Anxiety Levels in Participants can Increase Relative Right Frontal EEG in Affect Elicitation Studies

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Synopsis
Frontal EEG asymmetries have been a feature of interest for affect detection. However, at the same time, frontal EEG asymmetries have been of interest as a biomarker for depression and are known to be impacted by anxiety disorders as well. We recorded EEG from 32 participants (10 male, 21 female, 1 nonbinary) in a lab environment. Participants viewed an affective film and completed the Generalized Anxiety Disorder (GAD)-7 and Kessler-10 screening tools for anxiety and depression. Using the model of motivational direction, we observed greater relative right activity or greater left frontal alpha with increased anxiety scores in response to affective stimuli. Moving forward, as researchers are analyzing frontal alpha asymmetries as a feature of emotional processing, it would be important to consider 1) the model of emotion being used, and 2) the mental wellbeing of participants.

Background
Electroencephalography (EEG) can capture time- and frequency-domain features associated with emotional states to enable affective brain-computer interfaces (aBCIs) (Mühl et al., 2014). Affective state detection can be integrated into pre-existing BCI systems with the potential to improve engagement, performance and enjoyment (Mühl et al., 2014). It also has potential for neurofeedback systems for the treatment of anxiety and depression (Hammond, 2005; Choi et al., 2011). Advances in affect detection have progressed with in-laboratory studies investigating offline EEG in response to affect elicitation stimuli, such as music videos, films, and multimodal stimuli (Koesltra et al., 2012; Mirranda-Correa et al., 2021; Raheel et al., 2020). However, these studies either exclude individuals with affective disorders or do not mention their inclusion criteria for their participants. It is important to understand how affective disorders, such as anxiety and depression, can impact affect detection.
Frontal EEG asymmetries have been a feature of interest for affect detection. However, at the same time, frontal EEG asymmetries have been of interest as a biomarker for depression (Choi et al., 2011) and are known to be impacted by anxiety disorders as well (Hammond, 2005). Further, despite hypotheses that negatively valenced emotions are associated with right frontal activity and positively valenced emotions are associated with left frontal activity, results have been inconsistent across studies (Palmiero and Piccardi, 2017). Instead of the dimensional model (see Mühl et al., 2014), here we apply the motivational direction model. The motivational direction model may be able to consistently explain EEG frontal alpha asymmetries on the axes of approach and withdrawal motivation, and further that these asymmetries affect emotional processing (Quaedflied, et al., 2015). Here, we focus on anxiety and emotion. Anxiety has been associated with greater motivational withdrawal (Hammond, 2005).

Methods
We recorded EEG (64 channel, wet electrode, ANT Neuro eego mylab system) from 33 participants (10 male, 21 female, 1 nonbinary; $mean_{age}$ = 25.50, SD_{age} = 4.41, min_{age} = 18, max_{age} = 36) in a lab environment. Participants viewed an affective film and completed a modified IQ test;

the stimuli were presented in 2 orders to control for order effects. Participants also completed the Generalized Anxiety Disorder (GAD)-7 and Kessler-10 screening tools for anxiety and depression, respectively.

In this abstract, we focus on the affective film protocol. We used a 25-minute short film (Sing (Mindenki)) embedded with fear, excitement, disgust, happiness, sadness, and neutral scenes. The film was selected to be less than 30 minutes long, to receive at least a 75% approval rating from both critics and mainstream audiences using aggregated data from Google, Rotten Tomatoes and IMDB, and was to contain at least one scene for each basic emotion. At the end of the film, participants were re-shown the target scenes and asked to self-assess the valence (positive to negative), arousal (high to low stimulation), dominance (high to low control of their response), liking, familiarity, and to provide a discrete emotion label (see above).

Results

Anxiety can be associated with greater right frontal EEG asymmetries or withdrawal motivation. In the study of EEG frontal alpha symmetries and motivational direction, the following equation is used (see Harmon-Jones and Gable, 2018):

$$\log_{10} F4_{\alpha} - \log_{10} F3_{\alpha} > 0 : relative\ left\ or\ approach\ motivation$$
$$\log_{10} F4_{\alpha} - \log_{10} F3_{\alpha} < 0 : relative\ right\ or\ withdrawal\ motivation$$

In our case, we used the average across the frontal electrodes in the left and right frontal areas. For the left group we included Fp1, F3, F7, FC1, FC5. For the right group we included Fp2, F4, F8, FC2, FC6. Using the MNE-Python (Gramfort et al., 2013) we applied a notch filter at 60 Hz, a FIR bandpass filer from 3 to 40 Hz with zero-double phase, performed a linear detrend, and downsampled from 1000 to 256 Hz. For the left and right groups, we computed the power spectral density (PSD) for the total alpha band from 8 to 13 Hz for each channel using Welch's method. We took the combined mean of the PSD output for each channel, and subsequently took the common log of each mean, then subtracted the left group from the right group. Next, we analyzed the relationship between the alpha frontal asymmetry scores and the total scores on the generalized anxiety disorder (GAD)-7 clinical screening tool.

