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Quantifying the Spectrum of Depression

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Abstract

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Depression is a medically serious and widespread mood disorder that is difficult to diagnose in an objective manner. Dopamine irregularities have been strongly implicated in depression studies, and drug therapy based on dopamine is in wide use. However, the same neurological abnormalities associated with depression also affect other neural systems, including the vestibular system, in which involuntary muscle movements involved with the contralateral acoustic reflex are located. Using nigrostriatal pathways that transmit dopamine as a framework, this study investigated the biological and physiological links between depression and acoustic reflexes, and their potential usefulness for objectively assessing depression. Records of 52 randomly-selected patients who presented symptoms of depression were assessed to determine the relationship between depression and the contralateral acoustic reflex. The patients were both male and female, ranging in age from 23 to 84. Acoustic reflex threshold testing was assessed through ranges of frequencies using a tympanogram. The resulting individual average scores for the right ear and the left ear were then statistically tested against the medically accepted normal score using one-sample *t* tests. Evidence indicated that acoustic reflex abnormality may be concomitant with depression. These findings offer promising possibilities to researchers looking to develop a functional quantifiable assessment of patients who present with symptoms of depression. Addressing the wide variance of symptoms in patients may help mental health professionals determine which antidepressants to prescribe or if a patient is ready for a therapeutic process.

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Dedication

I dedicate this dissertation to a pursuit of a better understanding of both "God and Science." This dissertation is also dedicated to increasing cohesion between medical professionals and mental health providers for the sake of individuals struggling with depression. I am truly thankful to my beautiful loving wife and three children for their full support. My educational journey is a testament that God's plans are much larger than my own. I know I have not traveled this far without the support of those that believed in me when I did not even believe in myself. I am humbled by God's grace.

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I am humbled by the support of my entire family. This pursuit of higher education is to set the standard, not for achievement, but for the significance of the Bishop lineage. I would like to thank my mother for her example of what hard work really means. Thank you also to Coach Emory Bellard for believing in me when I just could not believe in myself. I wish to thank every male influence who has been a part of my journey through manhood. Thank you Lord for loving me and thank you for every struggle and every success You have seen me through.

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Chapter 1: Introduction to the Study

Introduction

Depression is a medically serious and widespread mood disorder that is difficult to diagnose in any objective manner. In their study of the genetics of depression, Mitjans and Arias (2012) pointed out that in addition to the symptomatic and behavioral complexity of depression, "there are no biological, biochemical or brain morphology markers that allow an unequivocal diagnosis of depression" (p. 24). In this study, I focused on a possible physiological exception to this statement. Specifically, I examined the relationship of dopamine nigrostriatal pathways in the human brain to both depression and contralateral acoustic reflex sensing.

Background

The ambiguity of clinical diagnoses of depressive symptoms may be a result of the non-quantifiable nature of assessment found throughout the American Psychiatric Association's (APA, 2013) *Diagnostic and Statistical Manual of Mental Disorders* (5th ed; *DSM*-5). As the standard that mental health professionals use to classify the variety of mental disorders, the *DSM-5* is extremely influential. In the *DSM-5*, the APA has attempted to add more detailed criteria "intended to facilitate an objective assessment of symptom presentations in a variety of clinical settings" (p. xxii). However, the APA has noted that while the "use of diagnostic criteria has been shown to increase diagnostic reliability . . . it is important to remember that these criteria are meant to be used as guidelines informed by clinical judgment and are not meant to be used in a cookbook fashion" (p. xxiii). The APA's criteria and categorical details of depression have a great

deal of variance in applying them to the process of diagnosing depression. This variance allows for professional judgment to be the strongest liability in diagnosis. As Alghowinem, et al. (2013) state, "current depression diagnosis is limited by assessment methods that rely almost exclusively on patient self-report and clinical judgments of symptom severity, risking a range of subjective biases" (p. 7547).

Quantification regarding depressive symptoms in patients is therefore very limited today, leaving room for my research and scientific assessment of the neurotransmitter dopamine as a scientific marker. Furthermore, the research findings offer the potential for ultimately minimizing the bias of mental health professionals in diagnosing depression. Dopamine irregularities have been strongly implicated in depression studies, and drug therapy based on dopamine is in wide use (Song, Li, & Arvey, 2011). However, the same neurological abnormalities associated with depression also affect other neural systems, including the vestibular system, in which involuntary muscle movements involved with the contralateral acoustic reflex are located.

Problem Statement

In this study, I sought to understand the degree to which patients who present depressive symptoms have abnormal contralateral acoustic reflexes. Currently, the DSM is the primary professionally accepted tool for assessing patients with depressive symptoms. There is cause for concern regarding the lack of viable quantification of patients' depression given the vast spectrum of the disorder and the problems created by misdiagnosis (Lecrubier, 2008). Current research on depression has emphasized subjective, qualitative diagnoses of patients who are expressing their personal

experiences and emotions to psychologists and psychiatrists. This dependence on subjectivity leaves a void in the pursuit of valid, unbiased scientific markers that could help to reduce diagnostic bias. Researchers have done very little work on trying to find connections between physiological measurements and objectively diagnosing depression. Only two groups of researchers to date have approached the field, including Drevets, Price, and Furey (2008), who worked with a neurocircuitry-based model for use with neuroimaging, and Alghowinem et al. (2013), who presented work linking depression with abnormal spontaneous speech and read speech.

There is, therefore, a strong need for studies that will lead to a more exhaustive exploration of the physiopathological connections involved with depression, which in turn may better diagnose, define and moderate depressive behaviors in individual patients. The need for further studies supports further research into the area of the contralateral acoustic reflex as a potentially valuable tool in the concrete physiological assessment of depressive disorders, which was also my goal in this research.

Purpose of the Study

This was a secondary data quantitative study. I used data from the Neurosensory Center of America (NSCA) in Austin, Texas. NCSA thoroughly tested acoustic characteristics of their patients who had been coded as depressed according to the coding standards presented in the DSM. In investigating this data, my purpose was to analyze whether or not there might be a physiological relationship between patients' vestibular responses measured during their acoustic testing and their diagnosed depressive state. The specific vestibular response of interest was the contralateral acoustic reflex (CAR).

The CAR had the potential to reveal a correlation between a patient's stapedius muscle response to a contralateral tonal acoustic stimulus and dopamine efficiency. The reason for the potential correlation was the fact that the CAR and dopamine both use the same neural pathway in the brain.

I analyzed the data to determine if there was a relationship between the independent variable of depression and the dependent variable of the CAR. My research and findings may lead to further studies that can then establish a measurable relationship between acoustic abnormalities and markers for dopamine based on muscle reflex.

Research Question and Hypotheses

RQ1: Do patients with depressive symptoms present an abnormal CAR?

H_0: There is no relationship between the CAR and depression.

H_1: There is a significant relationship between CAR and depression.

Theoretical and Conceptual Framework

Theoretical Foundation

The theoretical foundation for the possible connection between depression and the CAR lies within the nigrostriatal pathways that transmit dopamine and provide a direct indication of which neurochemical process is taking place regarding inner ear muscle movement. Axons from the midbrain's substantia nigra, a key motor center nucleus, use the neurotransmitter dopamine and carry signals up to an area of the basal ganglia that is known as the striatum, which then transmit them elsewhere, including to the inner ear (Substantia Nigra, 2013; see Appendix A).

The key to the specific influence of dopaminergic pathways on the contralateral acoustic reflex is their unique and direct physiological connection to the stapedius muscle found in the inner ear. The stapedius muscle, the smallest striped muscle in the human body, is strategically involved with the inner ear involuntary responses, and is sometimes confused with the stapes, the smallest human bone structure, found in the middle ear. The stapedius contracts involuntarily, as a reaction to acoustic stimuli, and pulls on the stapes. As Gierek (2007) has noted, "This movement causes stiffening of the incus and the malleus and also changes the pressure of the perilymph in the inner ear" (Abstract). This action of the stapedius works to cushion the vibration of the stapes bone, which if compromised, affects acoustic reactions or reflexes. The network of the acoustic reflex is located in the lower brainstem and is composed of both ipsilateral and contralateral routes. Ipsilateral routes occur when the sensing instrumentation uses the same ear as the acoustic test source, while the contralateral routes connect to the opposite ear after traveling through the central nervous system. The acoustic reflex response is dependent on sensory receptors in the cochlea, the afferent neurons, the brain stem, and the efferent neurons (Baloh, 2001). This process is a viable vestibular function for measurement studies due to its ease of testability and accessibility. Each of the vestibular functions that can be tested in this process is triggered by involuntary muscular responses, requiring no participation or response from the patients. Further, the acoustic reflex is an accurate test at multiple frequencies and is easily quantifiable.

