2020

Evidence-Based Diagnosis of Posttraumatic Stress Disorder Using Quantitative Electroencephalography

Roger Yoder
Walden University

Walden University

College of Social and Behavioral Sciences

This is to certify that the doctoral dissertation by

Roger W. Yoder

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. Reba Glidewell, Committee Chairperson, Psychology Faculty
Dr. Silvia Bigatti, Committee Member, Psychology Faculty
Dr. Gary Burkholder, University Reviewer, Psychology Faculty

The Office of the Provost

Walden University
2019

Abstract

Evidence-Based Diagnosis of Posttraumatic Stress Disorder

Using Quantitative Electroencephalography

by

Roger W. Yoder

MS, Walden University, 2015

BS Liberty University, 2003

Proposal Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Psychology

Walden University

October 2019

Abstract

Diagnosing post-traumatic stress disorder (PTSD) is challenging and is currently, diagnosis through self-administered checklists. Because a diagnosis of PTSD can open up significant benefits to compensation, education, and medical care, people can tailor their responses to the checklist to help ensure a diagnosis of PTSD. The purpose of the study was to examine the utility of the quantitative electroencephalograph for diagnosing PTSD. Frequency and presence of biomarkers and alpha brain wave symmetry in the frontal and parietal lobes were examined. Research questions involved examining the presence of alpha wave imbalance across the frontal lobe and between the right and left parietal lobes. A secondary data analysis was conducted using data from 108 subjects; these data included records from those with and without a PTSD diagnosis. The results of logistic regression showed that 63% of the clients diagnosed with PTSD were correctly identified and between 7% and 8% of the variance in PTSD was accounted for by frontal lobe asymmetry. The parietal lobe imbalance correctly classified PTSD in 59% of the patients and it identified 3.5–4.9% of the variance, suggesting that asymmetry in the frontal and parietal lobes should not be used as the primary method for diagnosing PTSD. Implications for social change include identifying an objective diagnostic tool that can potentially decrease the possibility of inaccurate diagnoses based on self-reported symptoms. This could lead to eliminating some of the shame and embarrassment veterans and first responders feel toward seeking help for PTSD.

Evidence-Based Diagnosis of Posttraumatic Stress Disorder Using Quantitative Electroencephalography

by

Roger W. Yoder

MS, Walden University, 2015

BS Liberty University, 2003

Proposal Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Psychology

Walden University

October 2019

Acknowledgments

First, I would like to thank my children, Eric, Rebecca, and Cody for their love and patience throughout this process. I could not have done this without you in my life.

I would also like to thank my partners, Jessica and Terese, for their love, understanding, patience and support. You have had to carry a heavier load while I focused on this project. You never complained and were always there for me. I love you both like family.

My mentor and now friend Dr. Rob Neils. You rescued me when I really needed a person in my life. Things were rough and I didn't think finishing this dissertation or program would be feasible. Thank you for showing me what friendship looks like again and for teaching me how to be a professional clinical psychologist. The psychology world is a bit diminished by your retirement. However, your contributions are seen across the field and your mark in history is secure.

Dr. Reba Glidewell, Dr. Silvia Bigatti, and Dr. Burkholder, Walden faculty, for agreeing to join me on this crazy journey in brain science. You stuck by me when things got tough and helped me limp through. You also helped me sort through my mental traffic jam regarding the fields of neuroscience and neurotherapy. Last, but not least, a deep thanks to Cecilia Younger, my patient dissertation coach. Anyone embarking on this journey should look her up for help. Her expertise and diligence made all the difference.

Table of Contents

List of Tables

Chapter 1. Introduction to the Study

Introduction

Posttraumatic stress disorder (PTSD) has long been recognized as a mental disorder related to exposure to traumatic events such as assault, warfare, and other threats on a person's life (Ntafoulis, 2016). Historians, such as Ntafoulis, have traced post-battle-related psychiatric symptoms as far back as ancient Greece and the middle Byzantine period. Over 2,000 years ago, Greek warriors would return from battle with symptoms that could not be explained by Hippocratic physicians (Ustinova & Cardeña, 2014). In the twenty-first century, PTSD remains a leading consequence of modern-day war. Today it is considered to be a signature injury, affecting approximately 1 in 12 veterans who served in Iraq or Afghanistan (Patel, 2015).

Ustinova and Cardeña (2014) noted that ancient historical methods used to care for damaged warriors, such as ritual cleansing and penance, would help ease the traumatic ruptures of self, time, and cognition. But they were short-term solutions. Because war-related trauma was considered a condition that medical providers of the time could not cure, long-term treatments were neither offered (Ustinova & Cardeña, 2014). Therapies currently used include trauma-focused psychotherapies and antidepressant medications.

Building on this history has shown mental health practitioners that PTSD and depression are often co-occurring. Researchers have long recognized that PTSD and major depressive disorder (MDD) can be linked in some manner (Kostaras, Bergiannaki, Psarros, Ploumbidis, & Papageorgiou, 2017). Kostaras et al. (2017) found

that comorbidity rates between PTSD and MDD can be as high as 36%. Each of these disorders could require different mental health treatment options. Difficulties differentiating between the two disorders carry significant implications (Kostaras et al., 2017).

These are not the only disorders that may need differentiation. PTSD can also be differentiated from other trauma- and stressor-related disorders in which exposure to a traumatic or stressful event is listed explicitly as a diagnostic criterion, such as reactive attachment disorder, disinhibited social engagement disorder, acute stress disorder, adjustment disorders, anxiety disorders, obsessive-compulsive disorder, and dissociative disorders. Differentiating among possible trauma-related disorders can be a crucial aspect of providing the most effective treatment (Blake, Lating, Sherman, & Kirkhart, 2014).

Military personnel, police officers, firefighters, emergency medical technicians, and other first responders are among those exposed to traumatic events in the course of their duties. Diagnosis and differentiation of PTSD from other disorders is typically accomplished through self-report assessments (You, Youngstrom, Feeny, Youngstrom, & Findling, 2017). Tsai et al. (2016) reported that self-assessments lack validity and authenticity. Furthermore, the symptoms of PTSD can be coached and rehearsed before a person visits a mental health therapist (Potik, Feldinger, & Schreiber, 2012).

Coaching and rehearsal can potentially be detected through malingering measures on assessments. Malingering—the exaggeration and/or feigning of symptoms for secondary gains—occurs for many reasons (Bryant et al., 2018), including access to

medications, compensation, and benefits. . Bryant et al. (2018) suggested that self-report instruments are particularly susceptible to malingering behaviors. In their study, they found that the students in the malingering group had much higher malingering scores than nonmalingering students. This suggests that the malingering students recognized the answers that could be key to a diagnosis of a mental health disorder.

However, assessment instruments can also vary greatly when evaluated for potential accuracy related to detection and differentiation of disorders. You et al. (2017) found that students reported symptoms more accurately than teachers reported the observed behaviors of the children. Assessments were found to rely on subjective measures that vary from person to person. Therefore, their accuracy and reliability continue to be a challenge. Researchers and clinicians (Vermetten, Baker, Jetly & McFarlane, 2016)., and authors of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed., American Psychiatric Association, *DSM-5*) continue to debate about under-diagnosing and overdiagnosing PTSD and other trauma-related disorders.

Background

Jokić-Begić and Begić (2003) conducted research on to the utility of qEEG for diagnosing mental disorders. This small pilot study used qEEG to compare qEEG in combat veterans with and without PTSD. Their study was able to confirm differences among qEEG characteristics between the combat veterans with PTSD and the control group of veterans without PTSD. The results demonstrated that veterans with PTSD had decreased alpha power and increased beta power, suggesting an altered neurobiology in

PTSD. The authors offered various explanations for decreased alpha activity and increased beta rhythm activity in those veterans with PTSD (Jokić-Begić & Begić, 2003).

Findings reported by a 2012 study conducted by Jaworska et al. (2012), were consistent with previous studies regarding alpha power, alpha wave activity, and asymmetry or imbalance. Unlike self-assessments, a technological instrument such as a qEEG can provide a standard measure of brain wave asymmetrical patterns in the frontal brains of individuals with depression or PTSD (Kemp et al., 2010). In a systematic review of 1178 EEG references, Lobo et al. (2015) found that qEEG held considerable ability as an evaluation tool for detecting these biomarkers. However, they concluded that further study on this evaluation tool was required. Power asymmetry, based on absolute frontal and parietal alpha, might provide another PTSD biomarker.

Prior research supports the efficacy of biomarkers as potential identifiers of specific mental disorders (Moss, Cannon, Thatcher, Koberda, & Gunkelman, 2014). Moss et al. explained that biomarkers have been approved by the Food and Drug Administration (FDA) to support or rule out a diagnosis of attention deficit and hyperactivity disorder. Identification of additional biomarkers through the use of qEEG brain scans are being studied as evidence-based sources for diagnosing mental disorders such as PTSD.

Problem Statement

An evidenced-based tool such as the qEEG can analyze brain function and more accurately detect biomarkers that would indicate the presence of PTSD (Rivers, 2013). First, increased global alpha brain wave activity at right parietal versus left parietal and

second, alpha brain wave asymmetry in the frontal lobe, can be potential biomarkers of PTSD (Lobo et al., 2015; Kemp et al., 2010). A common challenge related to diagnosing PTSD is the training associated with administering assessments that can identify PTSD symptoms (Brewin et al., 2017. It is anticipated that the International Statistical Classification of Diseases and Related Health Problems 11(ICD-11) will change criteria for PTSD, further supporting the need for an evidenced-based diagnostic tool able to diagnose PTSD and complex (repeated) PTSD (Brewin et al., 2017).

According to Frueh (2013), malingering associated with disorders such as PTSD can be difficult to detect. Veterans, police officers, and other first responders can reap financial benefits from a diagnosis of PTSD. A psychometrist or therapist may misunderstand or misdiagnose the observed behaviors believed to reflect PTSD (Yamaguchi et al., 2016). These behaviors might be observed by the clinician or experienced as symptoms by the patient. However, as highlighted by Yamaguchi et al. (2016), these symptoms and behaviors are subjective measures and can be misidentified or misinterpreted by both parties. In the case of a child, the parents and teachers might also inadvertently misread potential symptoms and behaviors. An objective diagnostic tool such as the qEEG would decrease the possibility of inaccurate diagnoses based on a patient's self-reported symptoms. The intent of this dissertation was to examine the frequency of biomarkers identified by qEEG in adults diagnosed with PTSD.

This problem statement addressed the indicators observed in the brain scans of individuals with PTSD. A database of brain scans showing patterns that have been confirmed to be associated with PTSD symptomatology could help improve the current

process of diagnosing PTSD. Recording and analyzing PTSD biomarkers would provide evidence-based approaches to diagnosing adults and children who have experienced traumatic events. In other words, identifying biomarkers will remove some of the subjectivity associated with the current self-report assessments.

Purpose of the Study

The purpose of this study was to identify biomarkers related to PTSD using qEEG. Biomarkers were qualified and quantified through direct observation of qEEG readings of brain activity. Current diagnostic methods only assess symptoms based on self-report instruments (Tsai et al., 2016). The use of qEEG to identify abnormal brain activity can be expected to provide a more accurate assessment by identifying specific brain wave activity and the presence of PTSD. Specifically, the presence of two potential biomarkers were sought: increased global alpha activity in the right parietal lobe and alpha asymmetry in the frontal lobe (Lobo et al., 2015; Kemp et al., 2010).

