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Frontal Alpha Wave Asymmetry in regard to Affect

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FRONTAL ALPHA WAVE ASYMMETRY IN REGARD TO AFFECT

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by

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ABSTRACT

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This study examines frontal alpha brain wave asymmetry (FAA) in relation to emotion processing. Previous research has shown that differences between left versus right FAA could exhibit a neurological marker for emotional intelligence (EI), mental health, and stress. Behavioral data were collected using Profile of Emotional Competence Questionnaire, Perceived Stress Questionnaire, Patient Health Questionnaire-9, and the Generalized Anxiety Disorder-7. This was followed by a series of resting EEG recordings. This study hypothesizes that participants who are mentally healthy, have higher EI scores and lower stress will display greater left FAA. The hypothesis is partially supported; participants with depression had greater right-sided FAA. It was also found that participants with left FAA had greater anxiety and participants with right FAA had less anxiety—this finding is the opposite of what was hypothesized. This study also found that people with greater EI had less depression, anxiety, and stress.

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CHAPTER I

INTRODUCTION

Emotions are a significant aspect of people's daily lives and, they play a crucial role in human social interactions, productivity, and task prioritization (Panksepp, 1998). Most individuals experience several emotional highs and lows throughout the day. For instance, at any given conscious moment, there is over a 90% chance that an individual is experiencing some sort of emotion (Trampe et al., 2015). Emotion processing in the brain has been investigated with many different brain imaging techniques. Due to its temporal sensitivity, the electroencephalogram (EEG) has been very helpful in investigating the neurological underpinnings of emotion processing (Lee & Hsieh, 2014). An EEG evaluates the electrical activity of the brain (i.e., brainwaves) at the millisecond (ms) level and is thought to provide a direct measure of brain function (Cohen, 2014). In emotion research the most commonly referenced wave is the alpha wave. Alpha waves reflect a calm and relaxed state of the brain and their frequency ranges from 8-12 Hz, the alpha band (Cohen, 2014). One popular use of the alpha wave is for studies that focus on emotion processing and frontal alpha asymmetry (FAA).

FAA is defined as the difference between right and left alpha wave activity over the frontal regions of the brain in an EEG (Davidson et al., 1990). In the current literature, FAA has been investigated in relation facets to emotional intelligence (EI; Sikka et al., 2019), stress (Zhang et al., 2018) and mental health (van der Vinne et al., 2017). For example, past research has shown that higher left FAA may indicate higher emotional intelligence, whereas higher right FAA may be associated with lower emotional intelligence (Goodman et al., 2013; Mikolajczak et al., 2010). Moreover, current research has shown that mental health and stress have a correlation with higher right side FAA activation (Düsing et al., 2016; Gollan et al. 2014). FAA has also been implicated in empathy, social decision-making, and emotional/motivational personality traits (Reznik & Allen, 2018). Chapter II provides background on frontal alpha asymmetry and its relation to alpha band activity, emotional intelligence, mental health, and stress.

CHAPTER II

LITERATURE REVIEW

Alpha Band Activity Related to FAA

Before external variables related to FAA are fully assessed, it is important to reference the associations between alpha band activity, asymmetry, and what it represents. As discussed above, alpha band activity is a wave form that occurs between 8-10 Hz when an individual is in a relaxed state (Cohen, 2014). It is a brain wave that is thought to originate in the occipital lobe and is noted for its low frequency background rhythms in healthy mature adults (St. Louis & Frey, 2016). Moreover, alpha band activity has been associated with increased mental coordination, calmness, and other facets related to improved wellbeing (Cohen, 2014). In order to record alpha activity with the use of an EEG, participants are commonly asked to close their eyes (St. Louis & Frey, 2016). When the eyes are opened, the alpha wave is diminished. The eyes-open and eyes-closed tasks creates a frequency trend known as an alpha rhythm that can be used to visualize a concrete pattern of brain activity during a relaxed state (St. Louis & Frey, 2016). Alpha band activity is utilized in many studies related to emotions due to its association with the rested state of the human mind. Likewise, across the cerebral cortex, alpha bands have been shown to be consistently symmetrical. Because of this, researchers have considered it as a highly accurate marker for general functioning in relation to abnormalities that cannot always be indicated by other neurological methods (St. Louis & Frey, 2016). This knowledge of alpha asymmetry is what initially led to the development of FAA and its popular use in emotion research (Hagemann et al., 2002).

Frontal lobe alpha asymmetry was originally discovered by Hagemann and colleagues in 2002 in association with personality (Hagemann et al., 2002). In their research, participants with higher right frontal alpha activity were shown to process information in a more positive way than participants with higher left frontal asymmetry. From this research, other studies expanded the use of FAA to formulate relationships between asymmetry and other external variables such as emotion processing and mental health (Gollan et al., 2014; Mikolajczak et al., 2010). The overarching goal in FAA research is to discover potential predictors in human behavior and general brain activity. FAA is especially useful in the field of predicting abnormalities in human behavior and in the prediction of disorders such as depression or anxiety. Having a baseline knowledge of alpha asymmetry in the frontal region of the brain holds large scale implications in terms of future prediction abilities for the mental healthcare field. Furthermore, it increases scientific understanding of the neural correlates of many well-known concepts in modern psychology, such as the dynamics of emotional intelligence, mental health, and stress.

Emotional Intelligence (EI)

EI is defined as the ability to regulate, interpret, assess, and express emotions (Salovey & Mayer, 1990). There is a wide selection of emotional intelligence quizzes that give an EI score, for instance The Emotional Regulation Questionnaire, Trait Emotional Intelligence Questionnaire, and The Profile of Emotional Competence Questionnaire (Mikolajczak et al., 2015; Petrides et al., 2007; Shields & Cicchetti, 1997). The EI score is thought to capture the degree to which someone can emotionally regulate, decipher, and articulate emotions of oneself and others. In order to evaluate the possible relationship between EI and FAA, Mikolajczak and colleagues (2010) were interested in knowing whether high or low emotional intelligence was correlated with either left or right FAA. To test the FAA, participants completed 4 eyes-open and 4 eyes-closed resting tasks while the EEG was measuring frontal alpha wave response. In order to test for emotional intelligence, the Trait Emotional Intelligence Questionnaire (TEIQue), a

French Emotional Intelligence questionnaire was used. Only four facets of EI were used for the purposes of the study: *well-being*, *self-control*, *emotionality*, and *sociability*. These traits were chosen due to their high reliability based on TEIQue values. The four traits were then compared along with FAA. The study's results showed that left FAA was correlated with high trait emotional intelligence.

In another study, Santesso et al. (2006) observed the relationship between emotional intelligence and FAA in children. In the first part of the experiment, children were told to relax while a resting EEG was completed (2-minutes, 1-minute eyes open and 1-minute eyes closed). Next, parents of the children completed a Child Behavior Checklist used to assess behavior traits in children (Achenbach, 2001). Two months later, parents were contacted to complete a *BarOn Emotional Quotient Inventory: Youth Version Observer Form* (BarOn & Parker, 2000). This emotional inventory asked parents to rate different aspects of intrapersonal emotional intelligence, interpersonal emotional intelligence, adaptability, and stress management. The study found that externalizing characteristics of children were the best predictors of FAA. Externalizing characteristics are behaviors that occur outwardly and are generally negative in nature (i.e., blatant disobedience, short temper, anger). Children who had negative externalizing traits such as, aggression and delinquency, had higher right FAA (Santesso et al., 2006). It was also found that children with externalizing issues additionally had low emotional intelligence.

Similarly, in a study on negative externalizing traits, Sikka et al. (2019) examined whether FAA had an effect on anger during sleep and in turn, emotional regulation (a component of EI). The participants spent two nights in a sleep lab where their brain activity was monitored with an EEG. Once participants reached rapid eye movement (REM) sleep, they were awakened 5 minutes later to tell researchers what they dreamed about, they were also asked to describe the emotions in their dreams and tell the experimenter the degree of intensity. The EEG was mainly analyzed during REM sleep cycle but was also recorded right before and after sleep occurred. The results of this study showed that FAA was a predictor of anger during REM sleep. Specifically, participants with greater right FAA experienced higher ratings of anger during dreams than participants with higher left FAA (Sikka et al., 2019). The authors suggested that this was due to poor emotional regulation in participants with greater right FAA, as they may not be able to deter anger in dreams because of their brain processing asymmetry.