According to Alghowinem et al. (2013), research regarding central nervous system disorders has explored possible biomarkers and their potential effects on

depression. Nigrostriatal cells utilize the neurotransmitter dopamine (Substantia Nigra, 2013). The bio-physiological process of dopamine and its influence on muscle contraction was important in this study due to patients' use or non-use of anti-depressant medications. I used patient data concerning anti-depressant medications to supplement the physiological outcomes of the CAR measurements. My findings may lead others to undertake more research regarding anti-depressant medication effects on CAR results. In Chapter 4, I present evidence concerning autonomic physiological responses to stimuli, which can then be scientifically linked to dopamine markers. My study, in turn, may contribute concrete, quantitative methods to the existing set of diagnostic tools used for depression, as well as improve the efficacy of such depression assessment.

Conceptual Framework

The vast symptomatic variations of depression present a challenge for all health professionals when assessing depressed patients, which is the concept behind my study of a possible link between depression and the physiological measurement of the CAR. As I show in the literature review, there has been a great deal of research done in the area of depression itself, including the roles of dopamine and serotonin, as well as in the complexity of the disorder, complicated by the complexity of the neurochemistry and operations of the human brain. That complexity contributes to the diagnostic difficulty and treatment of depression, further complicated by treatment side effects caused by antidepressants. Medical professionals have used the idea of collaborative diagnosis and treatment because of the subjective and difficult nature of assessing depression, but all of

the efforts have fallen short of an objective approach. Accurate assessment techniques need to be researched and implemented if possible.

In this research, I investigated measurement results that relate to neurotransmitters and the neurochemical operation of dopamine as a key to enabling a link to the autonomic nervous system via involuntary muscular reactions. The presence of such a link offers researchers an exciting potential physiological diagnostic method for patients presenting depressive symptoms by using the vestibular system, and specifically the CAR.

Nature of the Study

This was a quantitative study of secondary data. The data included patients' depressive or non-depressive states, as coded according to the standards presented in the DSM. I analyzed acoustic test measurements collected from NSCA patients. These patients each underwent a full neurological protocol consisting of six different tests, each of which was designed to contribute to an overall medical examination of the patient's vestibular system and how it functioned as a whole. These tests were a normal part of these patients' treatment at NSCA. While working with ENT physicians at NSCA, we determined the need for a study of vestibular function in depressed patients. In this study, the independent variable was the patient's depression status of either depressed or not depressed and the dependent variable was the CAR.

Covariates were not controlled in the NSCA reflex measurements, but nutrition and stress-induced factors could possibly affect results, and I recommend controlling for

these covariates in future studies. I collected measurements in three categories from MD Logic, the medical software used by the medical staff:

1. Patients who had no diagnosis of depression.
2. Patients who were diagnosed as depressed, but were not taking anti-depressants.
3. Patients who were diagnosed as depressed and were taking anti-depressants.

I recommend larger sample sizes of these categories and using them to analyze the resulting numbers through statistical testing, comparing known means of CAR measurements for non-depressed patients and the experimentally collected CAR measurements of depressed patients.

Definitions

I have used several clinical terms throughout this study. The *nigrostriatal pathways* that transmit dopamine provide a direct indication of which neurochemical process is taking place regarding inner ear muscle movement. *Acoustic reflex responses* are responses to auditory signals or stimulations, and are dependent on sensory receptors in the cochlea, the afferent neurons, the brain stem, and the efferent neurons. *Ipsilateral routes* of the acoustic reflexes occur when the sensing instrumentation uses the same ear as the acoustic test source, while the *contralateral routes* connect to the opposite ear, after traveling through the central nervous system. In this study, I analyzed the contralateral routes. *Abnormal reflexes* do not necessarily indicate a physiological hearing loss. In this case study, I studied abnormalities for relationship to dopamine levels and degree of depression, not hearing loss. NSCA performed the tympanometry

testing and other audio testing on each subject to eliminate hearing loss as a cause for any abnormality found in the CAR measurements.

Assumptions

Dopamine plays a significant role in the degree of depressive symptoms. However, this study does not include pre-acoustic testing for dopamine levels. External research has shown a relationship between those levels and depression in patients.

Scope and Delimitations

I addressed the correlation between the CAR and depressive symptoms in this study. A CAR/depression correlation is an exciting potential avenue for researchers to develop an objective diagnostic process that health professionals in the field of psychology can use for consistent diagnoses of depression. I studied secondary data from NSCA patients. This did not provide a diverse population of patients. Covariates such as gender, race, ethnicity, antidepressant usage, depression diagnostic codes, pre-acoustic testing of dopamine levels, and age were not included in my data analysis. Because of random patient selection from the NSCA data, I believe the results of my analysis are applicable to the general populace of depressed patients. However, I recommend that the covariates not analyzed in my study be included in future work in this area in order to further verify the generalizability of the findings of this research.

Limitations

The limitations of this study rest in three areas. The first limitation is patient racial, ethnic, and gender demographics. Most of the patients were white or Caucasian. There were no patients of African descent. The limitation this places on the study is the

fact that there is no control for demographics in general, thereby allowing possible differences in acoustic responses among differing groups. The second limitation was related to the vast nature of diagnoses of the many the patients who are treated at the NSCA. The third limitation of this study is dopamine efficacy in each individual patient. Dopamine efficacy may be influenced by biological processes that present differently daily, and by external stimuli such as weather, sounds, medication, and so on. I did not control for these variables in this study. I conducted this secondary study using non-biased physiological measurements, and then later compared them to patients' depressive or non-depressive states.

Significance

Quantification of depression may help with the overall assessment and proper treatment of depression. Addressing degree of depression may help the advancement of pharmacological validity in patients who suffer from depressive symptoms. Quantification of depression may also help clinical psychologists and other mental health professionals better understand if a depressed patient is ready for a psychotherapeutic process. Finally, accurate quantification of depression may help mental health professionals determine the efficacy of dopamine in individuals, thereby addressing degree of addiction, anxiety, PTSD, and other mental health problems that present vast spectrums of diagnosis.

Summary

Mental health professionals and medical doctors both depend on patients who present with depressive symptoms to qualitatively express their depressive state. This

requires those who are assessing the symptoms to depend on the willingly expressed subjective descriptions of those who are under the mental and emotional stress of their conditions. The resulting need for more cohesion among health care professionals is essential to the accurate and objective evaluation of patients along the vast spectrum of depression, given the degree of symptoms that may help to define the severity of any given depressive state. Therefore, I focused on the opportunities presented for objective depression diagnoses offered by the relationship between the CAR and the dopamine nigrostriatal pathways in the brain, along with dopamine markers. These relationships hold the potential for mental health professionals to quantify diagnoses of depression, enabling them to more properly and efficiently design treatment plans that will be effective in helping their patients improve in the fastest way possible.

Chapter 2: Literature Review

Introduction

In this chapter, I review the literature on general depression studies, focusing on the difficulty and confusion surrounding depression disorder diagnosis. I also review research on complicating factors connected to depression diagnoses, including neurochemistry and antidepressants. Additionally, this review includes information on the psychological connection between depression and subtle speech characteristic changes as possible objective indicators of depression. I also review research on neurotransmitters and the neurochemical operation of dopamine and serotonin, two key chemicals in the study of depression. Those two chemicals are important in the search for a link between depression and the autonomic nervous system, with its related muscular reactions. Such a link within the vestibular system, and in particular, acoustic reflex measurements, has the exciting potential of providing objective physiological diagnostic methods for those suffering from depressive disorders.