Kemp et al. (2010) found that alpha wave asymmetry across the frontal lobe is potentially unique to people with PTSD. A preliminary study by Wahbeh and Oken (2013) identified an increase in global alpha power in the right parietal region of the brain when compared to the left parietal region. The intention of this study was to provide an analysis that contributes to closing the gap in understanding the use of qEEG to identify abnormal brain activity and confirm a diagnosis of PTSD (Lobo et al., 2015; Kemp et al, 2010).

Research Questions

Earlier research has shown that alpha brain wave asymmetries across the frontal lobe (biomarker B1) and increased alpha brain waves in the right parietal lobe (biomarker B2) can potentially indicate the presence of PTSD. In this study, combinations of the two biomarkers as an effective form of PTSD diagnosis were examined. Alpha waves in the frontal lobe can range from 8–12 cycles per second. Elevated alpha in the left frontal lobe must be considered in comparison to the right frontal lobe. Both measurements could be in the normal range of 8–12 cycles per second and still be imbalanced.

Alpha brain wave activity of 12 cycles per second in the left frontal lobe would not be significant. However, an alpha of 12 cycles per second in the left frontal lobe and 8 cycles per second in the right frontal lobe would be significant, even though they are both within normal ranges. This situation can also be present when considering the parietal lobe. The alpha cycles per second being the same as the frontal lobes for this area was considered. Additionally, there might also be an interaction between the variables, independent of their effect on the brain. Analysis of the frontal and parietal lobes can? highlight any potential interactions between the lobes. The tool will potentially determine if the imbalance in the parietal lobe is also creating an imbalance in the frontal lobe or vice versa. Thus, the research questions were as follows:

1. Does a sample of tested adults diagnosed with PTSD have detectible alpha brain wave asymmetries across the frontal lobe?

2. Does a sample of tested adults diagnosed with PTSD have detectible alpha brain wave asymmetries across the parietal lobe?

Hypotheses

H_{01}: Adults diagnosed with PTSD do not have detectible alpha wave asymmetries across the frontal lobe (Biomarker 1) compared to adults who have not been diagnosed with PTSD.

(Ha_1): Adults diagnosed with PTSD have detectible alpha wave asymmetries across the frontal lobe (Biomarker 1) compared to adults not diagnosed with PTSD.

(Ho_2): Adults diagnosed with PTSD do not have detectible alpha wave asymmetries across the parietal lobes (Biomarker 2) compared to adults that have not been diagnosed with PTSD.

(Ha_2): Adults diagnosed with PTSD have detectible alpha wave asymmetries across the parietal lobes (Biomarker 2) compared to adults that have not been diagnosed with PTSD.

Nature of the Study

A quantitative non-equivalent control group quasi-experimental research design using archival records was used to examine the utility of qEEG scans for the diagnosis of PTSD. The study was anonymous; all patient files were extracted without identifying information. To ensure anonymity, prior to each patient's inclusion study, a random number was assigned. This random number was used as the primary identifier of the information related to a specific client. The random number was given to the researcher. The list linking the random numbers was established and secured at the practice that

gathered the data. The number was used in case there was issue with the patient file. To resolve such issues, the researcher reported potential issues to the practice manager and the manager resolved issues and provided the resolution if there was one, without identifying the patient to the researcher. The sample of brain scans was examined and compared for the presence of both biomarkers. A binary logistic regression was used to measure whether frequencies of detectible biomarkers were significantly different between the two groups of patients. The use of this data was approved by Walden University Institutional Review Board.

Theoretical Framework

The framework of this study centered on current concepts related to trauma and the diagnosis of mental trauma and trauma-related disorders such as PTSD. Carlson and Dalenberg (2000) provided a theoretical framework to address symptoms and organic changes to a person's brain produced by traumatic experiences. This framework supports the theory that PTSD causes psychological and organic changes in a person's brain. These changes can result in potentially disabling symptoms. These symptoms will, most likely, not be reduced or eliminated until they have been addressed through psychotherapy, psychopharmacological interventions, or both.

The *DSM-5* provides specific symptomology and behaviors that can be identified in order to diagnose disorders such as PTSD (*DSM-5*, 2013). However, some of these symptoms and behaviors can be associated with other disorders. Recognizing potential organic changes to a brain as an identifier and unbiased specifier is a benefit of the Carlson and Dalenberg (2000) framework. This theoretical framework is one of the few

that highlights interrelationships between brain function and trauma-related brain modifications.

People undergo potential traumas throughout a lifetime of development. Kira, Lewandowski, Chiodo, and Ibrahim (2014) offered a theoretical framework that supports traumatic experiences and its impact on a developing brain. Effects such as modified brain waves on a developing brain can produce symptoms that are potentially associated with changes in specific areas of the brain. These changes might be the source of identifiable symptomology and behaviors as a person progresses through the stages of brain development. An example might be a child that experiences a traumatic event that results in hypervigilance. This hypervigilance could be seen on a brain scan and become a biomarker for PTSD. The Kira et al. (2014) framework supports the portion of the study in regard to development and traumatic events (Kira, Lewandowski, Chiodo, & Ibrahim, 2014).

The study used a quasi-experimental quantitative experimental approach to determine potential relationships between variables. A quantitative study compares variables as a way to reveal potential relationships. The study framework was more conceptual, based on available data and the hypothesis (Creswell, 2014).

Definition of Terms

Alpha waves: Alpha waves represent brain wave activity that oscillates in the 8 – 12 cycles per second frequency range (Gerrard & Malcolm, 2007). This is the first brain wave activity discovered by Hans Berger, the inventor of electroencephalography (EEG). Alpha waves are the most obvious brain wave activity.

Biological marker: A biological marker (biomarker) is an identified indicator of a state or condition (Strimbu & Tavel, 2010). In this document, a biomarker is a potential identifiable brain condition that can be assessed and measured. Biomarkers were first identified in the 1950's in regard to biological conditions. Brain biomarkers became a focus in the 1970's and 1980's.

Brain wave activity: This is neural activity that occurs in the central nervous system (Gerrard & Malcolm, 2007). This electrical activity is rhythmic or repetitive and can be detected on an EEG. Alpha waves are of particular interest in this paper.

Frontal lobe and prefrontal cortex: These are parts of the brain located in front of the temporal and partial lobes in the mammalian brain (Miller, Freedman & Wallis, 2002). The prefrontal cortex covers the front of the frontal lobe and is responsible for functions associated with executive decision making and memory. Most importantly, this portion of the brain assigns emotions to anxiety related activity generated by the limbic system.

Hypervigilance: The DSM-5 defines hypervigilance as "An enhanced state of sensory sensitivity accompanied by an exaggerated intensity of behaviors whose purpose is to detect threats" (p.823) (APA, 2013). This enhanced state results in a person constantly scanning for threats and can lead to exhaustion. Hypervigilance can engage all of a person's senses.

Major depressive disorder (MDD): MDD is defined in the DSM-5 as a period of loss of interest and/or pleasure that results in a depressed mood that lasts more than 2

weeks (APA, 2013). MDD can also be associated with PTSD and PTSD related symptomology.

Parietal lobe: The parietal lobe is an area of the brain responsible for somatic responses, such a s touch and temperature, spatial awareness, attention, and visual motion (Smith, 2007). Of importance is the cognitive processing of sensory information.

Posttraumatic stress disorder (PTSD): PTSD is a mental disorder characterized by symptoms following exposure to trauma events (APA, 2013). Some of the symptoms include fears related to re-experiencing the event with emotional and behavioral reactions.

Quantitative EEG (qEEG): qEEG is a method of mapping and analyzing brainwaves using electroencephalography (Chabot & Serfontein, 1996). Leads are placed on the scalp of a person and electrical activity is detected and measured. The results are then compared to a database of brains in order to identify potential biomarkers for specific mental disorders.

Temporal lobe: These lobes of the brain are responsible for long term memory associated with the hippocampus (Smith, 2007). This area is also responsible for brain functions associated with emotional processing, language comprehension, and visual memory.

Assumptions, Scope and Delimitations, Limitations

Assumptions

The narrative databases are the result of qEEG brain scans of adults considered to be neurotypicals. Traditional, face-to-face assessments are used as a way to screen

and identify subjects that fall into the normal range of functioning. Scans of adults with only one mental health diagnosis were used. This study assumes that patients did not have a co-occurring mental health disorder. Databases correctly produced and recorded biomarkers that were analyzed and compared.

Scope and Delimitations

The databases of qEEG assessments conducted for this study were the primary source of brain scans. This helped ensure that the scans had been properly analyzed. Additionally, every brain scan in the database had undergone the same level of assessment. Each patient's qEEG was conducted with the same procedures and every patient was administered the same panel of traditional assessments with certified psychometrists or licensed mental health practitioners who had diagnosing as part of their scope of practice. . The delimitation associated with this study was that the brain scans used were limited to those already gathered and input into a database. This decision was made in order to help eliminate patients who were still in the diagnosing process.

Limitations. Todder, Levine, Abujumah, Mater, Cohen, & Kaplan (2012) support the identification of biomarkers in specific areas of the brain. These biomarkers could then be used to support a diagnosis of PTSD using qEEG. The sample size (N= 20) was small, but it could still provide an understanding of the potential functionality of biomarkers. The sample size of this case-comparison study was also small (N = 20) but was anticipated that evidence-based information of critical neurological importance would result.

Significance of the Study

The relationship between certain brain-function biomarkers and PTSD symptoms needs to be better understood. An increased awareness of this link can potentially improve diagnosis and targeting of therapeutic options. This study explored the presence of alpha asymmetries in the frontal lobe and alpha power imbalances between the right and left parietal lobes as potential biomarkers in identifying PTSD. Research on this gap in understanding may support the justification of using qEEG as a primary diagnostic tool for PTSD.

Implications for Positive Social Change

These findings could result in positive social change by providing an evidence-based process to support the diagnoses of PTSD. This social change might help eliminate some of the shame and embarrassment veterans feel toward seeking help for PTSD. Typically, veterans avoid potential diagnosis and treatment because the warrior culture frowns upon mental health issues as signs of weakness. Price (n.d.) indicated that the perceptions of the public toward law enforcement officers with PTSD can also be an area of positive social change. The author stressed that current public and governmental perceptions of job-related stressors for law enforcement are not readily supported by evidenced based diagnosing. Difficulties related to diagnosis and treatment can result (Price, n.d.). Changing these perceptions can improve care and inculcate a culture of positive social change that includes people dedicated to protecting the public.

Summary

Chapter 1 introduces the quantitative electroencephalogram as a tool used to identify potential biomarkers in a patient's brain. These biomarkers can be used as a way to provide an evidenced based diagnosis of trauma based mental disorders. Also presented were the problem statement, purpose, research questions, and hypothesis related to the study. Additionally, definitions of unique terms were addressed, as well as delimitations, the scope of the study, and potential limitations. Finally, the significance of the study and possible positive social changes were addressed.