Another important component of emotional intelligence is emotional regulation. Emotional regulation is the ability to interpret, decipher, and monitor the emotions of one-self and others. This aspect of emotional intelligence has also been linked to FAA. For instance, Hannisdottir et al. (2010), observed whether brain activity in early childhood was associated with emotional regulation in middle childhood when presented with a stressful situation. The authors hypothesized that children with greater right FAA would be more anxious and have poorer emotional regulation in later childhood (Hannisdottir et al., 2010). The study was conducted over a period of 4 ½ years, beginning when the participants were 4 ½ years old and ending when they were 9 years old. When the participants were 4 ½ years old, an EEG was obtained in order to establish a baseline recording. This consisted of recording brain wave activity during a 1-minute eyes closed and a 1-minute of watching *Sesame Street condition*. In the middle childhood section of the study, the parents of the children were asked to fill out *The Child Behavior Checklist* (Achenbach, 2001) and *The Emotion Regulation Questionnaire* (Shields & Cicchetti, 1997). These questionnaires were used to determine the emotional states of the participants. After completing the questionnaires, participants were asked to engage in a speech task designed to provoke anxiety. Before the task began, a 5-minute baseline recording was obtained with an

EEG. The study's findings showed that children with greater left prefrontal asymmetry were better at regulating emotions whereas children with greater right prefrontal asymmetry were poorer at regulating emotions (Hannisdottir et al., 2010).

In another investigation related to emotional regulation, Goodman et al. (2013) conducted a 3-phase study (*low arousal, moderate arousal, and high arousal*) to determine how different levels of arousal affect emotional regulation, working memory, and FAA. Eye blink startle (EBS) tasks were used to measure emotional regulation abilities. In these tasks, participants were presented with 3 separate stress/arousal conditions. Once these conditions were underway, a white noise startle occurred. Following the initial white noise startle, another one was presented 4 seconds later. The authors hypothesized that the 2nd startle would demonstrate the participants natural emotional regulation response through how quickly their EBS reduced (Goodman et al., 2013). Lastly, FAA was measured via an EEG. Results indicated that when enough stress was induced, participants with greater left FAA reported greater emotional regulation ability.

Mental Health

Another facet that has similar outcomes to emotional intelligence regarding FAA is mental health. For instance, Gollan et al. (2014) examined the effects of depression treatment on FAA. During pretreatment, the participants had their resting brain waves recorded with an EEG. Next, participants with depression were treated for 16 weeks with Behavioral Activation Treatments (e.g., been taught coping strategies), while participants without depression did not receive the treatment but were evaluated every week during a sixteen-week period. The EEG results demonstrated that the alpha brain waves had higher right FAA in depressed patient's pre-treatment and that there was no change post-treatment (Gollan et al., 2014). The asymmetry findings of this study were important because it demonstrates potential neural markers for depression.

In a similar study, Bruder and colleagues (2001) investigated the relationship between FAA and response to antidepressant medication (i.e., SSRI), in patients diagnosed with depression. Before SSRI treatment, participants underwent a baseline EEG recording consisting of 60 seconds of eye-open and eye-closed tasks. The specific SSRI used in treatment was Fluoxetine (brand name: Prozac), and the treatment consisted of a 12-week period. The results of the study showed that participants that were deemed non-responders to the SSRI medication had greater right FAA (Bruder et al., 2001). The authors concluded that there is a greater prediction for response to SSRI medication when a patient's FAA is known pretreatment.

Additionally, Blackhart et al. (2006) conducted a longitudinal study which investigated whether FAA could be a predictor of an individual developing anxiety. Participants completed the *Beck Depression Inventory* (Beck et al., 1961, 1988 as cited in Blackhart et al., 2006) as well as the *State-Trait Anxiety Inventory* (Spielberger, 1968 as cited in Blackhart et al., 2006) and had their baseline resting brain waves recorded with an EEG. Next, participants returned 3 weeks later to receive another baseline EEG. The findings of the study showed that, participants with higher right FAA as baseline reported having increased anxiety at the 1-year follow-up based on the comparison between the questionnaires. The authors speculated that alpha asymmetry could potentially be utilized as a predictor for psychiatric disorders and psychopathology. In a related study, Mathersul and colleagues (2008) observed the relationship between anxiety and depression in regard to FAA. In this study, participants took the *Depression Anxiety Stress Scale-21 (DASS-21)* to access whether they were depressed or anxious. In addition, resting alpha band waves were also recorded via an EEG. It was found that patients who had a higher degree of depression and anxiety, had greater right FAA (Mathersul et al., 2008).

In addition to depression and anxiety. FAA has also been evaluated in other mental health related issues. For example, Ischebeck et al. (2014), observed the relationship of FAA and obsessive-compulsive disorder (OCD). The study sample consisted of both participants with and without OCD. During the study, participants were asked to look at different types of pictures while an EEG was monitoring their brain waves. The pictures included two neutral, two negative, and two OCD related tasks in addition to a resting state condition. EEG findings showed, that participants with OCD, had greater right FAA across all of the different picture tasks and the resting condition. In contrast, the healthy control participants showed higher left FAA. The authors explain that their findings are related to previous studies that have shown that people with greater right FAA have a desire to withdraw because of anxiety/apprehensive related tendencies (Ischebeck et al., 2014). Moreover, other studies have shown that withdrawal tendencies are also linked to factors like anxiety and stress (Holahan et al., 2005).

Stress

Stress is defined as the feeling of an external or internal tension. Stress symptoms include fatigue, restlessness, irritability, insomnia, irrational thinking, and more. According to the American Psychological Association (APA), 3 out of 4 Americans experience general stress within any given month (Winerman, 2017).

Stress can also impact brain activity. For instance, Zhang and colleagues (2018) observed the possible relationship between stress and FAA. In this study, participants were exposed to water-temperature induced stress. Before the study began, a baseline EEG was obtained on all participants. Afterwards, participant's feet were placed in a tub of either warm or extremely cold water for 3-minutes. Participants were then told to remove and dry their feet from the tub and to wait 10-minutes. After the 10 minutes had gone by, another EEG measurement was obtained. The results showed that participants who were in the cold-temperature condition had greater right FAA especially in regions of the F7 and F8 electrode sites, indicating a possible relationship between stress and FAA.

In another study dealing with academic stress, Papousek et al. (2019) evaluated FAA regarding state/trait affect while testing. The study included psychology students who had taken a statistics of the social sciences course. The participants completed both an affective state and trait questionnaire and the Positive and Negative Affect Schedule before the experiment began (Papousek et al., 2019). The EEG was recorded during four different trials: initial resting condition, anticipation of task, 0 minutes after task 1, and 10 minutes after the second task. . All four EEG recording conditions consisted of 2 minutes of eyes open while focusing on a green dot across the room. For the anticipation portion, participants were told that the statistics questions that they were about to complete were questions from an admissions test into a master's programs and that they should know the answers. The first task consisted of three questions that were presented incrementally, and they had 30 seconds to read the question and 70 seconds to explain the answer. The second task was for participants to complete the 17-point joy and anxious tension Likert scale. The results of this study showed that trait positive affect was the biggest predictor in frontal asymmetry. Participants with more positive trait affect had higher left asymmetry, while participants with more negative trait affect had higher right asymmetry (Papousek et al., 2019). The results are congruent with previous findings of FAA and affect in that it showed that the participants with higher negative trait affect also showed higher right frontal asymmetry.

Another way to investigate stress is through cortisol testing. Cortisol is the primary stress-hormone produced in the adrenal glands located on top of each kidney. It is normally released in response to events and circumstances such as waking, exercising, and stress. Cortisol is also released during test taking, interviews, and public speaking, and helps drive motivation. In a recent study of FAA and stress, Düsing et al. (2016) found that in stressful social interactions (public speaking), participants who were able to maintain lower cortisol levels had higher left frontal asymmetry. Based on these results, the authors concluded that people with higher left asymmetry may be more motivated and less avoidant (Düsing et al., 2016). However, these results were somewhat surprising, as they do not exactly line up with previous research which shows that people with higher stress levels or cortisol levels, tend to have higher right FAA (Papousek et al., 2019; Zhang et al., 2018).

Research Question

Overall, as outlined in the above sections, frontal alpha asymmetry appears to be an important marker of emotional intelligence, mental health and stress. Although there are several different aspects concerning FAA and emotion processing, there are few studies that evaluate how multiple aspects interact collectively with FAA. In particular, evaluating facets that coincide such as emotional intelligence, mental health and stress may be beneficial additions to widen the scope of FAA research. The proposed study aims to broaden our understanding of FAA and emotion processing by evaluating EI, mental health and stress within the same study. Specifically, the proposed study seeks to investigate the possible relationship between FAA and emotional intelligence, mental health, and stress.