Literature Search Strategy

I used various professional databases of related books, journals, and articles to gather material for the literature review. I searched academic databases available through the Walden University library and the University of Texas online library, and professional databases that I accessed courtesy of the NSCA. No year limits were placed on the searches, though I gave preference to more recent research. I searched these databases for keywords and phrases, including but not limited to *depression diagnosis and ratio of the population, complicating factors to diagnosing depression, acoustic*

reflexes, acoustic testing, neurochemistry of depression, serotonin, antidepressants, dopamine, suicidality and ability to diagnose, depression and physiological markers, vestibular system, and *autonomic nervous system.*

Conceptual Framework

The vast symptomatic variations of depression present a challenge for all health professionals when assessing depressed patients, which is the concept behind my study of a possible link between depression and the physiological measurement of the CAR. The network of acoustic reflexes is located in the lower brainstem and contains ipsilateral and contralateral pathways. The contralateral pathway passes through the central nervous system on its way to the opposing ear, using the same pathways that dopamine uses in the brain. The stapedius muscle is strategically involved with the inner ear involuntary responses, and presents a viable vestibular function for measurement studies due to its ease of testability and accessibility. That measurement capability has the potential to provide an objective measurement of depression, and I did not find this concept specifically in any previous research literature.

Literature Review Related to Key Variables and Concepts

Depression: Definition and Diagnosis

Depression, a mood disorder that diminishes the quality of life, affects over 1 billion individuals worldwide. Lecrubier (2008) reported that, on average, 20% of adults need treatment for depression at some point in their lives, and close to half of those meet the criteria for a major depressive disorder. This analysis covered important points that may play a profound role in the assessment of depression and laid the groundwork for

assessing depression as related to disability and the quality of life (Lecrubier, 2008). The APA has defined depression as "major depressive disorder," and describes it as "a common and serious medical illness that negatively affects how you feel, the way you think and how you act" (What is depression, 2015, p. 1). The effects of depression range from mild to debilitating, but always include emotional sadness and/or a diminished or completely lost enjoyment of things, actions, or activities that once brought joy. Physical changes such as a loss of energy, slowed speech, altered sleeping habits (too little or too much), and appetite changes often appear as signs of depression. Effects that are more serious include difficulty in performing everyday tasks, problems thinking clearly, loss of the ability to make simple decisions, delusions and hallucinations, motor activity catatonia (either stiff musculature or uncontrolled movements), the development of suicidal thoughts, and suicide itself (APA, 2013).

The APA (2013), in an effort to help mental health professionals diagnose major depressive disorder, made its diagnostic criteria more extensive in the *DSM-5*. The organization also removed the previous exclusion from diagnosis of bereavement, based on clinical research. The base diagnostics, still the same as that in the *DSM-4*, includes three criteria:

- Five of nine listed symptoms must have existed in the patient for a given 2-week period of time, and must also be a change in function or behavior. One of the five must be either a depressed mood or the loss of pleasure or interest in nearly all life activities.

- The symptoms that are present must have caused dysfunction in important areas of life, such as social settings or job settings, or have caused significantly large measures of distress.
- These 2 weeks of symptoms must not be able to be attributed to either a physical medical problem or to substance abuse (APA, 2013).

The nine symptoms listed for the first criterion encompass the following for the prescribed 2-week period, with each occurring nearly every single day of that period:

1. A depressed, sad, empty, hopeless mood nearly all day.
2. An extremely lessened enjoyment of pleasure or interest almost all day in almost every activity in the subject's life.
3. Either a significant loss or increase in daily appetite or a marked weight loss or weight gain, equivalent to a monthly change of greater than five percent.
4. Either sleeplessness or extreme over-sleeping.
5. Excessively retarded or agitated psychomotor activity.
6. Significant energy loss or tiredness.
7. Extreme guilt or feelings of being personally worthless.
8. Much lowered ability to make decisions, concentrate or focus, or think clearly.
9. Repeatedly thinking about death or suicide, or a physical suicide attempt.

In each of these categories that cannot be measured, the *DSM-5* indicates the presence of that symptom depends on the observation of others or on a subjective account from the subject (APA, 2013). It is that subjectivity that accounts for a less than optimal method of diagnosing or determining a subject's categorization as having a major depressive

disorder. Many authors in my review of depression research noted the presence of that inefficiency, including Lecrubier (2008).

Lecrubier reported that numerous studies have shown, according to primary care findings, that accurate diagnosis of depressed patients is only minimally efficient. Lecrubier emphasized the seriousness of that inefficiency by showing that depression is a leading cause of disability and decreased quality of life, and concluding that a lack of modification in depressive patients resulted in unsatisfactory progress in the treatment phase of their depression. The author found that antidepressants are insufficiently prescribed, and that this insufficiency was behind the lack of success in efforts to prevent relapse in depression (Lecrubier, 2008).

In addition to the general problems of assessing and treating depression, Lecrubier (2008) also highlighted the lack of education regarding depression among private and governmental professionals, the same individuals who are responsible for the development and implementation of care models needed to establish sound, safe practices for patients. This led to Lecrubier's conclusion that better recognition and diagnosis of depression was needed through education, and better treatment could be achieved with the proper use of available antidepressants, as well as other pharmacotherapy, in the management of this mood disorder.

Adding to Lecrubier's general depression findings, Drevets, Price, and Furey (2008) indicated that stressful life events appear to be the primary precipitating cause of major depressive disorders (MDD), or the development of mood disorders. There is, however, a difference in the progressive nature and severity of symptoms between major

depressive episodes (MDE) and the MDD that Lecrubier discussed. Both can reflect behaviors that lead to a mistaken diagnosis. MDE and MDD can be differentiated by the explainable nature of a patient's behavior who presents with MDE, versus the unexplainable nature of behavior associated with stressful life events in those patients who present with MDD (Drevets, Price, & Furey, 2008).

Drevets et al. (2008) pointed out that, according to the World Health Organization, MDE causes a great deal of temporary disability in people worldwide. The authors also observed that there is a general lack of knowledge related to the pathogenesis of MDD. They explained that the lack of available tools for noninvasive assessment of the brain has hindered the expansion of research on the connections between MDD and neurobiology. They reported a need for further research on neuroimaging, which neurocircuitry-based models had proposed as a possible productive assessment tool for mood disorders (Drevets et al., 2008).

Another element in attempting to define, recognize, and treat depression and its relation to behavior involves taking into account the broad expanse of societal views of this mood disorder, including its occurrence and treatment across the boundaries of culture and ethnicity. Jimenez, Alegria, Chen, Chan, and Laderman (2010) detailed the ethnic gaps related to psychiatric illness in older adults. These gaps should not be overlooked given the diverse ethnic and cultural demographics of the United States. Jimenez et al. (2010) found overwhelming gaps of psychiatric illness between non-Latino whites and other minority groups in the United States. However, they did not address the misunderstandings related to cultural differences and norms. Nor did they explain their

statement of nativity relating ethnic minorities and psychiatric illnesses or their declaration that immigrants are at a lower risk of mental illness (Jimenez et al., 2010). The misguided notions related to culture and ethnicity leave open the door for literature and research to continue missing the mark in defining depression or mood disorders of individuals, resulting in sweeping generalized explanations of mental illness that may be described as educated guesses, at best. The lack of cultural discernment in depression assessment and treatment stems in part from a lack of education regarding individuals who may not define mental health in the same way as United States born individuals, or as members of various racial groups. The subjectivity of cultural and ethnic research biases in the clinical understanding or definition of depression add to the general environment in which research continues to fail to objectively assess the degree of depression in individual patients. The reason is a lack of any viable studies on concrete assessment methods other than the promising neuroimaging for neurocircuitry-based models mentioned by Drevets et al. (2008), as well as work with spontaneous and read speech done by Alghowinem et al. (2013), which I explain in the Acoustic Abnormalities section in this literature review. These examples show the need for future studies that will lead to a more exhaustive exploration of the physiopathological connections involved with depression. I believe one key study should be in the area of the CAR as a potentially valuable tool in the concrete physiological assessment of depressive disorders, which I propose as the goal of my present research analysis.

Serotonin and Dopamine

The roles of both serotonin and dopamine in patient behavioral outcomes of patients who present with depressive symptoms further compound the picture of depression and its complexities related to the broad spectrum of assessment. Song, Li and Arvey (2011) researched the functionality of the neurotransmitter serotonin and its subsystems responsible for regulating brain function such as sleep, cognition, endocrine activity, and most importantly for my research analysis, emotion. Regarding dopamine, on the other hand, the same research described it as a neurotransmitter that plays a profound role in human functions, such as cognition, motor function, and most importantly for my research analysis, motivation. Their research gave a detailed explanation of the biological processes and importance of dopamine receptors. These explanations were important, and offered a functional explanation of the differences in serotonin and dopamine, and their respective effects on patients.

