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Eye contact reveals a relationship between Neuroticism and anterior EEG asymmetry

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ABSTRACT

Although anterior functional brain asymmetry has been linked to individual differences in affect and motivation, its relations with the Five Factor Model personality traits remain unclear. We investigated anterior EEG alpha-activity asymmetry in response to variable degrees of social contact induced by different gaze directions of a "live" model. Neuroticism was negatively related to the anterior EEG asymmetry scores in response to direct gaze, indicating that higher levels of Neuroticism were associated with avoidance-related, relative right-sided functional brain asymmetry. Neuroticism was also related to behavioral direct gaze avoidance and subjective averted gaze preference. These relationships arose primarily from the Withdrawal aspect factor, suggesting that two subdomains of Neuroticism may be differentially related to approach-avoidance tendencies. These findings demonstrate that experimental manipulations of social contact can reveal personality related differences in anterior EEG asymmetry responsiveness, offering a motivationally salient alternative to resting state measures.

1. Introduction

A body of mainly electroencephalographic (EEG) evidence points to an association between lateralized anterior brain activity and numerous interrelated outcomes such as affective reactions, stable affective style, and development of psychiatric disorders (Coan and Allen, 2004; Harmon-Jones et al., 2010). Such findings have been explained by associating relative left-sided frontal brain activity with approach and relative right-sided activity with avoidance motivation (Davidson, 1992; Davidson et al., 1990). Intriguingly, however, findings from studies investigating the relationships between asymmetric activity patterns and personality traits that are conceptually related to approach and avoidance have been inconsistent (Schmidtke and Heller, 2004; Wacker, Chavanon and Stemmler, 2010). The present study tests two potential solutions for this problem. First, assuming that individual differences in anterior EEG asymmetry are best detected during motivationally salient situations (the capability model; Coan et al., 2006), we probe if experimentally manipulated social contact helps to uncover the relationship between the trait Neuroticism and asymmetry in anterior cortical activity. Second, we investigate whether aspect factors, an intermediate level of personality description between traits and facets (DeYoung et al., 2007), capture more sensitively than higher-order Neuroticism what is shared by personality and anterior EEG asymmetry.

1.1. Individual differences in functional anterior brain asymmetry

Anterior asymmetry is usually assessed using EEG alpha (8–13 Hz) power as an inverse measure of cortical activity. Relatively more power over the right hemisphere is thereby indicative of relatively stronger left-sided cortical activity and vice versa (for further details, see e.g. Allen et al., 2004). According to a popular affective-motivational model, the left-to-right gradient in frontal brain activity corresponds roughly to positive-negative gradient of valence of affective experiences and even more directly to approach-avoidance motivation (Davidson, 1992, 1998; Davidson et al., 1990; Harmon-Jones et al., 2010).

Around half of the variance in anterior EEG asymmetry has been attributed to a stable trait (Hagemann et al., 2005; Hagemann et al., 2002)[1] that may be an endophenotype of individual

[1] Note that these studies do not analyze the effects of situational aspects that have been shown to influence the anterior EEG asymmetry and its relation to individual difference variables. These include factors like unpleasantness of preparations (Blackhart et al., 2002) and the experimenter's gender as well as attractiveness (Wacker et al., 2013). A part of the anterior EEG asymmetry variability may, therefore, still originate from situational influences that are unaccounted for (see also Coan et al., 2006; Wacker et al., 2010).

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differences in affect and motivation. Relative right-sided anterior asymmetry in cortical activity has, for instance, been associated with negative affectivity (Tomarken et al., 1992), depression, and anxiety disorders (for a review, see Thibodeau et al., 2006). Relative left-sided asymmetry meanwhile is a correlate of positive affectivity (Tomarken et al., 1992), proneness to (hypo)mania symptoms (Harmon-Jones et al., 2002), and also trait anger (Harmon-Jones, 2007).

Implicating stable individual differences as a source of hemispheric asymmetries inevitably raises the question of how cortical activity patterns relate to psychometric personality traits. Accounts of personality such as the Reinforcement Sensitivity Theory (RST; Corr, 2004) and the Five Factor Model (FFM; Goldberg, 1993; McCrae and Costa, 2003; McCrae and John, 1992) postulate constructs related to avoidance (respectively, Behavioral Inhibition System or BIS and Neuroticism) as well as to approach (Behavioral Activation System or BAS and Extraversion) motivation (Elliot and Thrash, 2002, 2010; Lucas et al., 2000; Markon et al., 2005; Watson and Clark, 1992). Although the anterior EEG asymmetry correlations with BIS and BAS have been extensively studied, the results remain mixed (Wacker et al., 2010). Meanwhile, only few studies have linked anterior EEG asymmetry to the FFM traits of Neuroticism and Extraversion with equally inconclusive results. In one study, no significant relationships emerged between anterior EEG asymmetry and Neuroticism or Extraversion (Schmidtke and Heller, 2004) while in another Neuroticism correlated with anterior EEG asymmetry variability rather than its level (Minnix and Kline, 2004).