CHAPTER III

METHOD

Participants

The proposed study consisted of a sample of 10 Central Washington University (CWU) students. Participants were recruited via the CWU Sona research system. The Sona system is a Department of Psychology website that allows students to sign up for any ongoing psychology-related research studies. Signing up for studies gives the opportunity for the students to earn extra credit points, that may be awarded by their professors. All participants were 18 years of age or older and free of any substance use, persistent medication use, and neurological disorders.

Materials

Equipment

The Compumedics-Neuroscan EEG 32-channel Quik-Cap Hydro Net was used to measure general alpha activity, along with the SCAN 4 Neuroimaging Suite software for EEG collection and recording. The SCAN 4 software was also used to analyze all the brain waves and ERP grand averages for amplitude and latency. All visual stimuli were presented using the Compumedics-Neuroscan STIM^2 software program.

The Profile of Emotional Competence Questionnaire (PECQ)

Mikolajczak et al. (2015) developed the PECQ (see Appendix A) to assess emotional intelligence in terms of both interpersonal and intrapersonal variations. Within these two facets, the five main points that are observed are identification, understanding, expression, regulation and use of emotions. The questionnaire is 50 questions and takes approximately 15 minutes to take. The scale is 1 to 5, 1 being the statement does not describe you at all and 5 being the statement describes you considerably. For the analysis, there is an interpersonal, intrapersonal, and global emotional intelligence scores—the Cronbach's alpha for these scores are .90, .90, and .93 respectively (Brasseur et al., 2013).

Perceived Stress Questionnaire (PSQ)

The Perceived Stress Questionnaire (PSQ) was established to determine the degree of stress in people's lives generally, as well as in the given moment (see Appendix B). The questionnaire was developed by Levenstein and colleagues (1993) to determine stress levels for clinical settings as well as research studies. There are 30 questions on a scale of 1 (*almost never)* to 4 *(usually)* in terms of frequency of behavior. The approximate time usually needed to take the PSQ is 15-minutes. The Cronbach's alpha for this measure equals .92.

Patient Health Questionniare-9 (PHQ-9)

The Patient Health Questionniare-9 (PHQ-9) was developed to determine the depressive symptoms in a patient or participant in a quick time frame (Kroenke & Spitzer, 2002; see Appendix C). The PHQ-9 is free and open source to the public, which is why this particular questionnaire was selected. The PHQ-9 is primarily used as a diagnostic tool for depression in clinical settings. This 9-item questionnaire has a 4-point scale based on frequency of the behavioral occurrence, "0" meaning *not at all* and "4" meaning *nearly every day*. This questionnaire takes approximately 5 minutes to complete. The Cronbach's alpha for this measure is .86.

General Anxiety Disorder-7 (GAD-7)

The General Anxiety Disorder-7 (GAD-7) is a short, 7-item diagnostic tool to determine anxiety disorders in patients or participants (Spitzer et al., 2006; see Appendix D). The GAD-7 is a 7-item questionnaire and it uses the same scale as in the PHQ-9. This questionnaire also takes approximately 5-minutes to complete. The Cronbach's alpha for this questionnaire is .89.

Procedure

The participants were seated in front of a desk when they arrived at the laboratory. Once the participant settled in, they were handed an informed consent, along with a demographic information questionnaire (see Appendix E), and a handedness survey (see Appendix F). They were informed that if they become uncomfortable or want to leave at any time, they may do so without their course credit being affected. The participant was then handed the PECQ, PSQ, PHQ-9, and GAD-7. Once completed, they were fitted into the Compumedics-Neuroscan EEG 32-channel Quik-Cap Hydro Net. The participants were then told that they will go through a series of eyes-open and eyes-closed tasks. They were asked in that time to try and think of nothing, relax as much as possible, and to focus on a fixation cross on the wall for the eye-open task. There were a series of 5 eye-open and 5 eye-closed tasks, consisting of 2 minutes for each task resulting in a total 20 minutes per participant. The tasks went back and forth between eye-open and eye-closed and was counterbalanced. The participants' eyes remained closed for the duration of eye-closed tasks and their eyes remained open during eye-open tasks, although blinking is permitted. The principal investigator prompted the participants when to open and close their eyes (every 2 minutes).

EEG and Alpha Band Power Data Collection

Electrophysiological data was recorded from 32 electrode sites distributed evenly across the scalp using silver/silver-chloride (Ag/AgCl) electrodes attached to a silicone shell cap (Compumedics-Neuroscan) and a Compumedics-Neuroscan amplifier/stimulator with the Scan 4 Neuroimaging Suite software. Electrical impedance of each electrode was minimized to under 5mΩs, and the system was referenced on the nasion (i.e., the area between the eyebrows, above the nose). Eye blinks were monitored via an electrode positioned at the outer canthus (i.e., corner) of the left eye. Electrodes were aligned in a 10 to 20 system, meaning the distances between adjacent electrodes are either 10 or 20 percent of the total front-back, left-right distance of the skull. Data was recorded continually.

Amplification of the continuous EEG recording was from 0.15 to 70 Hz (1 to 100 Hz for the VEOG channel) and digitized through the Compumedics-Neuroscan acquisition interface system. Signal averaging was conducted after offline artifact rejection and baseline correction. The frequency band of alpha EEG waves (8 – 12 Hz) was evaluated to investigate FAA in relation to the questionnaire data collected from the participants on emotional intelligence, mental health, and stress.

Experimental Design and Variables

In order to obtain a global FAA score, the raw EEG data was transformed via Fast Fourier Transformation (FFT) in order to extract the alpha power activity. FFT is a computer algorithm that converts a signal from its original domain (e.g. raw data) to represent a specific frequency's voltage (Cooley & Tukey, 1965). In this case, the specific frequency that was examined from this transformation is the alpha power band (8-12 Hz) of each participant. From there, the voltage for each epoch was recorded in order to obtain the frontal asymmetry score. Lastly, a natural logarithmic formula was used to gather the frontal asymmetry score from each participant. The formula for global FAA is as follows (iMotions, 2018):

$$Frontal\ Alpha\ Asymmetry\ Score = \ln\left(\frac{alpha\ power\ right}{alpha\ power\ left}\right)$$

The electrode sites of focus include FP1, FP2, F7, F8, F3, F4, FC5, FC6, FC1, and FC2 (Mikolajczak et al., 2010). In the formula, these sites were calculated based on the left and right counterparts (e.g., FP1 and FP2). The calculation subtracts the natural logarithms of the right and left pairs. Since alpha activity is inversely related to cortical activity, higher scores indicate greater left frontal alpha activity than right frontal alpha activity (Mikolajczak et al., 2010).

Once the FAA scores are calculated for each participant, a correlation matrix was used to investigate the correlation between FAA, EI, depression scores, anxiety scores, and stress scores. After this is completed, a one-way MANOVA was used with FAA (left vs. right) as the independent variable and EI, depression, anxiety, and stress as the dependent variables. Although, once the correlation matrix was done, if there are variable(s) with no correlation with any of the other variables, these were not added to the MANOVA. Finally, a factor analysis between FAA, emotional intelligence, mental health, and stress was also performed.

Hypotheses

The following hypotheses are the predicted relationships between frontal alpha asymmetry and the external variables assess in this research:

H(1): FAA and EI. The participants with higher left FAA will have higher emotional intelligence scores globally, interpersonally, and intrapersonally. The participants with higher right FAA will have lower emotional intelligence scores globally, interpersonally, and intrapersonally.

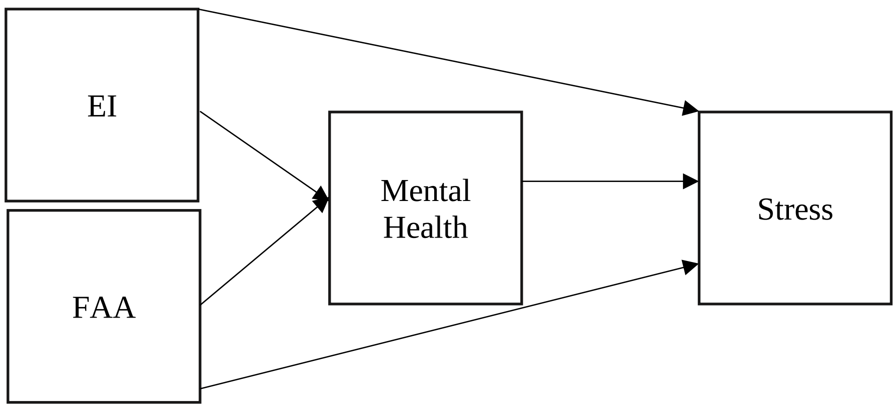
H(2): FAA and mental health. The participants with higher left FAA will have lower depression and anxiety scores. The participants with higher right FAA will have higher depression and anxiety scores.