The biological functionalities of both serotonin and dopamine were useful in the regulation and promotion of behaviors that may help in the assessment of depression, as clearly expressed and explained by Song et al. (2011). However, their research fell short in its explanations and links to the unique physiological influence each of the neurotransmitters had on depressed patients. Future researchers need to explore these links and help clear the confusing mix of explanations in the literature.

Marc Lewis (2011) presented a unique review of the ideas surrounding addiction, including the influential writings of G. Heyman. My purpose in this dissertation is not based on addiction, but Heyman's minimization of the importance of dopamine on

human behavior was noteworthy in Lewis' discussion. I am interested in the connection between dopaminergic pathways and human acoustic reflex pathways, so Heyman's ideas here would lessen the impact of such a connection. Heyman expressed a philosophical notion based purely on human behaviors that rest in subjective perspectives, environmental contexts, and personal values. Lewis (2011) presented a rebuttal of Heyman, explaining how important dopamine was to the neuromodulator and behaviors described as goal-related behaviors, therefore presenting dopamine as motivation in human behavior.

A review of the article related to brain changes, and the impact addiction has on the biological as well as the psychological conditioning, opens a window into human behaviors related to depressive behavior and neural restructuring, therefore influencing the use of dopamine in the individual patient. The research revealed that discussions must take place between medical professionals and professionals in psychology to establish collaboration. This collaboration could lead to a better model of science and assessment. Lewis (2011) concluded that it was very important to acknowledge the biological explanations related to dopamine, and never to exclude the philosophical explanations of human behaviors, along with their value in the assessment of depressed patients.

Problems with Serotonin

Interestingly, new neuroimaging on both animals and humans recently began to show that reduction in dopamine may play a profound role in depression. Related research showed that there was no direct correlational proof that antidepressants

enhanced dopamine in order to help individuals who presented depressive symptoms or behaviors (McManamy, 2007).

Leu-Semenescu et al. (2010) presented research on a particular medical case that helped to support the research that suggested serotonin may play less of a role in depression than once was suggested in the literature. The case was of a man with a genetic mutation called sepiapterin reductase deficiency. This genetic mutation was responsible for life long deficiency of both serotonin and dopamine. The research in this case led to some sound explanations that helped with defining the purpose of both serotonin and dopamine. Dopamine deficiency influenced coordination related to controlled and involuntary muscle movements. The researchers explained serotonin's role in a contrasting way to what the literature had presented in the past. The case noted that serotonin had been viewed as the "happy chemical." The patient in this case was not depressed but did present some other problems related to sleep deprivation. These researchers concluded by explaining that though the patient was found to have a low level of serotonin, depression was non-existent, failing to support the notion regarding serotonin as a "happy chemical."

Collaborative Care

Gensichen et al (2009) found that health care costs for depression accounted for about $83 billion dollars in the United States in 2009. They found that financial costs of depression could be assessed through exploring primary care, where most patients receive treatment for their depression. Their assessment of primary care yielded a profound view of the primary health care model in this study, showing that family physicians were

usually the first unit of support for patients who relied on the expertise of professionals to help with depressive behavior. This makes it imperative to detail the process of case management related to primary care, presented in the literature as collaborative. The researchers found that collaborative care has yielded an approach to assessment that was more encompassing, creating opportunities for utilizing diverse education and establishing a culture of care that was multidimensional in its treatment approach. Gensichen (2009) and his team explained that trials related to case management, primary care practices and collaborative care models revealed that symptoms of depression reduced with collaborative care of older patients. The authors also noted that even telephone support for such patients provided a limb of support that improved depressive symptoms. Collaborative care appeared to present an excellent mode of in-depth case management, including assessment and support methods that detailed a holistic approach to patients and their depressive symptoms.

Gensichen (2009) and his team presented information that embodied two primary components integral to my research analysis. The first is the collaborative care model just discussed. This model gives credence to the need for further explorations of widespread education, which holds the potential for establishing exhaustive assessments in support of health care professionals, while enhancing care for patients that present depressive behaviors. Secondly, however, this article fails to explore individualized outcomes of depressive behavior of patients. Symptoms of depression are presented as "reduced." This continues to leave open the need to research and establish new tools that may give insight into an infant stage of assessment, which can then show the degree of

depressive symptoms. The CAR may offer just such an assessment technique. This exploration of research may then lend psychiatric care physicians a more comprehensive detailed approach related to the use of anti-depressants with their patients.

Anti-Depressants

The literature as related to anti-depressants (AD's) reveals a vast array of their effects on patients and their depression, including their accompanying side effects. One such study by Vestergaard (2008) began to explore the effects of AD drugs on the central nervous system and the human skeleton. Such effects are of interest to my research analysis results, as they may reveal additional effects on acoustic reflexes beyond what depression itself may affect. Vestergaard (2008) found postural balance as being primary reason for falls leading to fractures, especially in elderly patients. He also found, in addition to creating the propensity to fall, that some AD's may inhibit essential pathways for what scientists describe as "bone turnover," which is responsible for bone material density. It is important to note that the mechanism for falls and the association between AD drugs and falls are still somewhat unknown. The behavioral ramifications of depression, however, are noteworthy in this article. The conclusions made by the author began to validate the impact of depression on behavior and the influence depression may have on decreased attention in patients that could lead to injury from falls or other accidents (Vestergaard, 2008).

Vitamin D Deficiency

Wilkins et al (2006) provided an interesting discussion concerning Vitamin D and its relationship to mood disorders including, but not limited to, seasonal affective

disorder, and the association between this mood disorder and Vitamin D deficiency. This discussion and association has exposed the prevalence of Vitamin D deficiency in older adults, leaving another window of needed physiological assessment methods to further understand the implications of Vitamin D deficiency and mood disorders in elderly populations (Wilkins, Yvette, Catherine, Birge & Morris, 2006).

In view of the work done by Wilkins et al (2006) neurpleptics are of interest, since they are drugs used for psychiatric disorders, including psychotic depression and bipolar disorder. These drugs have been suspected of having a negative effect on mineralization, causing concern with the production of Vitamin D (Vestergaard, 2008). Problems with the body's production of Vitamin D during early life may very well play a role in the mental function of individuals later in life (Holick, 2007). Some AD's, along with their connection to Vitamin D, require careful assessment and understanding of the negative effects or bio-functional educational markers that some AD's present. That work may lead to a more testable solution in the assessment of patients who present with depressive symptoms. The research and literature related to AD's and Vitamin D deficiency argue for more exhaustive investigations into and research concerning those AD's that are suspected of having such effects on the production of Vitamin D, now thought to play a role in brain function and development (Holick, 2007).

Another closely related area of investigation needing more work is with fibromyalgia, which has long presented symptoms of anxiety and depression in patients that suffer from the complicated nature of this medical condition (Armstrong, Meenagh, Bickle, Lee, Curran & Finch, 2006). These researchers reported a process of assessment

and measurement of anxiety and depressive symptoms. They used qualitative questionnaires to explore the relationship between levels of Vitamin D and behavioral outcomes that presented as anxiety and depression in fibromyalgia.

The links between Vitamin D deficiency and disorders such as depression were presented in the research literature as educational findings, but the sound research that helps with a process of understanding the mechanism and cause of such links is lacking. Holick (2007) tried to explain that Vitamin D sufficiency was important to receptor transcriptional activity in both early and later life for brain development and maintenance. The research regarding Vitamin D deficiency should help spur more investigation into the process of assessment that is more aligned with marker based assessment. Tracking a marker such as Vitamin D deficiency is quantitative and supports the purpose of my dissertation work in proposing useful physiological assessment tools such as the CAR for patients that present with depressive symptoms.

The lack of sound quantitative tools may play a role in the misunderstood depressive symptom-based outcomes in reviewed literature. Lecrubier (2008) attempted to explain the confusion in using qualitative tools, such as the Hamilton Rating Scale for Depression, as a single objective tool to assess the residual symptoms of patients who presented as satisfactory after metabolizing the AD fluoxetine. This finding in AD research validates the need for further development of quantitative analysis, supporting a more exhaustive assessment of AD outcomes, and illustrating need-based outcomes as a more solid tool for use in the assessment of depressed patients.

