sided frontal activation determined with EEG during a resting eyes open/closed condition [13]. On the other hand, it was also show that higher Ability EI, but not Trait EI, is associated with negatively correlated spontaneous fMRI signals between the basal ganglia/limbic network and posterior default mode network, and regions involved in emotional processing and regulation [7]. However, using fMRI positive correlations of brain activity in the medial frontal cortex and anterior cingulate cortex with various components of Trait EI were showed [18].

During resting state the brain regions are self-organized into intrinsic networks (default-mode networks) reflecting spontaneous emotion and cognition, that underlies task-based functioning [e.g. 17]. Results of EEG research have suggested that both trait and situational variables may influence baseline asymmetric frontal activity [3, 4]. Asymmetry of frontal cortical activity was determined in early studies by measuring alpha power [1] whereas later low-frequency delta, theta and high-frequency beta rhythms were used [11, 13]. In view of this, the present study aims to investigate how and to what extent individual difference in hemispheric activity relate to ordinary emotional behavior and emotion regulation by analysis of cortical oscillations at rest in widespread frequency range.

2. Methodology

Forty six right-handed university students, ranging in age from 18–22 years provided written informed consent to participate in complex psychometric and EEG study.

Prior to EEG registration, participants completed the Russian version of Barchard Emotional Quotient Inventory [8] as a self-report measure of trait EI. The measure includes 68 items, which respondents rate on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Total EI was the primary variable of interest from our analysis, but seven composite subscales were also available, measuring the ability to positive expressivity (PO), negative expressivity (NE), attending to emotion, emotion-based decision-making, responsive joy (RJ), responsive distress (RD), and empathic concern.

Forty color pictures were selected from the International Affective Picture System (IAPS)[10]. The computer-based presentation of stimulus set of the IAPS was designed to analyze individual self-rating of induced emotion. The participants viewed emotional pictures (unpleasant, pleasant) and indicated the extent to which they feel each stimuli-induced affect using a 7-point Likert scale. Positive and negative affect scores (Sp and Sn, respectively) were measured separately.

Also positive to negative ratio (Sp/n) was calculated for individual self-rating of induced emotion as well as the indices of PO to NE ratio ($C_{PO/NE}$) and RJ to RD ratio ($C_{RJ/RD}$), with higher scores indicating that participants feel more of positive emotions.

EEG was recorded during an eyes closed resting baseline using a 19-channel PC based Mitsar 4.2 system. The averaged power density for each of the six frequency bands from delta to beta2 using fast Fourier transformation was calculated. The asymmetry scores (C_AS) were computed by subtracting the value obtained at the right electrode from the corresponding value at the homologous left electrode for each of the 8 pairs of sites. Also, for the statistical analysis, the averaged for the anterior (frontal) and posterior (parieto-occipital) regions C_AS values were used.

3. Results

3.1. Relationships between emotional intelligence and affective measures

Correlation analysis was conducted on the self-report measures of EI and IAPS stimuli affect to examine relationships between EI traits and induced emotional reactivity. The results shown that only S_{EI} and RD positively correlated with Sn ($0.30<r<0.41$, $0.01<p<0.05$) whereas RD inversely related to Cp/n ($r= -0.33$, $p<0.05$). Also RJ/RD ratio ($C_{RJ/RD}$)inversely correlated with Sn and positively related to Sp/n as it is presented on Fig.1 ($p<0.05$).

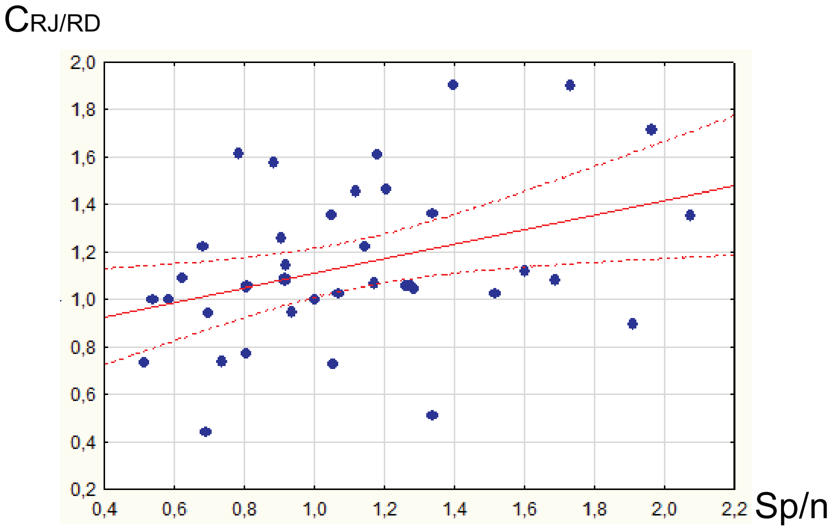

Figure 1: Correlation between the ratio indices of positive to negative emotion self-rating while measuring emotional intelligence ($C_{RJ/RD}$) and induced affect (Sp/n).