H(3): FAA and stress. The participants with higher left FAA will have lower stress. The participants with higher right FAA will have higher levels of stress.

H(4): FAA, EI, mental health, and stress. The factor analysis will show the indirect and direct effects (see Figure 1). EI and FAA have direct effects on mental health and stress. Mental health has a direct effect on stress. EI and FAA also indirectly effect stress through mental health.

Figure 1

Hypothesized Path Analysis



CHAPTER IV

RESULTS

Pre-Analysis Check

Before the standard statistical analyses, the assumptions of the dataset were tested for normality, skewness, and kurtosis. The EEG scans were also visually examined, as well as computationally scanned, for impedances and disruptions. Six participants data had to be removed because of disrupted scans. Disruptions include the inability to lower impedances, excessive movement artifact, noisy EEG recordings and electrode flooding.

Based on Table 1, although test for normality displays the distribution is atypical, there is no skewness and kurtosis with right Global FAA. There were not enough points with left Global FAA to determine skewness and kurtosis. The Shapiro-Wilke test for normality shows that the distribution is atypical because the values are greater than .05 with right Global FAA. Similarly, with left Global FAA, there are not enough points to define normality. There are also no missing data points within the results.

FAA

In order to obtain the frontal alpha asymmetry score, a Fast Fourier Transformation (FFT) was conducted within the Scan 4 software to extract the power (voltage) associated with each epoch within the alpha band (8-12 Hz). This was an essential step to be able to find the power of the alpha band. Findings showed that in the eye-closed tasks, participants had greater alpha band power compared to the eye-open tasks (see Table 2). This is congruent with the Berger effect, that indicates alpha waves are suppressed when eyes are open (Kirschfeld, 2005). Visual stimulation can be an inhibitor of alpha activity because alpha only arises in a restful state, too much stimulation impedes this wave. Although the participants were prompted to look at a fixation cross, which would yield minimal visual stimulation, the Berger effect still takes place.

Table 1. Normality, Skewness, and Kurtosis

		Global FAA	Global EI	Depression Score	Anxiety Score	Stress Score
N	Left	2	2	2	2	
	Right	8	8	8	8	
Missing	Left	0	0	0	0	
	Right	0	0	0	0	
Mean	Left	3.87	11.5	12.5	0.572	
	Right	3.90	8.63	5.50	0.496	
Median	Left	3.87	11.5	12.5	0.572	
	Right	3.98	5.50	4.50	0.467	
Skewness	Left	NaN	NaN	NaN	NaN	
	Right	0.371	0.518	0.0317	1.12	
Std. error skewness	Left	Inf	Inf	Inf	Inf	
	Right	0.752	0.752	0.752	0.752	
Kurtosis	Left	NaN	NaN	NaN	NaN	
	Right	-0.178	-2.02	-1.46	0.879	
Std. error kurtosis	Left	NaN	NaN	NaN	NaN	
	Right	1.48	1.48	1.48	1.48	
Shapiro-Wilk W	Left	NaN	NaN	NaN	NaN	
	Right	0.933	0.821	0.905	0.902	
Shapiro-Wilk p	Left	NaN	NaN	NaN	NaN	
	Right	0.545	0.048	0.320	0.304	

Table 2. Averages of Alpha Band Power (nV)

	Left Eye-Closed	Left Eye-Open	Right Eye-Closed	Right Eye-Open
Mean	161	102	149	98.3
Median	136	79.2	122	84.1

	Left Eye-Closed	Left Eye-Open	Right Eye-Closed	Right Eye-Open
Standard deviation	107	76.9	103	74.4
Minimum	50.5	44.8	46.6	51.9
Maximum	342	312	315	304

Correlation between FAA, EI, Mental Health, and Stress

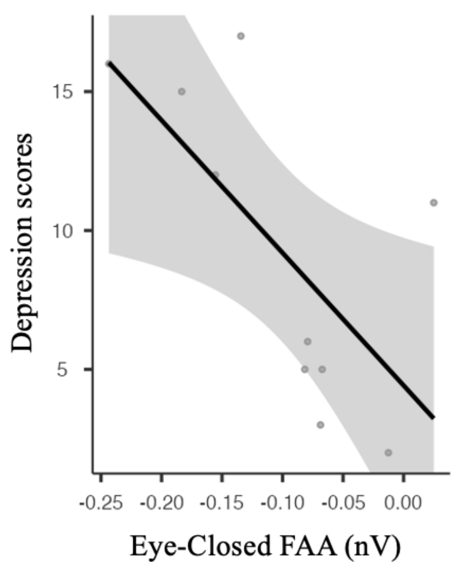
In order to assess the relationship between FAA, mental health, and stress scores, a correlation matrix was conducted (see Table 3). There is a strong negative correlation between depression and Global EI, $r(10)= -.817$, $p < .01$. There is a moderately strong relationship between depression and EI towards others, $r(10)= -.677$, $p < .05$. There is a moderate negative correlation between anxiety and Global EI, $r(10)= -.685$, $p <.05$. There is a strong positive correlation between anxiety and depression, $r(10)= .829$, $p < .01$. There is a moderate positive correlation between stress and depression scores, $r(10)= .655$, $p < .05$. There is a moderate negative correlation between EI toward others and stress, $r(10)= -.643$, $p < .05$. There is a moderate negative correlation between eye-closed FAA and depression scores, $r(10) = -.677$, $p < .05$ (see Figure 2). See Figures 3 and 4 for the visual representation of the relationships between EI, mental health, and stress. There was no correlation between FAA (Global, Eye-Closed, and Eye-Open) and EI, stress, and anxiety.

Table 3. Correlation Matrix

	Global EI	EI toward self	EI toward others	Depression Score	Anxiety Score	Stress Score	Eye-Closed FAA
Global EI	—						
EI toward self	0.669 *	—					
EI toward others	0.912 ***	0.459	—				
Depression Score	-0.817 **	-0.431	-0.677 *	—			
Anxiety Score	-0.685 *	-0.393	-0.465	0.829 **	—		
Stress Score	-0.610	-0.282	-0.643 *	0.655 *	0.617	—	
Eye-Closed FAA	0.366	0.183	0.339	-0.677 *	-0.293	-0.288	—

Note. * p < .05, ** p < .01, *** p < .001

Figure 2. Correlation between depression scores and eye-closed FAA



Note. Negative FAA scores = right-sided FAA while positive FAA scores = left-sided FAA.