Suicidality

Licinio and Wong (2005) reported that 60 to 70% of acutely depressed patients had thoughts of suicide and about 10 to 15% of those patients actually then committed suicide. It is important to note that they also reported that 50% of suicides happen in depressed adult patients, but there was more than a 20% increase in recent years when assessing suicide in depressed children.

Research concerning AD's and suicidality done by Barbui, Esposito and Cipriani (2009) generally showed a pathological process, one that is very complex and seemingly ever-changing, affecting subjects' brain functioning. The imbalanced associated effects of selective serotonin reuptake inhibitors in patients who present depressive symptoms have given cause for more research. The researchers revealed that the complex nature of AD's resulted in positive and negative associations that may influence any of three results: suicidal thoughts, completion of suicide, or reduced depressive behaviors. These findings strongly suggested that continued in-depth research into these areas of AD's is vital. The unknown safety risk of selective serotonin reuptake inhibitors (SSRI's) appeared to be explained by defining vulnerability in depressed individuals who present suicidal ideation. The degree of vulnerability related to SSRI's in this research was not as clearly defined, leaving room for inconsistencies that in turn explained the present limitations and safety concerns in the overall assessment of depressive symptoms in patients (Barbui, Esposito & Cipriani, 2009).

Barbui et al. (2009) detailed a study that began to open a window of opportunity into a quantitative analysis that exposed differences in attempted and completed suicides

of patients who presented on the spectrum of depression as moderate or severe. The strengths of the study were based on the large number of patients studied (200,000) and the increased risk and reduction of suicide completion in relation to age. The outcomes showed older adults benefited from SSRIs, while adolescents were at more increased risk of suicide from those same SSRIs. The weaknesses of this study rested in the assessed spectrum of depression. The literature is lacking in clearly delineating points on the depression spectrum, and could and should better address the need for accurate assessment in patients who present with depressive symptoms. This weakness further exposes the need for objective assessments that may help individual patients and lead to more substantially positive results in treatment, as the acoustic reflex research presented in this dissertation offers.

The relationship between AD's and suicide seen in research literature results cannot be fairly explained without examining the notions related to the useful and productive role AD's have played in the culture of medical and mental health professions. A strong argument that has been made when referencing the need of AD's, is the fact that suicide has usually occurred when individuals presented with depressive symptoms (Isacsson, Rich, Jureidini & Raven, 2010). This notion rests in the assumption that suicide most likely exists because of depression, and AD's help aid in the minimization of depressive thoughts. The argument generated from the literature regarding the association between the effects on patients who presented with depression and patient suicidal ideation, exposed a strong notion about the weak effectiveness of depression rating scales and the score validity, due to the qualitative nature of the scales. The

measurement of suicidal thoughts lost its validity in establishing a clinical explanation of determining to what degree an individual is depressed, when relying on depression rating scales (Isacsson et al., 2010).

AD withdrawals and completed suicide is a research area that must not be neglected. Though this area of research may help to bridge the gaps of assessment associated with links between AD withdrawal and suicide, it is clear that the literature generally falls short in presenting sound assessments that support either side of the argument. Isacsson et al. (2010) argued that AD's are not very effective, presenting strong evidence exposing flaws in clinical measurements trying to present a viable degree of assessment. Given that strong point, surveying the research literature still showed the researchers' propensity to express a profound over-generalization related to clinical science and AD findings related to causal factors of suicide. Up to this point, research has failed in its attempts at defining the differences in causal factors including life experiences such as unemployment, poverty, social relationships etc., and the link between the physiological process of AD's and the outcomes of suicide ideation (Isacsson et al., 2010).

The generalization of the literature does not stop with causal factors regarding clinical science and its findings between AD's and suicide. The capital generated from AD's seems to be a topic that is given limited attention but cannot be dismissed. Isacsson et al.(2010) gave examples of two studies that began to explore sales of AD's and their impact on suicide in men and women. The findings according to this literature were confusing and lacked sound explanations of the outcomes, leading to over-generalized

conclusions. This simply continued to support the need for more exploration regarding the influence of capital on the prescribing of AD's by medical professionals.

Barbui et al. (2009) supported the argument that AD's help with the minimization of depressive symptoms that may lead to suicide. However, their research did suggest that susceptible patients may be at risk of suicidal ideation, which may possibly be linked to the use of SSRI's. Their research findings and supporting definitions of susceptible patients were heavily correlated to the variable of patient age. AD's seemed to have a profoundly negative effect on adolescent and young adults, in comparison to older adults, who were found to benefit from AD's.

Leon, et al. (2007), extended the Black Box warning associated with pediatric suicidality to include young adults. This article focused on adult suicidality and found that AD's were only detected in one fifth of the autopsies of adult suicides related to this study. This article helped to support the notion related to assessment of the individual who presents with depression, by explaining that many of the suicides could have been prevented. The research was vague in its explanation of its findings, leaving more to be understood in regard to appropriate treatment. Though the purpose of this dissertation is not to support any treatment plan, it is important to detail the lack of associations between assessments and possible explorations of treatment plans in the literature. Weak explanations support the gaps in the literature that have been expressed throughout this literature review and leave more to be discussed in regard to AD's and the correlation, or lack thereof, to suicidality (Leon et al, 2007).

Leon et al. (2007) helped with an expansion of research on assessments that detailed six groups of suicide. The six groups were based on a description of findings related to the study in this article. The study analyzed the postmortem blood of individuals 18 years and older who completed suicide, to assess whether there was a presence of AD's. The results were based on 1419 adult suicides where only about 23% of the completed suicides presented AD's in the toxicology report. This article is useful when assessing factors that may help establish a baseline of support for the presence of AD's connected with depressed patients who commit suicide.

The first three groups of suicides were comprised of adults who presented with AD's postmortem:

1. Adults who were taking AD's, but with dose and duration insufficient.
2. Adults who were assumed to have taken the correct dosage and duration of AD's, but ADs had no effect.
3. Adults who responded to side effects, or showed withdrawal symptoms that may have been a factor in committing suicide.

The other three groups of adult suicides we`re defined as those who had toxicological testing, but AD's were not found in the postmortem blood:

1. Adults who were undiagnosed and never received AD's, or stopped taking AD's recently.
2. Adults who received no pharmacologic help for their depression, and used alternative methods, such as psychotherapy, but did not have success.
3. Adults who were experiencing AD withdrawals that led to suicide.

This article left much to be desired, regarding the assessment of AD's and suicide in adults. The large sample size and the systematic explanation of subgroups clearly helped with why this study took place. However, the missing links of the study were in assessing the degree of causal factors that led to suicide. I believe that the over-directed and complete abandonment of assessment for other disorders that may have contributed to suicide leaves this study void of validity in that area.

Barbui et al. (2009) presented research based on a meta-analysis of observational studies that provided much detail exposing the links between suicide and SSRI's. There were eight studies that were presented in this overall study and 200,000 participants that were used for the sample size. The sample size alone should give this study some validity. This article supported much of the literature presented in this dissertation, regarding connections between depressed individuals and their age. It also noted a critical point that must be reviewed and may give a glimpse into larger influences such as agendas that impact research conclusions. According to these researchers, the FDA reported neutral effects and positive effects of SSRI's among 18-25-year old. This report contradicts other similar studies and the average results from Barbui and his research team, exposing a research problem and creating confusion regarding SSRI's and suicide. Also, when assessing the validity of observational studies there were some factors that may have profoundly negative influences:

1. Differences in baseline made it difficult to adjust; meaning that limitations of observational studies many times were conducted without accounting for human error, and

2. observational studies were prone to bias.

Both of these problems these researchers found with observational studies exposed the need for an analysis of findings that offers a better explanation of study results.

Barbui et al. (2009) noted that differences in AD medications exposed a profoundly horrifying assessment that the use of some AD's increased the risk of suicide more than did others. This assessment by the authors' research supports why further detailed and accurate research needs to be done and why objective assessment methods need to be found. The research team made a great point by suggesting that the long-term efficacy and safety achieved by comparing AD's in trials may support the medical clinicians, by allowing for evidence-based medical decisions related to patients who present with depressive symptoms and AD's. All of this supports the importance of finding vital objective methods for assessing depression, which will assist in the accuracy and improved efficiency of AD treatments, and this makes the possibilities of the acoustic reflex studies in this dissertation even more promising.

