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Anxiety, depression, and oscillatory dynamics in a social interaction model

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ABSTRACT

Although anxiety and depression frequently co-occur and share a substantial part of genetic vulnerability and other risk factors, they are distinct disorders and their effect on social functioning and accompanying cognitive and emotional processing could be different. In this study, in a nonclinical sample, we compared effects of trait anxiety and depressive symptoms on oscillatory dynamics accompanying perception of emotional facial expressions in the context of social interactions. Anxiety was associated with a longer reaction time, with preference of avoidance behavior, and with enhanced event-related alpha desynchronization and diminished theta synchronization. Depression did not show significant behavioral effects and was associated with diminished alpha desynchronization and augmented delta and theta synchronization in prefrontal cortical regions. Thus, in spite of frequent comorbidity, anxiety and depression show opposite patterns of associations with oscillatory dynamics accompanying social interactions. These patterns imply that anxiety is associated with hyper-reactive attentional system, whereas depression show signs of diminished cognitive reactivity. Depression-related enhancement of low-frequency synchronization in prefrontal cortex may reflect a compensatory mechanism of cognitive and emotional upregulation, which depression-prone individuals engage in the process of social interactions.

1. Introduction

There is a debate in psychiatry research whether depression and anxiety should be combined into one category or should be treated as separate categories. One proposal is that major depression (MDD) and generalized anxiety disorder (GAD) should be treated as one category of distress disorders (Watson, 2005). Indeed, 95% of individuals who met criteria for MDD also met criteria for a current or past anxiety disorder (Brown et al., 2001). Twin studies show that co-morbidity between anxiety disorders and depression is explained by a shared genetic vulnerability for both disorders (Middeldorp et al., 2005). Moreover, biological, psychological, and social risk factors for anxiety and depression show many similarities, although some differences are also described (Vink et al., 2008). Thus, biological factors seem to be more important in predicting depression. Most important, differential effect of social factors on depression and anxiety was found (Vink et al., 2008), and, in general, GAD shares more similarities with other anxiety disorders than depression (Beesdo et al., 2010). In personality domain, both anxiety and depressive disorders are associated with neuroticism, but depression is also related to introversion (Clark et al., 1994). Accordingly, there is an increasing recognition of the role of dopamine in depression, but not anxiety (Berton et al., 2006; Tremblay et al., 2005). In sum, it appears that although anxiety and depression frequently co-occur and share a substantial part of genetic vulnerability and other risk factors, they are distinct disorders.

Most of relevant evidence has been obtained on patients diagnosed with MDD or GAD. Such diagnosis-based analyses have several limitations. Thus, Watson (2005) notes that the diagnostic criteria change significantly with each succeeding edition of the DSM. Besides, diagnosis-based analyses fail to account for the significant heterogeneity within many of the DSM disorders and are complicated by hierarchical exclusion rules (i.e., certain disorders are not diagnosed if they are judged to occur during the course of a co-existing disorder) (Watson, 2005). Moreover, the

Abbreviations: BDI, beck depression inventory; DMN, default mode network; EEG, electroencephalography; ERSP, event-related spectral perturbations; FDR, false discovery rate; GAD, generalized anxiety disorder; fMRI, functional magnetic resonance imaging; LPS, lagged phase synchronization; MDD, major depressive disorder;; MNI, montreal neurological institute; mPFC, medial prefrontal cortex; NBS, network-based statistic toolbox; PCC, posterior cingulate cortex; RT, reaction time.

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status of a patient has profound impact on individual's psychological condition, which may considerably complicate the interpretation of data. It is known that diagnosed MDD and GAD constitute just a part of various depressive and anxiety disorders (Hasin et al., 2005). Considerable number of sufferers do not seek professional help (Ohayon, 2007; Poulin et al., 2005). Therefore, preclinical studies in predisposed to anxiety and depression participants may bring information about 'true' effects of these vulnerabilities, which are not complicated by different subsidiary factors, such as consciousness of being sick and the effect of treatment.

Both depression and anxiety are associated with changes in emotion processing and impaired social functioning. Functional magnetic resonance imaging (fMRI) studies show modifications in the brain areas that are involved in emotion regulation (Cisler et al., 2010; Stuhrmann et al., 2011; Willner et al., 2013). Enhancement of brain activity in areas responsible for generation of negative affect and reduction of activity in areas involved in generation of positive affect is frequently observed in MDD patients (Anand et al., 2009; Stein et al., 2007; Stuhrmann et al., 2011). Moreover, both MDD and GAD are associated with changes in the ability to differentiate emotional stimuli (Anderson et al., 2011; Scheuerecker et al., 2010; van Wingen et al., 2011; Yoon et al., 2015). Thus, difficulty in identification of emotional facial expressions (particularly happy expressions) is frequently observed in MDD patients (Joormann and Gotlib, 2006; Leppänen, 2006). On the other hand, GAD patients and anxiety prone subjects recognize fear faces significantly better than controls (Srivastava et al., 2003; Surcinelli et al., 2006). One important point, which has not received due attention, is emotion processing in the context of social interactions. Indeed, the ability to identify correctly some emotional stimuli, such as emotional facial expressions, is crucial in the process of communication. Associated with depression and anxiety changes in social behavior (Cutler, 2005; De Silva et al., 2005; Dyrbye et al., 2006; Funder et al., 2000; Neumann et al., 2010) may partly stem from the disrupted ability to identify emotional signals coming from other people.