Chapter 2 presents a review of the literature on qEEG and brain biomarkers. It also highlights strategies on changes in brain speed and power in different parts of the brain. Specifically, potential organic changes to the brain of a person with PTSD and other trauma-related mental disorders are explored. The gap on the identification of biomarkers in the frontal and parietal lobes is also explored. Chapter 2 includes ongoing studies related to brain biomarkers and brain wave activity. The theories introduced in Chapter 1 are presented and further supported.

Chapter 3 is the area in which methods and procedures are described. The selection of subjects and the collection of data is outlined. This study uses data that had already been collected; no participants were recruited. Justification for the number of subjects and the selection criteria regarding digital records are explained.

Chapter 4 reports the results of the data analysis. The data set includes a range of brain scans from neurotypical adults diagnosed with PTSD and other mental health

disorders. Biomarkers from other disorders provided a level of consistency. This chapter contains narrative statements related to the presentation of the findings for this study.

Chapter 5 offers the interpretation of the study as related to the necessity of the identification of biomarkers related to PTSD and other trauma-related mental disorders. This is also the area that addressed positive social change regarding veterans' perceptions regarding mental health care. Recommendations for use of these findings and suggestions for future studies are also offered.

Chapter 2: Literature Review

Introduction

The diagnosis of PTSD is problematic for states, cities, police departments, private companies and governments, to name a few. This includes, for example, the struggles faced by the Department of Veterans Affairs regarding the diagnosing of PTSD for compensation and benefits claims, as well as lower level governmental agencies and private companies with workers who many experience traumas. People with PTSD symptoms are sometimes misdiagnosed and end up being incorrectly treated and/or attempting to self-medicate. Because a diagnosis of PTSD can open up significant benefits related to compensation, education, and medical care, there is the problem of secondary-gain and malingering, or accusations of malingering by potential PTSD patients. Using a tool that analyzes brain wave activity is one way in which subjective factors can be removed from the process.

A 2011 study conducted by Jackson et al. (2011) revealed that mental health professionals, primarily psychologists, did not typically use assessment instruments to diagnose PTSD. This study indicated that 53% of the clinicians receiving and returning surveys preferred to use an interview over evidenced-based assessment instruments, such as the Clinician Administered PTSD Scale (CAPS). Of the respondents, 59% never used assessment instruments in the diagnosing process. This overreliance on a subjective interviews and perceived expert opinion could allow for increased malingering and secondary gain. Jackson et al. (2011) highlighted the increase in Vietnam era veterans seeking benefits for delayed PTSD symptoms. The authors

indicated that secondary-gain incentives might lead some veterans to malinger as a way to receive or increase compensation through the Veterans Administration (VA) Benefits office.

As an example of the quandary created by subjective assessments, McNally and Frueh (2012) argued that the Jackson et al. (2011) study minimizes the problems related to secondary-gain and malingering in the administration of veterans' benefits related to PTSD. McNally and Frueh`) highlighted a VA Inspector General report, which indicated that only 21% of veterans receiving at least 50% compensation for PTSD had an identifiable traumatic incident in their service history. Exacerbating the potential for malingering is the expansion of PTSD symptoms to include people who experience a fear of hostile military and/or terrorist activity. The report revealed that a vast majority of veterans would cease PTSD mental health treatments when compensation ratings would reach 100%. These types of conflicting reports and studies reinforce the need for an objective assessment process, much like that of an X-ray revealing a broken bone.

Marx et al. (2012) responded to the Jackson et al. (2011) study and the McNally and Frueh (2012) rebuttal reply. Marx and colleagues came to the defense of veterans, VA clinicians, and the assessment process related to PTSD. Their response highlights potential inaccuracies in/of what exactly? related to the reasons for delayed PTSD assessments for Vietnam era veterans. These potential inaccuracies include insufficient sample size and generalization of results across the entire veteran population. The authors also indicate that steep increases in the number of veterans applying for PTSD compensation is far higher than other potential disorders. The reasons for this increase

can possibly be attributed to better education and other factors compelling people to seek treatment and compensation other than secondary gain and malingering.

However, it is important to emphasize that the Veteran's Administration is not the only organization struggling with the diagnosing of PTSD. Workman's compensation, social security, civil lawsuits, and other civilian agencies and organizations also experience these challenges (Matusko, Kemp, Paterson & Bryant, n.d.). Matusko et al. (n.d.) highlight that few psychological assessors will screen for malingering. However, psychiatrists appear to be the exception. Analysis of the data produced by psychiatrist in Australia indicates that over 50% of the people assessed for PTSD triggered indexes related to malingering.

The following review of the literature offers that the diagnosis of PTSD presents challenges for clinicians and patients. Currently, the diagnosing process is based on diagnostic interviews and self-report instruments that rely on patient disclosures and clinician observable symptoms (Jackson et al., 2011). The identification of biomarkers related to brain activity that can be detected through a qEEG analysis could present a more effective diagnostic process and tool.

Literature Search Strategy

The literature search strategy focused on the problem, things that need further understanding and then on potential solutions. This is an emerging area of psychology. Applying brain function and physiology to potential mental disorders needs to be developed as the research emerges. For these reasons, a comprehensive search strategy

that focuses on development of specific ideas was an important starting point for this paper.

The following electronic databases—a, b, c, d—were searched using the following key words: *quantitative electroencephalography (), brain waves, biomarkers, brain power, alpha waves, posttraumatic stress disorder, and PTSD*. I used a chronological focus for each portion of the literature review. The intent was to show the original research, where it has progressed to, and then additional areas of study, followed by the gaps I am addressing. One important question was to identify how qEEG been used in the past to help diagnose mental disorders.

The problem remains of finding an objective assessment process for veterans in regard to PTSD claims to the Veterans Benefits Administration (VBA), a division of the VA, social security, and other agencies struggling to properly support people. This part of the literature review focused on searches related to the number of veterans seeking compensation and the assessment methods used in the diagnosing process. Key words included in this part of the literature review included *PTSD assessment instruments, PTSD claims, diagnosing PTSD, secondary gain malingering*. The results were then narrowed down using search terms related to veterans by era, combat service, traumatic events, and VA assessment process. These results were then presented in a chronological manner. This was one way in which the research could be outlined in a way that reflects the manner in which the research has been conducted and hope it has evolved over time.

These searches revealed findings that need further understanding, such as how certain brain powers and speeds can be identified using technology such as qEEG. However, the interactions between different areas of the brain is still an area of research and understanding. An example could be used that an imbalance in a certain brain wave activity across the parietal lobes might also cause an imbalance in other areas of the brain. For this reason, it is important to include interactions across lobes of the brain and then also evaluate potential interactions between different lobes of the brain. Search terms regarding brain asymmetry, brain power, brain speed, and frontal/parietal lobe imbalance were used in support of this area of the literature review.

Potential solutions regarding objective assessment instruments were then searched as part of the literature search strategy. Other disorders, such as attention deficit hyperactivity disorder (ADHD) and depression, were used as part of the search terms for this area. Some of these areas have been extensively researched and can provide some valuable insights and support for this study. ADHD in particular has been an area that has been researched and analyzed for many years. The Food and Drug administration approved qEEG as a supportive tool that can be used in conjunction with traditional assessments in the diagnosis of ADHD (Rivers, 2013).

This comprehensive literature review reflects the current and past state of qEEG research. This research is then applied in a manner that supports the use of this technology in the diagnosis of mental health disorders. On the other hand, this information can also potentially support the absence of a suspected mental health disorder, such as PTSD.

Theoretical Foundation

The DSM-5 provides specific symptomology and behaviors that can be identified in order to diagnose disorders such as PTSD (APA, 2013). However, some of these symptoms and behaviors can also be associated with other disorders. Recognizing potential organic changes to a brain as an identifier and unbiased specifier is a benefit of the Carlson and Dalenberg (2000) framework. Additionally, this theoretical framework is one of the few that highlights interrelationships between brain function and trauma related brain modifications.

Addressing and identifying symptoms and linking them to organic changes to a person's brain produced by traumatic experiences is one alternative to traditional neuropsychological assessment. This framework supports the theory that PTSD causes psychological and organic changes in a person's brain. These changes can result in potentially disabling symptoms. These symptoms will, most likely, not be reduced and/or eliminated until they have been addressed through psychotherapy, psychopharmacological interventions, or both.

The manner in which veterans are maligned by the Department of Veterans Administration and the manipulation of the system by some veterans can be disheartening (Jackson et al, 2011). Research indicates that between 40 and 60% of veterans will be diagnosed with PTSD (Tsai et al., 2016). This represents a significant number of people being diagnosed using traditional assessment instruments. The presence of only one of the four potential biomarkers associated with PTSD could be an indicator of a single disorder such as major depressive disorder or a generalized anxiety

disorder. This type of detectable organic brain change could be the basis for a person being granted care, denied care and provided or declined compensation.

On the other hand, people could be exaggerating or presenting false symptoms as a way to manipulate the disability and determination system (Jackson et al, 2011). This type of malingering can be prevented through the use of an objective assessment instrument that can gather and analyze brain wave activity. More importantly, veterans and other people seeking care and/or compensation, would be able to use this objective system as a support for initial claims and future appeals. The authors highlight that approximately 9% of the greater population can be expected to develop PTSD after a traumatic event. This is far lower than the PTSD rates detected by the VA using traditional psychological assessment instruments. It is even lower than the number of people in the general population that typically develop PTSD following a traumatic experience. However, these numbers can be skewed based on the trauma and other factors. An example is survivors of rape and sexual assault. Mboqi-Mbalo, Zhang, and Ntuli (2017) found in a study analyzing statistics related to women and sexual assault found that 53% of the subjects reported symptoms associated with PTSD and depression.

Carlson and Dalenberg (2000) provide the theoretical foundation for this dissertation. The authors have developed this theory based on previous research supporting the effects of traumatic experiences on a person. Factors related to a trauma can result in cognitive, affective, behavioral, and physiological changes in a person. Additional factors, such as stage of development and biological effects can exacerbate

the impact of the trauma on the person brain form and function. In other words, traumatic events can result in observable changes to a person's brain.

A qEEG can detect these types of changes to the brain and produce identifiable biomarkers. Carlson and Dalenberg (2000) further explain that these identifiable changes can potentially be the source of (or the effects of) depression, aggression, and behavioral changes, just to name a few. The area of the brain affected can possibly indicate the level of dysfunction related to PTSD and other trauma related disorders. For instance, depression can be identified by qEEG through the detection of an imbalance (asymmetry) between the brain wave activity in the right and left frontal lobes of the brain. This asymmetry would be a potential biomarker that could be detected and combined with other biomarkers to diagnose PTSD based on an observable change to a person's brain function.

The traumatic framework identified by Carlson and Dalenberg (2000) is based on a fight or flight or freeze limbic system response. The model recognizes that these responses can then be reignited (triggered) at a later time in which a similar threat is encountered by the victim. The rush of adrenaline, dopamine, and other chemicals in the body through activation of the sympathetic nervous system is one potential source of organic changes in the brain. The persistent nature of the symptoms points toward a change of state within the brain and body of a traumatized person. The authors use the example of a person that disassociates during a traumatic event as an indicator of a change to the basic function of the persons brain. When triggered by a later situation that is similar to the trauma, the person has an almost identical reaction.