3.2. Relationships between resting EEG and emotional intelligence and affective measure

On first step of correlation analysis the total indices of EEG power and hemispheric asymmetry in anterior and posterior cortex for each EEG frequency band were used. The significant inverse relations between the delta C_AS in anterior cortex and both S_{EI} and Sn (Fig. 2A) together with positive correlations with Sp/n and $C_{RJ/RD}$ were found (0.32<r<0.41, 0.01<p<0.05). On second step, we analysed regional specificity of obtained effects. A mapping of significant correlation between the delta power and both Sn and Sp is presented on Fig. 2. So, Sn is positive associated with delta synchronization in the Fp2, F4, F8, T4, and T6 sites whereas Sp significant correlated with delta rhythm in the C3, P3, T5, and Pz (0.001<p<0.05). No significant correlations were found between the delta power in each site and S_{EI} or $C_{RJ/RD}$measures.

In the theta band positive correlations were significant between C_AS in the anterior cortex and both Sp/n and $C_{PO/NE}$(r<0.32, p<0.05), mostly in F7/F8 for Sp/n and F3/F4 for $C_{PO/NE}$.

In the alpha1 band only $C_{RJ/RD}$correlated with C_AS in the anterior cortex (r<0.34, p<0.05) whereas Sn and S_{IAPS} tended to inverse relations with C_AS in the posterior cortex (r< - 0.29, p<0.09).

In the high-frequency alpha 2 band Sp/n and $C_{PO/NE}$(0.48<r<0.34, 0.004<p<0.05) as well as Sn (r=- 0.39,p=0.02) significantly related to C_AS in the anterior cortex. For $C_{PO/NE}$ these correlations were significant in the FP1/Fp2, F3/F4, and F7/F8 sites

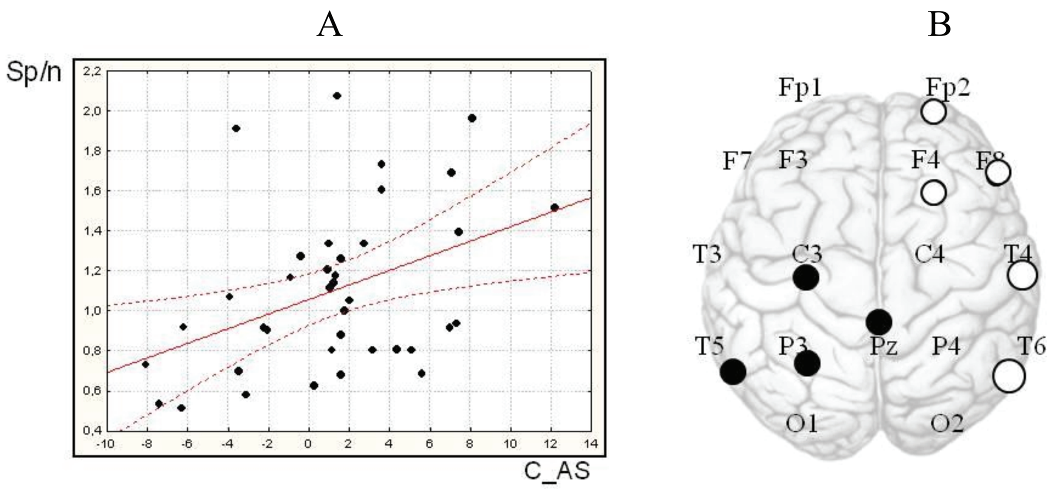

Figure 2: A - relationship between delta power asymmetry (C_AS) and the ratio of positive to negative affect (Sp/n); B - mapping of the delta power correlated with positive affect (Sp) (full circles) and negative affect (Sn) (empty circles).

whereas for Sp/n and Sn this association was mainly attributable to the F7/F8. The similar relationships between both Sn and Sp/n ($r<0.45$, $p<0.05$) and anterior C_AS of alpha2 were found in the beta1 band. Correlation between beta1 C_AS and CPO/NE was marginally significant ($r=0.32$, $p=0.07$) and reached significance only for F3/F4 ($r=0.41$, $p=0.02$).

In the beta2 positive relations were obtained between C_AS in the posterior cortex and both S_{EI}, S_{IAPS}, and Sn ($0.47<r<0.36$, $0.006<p<0.04$). Tendency to negative correlations was found between C_AS in the anterior cortex and both $S_{IAPS}$and Sn ($p<0.06$) as well as between C_AS in the posterior cortex and both $C_{PO/NE}$and $C_{RJ/RD}$($p<0.1$).