Figure 3. EI, Mental Health, and Stress Correlation Matrix

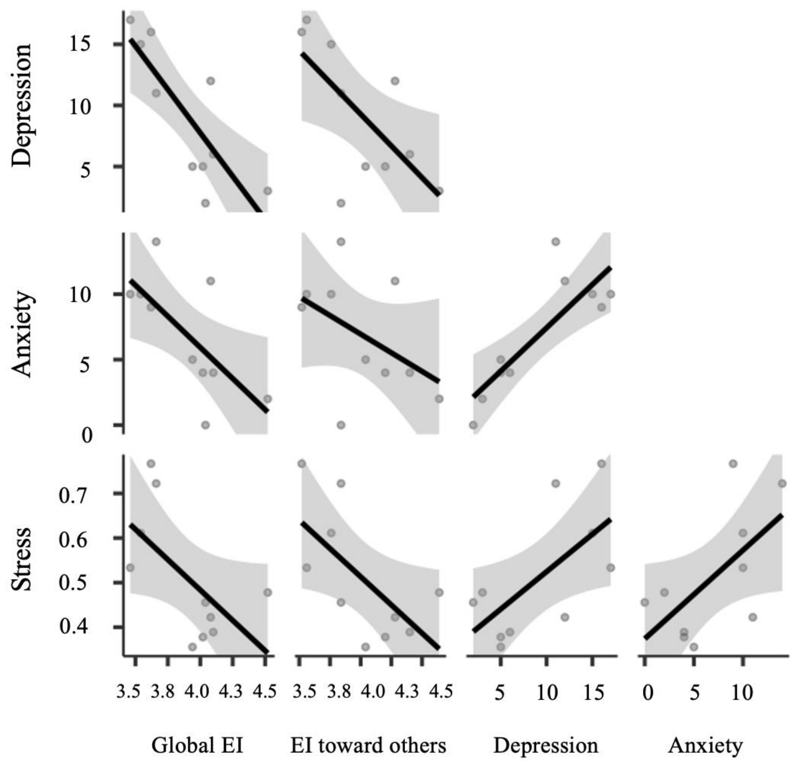
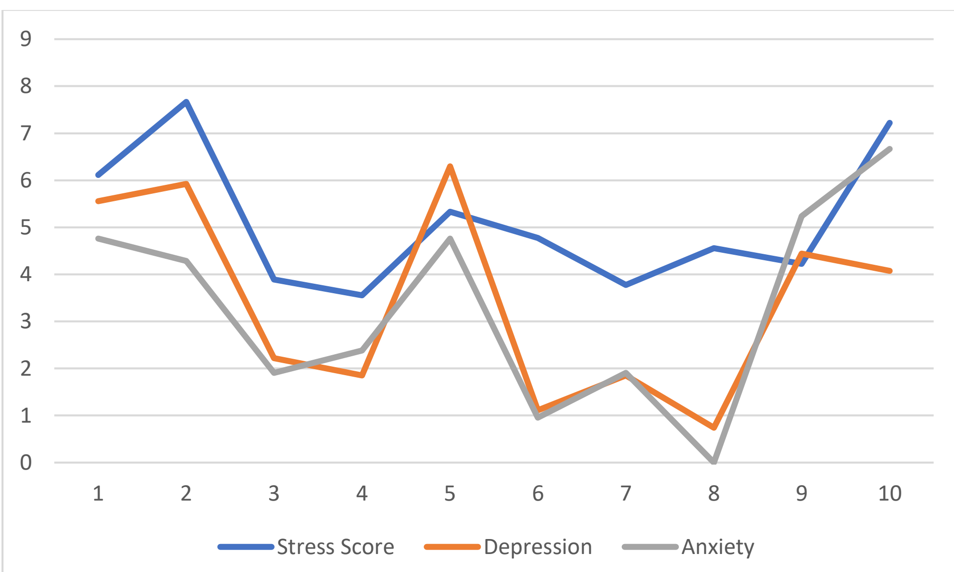


Figure 4. Depression, Anxiety, and Stress Comparison



Note. This chart represents altered scores to display equivalent scaling between depression, anxiety, and stress. The scale represented in this figure is 1-10.

Mental Health and Affect

In order to assess the mental health and affect of participants, descriptive statistics were observed (see Table 4). The Global EI score ranged from 0-5. The Profile of Emotional Competence Questionnaire, which yields the EI scores, does not have a scale indicating low, moderate, and high EI. Although, the average EI score was 3.90 (*SD*= 0.33) which indicates that most participants had moderate to high EI. The depression scores ranged from 0-27 (*normal*: 0-4, *mild*: 5-9, *moderate* 10-14, *moderately severe*: 15-19, *severe* 20-27). The participants average depression magnitude was *mild* (see Table 4) with half of the participants experiencing moderate/moderately severe depression. The anxiety scores ranged from 0-21 (*normal*: 0-4, *mild*: 5-9, *moderate* 10-14, *severe*: 15-21). The participants average anxiety magnitude was *mild* (see Table 4) with a majority of the participants experiencing a degree of anxiety. The stress scores ranged from 0-1. The Perceived Stress Questionnaire, which yields the stress scores, does not have a scale indicating low, moderate, and high stress. Although, the minimum stress score was 0.356 which indicates that every participant was experiencing at least a moderate amount of stress.

Table 4. Mental Health and Affect Descriptives

	Global EI	**Depression Score**	**Anxiety Score**	**Stress Score**
Mean	3.90	9.20	6.90	0.511
Median	3.98	8.50	7.00	0.467
Standard deviation	0.325	5.65	4.51	0.145
Minimum	3.46	2	0	0.356
Maximum	4.52	17	14	0.767

FAA and Anxiety

A One-Way MANOVA was conducted to assess if there was an overall difference between Global EI, Depression scores, Anxiety scores, and Stress scores in relation to Global FAA (see Table 5). The results suggested there was a significant effect with Global FAA as the predictor variable, $F(4, 5) = 0.17$, $p = .03$. A series of One-Way ANOVAs were conducted to find the specific difference with the mental health and affect variables (see Table 6). It was found that there is a statistically significant relationship between Global FAA and Anxiety scores, $F(1, 8) = 6.00$, $p = .04$.

Table 5. One-Way MANOVA

Multivariate Tests

		value	F	df1	df2	p
Global FAA	Wilks' Lambda	0.165	6.31	4	5	0.034

Table 6. One-Way ANOVAs with Global FAA

	F	df1	df2	p
Global EI	0.0165	1	8	0.901
Depression Score	0.3856	1	8	0.552
Anxiety Score	6.0019	1	8	0.040
Stress Score	0.4148	1	8	0.538

A Post-hoc analysis (Tukey’s) was conducted to assess the specific relationship between Global FAA levels (left vs. right) and anxiety (see Table 7). The Post-hoc comparison showed that participants with left Global FAA had higher Anxiety scores (*M*=12.50, *SE*= 2.56) and participants with right Global FAA had lower Anxiety scores (*M*=5.50, *SE*= 1.28) (see Table 8 &

Figure 5). These results do not support H_2, this will be further elaborated in the discussion section.

Table 7. Post-Hoc Comparison

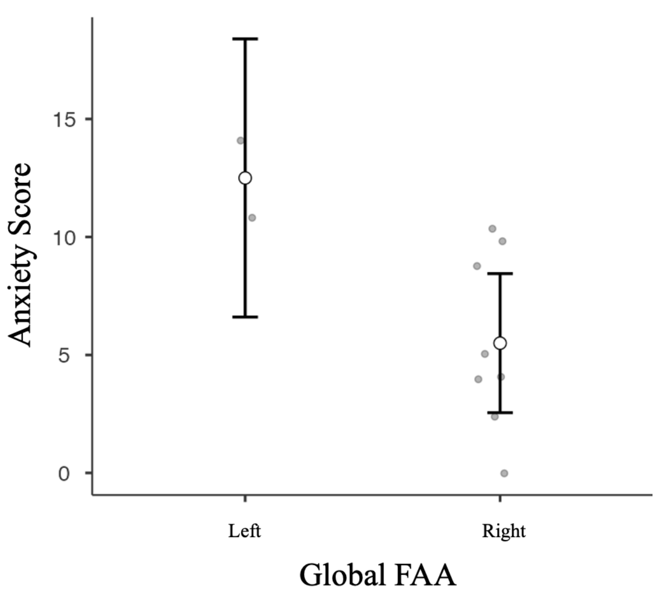
Comparison							
Global FAA		**Global FAA**	**Mean Difference**	**SE**	**df**	**t**	**p_{tukey}**
Left	-	Right	7.00	2.86	8.00	2.45	0.040

Note. Comparisons are based on estimated marginal means

Table 8. Anxiety Scores with Right and Left FAA

			95% Confidence Interval	
Global FAA	**Mean**	**SE**	**Lower**	**Upper**
Left	12.50	2.56	6.61	18.39
Right	5.50	1.28	2.55	8.45

Figure 5. FAA and Anxiety Score Plot



Activation Examples

Below are examples of a participant's alpha brain wave pattern (see Figures 6, 7, & 8). Alpha waves have gradual oscillating patterns that range between 8-12 Hz., Figure 6. is an example of a participant in a alpha-state displaying these patterns. Figures 7 & 8 are examples of a participant with left sided alpha activation (see Figure 7.) and overall activation (see Figure 8.).