One culprit behind the mixed results may be related to the experimental conditions while measuring EEG asymmetry (for further details, see Coan et al., 2006; Wacker et al., 2010). Traditionally, asymmetry scores are computed from the EEG data collected during a minimally stimulating resting state. However, a growing body of research suggests that the resting state measure may not, after all, be sufficiently immune to situational variables (Blackhart et al., 2002; Kline et al., 2002; Peterson and Harmon-Jones, 2009; Wacker et al., 2008; Wacker, Mueller et al., 2013). According to the interactionistic approach to personality biomarkers, in general (Stemmler and Wacker, 2010), and the capability model of EEG asymmetry, in particular (Coan et al., 2006), meaningful associations between personality and functional anterior brain asymmetry might be best captured in trait-relevant situations that actively engage the underlying biological systems. In line with this prediction, several studies have found expected asymmetry effects regarding individual difference variables using specific manipulations as opposed to resting state recordings (Crost et al., 2008; Davidson et al., 2000; Stewart et al., 2014). The present study extends the use of experimental manipulation of the recording situation to investigate the relationship between anterior EEG asymmetry and Five Factor Model Neuroticism.

1.2. Social contact as a trait-relevant situation for associating anterior EEG asymmetry with Neuroticism

In this study, we will concentrate on finding a trait-relevant experimental context for associating Neuroticism with asymmetry in anterior cortical activity. Preliminary evidence suggests that increased salience of social aspects of a situation may be important in revealing these relationships. For instance, anterior EEG asymmetry was related to trait defensiveness as well as anxiety after receiving public negative feedback but not after receiving private or positive feedback (Crost et al., 2008). So far, however, no study has systematically investigated the link between anterior EEG asymmetry and Neuroticism during controlled manipulation of social contact.

One straightforward way to manipulate the degree of social contact involves varying the gaze direction of a person in a setting where two people are facing each-other. Gaze direction carries information about the viewer's locus of attention (Frischen et al., 2007) and together with facial expressions his or her motivational tendencies (Adams and Kleck, 2005, 2003). These signals have been shown to have distinct effects on the person receiving them. Experiencing direct gaze from a social partner, signaling interest and approach tendencies, can elicit approach-related left-sided asymmetry in anterior cortical activity while averted gaze, indicating lack of interest or avoidance, has been related to weaker left-sided or stronger right-sided asymmetry in cortical activity (Hietanen et al., 2008; Pönkänen et al., 2011).

There is also evidence that Neuroticism or similar constructs are related to differences in gaze behavior and affective evaluations of gaze direction. Behavioral gaze avoidance has, for instance, been linked to social anxiety (Schneier et al., 2011; Schulze et al., 2013), high self-reported Neuroticism (Campbell and Rushton, 1978), and low self-esteem (Vandromme et al., 2011). While facing a person gazing at them, people with higher Neuroticism scores have also been shown to report stronger subjective avoidance motivation (Helminen et al., 2011). Taken together, these findings suggest that looking at another person with direct gaze should reveal Neuroticism-related differences in anterior EEG asymmetry. Note that observing such effects may require participants to look at another person presented "live" rather than pictures of faces presented on a computer screen (Hietanen et al., 2008; Pönkänen et al., 2011). The live condition adds authenticity as participants are aware of being looked at and perceive the potential for interaction with the stimulus person. Thereby increased motivational salience of the stimuli may be required to fully engage the approach and avoidance systems underlying anterior EEG asymmetry (see also Gable and Harmon-Jones, 2008).

1.3. Aspect factors of Neuroticism and anterior EEG asymmetry

Another reason for mixed associations between frontal EEG asymmetry and personality may be the reliance on too broad trait definitions. In order to better link dispositions to their biological underpinnings, a lower-order aspect factor level of the FFM has been proposed by DeYoung et al. (2007). Aspect factors divide each trait into two correlated, yet distinct domains. In accordance with a tradition to distinguish internalization and externalization (Kendler and Myers, 2014; Krueger et al., 2001), Neuroticism can be decomposed into Withdrawal and Volatility. Withdrawal is related to inhibition and is characterized by anxiety, depression, high self-consciousness, and feeling vulnerable. Volatility, on the other hand, captures the disinhibition aspect of Neuroticism and is related to lability, irritability, angry hostility, and impulsiveness. With regard to affective-motivational responding, Volatility is linked to hypervigilance to cues of negativity, while Withdrawal is associated with passive avoidance (Cunningham et al., 2010). Withdrawal has also been related to the Behavioral Inhibition System (BIS) sensitivity and Volatility to the fight component of the Fight-Flight-Freeze System (FFFS) of the Reinforcement Sensitivity Theory (Corr et al., 2013).

As the two aspects of Neuroticism have marked differences regarding underlying motivational tendencies, it would be expected that they would relate differently also to anterior EEG asymmetry. Withdrawal should be more strongly correlated with right-sided cortical activity, given that BIS has been related to this pattern (Shackman et al., 2009; Sutton and Davidson, 1997; Thibodeau et al., 2006). Meanwhile, Volatility involves states that are at least partially approach-motivated (Harmon-Jones et al., 2010) suggesting a relationship with left-sided cortical activity or a mixed pattern.