In this study, in a nonclinical sample, we aimed to investigate the effect of trait anxiety and depressive symptoms on oscillatory dynamics accompanying perception of emotional faces in the context of social interactions. To this end, we used an experimental model of social interactions, which has been validated in previous studies (Knyazev et al., 2011, 2013). Specifically, it has been shown that perception of facial stimuli in the context of social interactions was accompanied by alpha band desynchronization whose sources were determined in the default mode network (DMN), whereas perception of the same stimuli in the context of emotion recognition was accompanied by alpha desynchronization centered in other cortical regions (Knyazev et al., 2011). Since DMN is presumably involved in the processing of social stimuli (Buckner et al., 2008; Raichle et al., 2001), this evidence could be taken to indicate that the social interaction model is adequate in eliciting social stimuli-related activation in the brain. Because much (mostly fMRI) evidence shows that anxiety and depression are associated with marked changes in functional connectivity between different brain regions (Broyd et al., 2009; Greicius et al., 2007; Hamilton et al., 2013; Marchetti et al., 2012; Menon, 2011; Sheline et al., 2010), we, beyond channel- and source-level spectral power analysis, also aimed to investigate effects of anxiety and depression on event-related connectivity changes. Based on existing evidence (Knyazev et al., 2013), we expected that high TA scorers would choose avoidance behavior more frequently. In EEG domain, we expected that TA would be associated with enhanced alpha band desynchronization and diminished theta band synchronization (Aftanas et al., 1996, 2003; Knyazev et al., 2008, 2015a, 2015b). Due to the scarcity of evidence, no predictions were formulated regarding depression-related effects.

2. Results

2.1. Behavioral results

Mean (SD) BDI score was 7.8 (6.9). Using the suggested in BDI manual cutoffs, 35 out of 44 (80%) participants fall into the minimal depression range, 6 (13%) into the mild depression range, and 3 (7%) into the moderate depression range. There were no participants scoring in the severe depression range. Mean (SD) TA score was 43.6 (11.2), which is similar to the mean TA level (41.1, 10.4, N=337), in a normative Russian sample (Knyazev et al., 2004). BDI and TA moderately correlated with each other ($r=0.56$, $p<0.001$). Independent samples *T*-test showed that BDI ($t=2.9$, $p=0.006$) and TA ($t=1.8$, $p=0.082$) were higher in females. Given the substantial correlation between BDI and TA, the BDI scale was residualized on the TA scale by means of linear regression in order to obtain a measure of 'pure' depression (hereafter BDI-r). The new variable did not correlate with TA ($r=0$) and correlated with BDI ($r=0.83$, $p<0.001$). Both BDI and BDI-r were used in subsequent analyses.

Repeated-measures ANOVA was used to analyze the effects of emotional expression (3 levels), sex of presented face (2 levels), and behavioral choice (3 levels) on the numbers of choices. The main effect of choice, $F(2, 84)=63.8$, $p<0.001$, $\eta^2=0.60$, showed that participants more frequently chose avoidance and friendship and least frequently attack. Interaction face × choice, $F(4, 168)=50.6$, $p<0.001$, $\eta^2=0.55$, showed that participants most frequently attacked and avoided angry faces and offered friendship to happy faces. Effects of BDI and BDI-r were not significant. A significant interaction TA × choice was found, $F(2, 82)=3.8$, $p=0.027$, $\eta^2=0.08$, which showed that higher TA scores were associated with a more frequent choice of avoidance and less frequent choice of friendship.

The same analysis was performed using reaction time (RT) as outcome. Mean over all trials RT was 5489 ms (95% CI 5120−5858). The main effect of choice, $F(2, 84)=88.5$, $p<0.001$, $\eta^2=0.68$, and facexchoice interaction, $F(4, 168)=58.2$, $p<0.001$, $\eta^2=0.58$, were significant. On average, the mean RT was highest for the choice of attack. The face × choice interaction showed, however, that it was true only for neutral and happy faces. For angry faces, the choice of friendship took the longest time. Effects of BDI and BDI-r were not significant. The main effect of TA was marginal, $F(1, 41)=3.8$, $p=0.057$, $\eta^2=0.09$, with anxious participants showing higher RTs. There was also a marginal interaction TA × face, $F(2, 82)=3.1$, $p=0.051$, $\eta^2=0.07$, showing that the increase of RT in anxious participants was most pronounced for angry faces.

2.2. Channel-level EEG results

Most prominent effects were found in the first 1000 ms of the test interval. Fig. 1 shows significant correlations of the three psychometric variables with ERSP values during processing angry, neutral, and happy faces in the context of social interactions. BDI and BDI-r showed exclusively positive, whereas TA showed exclusively negative correlations. Moreover, whereas effect of BDI is mostly limited to the beginning of the test interval (100–200 ms), after regressing out variance due to TA, BDI-r shows widespread positive correlations with ERSP values in theta and alpha bands over the entire test interval. Negative correlations of TA were also observed in alpha and theta bands in times between 200 and 1000 ms.

2.3. sLORETA results

In sLORETA, regression analysis of psychometric variables scores was performed on the paired contrast test minus baseline interval.