Figure 6. Alpha Band Waves EEG Example

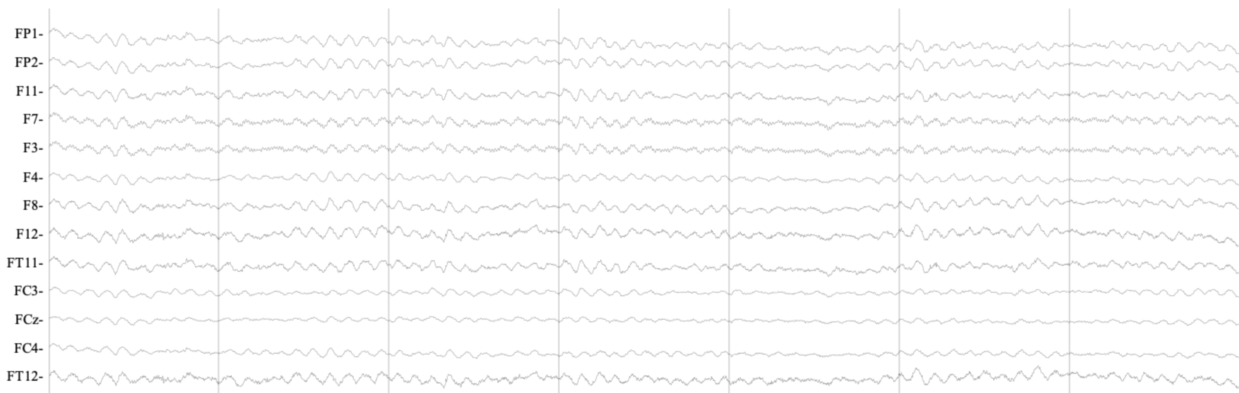


Figure 7. Alpha Activation Visual Example

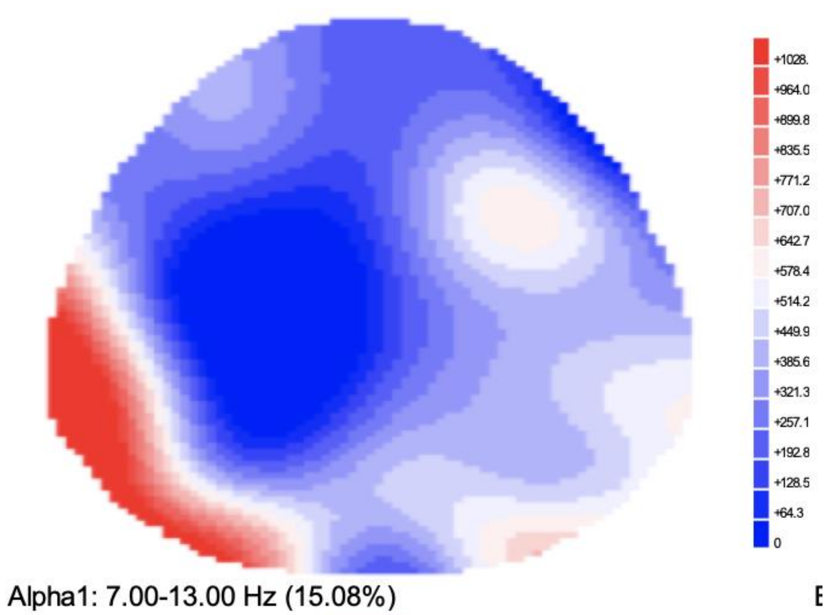
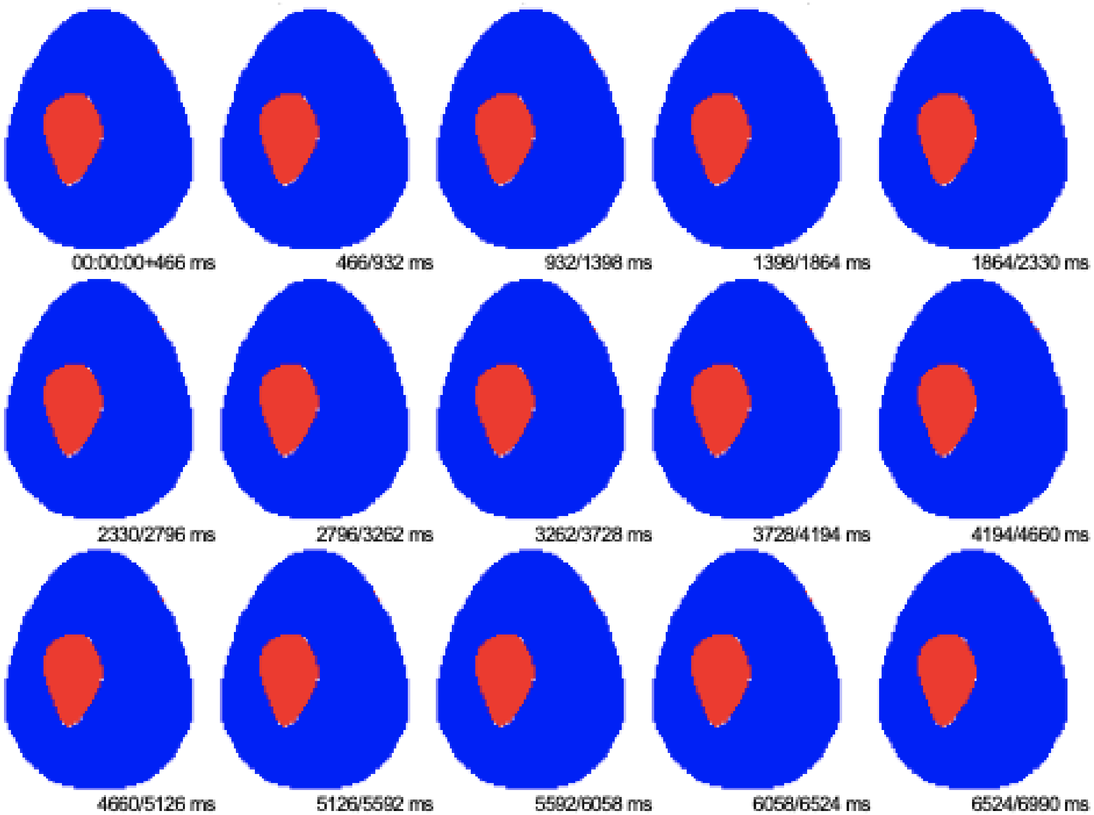


Figure 8. Activation Visual Example



CHAPTER V

DISCUSSION

This study aimed to discover the relationship between FAA, EI, mental health, and stress. Overall, the current results showed that there were differences between left and right alpha band power in terms of mental health. Moreover, mental health was the only component that had relationships with all the other factors studied (FAA, EI, and stress). Results also showed that mental health and stress had strong negative correlations with EI. Additional findings showed that high depression, anxiety, and stress scores denoted lower EI scores, while low depression, anxiety, and stress scores indicated higher EI scores. Regarding mental health, there was also a relationship between eye-closed FAA scores and anxiety scores. Specifically, participants with higher anxiety had left FAA while participants with lower anxiety had right FAA. It is interesting to note that findings on anxiety and FAA seem to contradict past research. The following sections will evaluate what the current results may indicate in terms of the existing literature.

FAA and EI

In regard to FAA and EI, the current study found that there was no correlation between any of the facets of FAA (Global, eye-closed, eye-open, right, left) and the facets of EI (Global, toward self, and toward others). To look further into the relationship between alpha band power and EI, the overall sum of alpha of each participant was compared to their EI score. It was found that there was no correlation between alpha band power to EI scores. These results do not support previous research that indicated that people with left FAA have higher EI while people with right FAA have lower EI (Mikolajczak et al., 2010; Santesso et al., 2006; Sikka et al., 2019; Hannisdottir et al., 2010; Goodman et al., 2013).

One reason for the differences found in the current study may be the fact that in previous research the authors used different measures to obtain EI scores. For example, Mikolajczak and colleagues (2010) used a trait EI questionnaire and Santesso and colleagues (2006) had parents rate their child's EI. These methods could be more accurate because trait EI questionnaires have questions based on characteristics while the PECQ, which was utilized in the current study, has questions based on speculative emotional occurrences. This can yield inaccurate EI scores because it is difficult for participants to imagine themselves in vague, hypothetical emotional scenarios. Moreover, a component of EI is determining if a person uses reasoning or reaction (emotional regulation) in emotional situations and this can be difficult to determine when the participant is not in an actual emotionally activating situation. In addition, in a study conducted by Santesso et al. (2006), the participants were minors, so the authors asked the parents questions about their emotional reactivity. This form of obtaining EI scores can be beneficial because the answers are coming from a quasi-objective 3rd party that has an outside perspective of the participant's emotional responsiveness, although, there is potential parental bias. Participants who are unself-aware may not recognize how they emotionally react which can lead to inaccurate results. Consequently, the PECQ used in the current study might not have been a sensitive enough tool in obtaining precise EI scores and therefore be related to the different FAA findings.