People undergo potential traumas throughout a lifetime of development. Kira, Lewandowski, Chiodo, and Ibrahim (2014) offer a theoretical framework that supports traumatic experiences and the impact on a developing brain as outlined by Carlson and Dalenberg (2000). This effect can produce symptoms potentially associated with changes in specific areas of the brain. These changes might be the source of identifiable symptomology and behaviors as a person progressed through the stages of development. An example might be a child who experiences a traumatic event that results in hypervigilance. This hypervigilance could be viewed on a brain scan and become a biomarker for PTSD. The Kira et al. (2014) framework supports the portion of the study in regard to development and traumatic events.

A Review of the Literature

Combat stress related disorders are among the most consistent and documented psychiatric conditions throughout history (Ustinova & Cardeña, 2014). The ancient Greeks would notice changes in warriors they sent off to defend their country and invade others. However, the physicians from ancient Greek times typically would document the changes but would not treat the potential disorders that they could not explain.

Ustinova and Cardeña (2014) explained that three factors should be present in order for a brain to be considered traumatized. The first is a biological predisposition related to susceptibility of a person to have a linger trauma response. The second is coping strategies that can build resiliency as a potentially prophylactic effect to protect a person from trauma. The third is a social support system that can help ease a

traumatized person. The area of interest from Ustinova and Cardeña (2014) is the potential genetic predisposition of a person to be vulnerable to lingering emotional responses after a traumatic event. The lingering organic changes to a person's brain might not have been detectable in history. However, modern technologies have progressed to the point in which brain form and function can be evaluated through the use of objective brain assessment instruments such as a qEEG. Subjective instruments, while well supported for validity and reliability, still have affects that can be misread or manipulated by a patient or assessor. A process that is based on objective instruments can help minimize or eliminate subjective factors associated with the current PTSD evaluation process.

Self-report assessment instruments are the most common method of diagnosing PTSD. However, these types of instruments, while well-supported, can be influenced by the person being assessed and potential biases of the assessor. Tsai, Pietrzak, Hoff, and Harpaz-Rotem (2016) highlighted the importance of developing a way to diagnose PTSD outside of the current self-report instruments. Tsai et al., (2016) found that differences in the criteria of a self-report instrument resulted in a greater than 20% difference in the number of people diagnosed with PTSD. For instance, veterans assessed using one criterion resulted in 40% of the population being diagnosed with PTSD. However, using the clinician documented criteria resulted in 62-84.5% of the population screening positive for PTSD.

The Tsai et al. (2016) numbers show a drastic increase over the 9% rate of PTSD occurrence in the general (non-military) population, as indicated by Carlson and

Dalenberg (2000). One possible reason for the increase cited by Tsai et al. (2016) is that VA clinicians were aware of the assessment results and still relied on clinical skills to reach a diagnosis. QEEG biomarkers related to PTSD could be utilized to support or rule-out a PTSD diagnosis. Overall, the data from this study was applied to the veteran population. However, there is potential for further research to open it up to all people that have experienced PTSD symptoms.

A process to diagnose PTSD that cannot be controlled or affected by the assessor or patient would help increase reliability and validity of the PTSD screening process. Falconer et al. (2008) focuses on autonomic functions in the brain that are affected by PTSD. This study indicated that left cortical responses in people with PTSD were detectible biomarkers. This potential activation imbalance could help provide data that can be analyzed and evaluated outside of typical self-report instruments used for current diagnosing. The finding of increased left cortical activity and decreased right cortical activity might be a potential biomarker of PTSD.

Further imbalances in brain wave asymmetry between the left and right sides of the brain are also of interest. Depression and anxiety are two disorders that commonly occur with PTSD. Metzger et al. (2004) found that unique brain patterns could be used to identify depression and anxiety. Specifically, the Metzger et al. (2004) study indicated that Vietnam era female nurses had changes in right side frontal and parietal asymmetry when being assessed for PTSD symptomology. This study is potentially a foundational document in the exploration of brain function and the use of biomarkers in relationship to potential mental disorders.

The Metzger et al. (2004) study identified a potential gap for future study related to PTSD through analysis of increased/decreased parietal activity on the right side of a person's brain. These findings support potential partial imbalances as one potential biomarker for PTSD. However, as with frontal cortical imbalances, this biomarker should not be considered as a single diagnostic indicator for PTSD. The proximity of the right parietal increase to the temporal lobe makes these findings interesting and potentially significant. Potential bleed over between the right parietal and the right temporal lobe imbalances with the left side of the brain are not common and could be detectable biomarkers of PTSD.

Relationships associated with asymmetry across multiple lobes when measured right to left versus individual lobes has shown that biomarkers might serve as differentiators of potential mental disorders. The Metzger et al. (2004) study indicated that frontal, temporal, and parietal activity can be evaluated through qEEG. This evaluation was used in an attempt to detect brain power and asymmetries across lobes. However, the research did not evaluate whether or not activity in one lobe might be affecting the asymmetries across additional lobes of the brain. For instance, the researchers did not find significant asymmetries across the frontal lobes of the subjects. This could be an indicator that the PTSD symptoms did not result in an imbalance between the right and left frontal lobe. However, there were detectable imbalances in brain power between the left and right parietal lobes of the subject's brain.

The Metzger et al. (2004) study is significant because it reinforced and explored the relationship between depression and PTSD. Most notable is that major depressive

disorder alone has a distinct pattern, and depression co-occurring with PTSD has a different pattern all together. These patterns are potential indicators that can be used as biomarkers in the confirmation or rule-out of a PTSD diagnosis. Alternatively, these biomarkers could be used to confirm or rule out an independent major depressive disorder, anxiety disorder, and other mental disorders as identified in the DSM-5. This study is one of the foundational documents indicating that mental disorders can potentially be identified through the assessment and evaluation of brain activity. It is also one of the first studies that allows for precise differentiation between similar, comorbid, and cooccurring disorders. It also highlights that an independent disorder can have an impact on the way brain function is changed as a result of an activation (triggering) traumatic incident.

Further support for the use of brain wave biomarkers is found in the areas related to limbic system activity. Anxiety is a common co-occurring disorder with PTSD. Identifying biomarkers in the brain based on potential asymmetries between the right and left side of the brain has been identified in past studies. Harper, Rasolkhani-Kalhorn, and Drozd (2009) provided an exploration of trauma and the changes in the limbic system as related to hypervigilance and anxiety. The symptoms and brain effects can potentially be applied to the diagnosing of anxiety. The amygdala is the part of a person's autonomic nervous system that triggers the fight, flight, or freeze response. The fight or flight response can present in a similar manner to the symptoms associated with PTSD. While the article focuses on eye movement desensitization and reprocessing

(EMDR), the same findings might be used as a way to identify PTSD and anxiety biomarkers based on limbic system responses and reactions.

A PTSD indicator would be the combination of changes in brain power visible in frontal and parietal lobes of the brain. Both changes would be considered abnormal activity in the brain. The potential indicators would be an increase on one side of the frontal cortex in alpha power (Lobo et al., 2015, Kemp et al, 2010). The authors further explain that increases in alpha power in this part of the brain have previously been associated with depression. Depression is a common disorder associated with PTSD (Kemp et al, 2010). The second part, identified by the authors, would be a significant increase in alpha power behind the person's right ear. This area is commonly referred to as the T6 location on the brain. The T5 Area of a person's brain is located behind the left ear. This is the area that would be the focus for comparison of brain wave activity across and between lobes of the brain.

The Kemp et al, (2010) study is interesting because it is one of the first that focuses on hyper and hypo brain activity in relationship to depression and anxiety. The researchers hypothesized that anxiety could present with hyperactivity in the right parietal lobe and that depression might result in hypo activity in this region. Both of these results could be key indicators of an identifiable biomarker that could be used to confirm or dismiss a potential PTSD with anxious and/or depressive features. Overall, another potential brain wave activity and power biomarker that could be a clue to the potential organic changes that might occur in a traumatized brain. Another significant finding in this study is that the alpha brain wave activity in PTSD patients showed a

global increase across the frontal, parietal, and temporal lobes. This finding was not further explored in this study. However, it is another potential clue and area for further study by follow-on researchers.

Alpha waves in particular are a point of key interest when associated with depression and PTSD (Kemp et al., 2010). As explained earlier, alpha wave asymmetry is a potential key biomarker for many disorders. The Kemp et al. (2010) study explores a potential relationship between PTSD and alpha asymmetries in the frontal and parietal lobes. It is important to note that the alpha wave activity may be within the expected range but still be imbalanced across the frontal and/or parietal lobes of the brain. This study focuses on these potential imbalances between the left and right sides of a subject's brain, in the frontal and parietal lobes in particular. However, as with other studies, possible associations across brain lobes on the same side of the brain is an area of little research. For instance, is an imbalance from the left to the right side of the parietal lobe consistent with an imbalance in the frontal lobe? Hopefully, this dissertation will help answer this question.

The findings of the Kemp et al. (2010) study indicate that imbalances existed in the study subjects. In this study, the brain waves of 44 patients with MDD, PTSD, and or a combination of the two disorders were compared to healthy/normal subjects. The study revealed imbalances across the frontal lobe in the subjects with MDD and PTSD. However, a different pattern was present when the subject had MDD alone or PTSD alone. The PTSD subjects presented a localized right frontal imbalance in brain wave activity. However, the subjects with MDD appeared to have imbalances localized in the

left frontal lobe. These findings might be significant when attempting to determine and differentiate between related and unrelated trauma disorders. This differentiation could then result in biomarkers that are readily apparent when evaluated with a standard qEEG assessment of a person's brain wave activity. In this case, alpha brain wave power imbalances across the frontal and parietal lobes are the significant areas revealed in this study.

Preliminary research has been conducted regarding the presence of potential biomarkers as indicators of PTSD. Bandelow et al. (2016) identifies frontal lobe asymmetry as a potential biomarker for PTSD. However, this imbalance in alpha band power can also be indicators of other disorders. Depression is one disorder that also can also be identifed through the identification of increases in frontal alpha band activity on the left side and decreased activitiy on the right side. However, further research is need in order to determine if one area of the brain might be influencing the asymetries in other parts of the brain. The Bandelow et al. (2016) paper identifies potential independent biomarkers. However, identifying potential relationships between different lobes of the brain might help better understand the brain functioning process as related to PTSD.

Comparison of left and right brain power activity has been an area of focus. However, identification of imbalances as potential biomarkers does not take in to account possible interactions between different and separate lobes of the brain. For instance, a paper published by Gordon, Palmer, and Cooper (2010) indicates that alpha band asymmetry was not present in all of the subjects assessed through qEEG. However,

the number of subjects presenting with this potential biomarker is significant and warrants further exploration. This finding supports the need for a second potential biomarker to support fontal alpha band imbalance as a possible indicator of PTSD or for a PTSD related depression. Additionally, potential interactions between lobes of the brain and not just across the same lobes is an area also needing further study.

Quantitative electroencephalography (qEEG) provides a way to gather and analyze brain functioning and activity. Jokić-Begić and Begić (2003) conducted and presented the groundbreaking research related to qEEG and diagnosing mental disorders. As an example, qEEG can detect increases and decreases in brain wave activity such as beta and alpha waves. This ability potentially leads to the identification of areas in the brain that might not be functioning as found in neurotypical brains. These areas of abnormal activity can then be identified as biomarkers for mental health disorders such as PTSD. The Jokić-Begić and Begić (2003) study focused primarily on combat veterans with PTSD. However, these findings might also be extrapolated across all populations of people with a potential traumatic disorder.