Acoustic Abnormalities

Some of the research on acoustic abnormalities revealed some hint of knowledge of noise sensitivity in depressed patients. Some work by Alghowinem, et al, (2013) reported on possible biomarkers from central nervous system disorders that may have a potential effect on depression studies. A 2007 research finding found the vestibular system to be a modulating network involved in behavioral functions, and this supports the possibility of finding a depression marker in acoustic studies, as acoustics are part of the vestibular system (Meli, Zimatore, Badaracco, Angelis & Tufarelli, 2007). However, no

literature was found on the research topic presented in my research analysis concerning the CAR and depression.

Bar-Haim (2002) used personality as a variable that presented some interesting notions about differences in adulthood that are expressed as introverted/extroverted. The literature explained that Eysenck's theory (1967), which was related to the behavior of being introverted or extroverted, was directed through the biological processes reflected in limbic activation. He felt that stimulation or lack thereof in both introverted and extroverted subjects led to an assumption that an individual expressed a need for the behavior that reflected the corresponding needed level of environmental stimulus.

The specific findings found in the literature provided some research that attempted to link physiological characteristics with psychological behavior as I have expressed the need for throughout this dissertation. The notion that noise-sensitive adults presented behaviors that reflected as less secure in social interaction was an essentially unconscious physiological response (Bar-Haim, 2002). This is a key point in the search for a biological assist in depression diagnoses and is a possible path around the findings of Mitjans and Arias, who, in their depression genetics study, found no biological markers in the brain or in the body's biochemical pathways indicating depression (Mitjans, 2012). Bar-Haim's finding is not a biological marker but can be linked to the involuntary muscle responses that the neurotransmitter dopamine may affect to provide a key functional assessment needed to quantify degrees of abnormalities in the CAR in patients who present with depression.

The literature presented some unique assumptions that began to explore the vestibular health of patients in recent studies. The findings of Meli et al. (2007) concerning the vestibular system as modulating neural networks involved in behavioral functions was a link to my research analysis of the CAR. Alghowinem et al, (2013) did find encouraging results with their work studying clinical depression classifications related to acoustic features in both spontaneous and read speech. Their research supported the hypothesis that spontaneous speech characteristics, especially in the beginning spoken sentences, performed promisingly well in detecting and classifying depression. Assumptions in the literature that behavioral functions and the limbic system's activity may be influenced by vestibular systems give a reason for the study presented in chapter 3 of this dissertation. The biological and physiological processes of dopamine may help to establish functional links to involuntary muscle movements in depressed patients.

Summary and Conclusions

All of these possible relationships among involuntary muscular responses, dopamine, and depression provide an exciting area of research that could potentially provide a major inroad into more effective assessments of depressive disorders. This has the potential of providing quantitative assessment tools, which could lead to much more concrete depression diagnoses, as well as enhance potential treatment methods and their efficacies. Acoustic reflexes offer an easily obtained physiological measurement for patients who complain of depressive conditions. If those reflexes prove to be reliable and consistent, in relation to depressive markers and symptoms, as I believe they will, they will offer an

invaluable tool to clinicians and professionals trying to improve the assessment and treatment of such patients. The following chapters of this dissertation explore in particular the relationship of abnormal CAR to dopamine markers and depressive symptoms and disorders.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study of secondary data was to examine the relationship between acoustic abnormality and depression in patients with depressive symptoms. This relationship depends on the dopamine nigrostriatal pathways in the human brain and their connection and relationship to both depression and to CAR sensing. The NSCA in Austin, Texas, obtained the data I used for this study during the course of their normal patient treatment process, though the relationship between acoustic abnormality and depression in this data has not been examined previously. In this chapter, I will describe the acoustic testing methods physiology, patient selection, acoustic testing instrumentation, patient data collection prior to testing, acoustic test data collection formatting, and sample acoustic test results.

Research Design and Rationale

My primary research question was: To what degree do patients with depressive symptoms present abnormal CAR? To try to answer this question, I analyzed the test data collected from NSCA patients. These patients each underwent a full neurological protocol consisting of six different tests, each designed to contribute to an overall medical examination of each patient's vestibular system, giving a picture of how it functions as a whole. To be clear, these tests were a normal part of these patients' treatment at NSCA, not an additional experimental protocol. These tests offer physicians a snapshot in real time of how touch, sight, and hearing work together, thus presenting the desired functional depiction of the vestibular process for each individual patient. The tests

consist of the otoacoustic emissions (OAE) test for the right and left ears, the tympanogram, the CAR, the ipsilateral acoustic reflex, and the sensory integration test.

Acoustic reflex thresholds were measured in both ears of each patient, and both ipsilateral and contralateral measurements were recorded. The pathways for these two tests are significantly different and add differing information to patient assessments. To illustrate the testing methods used in this study for each pathway, I developed the following block diagrams that offer pictures for the ipsilateral and contralateral testing of the right ear.

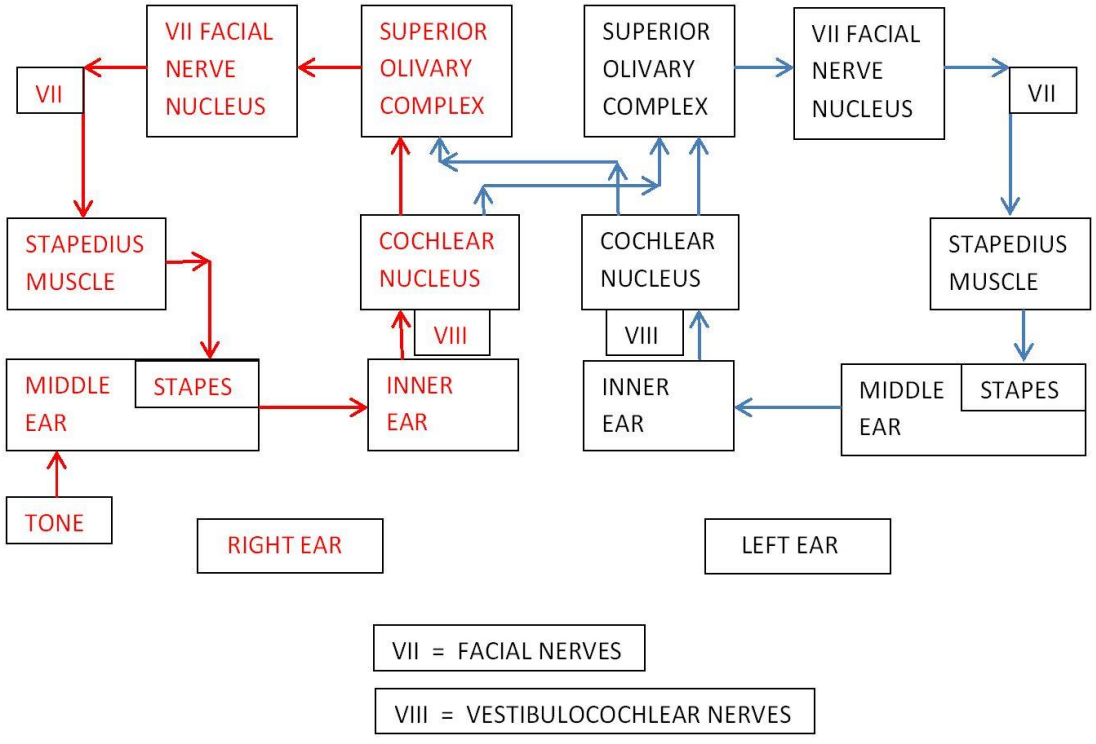


Figure 1. The right ipsilateral pathway. This illustrates a sound entering in the right ear and the response also being measured in the right ear.

In the right ipsilateral pathway, sound enters the right ear, passing through the middle and inner ears. Converted to a nerve signal, it reaches the cochlear nucleus through the VIII nerve. The signal then travels to the right superior olivary complex and then the right facial nerve (VII) nucleus, which sends the signal to the right facial nerve. That nerve then causes the right stapedius muscle to contract and pull the right stapes bone down and out, away from the middle ear (Emanuel, 2009).

Figure 2 illustrates the neurological pathway that a sound signal takes when originating outside the right ear and traveling across the opposite side to the left ear, which is the contralateral pathway I used in this study.