FAA and Mental Health

The relationship between FAA and mental health is relatively new in current literature. There is not much information regarding the association between FAA and mental health because FAA itself is a newer phenomenon and has only more recently been linked to mental health and emotional processing (Allen et al., 2018). In the current study, the interconnection between emotion and FAA was further evaluated. Specifically, it was found that there was a moderately strong negative correlation between eye-closed FAA and depression scores. These results were created in-part by the Gerber Effect which demonstrates that alpha activity is hindered when eyes are open because visual stimulation impedes the brain from being in an alpha state (relaxed state; Kirschfeld, 2005). Furthermore, eye-closed FAA might yield more reliable scores, in terms of FAA, because alpha waves occur under minimal sensory stimulation. The current results showed that the participants with higher depression scores had greater right-sided FAA, this supports the second hypothesis. Moreover, this result supports previous literature that demonstrated that people with higher depression scores have greater right FAA (Bruder et al., 2001; Gollan et al., 2014). This provides further evidence that there is a relationship between depression and hemispheric differences of alpha activity regarding depression and emotional processing.

Lastly, it was found that there was a statistically significant relationship between Global FAA and anxiety scores. A post hoc comparison was conducted to assess the nature of the relationship and it was found that participants with right FAA have lower anxiety scores and participants with left FAA have higher anxiety scores. Interestingly, these results were not expected and do not support previous literature stating that left FAA is associated with lower anxiety levels (Blackhart et al., 2006; Ischebeck et al., 2014; Mathersul et al., 2008). A possibility for the current studies conflicting results regarding FAA and anxiety scores could be that people with higher EI also have higher anxiety. Previous research has shown that people with higher trait EI have much higher anxiety levels than people with lower trait EI (Guil et al., 2019). There has been some debate in the current literature whether anxiety is linked with high or low EI. Anxiety is thought to be a very reactive stress-state (Padgaonkar et al., 2021) which could show poor emotional regulation (fact of EI) although it could also show a hyperawareness to emotion and emotional reactivity which would show high EI.

FAA and Stress

Another unexpected result of the current study was the finding of no correlation or relationship between the facets of FAA and stress. This finding is likely due to the fact that stress is a short-term feeling, and it is difficult to gauge long term stress because anxiety is considered long term stress. The PSQ (stress questionnaire used in the current study), among most other stress questionnaires, evaluates state (present-day) stress. The accuracy of the answers could have been erroneous because in the current study only trait FAA was obtained and considered—given that the tasks were resting states. Moreover, the current study acquired general resting alpha patterns and activity, which is the participants trait alpha activity (long-term). Thus, stress is not a viable measure because stress is short-term. Since the tasks did not induce stress in the current study, an absence of relationship is understandable.

FAA, Emotional Intelligence, Mental Health, and Stress

The fourth hypothesis specified that there were direct and indirect effects between EI, FAA, mental health, and stress. This hypothesis was dependent upon the amount of participants attained (approximately 30 participants were required in order to run the factor analysis adequately) and since the current study was only able to recruit 10 participants, there was insufficient data to conduct a factor analysis in regards to H(4).

EI and Mental Health

A notable result of the current study is the relationship between EI, mental health and stress. There is a moderately-strong to strong negative correlation between Global EI, Depression Scores, Anxiety Scores, and Stress Scores. The higher the depression, anxiety, and stress scores, the lower the Global EI scores—with a similar relationship between the mental health variables and “EI toward others” but to a smaller degree in terms of magnitude. This shows that participants with higher overall EI have lower levels of depression, anxiety, and stress levels and participants with lower overall EI have higher levels of depression, anxiety, and stress. Furthermore, this means that people who have a greater ability to regulate, interpret, assess, and express emotions (facets of EI) have lower instances of depression, anxiety, and stress. This is an important finding as it indicates that EI may be linked to mental health. It would be worthwhile to explore this relationship further to determine if high EI causes lower mental health instances or if lower mental health instances cause higher EI and vice versa.

The current study also found a moderately strong positive correlation between depression, anxiety, and stress. This shows that participants with lower depression levels also had lower anxiety and stress levels, while participants with higher depression levels also had higher anxiety and stress levels. Figure 4 displays the relationship of depression, anxiety, and stress scores between the participants. This figure shows how conjoined the relationship is, especially between depression and anxiety. This relationship displays a pattern between the relationships that if one score is high, moderate, or low, the other facets are going to have the same magnitude of severity, or lack thereof. For example, if an individual has high depression, based on these results, there is a high chance they will have high anxiety and high stress as well. The potential reason for these congruencies is that stress is a principal factor in provoking depression and anxiety (Rackoff et al., 2020). For instance, high stress instigates high depression and high anxiety.

Limitations and Future Directions

One limitation of the current study was the low number of participants. This hindered pre-analysis assumption checks because there was not enough data to uncover normality, skewness, and kurtosis properly. Although not unique to the current study, another limitation was the eye-open and eye-closed experimental design. The participants were prompted to try their best to think of nothing while doing these tasks but there was no way of accessing if they accomplished this. It was important for participants to have a clear mind because any sort of mental stimulation can hinder alpha activity. A method of relaxing participants before the tasks could be beneficial in the future to make this commonly used method more exact.

Another limitation was the difficulty in obtaining accurate EI scores based on self-report. For instance, a component of EI is self-awareness and if a participant has low self-awareness, they may not necessarily answer questions accurately and they may overestimate their EI, while people with high self-awareness may believe that they are not as emotionally intelligent as they are. This is a classic example of the Dunning-Kruger effect in terms of EI ability. The Dunning-Kruger effect is a phenomenon that when a person has low ability, they tend to overestimate their capability and when a person has high ability, they tend to underestimate their capability. Regarding the PECQ, the Dunning-Kruger effect could be an active consequence to the validity of the questionnaire.

The name of EI questionnaires can also pose a potential limitation. For example, participants can see that the principal investigator is trying to determine “emotional intelligence” or “emotional competence” because it is in the name of the questionnaire. Seeing this could influence how the participant answers the questions. With EI questionnaires, it is apparent what ranking is the “best” and what is the “worst,” so the answers can easily be manipulated based on what the participant wants their EI score to be.

An interesting alternative approach and future experiment to ascertain EI scores might be to interview participants. A qualitative method would be worthwhile because participants can be interviewed regarding how they would respond to certain situations to determine their EI score, rather than having them rank how well they are at emotional tasks/situations.

In terms of alpha band power, a worthwhile future direction might be to observe the relationship between the variation of alpha power between participants. For instance, there were some participants that went into an alpha state almost immediately while others went into an alpha state 12-minutes into the study. There were also participants that had very high alpha power (voltage) while others had very low power. It might be valuable to explore these individual variations to determine what causes sooner/later and strong/weak alpha waves and the impacts these individual differences may have for EI, emotional processing and mental health.

Lastly, another limitation could be the effects of the COVID-19 pandemic on mental health and stress. In this study, it found that all the participants had some degree of depression and most participants had anxiety and stress. These factors could be related to and be exacerbated by the stressors and isolation of the pandemic. Furthermore, the *history effect* caused by COVID-19 could be a possible confound.

Conclusion

Emotion processing in humans is a complex neural process that includes neurons, neurotransmitters, neurophysiology (e.g., alpha waves, FAA) and multiple brain regions. The proper function of all these factors makes up the complexities of life, decisions, emotions and ultimately impact mental health.

In the current study, it was found that FAA has a complex relationship with mental health. Specifically, it was found that people with greater depression had greater right FAA. It was also found that people with greater anxiety had left FAA and people with less anxiety had right FAA. These results seem paradoxical because previous research demonstrated that poor mental health was associated with right FAA while good mental health was associated with left FAA. It would be worthwhile to explore this contradictory relationship further because of the importance of accurate diagnoses and treatment of mental health disorders.

Furthermore, the current study found that people with higher EI had lower instances of depression, anxiety, and stress. EI is an important concept to explore further because it has been shown that it may have a positive impact on mental health if increased. For instance, research has shown that EI is a skill that can be developed by mental exercises and training (Delhom et al., 2020) and mindfulness training (Nadler et al., 2020; Wing et al., 2006). Moreover, people with high EI have greater leadership qualities, greater relationship satisfaction, better reasoning/decision making skills, higher cognitive ability (Malouff et al., 2014; Uhrich et al., 2021), and as found in the current study, better mental health outcomes.

In sum, EI may be linked to more exemplar mental health and FAA is a potentially important neural correlate of emotion processing. Both phenomena warrant further research to enhance our understanding of human emotion processing and mental health. Furthermore, as indicated by the current study, using EEG methodology can be a useful tool to investigate the complexities of emotion processing in the human brain.