Identification of potential biomarkers is one solution for the accurate diagnosis of PTSD and other mental disorders. Todder et al. (2012) conducted research supporting the identification of biomarkers in specific areas of the brain. These biomarkers can then potentially be used to support an evidenced based diagnosis of PTSD using qEEG. The sample size (N = 20) is low but still provides an initial study into the potential functionality of biomarkers. A typical qEEG uses a process in which the subject performs the assessment that includes 10 minutes with eyes open, 10 minutes with eyes

closed, and 6 minutes of hyperventilation. However, in this study, the participants only spent 3 minutes with their eyes open for the qEEG assessment. This limitation is significant when the results might be compared to the larger population. Each phase of the qEEG is designed to gather and analyze different states of a person as they relate to brain activity.

Identification of potential biomarkers is not the only potential benefit. Using the qEEG to guide treatment could be a logical next step. Wahbeh and Oken (2013) provides the efficacy of qEEG directed biofeedback/neurofeedback treatments for PTSD. In other contexts, the results of this research allow for constant monitoring of PTSD symptoms while the person is training. Typically, qEEG's are conducted every 9 – 15 months as a way to monitor progress. With this process, the biomarkers are highlighted and addressed as training progresses. Furthermore, Wahbeh and Oken (2013) identify some biomarkers related to heartrate and respirations that could be used in combination with future research.

Additional biomarkers can further improve the ability for a practitioner to provide a solid diagnosis. A Jaworska et al. (2012) study provided a focus on alpha and beta waves provides consistency with previous studies and solidifies the foundations for future research. Power asymmetry, based on absolute frontal and parietal alpha, might be a finding that could provide another PTSD biomarker. Anger and hypervigilance are both symptoms listed in the DSM-5 for PTSD (APA, 2013).

Conclusion

The utilization of objective, evidenced-based diagnostic tools can help properly diagnose, treat, and support people suffering from trauma related mental disorders such as PTSD. Further research needs to continue as the world struggles with war, terrorism, and other violent acts that people inflict on others. The literature reviewed in Chapter 2 provides the foundational evidence and highlights the need for an objective assessment instrument for PTSD.

Chapter 3: Research Method

Introduction

The purpose of this study was to identify potential brain function biomarkers that can be used to assist in the detection or absence of PTSD-related symptoms and behaviors. This study was based on the theoretical framework and foundation of Carlson and Dalenberg (2000), who developed their theory on previous trauma-related research on the effects of traumatic events on people. The framework was based on the understanding that factors related to a trauma can result in cognitive, affective, behavioral, and physiological changes in a person. Traumatic events can result in observable changes to a person's brain. The IRB approval number for this study is 05-14-19-0491142

The study used a database of brain scans that were analyzed using current diagnosis criteria in the *DSM-5*. The goal was to detect imbalances in alpha brainwave activity in two separate lobes of the brain. These lobes were identified in previous research, which included? the distance from each other in the brain. Previous research focused on imbalances on the left and right side of each brain lobe. This study focused on the frontal and parietal lobes of a person's brain.

Research Design and Approach

A quantitative archival research design was used to analyze data from qEEG scans and from a patient diagnosis of PTSD as a way to identify potential correlations between asymmetric brain wave activity in the frontal and parietal lobes of a subject's brain. Quantitative research methods were selected based on the data analysis strengths

associated with the ability to use quantifiable questions of an instrument-based database as a way to identify potential relationships between and across the designated variables (Creswell, 2009). The archival research design was selected based on the availability of data in an existing database as well as access to normative databases. These archives of patient information formed the basis of this study. Previous studies indicated that poor brain wave asymmetry across the frontal lobes could indicate depression and/or anxiety.

However, studies on the additional effects of brain wave activity across other brain lobes or between brain lobes had not been conducted to the same level. Binary logistic regression was used to analyze potential relationships between the existence of diagnosed PTSD and each variable—symmetry and asymmetry of brainwaves—independently and as a group (Creswell, 2009). Binary logistic regression also provided additional information about the potential interactions between each of the variables and across all factors. This is a potential finding when considering that the excess alpha in the prefrontal cortex might be a cause of excess alpha asymmetry in the parietal lobes, or vice versa.

An existing qEEG database and research conducted on patient clinical records were the two sources of data for this study. The patient files included a confirmed diagnosis of PTSD or a disorder other than PTSD. The following variables were identified for use in this study: the dichotomous dependent variable was PTSD (yes or no); the dichotomous independent variable of excess alpha across the frontal lobes (yes

or no), and another dichotomous independent variable of excess alpha across the parietal lobes (yes or no) were analyzed using binary logistic regression.

Setting and Sample

Population

The population for this study consisted of all clients and patients agreeing to participate in a qEEG brain function analysis and neuropsychological screening as part of their assessment process for mental health therapy at a large private medical practice on the west coast of the United States. There are over 400 clients and patients previously or currently being assessed at this facility. The practice provides a full range of mental health assessments and therapy to people aged 4–90.

Participants

Participants for this study were selected using a two-stage cluster sampling procedure. The first stage is that all records of patients who agreed to participate in the analysis and screening of study were extracted and divided into two groups. The first group consists of all patients diagnosed with PTSD. The second group consists of clients and patients that are not diagnosed with PTSD, or other mental health disorders.

The second stage of the sampling procedure is a random selection of the clients and patients in each group. A random selection of 108 clients and patients, 54 having a diagnosis of PTSD and 54 without, were selected for inclusion into the study. The inclusion criterion was:

1. Clients and patients between the ages of 18 and 90 years.

The exclusion criteria were:

1. A diagnosis of mental health disorder other than PTSD.
2. PTSD clients and patients having co-occurring mental health diagnoses. This includes subjects with two or more mental health diagnosis or substance abuse disorder.

Records were analyzed in a way that maintain participant anonymity. The data extracted did not contain identifying information. Each participant was given a random identification number, which was assigned by the institution. The list linking the patient with the identification number remained in a locked file with the business manager. In case of any issues with the extracted data, the researcher consulted with the business manager and the business manager would assign someone at the institution to investigate the issue. The result(s) were provided to the researcher maintaining the anonymity of the study participant.

The study was anonymous; therefore, the name and any identifying information of the client/patient was unknown to the researcher and the findings were reported only in the aggregate. Each participant had a random number assigned in order to mask the identity of the person.

Variables, Measurements, and Instruments

Two independent and one dependent variable were used for this proposed study. This section describes each independent variable and dependent variable. Specifically, it describes how each variable as defined and how they were measured.

Demographic Variables

The following demographic variables were extracted from the records of the participants. These variables were used to summarize, describe, and compare the samples. In addition, the demographic variables were used to compare the group diagnosed with PTSD with the group that does not have an existing diagnosis of PTSD. The following variables were extracted from the participant's records:

1. Age
2. Gender
3. Other non-mental health illnesses
4. Reason for the qEEG

Independent Variables

The independent variables in this study was the comparison of alpha brain waves between the left and right frontal lobes and between the left and right parietal lobes to determine if the speed of alpha brainwaves is synchronous or asynchronous.

Alpha wave activity was assessed through an evaluation of the qEEG in participant records. The Neuroguide Normative Database was used to evaluate participant's qEEG record into cycles per second for the alpha waves in both hemispheres of the frontal and parietal lobes. The neuroguide program produces a table that presents the amplitude and cycles per second of brain wave activity in specific locations on a person's brain. The numbers were arranged in a left and right manner and symmetry and asymmetry were easily observable, based on the numbers in the table. For this study, alpha wave cycles per second were used. This table was copied into

Excel. The speed of the right frontal lobe (F3) was compared to the speed of the left frontal lobe (F4). This difference was calculated in Excel subtracting the F3 from F4. If the absolute value of the difference between F3 and F4 was within 1 cycle per second, the frontal lobes were considered synchronous. If the difference between F3 and F4 greater than 1 cycle per second, the frontal lobes were considered asynchronous.

Similarly, the parietal lobes were evaluated for synchronous and asynchronous alpha waves. Using the neuroguide normative database, the speed of the right parietal lobe (P3) was compare to the left parietal lobe (P4).

The following are the independent variables

1. Synchronous frontal lobe: yes/no
2. Synchronous parietal lobe: yes/no

Dependent Variable

The dependent variable was the diagnosis of PTSD, which is measured as yes or no. A diagnosis of PTSD was assessed using the *DSM-5* criteria. A person meeting or exceeding the symptoms and behaviors defined by the *DSM-5* criteria for PTSD diagnosis was considered having PTSD. All persons not meeting the PTSD criteria defined by *DSM-5* was considered a "no" in the study. The subject that does not meet criteria could have a different mental health diagnosis or no diagnosis as identified by ICD-10 identifiers.

The patient was evaluated using the PTSD Diagnosis Scale. This is a 30-item structured interview based on *DSM-5* criteria. Thatcher, Biver, North, Curtin, and

Walker (2003) provided the following description of the neuroguide normative database:

> The Neuroguide normative database in versions 1.0 to 2 4 6 included a total of 625 carefully screened individual subjects ranging m age from 2 months to S2 years. NO 2.5.1 (6 12 200S) involved the addition of 53 adult subjects ranging in age from 18 3 years to 72 6 years resulting in a normative database of 678 subjects. The inclusion exclusion criteria, demographics, neuropsychological tests, Gaussian distribution tests and cross validation tests are described in several peer reviewed publications (Thatcher et al, 1953; 1987, 2003). Two year means were computed using a sliding average with 6 month overlap of subjects This produced a stable and higher age resolution normative database with a total of 21 different age groups. The individuals used to create the normative database met specific clinical standards of no history of neurological disorders, no history of behavioral disorders, performed at grade level in school, etc. Most of the subjects in the normative database were given extensive neuropsychological tests. (p. 7)

The PTSD Diagnosis Scale has demonstrated high internal consistency (alpha = .95) and test-retest reliability (r = .90). In addition, it showed good divergent validity with the Beck Depression Score (Foa, 2016).

Power Analysis

A power analysis was conducted to determine the sample size that would be needed to test each null hypothesis with a power of 0.80, with alpha set at 0.05 and a

medium effect size of 0.30. The power analysis was conducted using the the G*Power 3.1 online calculator. A total sample size of 108 participants is needed to test each of the null hypotheses.

Design

To examine the relationship between PTSD and alpha waves, a non-equivalent control group design was used (Cook & Campbell, 1968). In this design, participants were grouped according to their diagnosis of PTSD. Thus, random assignment to group did not occur.

In the non-equivalent control group design clients in Group A had an existing diagnosis of PTSD. The second group, Group B is the control group and did not have a diagnosis of PTSD. Clients in both groups were evaluated using the qEEG. The results of the qEEG were used to evaluate the correlation between PTSD and alpha bran wave activity.

Procedure

A total sample of 108 randomly selected records were identified at the private practice to be extracted and used in this study, 54 diagnosed with PTSD and 54 not diagnosed with PTSD. Because there has been no evidence to support brain waves difference based on demographic variables, a random sample was selected. Computer generated random number assignment were used to select patient records. The following information was extracted from the patient's record: gender, age, qEEG, PTSD diagnosis and other non-mental health illnesses and reason for qEEG. The qEEG was

further evaluated using the Neuroguide Normative Database to assess synchronous and asynchronous alpha activity in the parietal and frontal lobes.