Using the mapping of beta2 power due to revealed effect of S_{EI}, numerous correlations were obtained only for 'Emotion-based decision-making' (Fig.2 A). Regional specificity of beta2-associated effects of Sp and Sn are shown on Fig.2 B and C, respectively.

4. Discussion

The aim of study was examined the brain activity characteristics relevant to the understanding multidimensional construct of EI. In addition we determined whether alteration of EEG asymmetry could change due to the self-reported affects on pleasant and unpleasant stimuli.

It was found weak association between EI scores and self-report measures of affect induced by IAPS stimuli. Only the index of RD as EI component was interrelated with

Sn that indicating smaller individual variability and greater unity in the assessment of negative affect. This opinion is confirmed positive relation between $C_{RJ/RD}$and Sp/n.

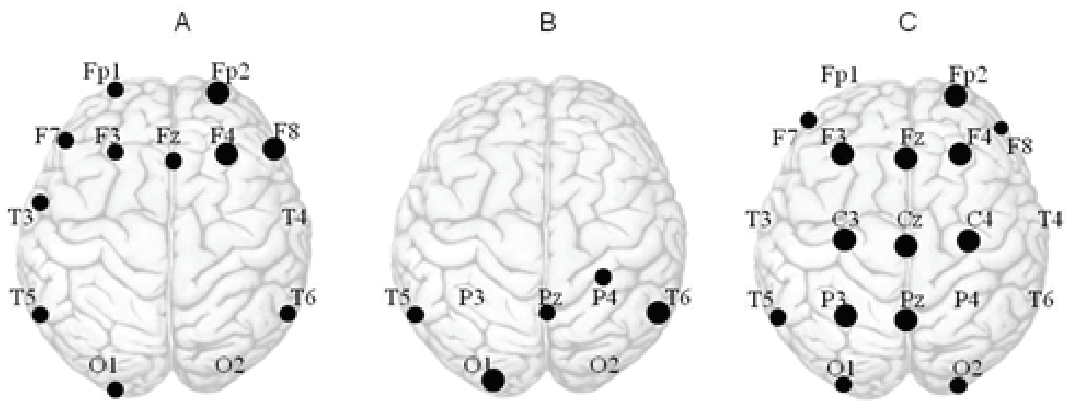

Figure 3: Mapping of the beta 2 power positive correlations with the emotional intelligence scale (Emotion-based decision-making) (A), negative affect index (Sn) (B), and positive affect (Sp) (C). Size of circles indicates p: small for p<0.05, large – p<0.01.

So, a more stable indicator of individual emotionality is the ratio of positive to negative emotional measures but not their absolute rating. It should be stressed that positive relation between S_{EI} and Sn suggests that self-assessment of negative affect is dominated in total EI measure.

The obtained EEG correlates of different EI components indicate that on widespread frequency range of oscillations the anterior cortex dominates in emotion-associated hemispheric asymmetry whereas on high frequency beta 2 – the posterior area of cortex. The revealed mapping of associations between delta oscillation and both Sn and Sp is in line with well known hypothesis of the right-hemispheric dominance in negative emotion and the left hemisphere in positive affect [1, 2]. Inverse relationship between delta power asymmetry (C_AS) and S_{EI} combined with positive relation of the beta 2 C_AS to S_{EI} support an association of higher trait EI and greater relative left-sided activation determined by EEG [6, 13].

It should be stressed that exactly 'Emotion-based decision-making' as component of EI was associated with higher cortical activation predominantly in the anterior area and in the left hemisphere (see Fig.2). This finding corresponds to regulation role of prefrontal cortex in emotional processes [5, 16]. Positive relationships between both Sn and Sp measures and the right-hemispheric delta and beta2 oscillations can be supposed to dominance the right hemisphere in emotion regulation by inhibition processing [4, 9].

However together with these effects, positive association C_AS in low frequency from delta to alpha in the anterior cortex with Sp/n was shown that can be explained by multifactorial mechanism of hemispheric involvement in emotional regulation and multifaceted nature of EI. Indeed, variable hemispheric asymmetries in anterior-posterior direction related to both negative and positive emotions were shown in some other researches using neuroimaging or electroencephalographic techniques [4, 14, 15, 18]. Our findings can be interpreted as coupling the frontal neural networks involved in regulation and control of different emotional states and posterior neural mechanisms of information selection based on emotional attributes.

5. Conclusions

Not only frontal but also posterior EEG activity reflects both individual emotional characteristics of behavior and emotion-regulatory capabilities. Traits EI and induced affects are associated with hemispheric asymmetry in widespread range of cortical oscillations including not only the alpha but also the delta and beta2 frequency bands. Our findings extend data on resting EEG asymmetry and individual differences in affective style. More pronounced effect in the ratio of positive to negative affect highlight the importance of considering opposite emotional states when examining psychophysiological correlates of emotionality.

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