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APPENDIXES

Appendix A

Profile of Emotional Competence Questionnaire

	1	2	3	4	5
1. As my emotions arise I don't understand where they come from.					
2. I don't always understand why I respond in the way I do.					
3. If I wanted, I could easily influence other people's emotions to achieve what I want.					
4. I know what to do to win people over to my cause.					
5. I am often a loss to understand other people's emotional responses.					
6. When I feel good, I can easily tell whether it is due to being proud of myself, happy or relaxed.					
7. I can tell whether a person is angry, sad or happy even if they don't talk to me.					
8. I am good at describing my feelings.					
9. I never base my personal life choices on my emotions.					
10. When I am feeling low, I easily make a link between my feelings and a situation that affected me.					
11. I can easily get what I want from others.					
12. I easily manage to calm myself down after a difficult experience.					
13. I can easily explain the emotional responses of the people around me.					
14. Most of the time I understand why people feel the way they do.					
15. When I am sad, I find it easy to cheer myself up.					
16. When I am touched by something, I immediately know what I feel.					
17. If I dislike something, I manage to say so in a calm manner.					
18. I do not understand why the people around me respond the way they do.					
19. When I see someone who is stressed or anxious, I can easily calm them down.					

20. During an argument I do not know whether I am angry or sad.					
21. I use my feelings to improve my choices in life.					
22. I try to learn from difficult situations or emotions.					
23. Other people tend to confide in me about personal issues.					
24. My emotions inform me about changes I should make in my life.					
25. I find it difficult to explain my feelings to others even if I want to.					
26. I don't always understand why I am stressed.					
27. If someone came to me in tears, I would not know what to do.					
28. I find it difficult to listen to people who are complaining.					
29. I often take the wrong attitude to people because I was not aware of their emotional state.					
30. I am good at sensing what others are feeling.					
31. I feel uncomfortable if people tell me about their problems, so I try to avoid it.					
32. I know what to do to motivate people.					
33. I am good at lifting other people's spirits.					
34. I find it difficult to establish a link between a person's response and their personal circumstances.					
35. I am usually able to influence the way other people feel.					
36. If I wanted, I could easily make someone feel uneasy.					
37. I find it difficult to handle my emotions.					
38. The people around me tell me I don't express my feelings openly.					
39. When I am angry, I find it easy to calm myself down.					
40. I am often surprised by people's responses because I was not aware they were in a bad mood.					
41. My feelings help me to focus on what is important to me.					
42. Others don't accept the way I express my emotions.					
43. When I am sad, I often don't know why.					

44. Quite often I am not aware of people's emotional state.					
45. Other people tell me I make a good confidant.					
46. I feel uneasy when other people tell me about something that is difficult for them.					
47. When I am confronted with an angry person, I can easily calm them down.					
48. I am aware of my emotions as soon as they arise.					
49. When I am feeling low, I find it difficult to know exactly what kind of emotion it is I am feeling.					
50. In a stressful situation I usually think in a way that helps me stay calm.					

Appendix B

Perceived Stress Questionnaire

The Perceived Stress Questionnaire

Instructions for the General questionnaire

For each sentence, circle the number that describes how often it applies to you in general, *during the last year or two.* Work quickly, without bothering to check your answers, and be careful to describe your life *in the long run.*

	Almost	Sometimes	Often	Usually
1. You feel rested	1	2	3	4
2. You feel that too many demands are being made on you	1	2	3	4
3. You are irritable or grouchy	1	2	3	4
4. You have too many things to do	1	2	3	4
5. You feel lonely or isolated	1	2	3	4
6. You find yourself in situations of conflict	1	2	3	4
7. You feel you're doing things you really like	1	2	3	4
8. You feel tired	1	2	3	4
9. You fear you may not manage to attain your goals	1	2	3	4
10. You feel calm	1	2	3	4
11. You have too many decisions to make	1	2	3	4
12. You feel frustrated	1	2	3	4
13. You are full of energy	1	2	3	4
14. You feel tense	1	2	3	4
15. Your problems seem to be piling up	1	2	3	4
16. You feel you're in a hurry	1	2	3	4
17. You feel safe and protected	1	2	3	4
18. You have many worries	1	2	3	4
19. You are under pressure from other people	1	2	3	4
20. You feel discouraged	1	2	3	4
21. You enjoy yourself	1	2	3	4
22. You are afraid for the future	1	2	3	4
23. You feel you're doing things because you have to not because you want to	1	2	3	4
24. You feel criticized or judged	1	2	3	4
25. You are lighthearted	1	2	3	4
26. You feel mentally exhausted	1	2	3	4
27. You have trouble relaxing	1	2	3	4
28. You feel loaded down with responsibility	1	2	3	4
29. You have enough time for yourself	1	2	3	4
30. You feel under pressure from deadlines	1	2	3	4

Instructions for the Recent questionnaire

For each sentence, circle the number that describes how often it applied to you *during the last month.*
Work quickly, without bothering to check your answers, and be careful to consider only *the last month.*
Score 5-circled number for items 1, 7, 10, 13, 17, 21, 25, 29
Score circled number for all other items
PSQ Index = (raw score-30)/90.

Appendix C

Patient Health Questionnaire-9

Authors: Janet B.W. Williams and Dr. Kurt Kroenke –Open Source Questionnaire

PATIENT HEALTH QUESTIONNAIRE-9 (PHQ-9)

Over the last 2 weeks, how often have you been bothered by any of the following problems? *(Use "✔" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

FOR OFFICE CODING __0__ + ______ + ______ + ______

=Total Score: ______

If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult at all	**Somewhat difficult**	**Very difficult**	**Extremely difficult**
☐	☐	☐	☐

Developed by Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke and colleagues, with an educational grant from Pfizer Inc. No permission required to reproduce, translate, display or distribute.

Appendix D

Generalized Anxiety Disorder-7

Authors: Drs. Robert L. Spitzer, Janet B.W. Williams, Kurt Kroenke—Open Source Questionnaire

GAD-7

Over the <u>last 2 weeks</u>, how often have you been bothered by the following problems? *(Use "✔" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Feeling nervous, anxious or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3

(*For office coding: Total Score T____ = ____ + ____ + ____*)

Appendix E

Participant History Questionnaire

Brain Dynamics & Cognitive Neuroscience Lab

Central Washington University

Participant History Questionnaire

1. What is your age? ____________

2. What is your biological sex?
   - ❑ Male
   - ❑ Female
   - ❑ Prefer not to answer

3. What is your race/ethnicity? ____

4. Have you ever had a concussion, stroke, seizure, or any other traumatic brain injury?
   - ❑ Yes
   - ❑ No

   If yes, please explain the injury and when this occurred.

   ____

5. Do you have a vision impairment that cannot be corrected for with lenses or glasses?
   - ❑ Yes
   - ❑ No

6. Do you have a hearing impairment that cannot be corrected for with a cochlear implant or hearing aids?
   - ❑ Yes
   - ❑ No

7. Have you taken any pharmaceutical or nonpharmaceutical drugs within the past two weeks?
   - ❑ Yes
   - ❑ No

   If yes, please specify.

   ____

Appendix F

Handedness Survey

Brain Dynamics & Cognitive Neuroscience Lab

Central Washington University

Hand Preference Questionnaire

Please indicate which hand you use for each of the following activities by circling:
R for right **L** for left or **E** for either

Which hand orientation would you use:

To write a letter clearly?	R	L	E
To throw a ball to hit a target?	R	L	E
To hold a racket in tennis, squash, or badminton?	R	L	E
To hold a match while striking it?	R	L	E
To cut with scissors?	R	L	E
To guide the thread through the eye of a needle?	R	L	E
At the top of the broom while sweeping?	R	L	E
At the top of the shovel when moving sand?	R	L	E
To deal a deck of cards?	R	L	E
To hammer a nail into wood?	R	L	E
To hold a toothbrush while cleaning your teeth?	R	L	E
To unscrew the lid of a jar?	R	L	E
To play your most practiced instrument?	R	L	E
To hold a pick while playing guitar?	R	L	E

If you use the RIGHT HAND for all these actions, are there any one-handed actions for which you use the left hand? Please list:

If you use the LEFT HAND for all of these actions, are there any one-handed actions for which you use the right hand? Please list:

Were you born one of TWINS? _________ or TRIPLETS? _________

If yes, please indicate the hand preference of your twin or triplets. _____________________
If you have children, please indicate the hand preference of your:

First Child __________ This child's other parent ____________

Second Child __________ This child's other parent ____________

Third Child ___________ This child's other parent _____________