Discussion

We observed more negative asymmetry scores or relative right, withdrawal motivation in participants with greater GAD-7 scores. These results are in line with previous work showing greater relative right or withdrawal motivation being associated with anxiety. Moving forward, as researchers are analyzing frontal alpha asymmetries as a feature of emotional processing, it would be important to consider 1) the model of emotion being used, and 2) the mental wellbeing of participants. For 1), most works in EEG affect detection rely on the dimensional and discrete models of emotion (Mühl et al., 2014). This pattern has positively impacted the field's ability to create standardized methods of analyses, however, these models have been shown to not consistently explain some EEG features. For example, frontal alpha asymmetries may be more consistently explained by motivational direction (Harmon-Jones and Gable, 2018). Further, the relationship we observed in this study between the relative right frontal activity and level of anxiety has been observed prior. It has also been observed with depression. This raises the possible importance of adding measures of mental wellbeing to studies of EEG affect detection.

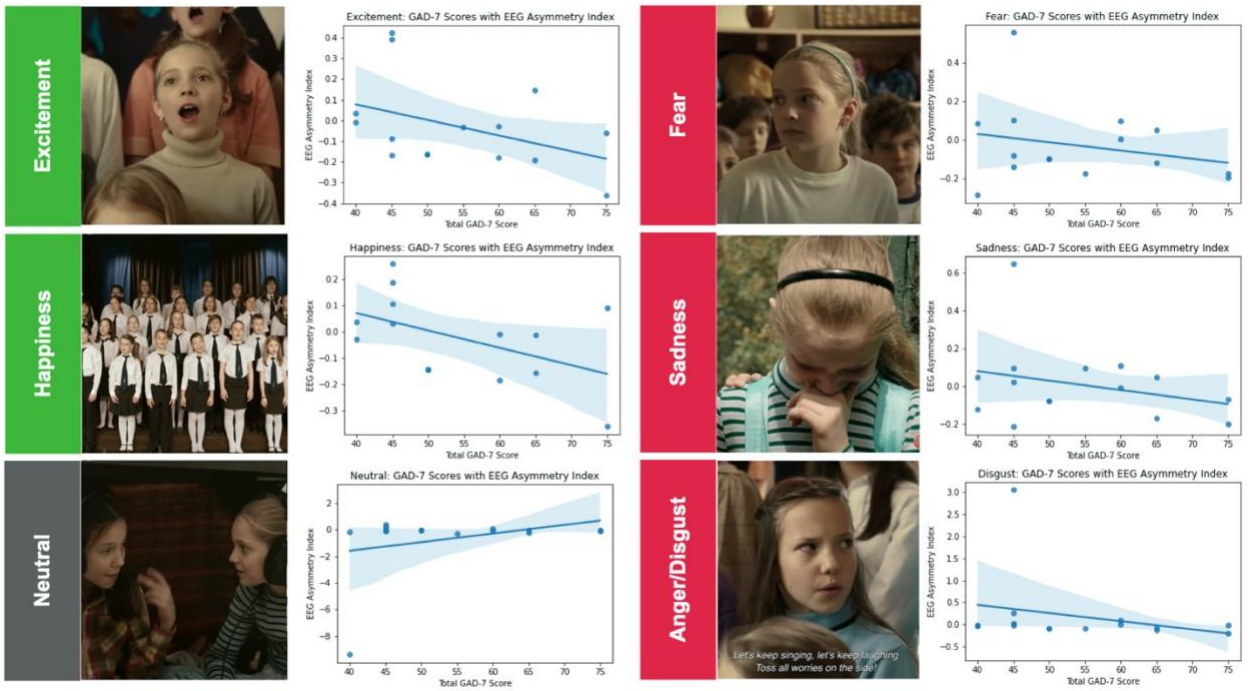

Figure 1. GAD-7 scores with frontal alpha asymmetry scores, labeled EEG Asymmetry Index (see Results section). A more negative EEG asymmetry index indicates greater relative right frontal EEG activity. As total GAD-7 scores increase, relative right frontal EEG increases in response to highly positive or negative, but not neutral stimuli.

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