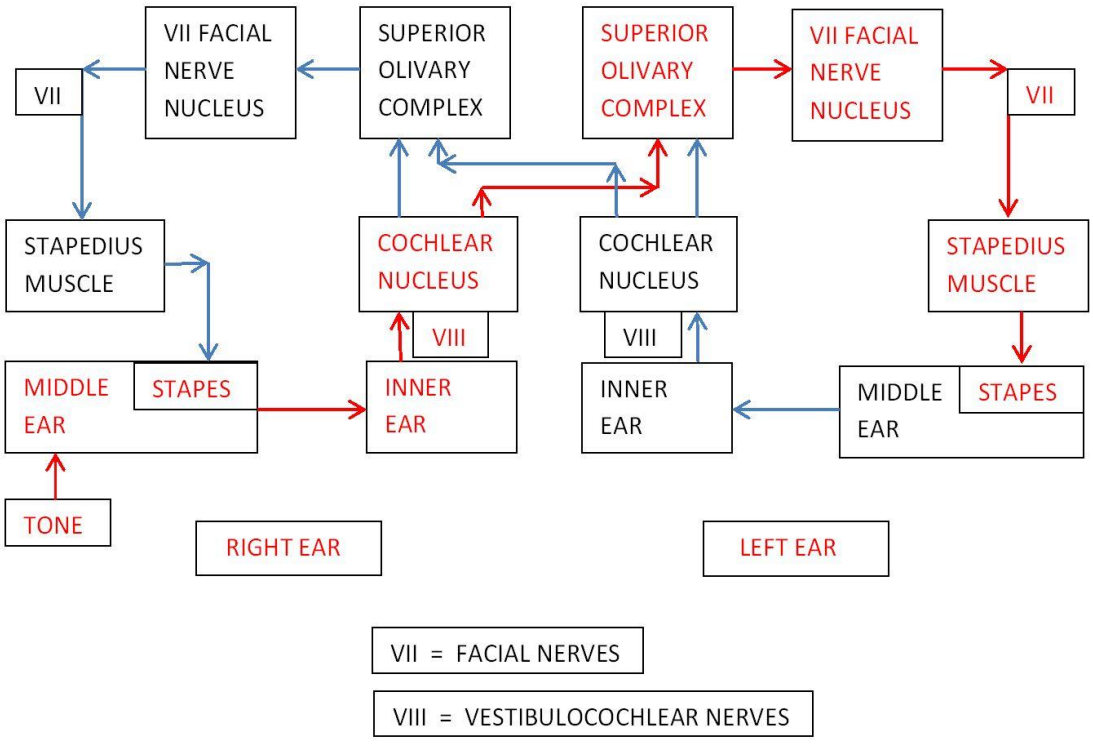


Figure 2. The right contralateral pathway. This illustrates a sound entering in the right ear and the response being measured in the left ear.

In the right contralateral pathway, sound enters the right ear, passing through the middle and inner ears. Converted to a nerve signal, it reaches the cochlear nucleus through the VIII nerve. The signal then travels across to the left superior olivary complex and then the left facial nerve (VII) nucleus, which sends the signal to the left facial nerve. That nerve then causes the left stapedius muscle to contract and pull the left stapes bone down and out, away from the middle ear (Emanuel, 2009).

Role of the Researcher

In this quantitative study of secondary data, I was an observer only. I did not participate in the testing itself and did not have any relationship with or influence over the test subjects. The subjects, testing, and data collection were all handled by the NSCA, an otolaryngology-based medical practice founded in 2001 in Austin, Texas, where I work. Since I had no connection to the test subjects, there was no personal bias in analyzing these test results, and no conflict of interest or incentives involved. The numerical digital and analog test results required no subjective analysis, thereby eliminating any subjective bias in reviewing these results.

Methodology

Population and Sample

Participants for the study were obtained from NSCA. Participants, both men and women, were randomly selected from a secure medical database that houses data from all patients who have received medical assessment, treatment, or consultations from Dr. Kendal Stewart, Chief Medical Doctor, or Wally Taylor M.D. The study was performed, and the sample standard deviation calculated. Power estimates were done after the initial

test was run and was high enough to validate the sufficiency of our sample size. Information collected concerning each patient included race, age, gender, depression/headache symptoms for some, antidepressant medications, and acoustic reflex score results. All of these patients were diagnosed as depressed to one degree or another. Therefore, the sample provides appropriate data to compare with published medically considered normal acoustic reflex measurements (Hain, 2014). The analysis used all these patients, with no regard to their diagnoses.

Data Collection Prior to Testing

Participants for the study were selected based on medical information presented in medical files between 2012 and 2014. The following categories were included with each subject where the information was available: Age; gender; depressive symptoms according to diagnostic codes 296.50 (bipolar disorder), 296.30 (depression recurrent), 296.20 (depression-one episode); and any use of anti-depressive medication/non-use of anti-depressive medication detail in patient's chart. The names of participants in the data were concealed and patients were selected by office administration. Information regarding testing results were collected by diagnostic technicians.

Instrumentation and Operationalization

The test data in this research consist of results from the OAE test for the right and left ears, the tympanogram, the CAR, the ipsilateral acoustic reflex, and the sensory integration test. A tympanometer was used as instrumentation. Practitioners use this device to perform pressure tests of the tympanic membrane (eardrum) and middle ear, resulting in tympanograms (see Figure 3 below). It is also able to run acoustic reflex

testing of the actions within the middle ear structures and their neurological connections to the brain. Middle ear dysfunction may affect the accuracy of many diagnostic tests; therefore, tympanometry provides a measure of reliability. Tympanometry is used to measure the compliance of the eardrum with pressure modification varied from 200 to 400 daPa.

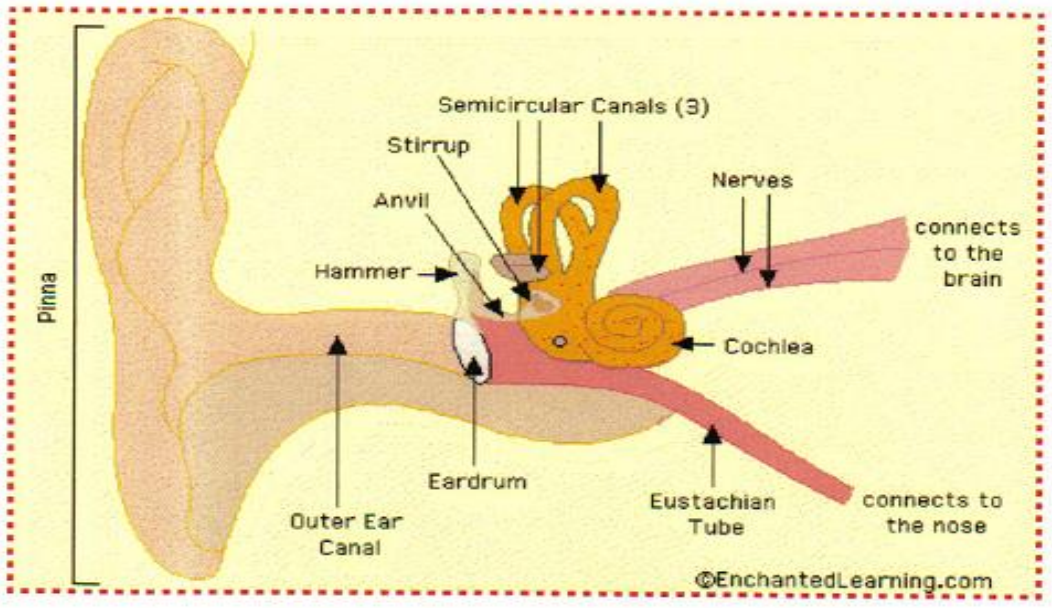


Figure 3. Diagram of the physiology of the ear (Stewart, K., Gonzalez, J., & Haynes, S. (2004-2012). Reprinted with permission.

In tympanometry, static immittance is expressed as equivalent volume in cubic centimeters and normal values range from about 0.30 to 1.60 cm under normal atmosphere pressure. NSCA classified the tympanograms by normal and abnormal types. Type A is the normal type consistent with normal tympanic membrane mobility. (Static compliance must be at least 0.3). Abnormal types are as follows:

- Type B**.** This type is consistent with little to no tympanic membrane mobility

(Static compliance must be at 0.1). This will affect acoustic reflex (AR) reliability.