Data Analysis Plan

Descriptive statistics were assessed for the demographic, independent, and dependent variables. Categorical variables were summarized using frequencies and percent. Continuous variables were summarized using means and standard deviations. To assess comparability of groups, the demographic variables, reasons for qEEG and other non-mental health illnesses were compared. A chi-square was used to assess group differences for categorical data. T-test was used to assess group differences for continuous variables.

The dependent variable was diagnosis of PTSD (yes or no). The independent variable was frequency and/or power symmetry (yes or no) across frontal lobe. A logistic regression was used to test whether PTSD can be predicted from knowing extent of symmetry across the frontal lobe. From the logistic regression, an odds ratio was estimated. To examine the model fit, Hosmer and Lemeshow test was used. A p-value greater than 0.05 indicates the data fit the model. To assess the relationship between PTSD and frontal lobe symmetry, the variance accounted for were used. In addition, the overall accuracy of predictions was examined.

To assess the contribution of detectable frequency and/or power symmetry of alpha waves in the parietal lobe, a logistic regression was used to predict PTSD from the extent of symmetry of the alpha brain activity across the parietal lobes (yes or no). From the logistic regression an odds ratio was estimated. To examine the model fit, Hosmer

and Lemeshow test was used. A p-value greater 0.05 than indicates the data fit the model and the model is reliably significant. To assess the relationship between PTSD and parietal lobe symmetry, the variance accounted for was used. In addition, the overall accuracy of predictions was examined. SPSS version 22 was used to conduct the analysis.

Ethical Considerations

All data for this study is archival data collected as part of the typical assessment process at this private practice. Information was masked and all identifying information was removed prior to placement in the study data collection sheets. Data will only be kept on a computer system with two levels of password protection. Access to study related information and files was restricted to the practice site director, dissertation committee, and the researcher. All files related to this study were maintained in a secure archive in accordance with current APA guidelines after study completion and then destroyed. The site director has approved the process of masking the data and use in this dissertation.

Threats to Validity

The primary instrument for this study is the qEEG brain function scan. It has been shown to be both reliable and valid for purposes of data collection (brain wave patterns) and preparation for analysis. The instruments used to diagnose PTSD have been used for many years with well-established validity and reliability. Each screening tool and neuropsychological instrument has been applied and evaluated by a licensed practitioner with diagnosing as part of their scope of practice. For this reason, the

historical information regarding validity and reliability of standard screening tools and neuropsychological instruments is not explored in this study. However, the external and internal validity associated with qEEG were presented.

Threats to External Validity

Generalization is significant in that the results should be applicable to the larger population. In other words, the larger the population would better represent the population in general. However, this study is limited to the qEEGs from one practice that meet the inclusion criteria.

In addition, there is a potential interaction between the reason a person is referred to get a qEEG and diagnosis of PTSD. Some clients may have PTSD and are not diagnosed with PTSD. Many people pick this practice because a qEEG may help identify specific mental health disorders. Mental and emotional trauma is a specialty at this clinic and could have a disproportionate number of clients from this population.

Threats to Internal Validity

Thatcher (2010) indicates that the strengths of the quantitative aspect of an EEG differentiates the qEEG and a typical EEG. High levels of test-retest and split half results make quantitative evaluation stronger than traditional EEG readings. A qEEG shows strong content validity and has correlations to other traditional assessment instruments such as MRI, SPECT, and neuropsychological testing (Thatcher, 2010).

Internal validity will potentially be stronger as the database of qEEG brain scan grows. The current database exceeds the G*Power estimate and should be significantly larger by the time the data is available for analysis. Currently, the available database

contains qEEG results from clients assessed as part of the normal clinical intake and reassessment process. Threats to validity of the database could include improper placement of leads and poor coherence related to the connection between client and the equipment. This threat has been countered by each of these items being inspected by at least one other trained observer prior to starting a qEEG brain wave assessment.

Summary

Chapter 3 presents the methodology used to evaluate the study research questions and understand the variables as identified in Chapter 1. The literature review emphasized the importance of a strong evidence base when evaluating the potential presence of abnormal brain wave activity. The intention to use binary logistics regression should allow for an increased understanding of Alpha wave activity within specific lobes of the brain and then between lobes of the brain. Focus of the study is primarily on the frontal and parietal lobe brain wave activity.

Chapter 4: Results

The intent of the study was to determine if certain brain wave imbalances represent and match the symptomology experienced by people with PTSD. The ability to extrapolate this information from the front to the back of the brain could increase the strength of a biomarker. This would differentiate qEEG from traditional neuropsychological assessment in that a reading of brain scan could potentially replace subjective assessment processes.

This chapter focuses on the analysis of, and results from, the data on brainwave asymmetry in the frontal and parietal lobes in diagnosing PTSD. It consists of six sections. The first section summarizes the procedures used to analyze the data. The second section summarizes the procedure used to classify a patient as having PTSD or not. The third describes the sample that was used in the analysis. The fourth examines Research Question 1, which considers the impact of frontal lobe asymmetry on PTSD. The fifth examines Research Question 2, which assesses the impact of parietal lobe asymmetry on PTSD. The sixth section summarizes the diagnostic screening utility of using asymmetrical brainwaves to detect PTSD.

Summary of Procedures

The individuals used in this study were clients of a private practice who had been referred to the practice for a qEEG procedure; 108 individuals were included in the sample. Each client in the study had a been evaluated for PTSD using the criteria in the *DSM-5*. In addition, the qEEG had been evaluated for brainwave asymmetry of the frontal lobe and parietal lobes. Additional information extracted from the client files

included gender, age and PTSD diagnosis (yes or no). To assess the use of the frontal lobe asymmetry, a logistic regression was conducted in detecting PTSD. To assess the use of the parietal lobe asymmetry, an initial logistic regression was conducted to detect PTSD.

Summary of PTSD Diagnosis

The clients in this study were classified as having PTSD or not having PTSD through an assessment using the *DSM-5* criteria. A person meeting or exceeding the symptoms and behaviors defined by the *DSM-5* criteria for a PTSD diagnosis was considered to have PTSD. All persons not meeting the PTSD criteria defined by *DSM-5* was considered a no in the study. Any subject who did not meet criteria could have a different mental health diagnosis or no diagnosis, as identified by ICD-10 identifiers.

Sample

A total of 108 clients from a private practice were included in this study (see Table 1). Half of the clients had a diagnosis of PTSD using the criteria in the *DSM-5*; the other half were not diagnosed with PTSD. Approximately 53% of the clients identified as female. In the sample, there was one person who was born male and identified as female, and one person who was born female and identified as male. Approximately 42% of the clients were between the ages of 31 and 50 years old; 39.8% were less than 30 years old and approximately 18% were older than 50 years old.

With respect to asymmetry, approximately 52% had frontal lobe brainwave asymmetry and 59% had parietal lobe brainwave asymmetry. In addition, 57% had a non-PTSD diagnosis (other mental health, nonPTSD-related, diagnoses).

Table 1

Sample Demographics

	n (%)
Total	108 (100%)
PTSD diagnosis	
No	54 (50)
Yes	54 (50)
Gender identity	
Female	57 (52.8)
Male	51 (47.2)
Frontal lobe asymmetry	56 (51.9)
Parietal lobe asymmetry	64 (59.3)
Non-PTSD diagnosis	63 (57.4)
Age (in years)	
<30	43 (39.8)
31 to 50	45 (41.7)
51+	20 (18.5)

The Impact of Frontal Lobe Asymmetry on PTSD

Research Question 1: Does a sample of tested adults diagnosed with PTSD have detectible alpha brain wave asymmetries across the frontal lobe?

1. *H0*: There is no relationship between detectable alpha brain wave asymmetries across the frontal lobe and PTSD.
2. *H1*: There is a relationship between detectable alpha brain wave asymmetries across the frontal lobe and PTSD.

Table 4.2 provides the regression coefficients derived from the logistic regression used to assess the impact of frontal lobe asymmetry in correctly identifying patients with

PTSD. The regression coefficient for frontal lobe asymmetry is -1.60 with a standard error of 0.40. Indicating a negative association between frontal lobe asymmetry and PTSD. In this univariate model, the model was significant (chi-square=7.35, df=1, p=0.007). However, the logistic regression model did not fit the data, thus the results of p<0.0001 were not reliable (Hosmer & Lemeshow). From the logistic regression model, 63% of the clients diagnosed with PTSD were correctly identified and between 7% and 8% of the variance in PTSD was accounted for by frontal lobe asymmetry (see table 4.3). There is not enough data to reject the null hypothesis.

Table 2

Logistic regression model: frontal lobe

Variable	β (s.e.)	χ^2	p-value	Cox & Snell R^2	Nagelkerke R^2
Overall Model		7.35	.007	6.6%	8.8%
Frontal lobe asymmetry	-1.60 (.40)				
Constant	.55 (.29)				

Table 3

Correct identification of PTSD: frontal lobe logistic regression

		Predicted Classification of PTSD		Percent Correct
True Classification		No	Yes	
PTSD	No	35	19	64.8%
	Yes	21	33	61.1%
Overall Percentage				63%

The Impact of Parietal Lobe Asymmetry on PTSD

Research Question 2: Does a sample of tested adults diagnosed with PTSD have detectible alpha brain wave asymmetries across the parietal lobe?

1. *H0*: There is no relationship between detectable alpha brain wave asymmetries across the parietal lobe and PTSD.
2. *H1*: There is a relationship between detectable alpha brain wave asymmetries across the parietal lobe and PTSD.

Table 4.4 provides the regression coefficients derived from the logistic regression used to assess the impact of parietal lobe asymmetry in correctly identifying patients with PTSD. The regression coefficient for parietal lobe asymmetry is 0.78 with a standard error of 0.40. Indicating a positive association between parietal lobe asymmetry and PTSD. In this model, the model was significant (chi-square=3.86, df=1, p=0.05). However, model did not fit the data (Hosmer & Lemeshow p<0.0001). Fifty-

nine percent of the clients diagnosed with PTSD were correctly identified and between 3.5% and 4.9% of the variance in PTSD was accounted for by parietal lobe asymmetry (see table 4.5). The percent of non-PTSD diagnosed clients were correctly identified was 50%, suggesting a poor performance of the model correctly classifying PTSD.

Table 4

Logistic regression model: parietal lobe

Variable	β (s.e.)	χ^2	p-value	Cox & Snell R^2	Nagelkerke R^2
Overall Model		3.86	.05	3.5%	4.9%
Parietal lobe asymmetry	.78 (.40)				
Constant	-.46 (.31)				

Table 5

Correct identification of PTSD: parietal lobe

		Predicted Classification of PTSD		Percent Correct
True Classification		No	Yes	
PTSD	No	27	27	50%
	Yes	17	37	68.6%
Overall Percentage				59.3%

Summary: Evaluation of Diagnostic Tests

Brain wave analysis, as a potential diagnostic test, might be a way to help determine the appropriateness of qEEG results of frontal lobe and parietal lobe brain waves to diagnose PTSD. In day-to-day clinical practice, it would potentially be more efficient to be able to rule out PTSD or rule in PTSD using an objective measure as opposed to the gold standard of administering the criteria of the *DSM-5*. Table 4.6 presents the comparison of the sensitivity, specificity, predicted values and the likelihood ratio.

Table 6

Diagnostic Summary Comparison

	Model 1 Parietal lobe	Model 2 Frontal lobe
Sensitivity	68.50%	61.10%
Specificity	50%	64.80%
PV+	57.80%	63.50%
PV-	61.40%	62.50%
LR+	1.37	1.73
LR-	0.63	0.6

Examining the model with the independent variable parietal lobe, the presence of asymmetry in the parietal lobe is inappropriate. As seen in Table 4.6, both the sensitivity and specificity are low (68.5% and 50%, respectively). A sensitivity of 68.5% indicates that approximately 31.5% of the sample was classified as a false positive. A specificity of 50% indicates that approximately half of the sample was

misclassified as a false negative. High value of sensitivity and specificity suggest this model is not appropriate to correctly classify PTSD. Confirming the information sensitivity and specificity provide, the positive likelihood ratio (LR+) is 1.37 indicating a small power to rule in PTSD. The negative likelihood ratio (LR-) .6 indicates a small power to rule out PTSD.

Similarly, the second model with the frontal lobe as the independent variable does not correctly classify PTSD clients. A sensitivity of 61% and specificity of 64.8% suggests a high proportion of false positives and false negatives, respectively. Confirming the information sensitivity and specificity provide, the positive likelihood ratio (LR+) is 1.73 indicating a small ability to rule in PTSD. The negative likelihood ratio (LR-) .6 indicates a small ability to rule out PTSD.

Chapter 5: Conclusions and Recommendations

The purpose of the study was to determine if certain brain wave imbalances represent and match the symptomology experienced by people with PTSD. This chapter presents the conclusions and recommendations of this study. It consists of four sections. The first section summarizes the results of the study. The second section identifies the conclusions drawn from the study. The third section discusses the limitations of the study, and the last section suggests future directions.

Summary of the Results

Research Question 1: Does a sample of tested adults diagnosed with PTSD have detectable alpha brain wave asymmetries across the frontal lobe?

1. *H0*: There is no relationship between detectable alpha brain wave asymmetries across the frontal lobe and PTSD.
2. *H1*: There is a relationship between detectable alpha brain wave asymmetries across the frontal lobe and PTSD.

The results of the logistic regression suggest:

a. There is no relationship between frontal lobe asymmetry and PTSD.
b. Frontal lobe asymmetry does not classify PTSD well. Frontal lobe asymmetry should not be used alone to diagnose PTSD.

Research Question 2: Does a sample of adults diagnosed with PTSD have detectible detectable alpha brain wave asymmetries across the parietal lobes?

1. *H0*: There is no relationship between detectable alpha brain wave asymmetries across the parietal lobe and PTSD.

2. *H1*: There is a relationship between detectable alpha brain wave asymmetries across the parietal lobe and PTSD.

The results of the logistic regression suggest:

a. There is no relationship between parietal lobe asymmetry and PTSD.
b. Parietal lobe asymmetry does not classify PTSD, it provides an unreliable classification of PTSD. Parietal lobe asymmetry should not be used alone to diagnose PTSD.

Discussion

PTSD is a topic of particular relevance, not only for military personnel and veterans, but also police officers, firefighters, emergency medical technicians, and other first responders who are among those exposed to traumatic events in the course of their duties. Typically, PTSD is diagnosed using the criteria in the *DSM-5,* using self-report measures. Instruments based on *DSM-5* have been assessed as reliable and valid in diagnosing PTSD. However, a by-product of self-administered inventories is that PTSD symptoms can be coached and rehearsed before a person visits a mental health therapist (Potik, Feldinger, & Schreiber, 2012). In addition, self-report measures require patients to have sufficient insight into the extent and impact of their symptoms and to provide accurate information to clinicians and researchers. A number of factors can influence self-report, including the desire to appear more or less symptomatic than one is in reality (Bryant et al., 2018). This can result in misdiagnosing patients.

In contrast, the use of biomarkers, such as brain wave asymmetry in the frontal and parietal lobes, would be considered diagnostic testing. The purpose of using

biomarkers would be to obtain objective evidence of the presence or absence of PTSD. In addition, asymmetry would be used to confirm the diagnosis of PTSD, even when the person is asymptomatic. Ideally, the use of asymmetry in the frontal and parietal lobes would be accurate, providing high sensitivity and specificity. Unfortunately, diagnostic screening is not perfect, and screening should have a low likelihood of errors, such as false positives and false negatives.

This study evaluated asymmetries in brainwaves from qEEGs as a way to potentially provide evidence in supporting asymmetry in brain waves in the frontal and/or parietal lobes as objective diagnostic tools for PTSD. The screening for PTSD can serve multiple purposes. The first is to identify individuals at high risk for developing PTSD, but who have not manifested its symptoms. Individuals who are at a high risk for future development of PTSD can be treated before symptoms appear. In addition, an offered support mechanism to address symptoms could provide therapeutic value.

Second, in addition to risk assessment, screening provides an opportunity for early detection or identification of PTSD cases in individuals who are experiencing some PTSD symptoms but do not meet full criteria. Screening also provides the ability to discover previously unidentified cases of more chronic and severe PTSD. These individuals would be candidates for currently available evidence-based interventions. In addition, being able to identify such cases of PTSD would not only increase the incidence and prevalence, it also would facilitate the research efforts to better understand PTSD and develop additional treatment options. Finally, being able to objectively identify PTSD would assist practitioners in separating PTSD from depression

and other mental health issues, preventing unnecessary administration of depression medications and management of serious side effects, potentially improving the quality of life of PTSD patients (Jackson et al., 2018).

To be an effective objective measure of PTSD, the screening classification of frontal and parietal lobe asymmetry did not separately provide support for accurate diagnosis of PTSD. Using either parietal lobe asymmetry or frontal lobe asymmetry produced results that were unreliable. These results suggest that asymmetry in the frontal and parietal lobes should not be used as the primary screening method for PTSD. However, the model can be used in a supporting role, as a brief screening tool, to trigger the traditional processes to diagnosis of PTSD to rule PTSD out as a potential mental health condition and/or disorder. While Thatcher, (2010) has indicated neuropsychological testing has promise in the objective correct classification of PTSD, these results indicate that neuropsychological testing might be enhanced through comparisons to a patient's brain wave activity.

The major implications of the hypothesis not being supported is that brain waves in the frontal and parietal lobes might not be sufficient to diagnose PTSD. The addition of additional biomarkers from additional brain lobes, such as temporal lobe changes, might add additional diagnostic credibility. Another potential implication is the continued use of assessments that might not provide the diagnostic fidelity needed for a disorder as complex as PTSD. These implications potentially support future research efforts regarding brainwave activity and the identification of biomarkers related to mental health disorders.

Limitations and Delimitations

The primary limitation to this study is that the sample consisted of individuals who used a single private practice. This study did not take into consideration how the clientele of this practice differs from other medical practices. There were two delimitations in this study. First, the study was conducted in one geographic location. Therefore, the results may not generalize to other geographic locations. Second, the research was conducted at a private medical office and therefore the assumption that the results would be the same at other medical practices should be avoided. Despite the limitations of this study, examining the use of asymmetrical frontal and parietal lobe brainwaves is important insights in the area of diagnostic testing of PTSD.

Conclusion

This study explored the presence of alpha asymmetries in the frontal lobe and alpha wave imbalances between the right and left parietal lobes as potential biomarkers in identifying (or ruling out potential) PTSD. However, the relationship between certain brain function biomarkers and PTSD did not yield significant results that would indicate the utility of the biomarkers as a primary diagnostic tool. Thus, the results do not provide an evidence-based process to support the diagnosis of PTSD.

The primary purpose of this study was to correctly diagnose PTSD using biomarkers based on asymmetry of alpha brain waves across the frontal and parietal lobes. The results of this study do not provide support for the conclusion below. These conclusions are limited to using a single measure of asymmetry of alpha brain waves

across the parietal lobe and asymmetry of alpha brain waves across the frontal lobes separately without using additional demographic variables or the interaction of the asymmetrical alpha brain waves between the parietal and frontal lobes.

1. Asymmetry across the frontal lobe is not appropriate for diagnosing PTSD. This finding is inconsistent with Bandelow et al. (2016), who identified frontal lobe asymmetry as a potential biomarker for PTSD. Bandelow et al. (2016), also found that the increase in asymmetry in the frontal lobe can also be indicators of depression. However, in this study people with depression were not included in the study.
2. The findings were also inconsistent with Metzger et al. (2004) in identifying unique brain patterns in identifying depression and anxiety in Vietnam era female nurses. Metzger et al, found the nurse had changes in right side frontal and parietal asymmetry when being assessed for PTSD symptomology. While this study was foundational for the exploration of brain functions and the use of biomarkers in relationship to potential mental disorders, Metzger et al. (2004) did not isolate nurses with PTSD from depression and anxiety. In addition, Metzger et al. (2004) focused on the right side of the parietal lobe and found biomarkers can be used in the confirmation or rule out of PTSD diagnosis. The current study supports the use of biomarkers in ruling out PTSD. The negative likelihood ratio indicates asymmetry across the frontal lobe has a small power to rule out PTSD.

3. Kemp et al. (2010) found that PTSD patients showed a global increase across the frontal and parietal lobes. In particular, Kemp et al. (2010) found PTSD subjects presented a localized right frontal imbalance in brain wave activity. This study is inconsistent with Kemp et al. (2010) findings, there were no statistically significant increase in asymmetric alpha brain waves in the frontal or parietal lobes.
4. Jokić-Begić and Begić (2003) studied combat veterans with PTSD and found abnormal brain activity identified as biomarkers for mental health. Jokić-Begić and Begić (2003) suggested the findings might be extrapolated across all populations of people with PTSD. The findings of this study are inconsistent with extrapolating abnormal brain activity to diagnosis PTSD.

Biomarkers related to brain wave activity had been informally identified by qEEG practitioners as a way to potentially identify mental health disorders. The potential PTSD biomarker, parietal lobe asymmetry, has been a way to highlight clients that have experienced trauma. The desire to link this potential biomarker to the known anxiety and depression biomarkers was anticipated to help solidify a more definitive identification of PTSD related biomarkers. This study has provided additional information related to potential PTSD related biomarkers. However, these potential biomarkers will need to be used with caution and only as a way to identify patients for further, more evidenced based, assessment processes and methods.

Future Research Recommendations

Future research considerations could include additional brain biomarkers. The addition of potential brain patterns might provide increased accuracy when brain wave asymmetries are detected. Including data gathered from other systems might also provide better results. For instance, heart rate and/or breathing rate could be an indicator of an increase in distress.

Ultimately, the technology and future research should progress to the point that biomarkers can be potential indicators related to mental health disorders. The important message from this dissertation is that biomarkers may exist, but just not with the level of reliability that is attainable at this point. Adding additional factors and improved equipment could be ways in which the reliability of the date could be improved. It is important to note that these data might indicate a potential for a screening tool for PTSD based biomarkers. However, at this point, traditional methods related to neuropsychological assessment must be used in order to arrive at a diagnosis for PTSD.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Arlington, VA: American Psychiatric Publishing.

Bandelow, B., Baldwin, D., Abelli, M., Altamura, C., Dell'Osso, B., Domschke, K., ... & Nutt, D. (2016). Biological markers for anxiety disorders, OCD and PTSD–a consensus statement. Part I: neuroimaging and genetics. *The World Journal of Biological Psychiatry*, *17*(5), 321-365.

Blake, R. A., Lating, J. M., Sherman, M. F., & Kirkhart, M. W. (2014). Probable PTSD and impairment in witnesses of work-related fatalities. *Journal of Loss and Trauma*, *19*(2), 189-195. doi:10.1080/15325024.2013.775889

Brewin, C. R., Cloitre, M., Hyland, P., Shevlin, M., Maercker, A., Bryant, R. A., & ... Reed, G. M. (2017). A review of current evidence regarding the ICD-11 proposals for diagnosing PTSD and complex PTSD. *Clinical Psychology Review*, *58*1-15. doi:10.1016/j.cpr.2017.09.001

Bryant, A. M., Lee, E., Howell, A., Morgan, B., Cook, C. M., Patel, K., & ... Suhr, J. A. (2018). The vulnerability of self-reported disability measures to malingering: A simulated ADHD study. *The Clinical Neuropsychologist*, *32*(1), 109-118. doi:10.1080/13854046.2017.1346145

Chabot, R. J., & Serfontein, G. (1996). Quantitative electroencephalographic profiles of children with attention deficit disorder. *Biological Psychiatry*, *40*(10), 951-963. doi:10.1016/0006-3223(95)00576-5

Creswell, J. W. (2009). *Educational research. Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Carlson, E. B., & Dalenberg, C. J. (2000). A conceptual framework for the impact of traumatic experiences. *Trauma, Violence, & Abuse*, *1*(1), 4-28. doi:10.1177/1524838000001001002

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Frueh, B. C. (2013). A dilemma of logic for the VA? *Psychiatric Services*, *64*(1), 1. doi:10.1176/appi.ps.640101

Gerrard, P., & Malcolm, R. (2007). Mechanisms of modafinil: A review of current research. *Neuropsychiatric Disease and Treatment*, *3*(3), 349–364.

Gordon, E., Palmer, D. M., & Cooper, N. (2010). EEG alpha asymmetry in schizophrenia, depression, PTSD, panic disorder, ADHD and conduct disorder. *Clinical EEG And Neuroscience*, *41*(4), 178-183.

Harper, M. L., Rasolkhani-Kalhorn, T., & Drozd, J. F. (2009). On the neural basis of EMDR therapy: Insights from qEEG studies. *Traumatology*, *15*(2), 81-95. doi:10.1177/1534765609338498

Jackson, J. C., Sinnott, P. L., Marx, B. P., Murdoch, M., Sayer, N. A., Alvarez, J. M., & ...

Speroff, T. (2011). Variation in practices and attitudes of clinicians assessing PTSD-related disability among veterans. *Journal of Traumatic Stress*, *24*(5), 609-613. doi:10.1002/jts.20688

Jaworska, N., Berrigan, L., Ahmed, A. G., Gray, J., Bradford, J., Korovessis, A., ... & Knott, V. (2012). Resting electrocortical activity in adults with dysfunctional anger: a pilot study. *Psychiatry Research: Neuroimaging*, *203*(2), 229-236.

Jokić-Begić, N., & Begić, D. (2003). Quantitative electroencephalogram (qEEG) in combat veterans with post-traumatic stress disorder (PTSD). *Nordic Journal of Psychiatry*, *57*(5), 351-355. doi:10.1080/08039480310002688

Kemp, A.H., Griffiths, K., Felmingham, K.L., Shankman, S.A., Drinkenburg, W., Arns, M., Clark, C.R., Bryant, R.A., 2010. Disorder specificity despite comorbidity: resting EEG alpha asymmetry in major depressive disorder and post-traumatic stress disorder. Biol.Psychol.85,350–354.

Kira, I. A., Lewandowski, L., Chiodo, L., & Ibrahim, A. (2014). Advances in systemic trauma theory: Traumatogenic dynamics and consequences of backlash as a multi-systemic trauma on Iraqi refugee Muslim adolescents. *Psychology*, *5*(5), 389-412. doi:10.4236/psych.2014.55050

Kostaras, P., Bergiannaki, J., Psarros, C., Ploumbidis, D., & Papageorgiou, C. (2017). Posttraumatic stress disorder in outpatients with depression: Still a missed diagnosis. *Journal of Trauma & Dissociation*, *18*(2), 233-247. doi:10.1080/15299732.2016.1237402

Lobo, I., Portugal, L. C., Figueira, I., Volchan, E., David, I., Garcia Pereira, M., & de Oliveira, L. (2015). EEG correlates of the severity of posttraumatic stress symptoms: A systematic review of the dimensional PTSD literature. *Journal of Affective Disorders*, *183*210-220. doi:10.1016/j.jad.2015.05.015

Marx, B. P., Jackson, J. C., Schnurr, P. P., Murdoch, M., Sayer, N. A., Keane, T. M., & ... Speroff, T. (2012). The reality of malingered PTSD among veterans: Reply to McNally and Frueh (2012). *Journal of Traumatic Stress*, *25*(4), 457-460. doi:10.1002/jts.21714

Matusko, D. B., Kemp, R. I., Paterson, H. M., & Bryant, R. A. (n.d). The assessment of post-traumatic stress disorder for workers' compensation in emergency service personnel. *Australian Psychologist*, *48*(6), 420-427. doi:10.1111/ap.12009

Mgoqi-Mbalo, N., Zhang, M., & Ntuli, S. (2017). Risk factors for PTSD and depression in female survivors of rape. *Psychological Trauma: Theory, Research, Practice, And Policy*, *9*(3), 301-308. doi:10.1037/tra0000228

McNally, R. J., & Frueh, B. C. (2012). Why we should worry about malingering in the VA system: comment on Jackson et al. (2011). *Journal of Traumatic Stress*, *25*(4), 454-456. doi:10.1002/jts.21713

Metzger, L. J., Carson, M. A., Paulus, L. A., Paige, S. R., Lasko, N. B., Pitman, R. K., & Orr, S. P. (2004). PTSD arousal and depression symptoms associated with increased right-sided parietal EEG asymmetry. *Journal of Abnormal Psychology*, (2), 324.

Meyer, T., Smeets, T., Giesbrecht, T., Quaedflieg, C. M., Smulders, F. Y., Meijer, E. H., &

Merckelbach, H. J. (2015). The role of frontal EEG asymmetry in post-traumatic stress disorder. *Biological Psychology*, *108*62-77. doi:10.1016/j.biopsycho.2015.03.018

Miller, E. K., Freedman, D. J., & Wallis, J. D. (2002). The prefrontal cortex: categories, concepts and cognition. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *357*(1424), 1123–1136. http://doi.org/10.1098/rstb.2002.1099

Moss, D., Cannon, R., Thatcher, R., Koberda, J. L., & Gunkelman, J. (2014). Special issue: Advances in the use of QEEG and neurofeedback for ADHD. *Biofeedback*, *42*(2), 37-38. doi:10.5298/1081-5937-42.2.09

Ntafoulis, P. (2016). A war psychiatry approach to warfare in the Middle Byzantine period. *History of Psychiatry*, *27*(4), 458-471. doi:10.1177/0957154X16663148

Patel, B. R. (2015). Caregivers of veterans with "Invisible" injuries: What we know and implications for social work practice. *Social Work*, *60*(1), 9–17. https://doi-org.ezp.waldenulibrary.org/10.1093/sw/swu043

Potik, D., Feldinger, E., & Schreiber, S. (2012). Issues in psychotherapeutic encounters of patients suspected of post-traumatic stress disorder malingering. *European Journal of Psychotherapy and Counselling*, *14*(3), 261-277. doi:10.1080/13642537.2012.713185

Rivers, S. (2013). FDA permits marketing of first brain wave test to help assess children and teens for ADHD. *U.S. Food and Drug Administration*. Retrieved from http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm360811.htm

Scheeringa, M. S., Myers, L., Putnam, F. W., & Zeanah, C. H. (2012). Diagnosing PTSD in early

childhood: An empirical assessment of four approaches. *Journal of Traumatic Stress*, *25*(4), 359-367. doi:10.1002/jts.21723

Smith, K. (2007). *Cognitive Psychology: Mind and Brain*. New Jersey: Prentice Hall. pp. 21, 194–199, 349.

Strimbu, K., & Tavel, J. A. (2010). What are Biomarkers? *Current Opinion in HIV and AIDS*, *5*(6), 463–466. http://doi.org/10.1097/COH.0b013e32833ed177

Thatcher, R. W., Walker, R. A., & Giudice, S. (1987). Human cerebral hemispheres develop at different rates and ages. *Science (New York, N.Y.)*, *236*(4805), 1110–1113. DOI: 10.1126/science.3576224

Thatcher, R.W., Biver, C.L., North, D., Curtin, R., and Walker. R.W. (2003), Quantitative EEG Normative Databases Validation and Clinical Correlation *Journal of Neurotherapy*, 7(3-4) 87-121

Thatcher, R. (2010) Validity and Reliability of Quantitative Electroencephalography, *Journal of Neurotherapy*, 14:2, 122-152, DOI: 10.1080/10874201003773500

Todder, D., Levine, J., Abujumah, A., Mater, M., Cohen, H., & Kaplan, Z. (2012). The quantitative electroencephalogram and the low-resolution electrical tomographic analysis in posttraumatic stress disorder. Clinical EEG and neuroscience, 43(1), 48-53.

Tsai, J., Pietrzak, R. H., Hoff, R. A., & Harpaz-Rotem, I. (2016). Accuracy of screening for posttraumatic stress disorder in specialty mental health clinics in the U.S. Veterans Affairs Healthcare System. *Psychiatry Research*, *240*157-162. doi:10.1016/j.psychres.2016.04.036

Ustinova, Y., & Cardeña, E. (2014). Combat stress disorders and their treatment in ancient Greece. *Psychological Trauma: Theory, Research, Practice, And Policy*, *6*(6), 739-748. doi:10.1037/a0036461

Vermetten, E., Baker, D. G., Jetly, R., & McFarlane, A. C. (2016). Concerns over divergent approaches in the diagnostics of posttraumatic stress disorder. *Psychiatric Annals*, *46*(9), 498-509. doi:10.3928/00485713-20160728-02

Wahbeh, H., & Oken, B. S. (2013). Peak high-frequency HRV and peak alpha frequency higher in PTSD. *Applied Psychophysiology And Biofeedback*, *38*(1), 57-69. doi:10.1007/s10484-012-9208-z

Yamaguchi, T., Nemoto, T., Tsujino, N., Takeshi, K., Mizuno, M., & Fujii, C. (n.d). Differences between subjective experiences and observed behaviors in near-fatal suicide attempters with untreated schizophrenia: a qualitative pilot study. *Annals of General Psychiatry*, *14*

You, D. S., Youngstrom, E. A., Feeny, N. C., Youngstrom, J. K., & Findling, R. L. (2017). Comparing the diagnostic accuracy of five instruments for detecting posttraumatic stress disorder in youth. *Journal of Clinical Child and Adolescent Psychology*, *46*(4), 511-522. doi:10.1080/15374416.2015.1030754