- Type B with Large Volume (LgC1)**.** This type is consistent with tympanic membrane perforation or pressure equalization.
- Type C**.** This type is consistent with negative pressure in the middle ear space (peak at -200 for adults; static compliance must be at least 0.3).
- Type AS**.** This type is consistent with restricted movement in the middle ear space (low static compliance, must be 0.2). This also may affect AR reliability.
- Type AD**.** This type is consistent with flaccid tympanic membrane mobility (High static compliance). The high static compliance will affect reliability of the acoustic reflexes.

OAE's are sounds found in the external ear canal following an acoustic stimulation. These emissions are generated from movement of the outer hair cells of the cochlea and audiologists can use these measurements to investigate the status of the cochlea. The activity in the cochlea requires energy. Therefore, the metabolism of the cochlea is very high. The OAE are extremely sensitive to the complex processes in the cochlea. They thus highly correlate with cochlear dysfunction, and indirectly correlate with other sensory dysfunction. Figure 4 below illustrates the method of generation of the OAE.

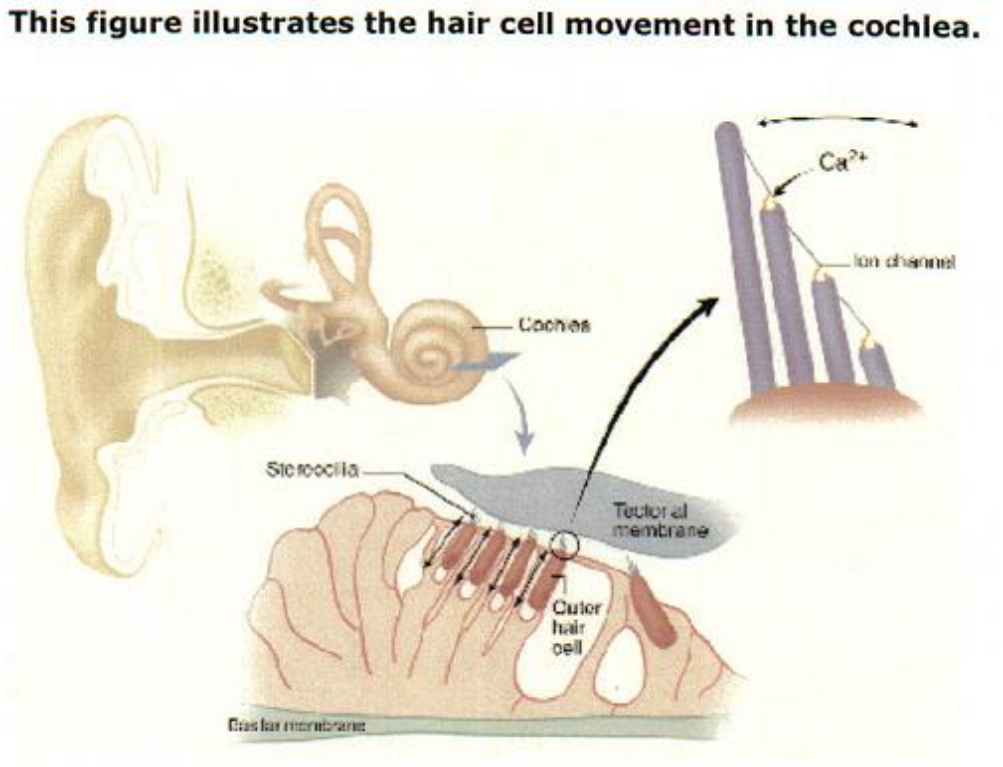


Figure 4. Diagram of cochlear hair cell movement (Stewart, K., Gonzalez, J., & Haynes, S. (2004-2012). Reprinted with permission.

Before running an OAE test, the instrumentation was calibrated to ensure a good seal with the patient's ear canal, as well as the correct signal path for initiating sounds. Figure 5 below illustrates the calibration curves typically seen in instrument preparation, including a sample of an unacceptable calibration curve, followed by an example of a properly calibrated instrument.

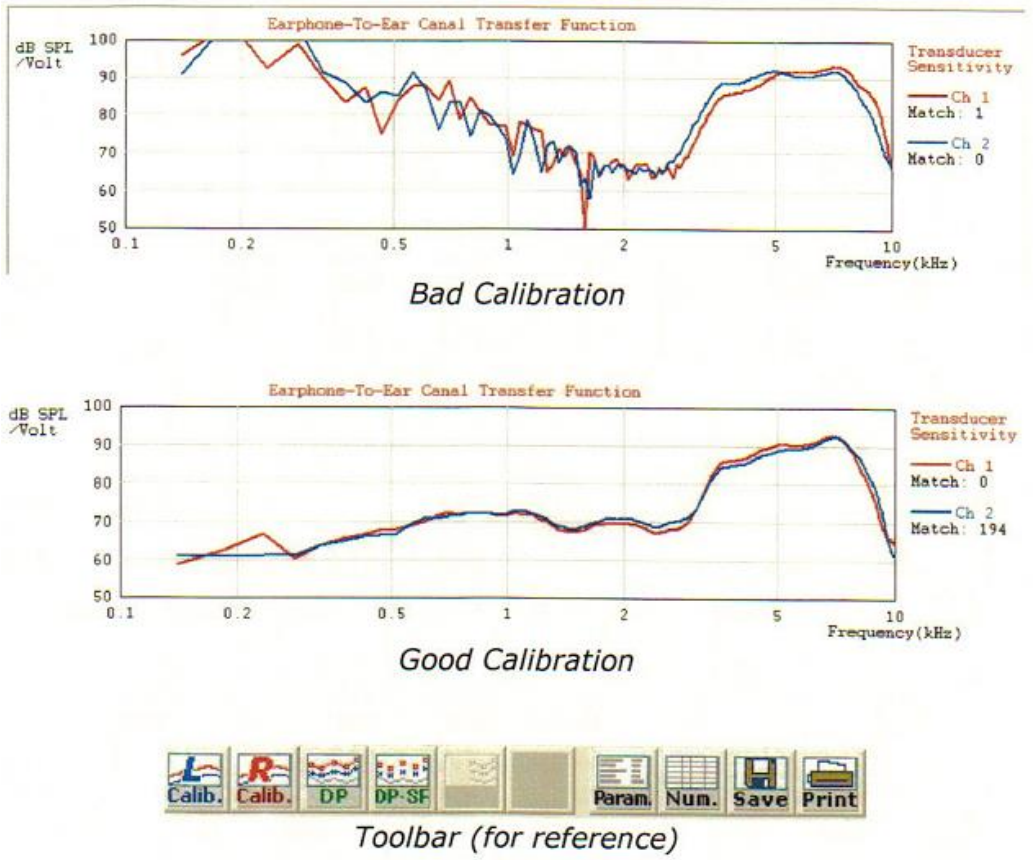


Figure 5. Diagram of OAE calibration curve (Stewart, K., Gonzalez, J., & Haynes, S. (2004-2012). Reprinted with permission.

Normal middle ear function is required for the interpretation of the OAE. Middle ear dysfunction may reduce OAE amplitudes or may eliminate the response entirely.

Desired Results: Smooth response at the top of the shaded area, with symmetry between the ears.

Abnormal Results: Increased amplitude (represents disinhibition of the end organ). Decreased amplitude (represents cochlear [outer hair-cell] dysfunction). Peaks and Valleys (typically represent inflammation of the organ). Asymmetrical response

(indicating the end organs are sending the brain differing information). Figure 6 offers an example below.

Example:

The red dots represent the right ear. The blue dots represent the left ear. The yellow bar indicates the standard deviation for normal. The green line represents the noise floor (ambient noise). Frequencies are represented from low to high from left to right.

A normal response should indicate a smooth response along the top of the yellow line. Ideally, both ears should be symmetrical.

Figure 6. Diagram of an OAE test result for both ears (Stewart, K., Gonzalez, J., & Haynes, S. (2004-2012). Reprinted with permission.

Figure 7 below illustrates each of the components of the six tests administered to each of the test subjects in the data to be collected by NSCA. The top charts are the results of the Otoacoustic Emissions Test, one for the right ear results, and one for those from the left ear. The second section of the charts illustrates results for the Contralateral Acoustic Reflex Threshold and the Ipsilateral Acoustic Reflex Threshold for both ears,

accompanied by the Tympanogram results. The final charts show the Sensory Integration Test results for COG (Center of Gravity) sway velocity and COG alignment.

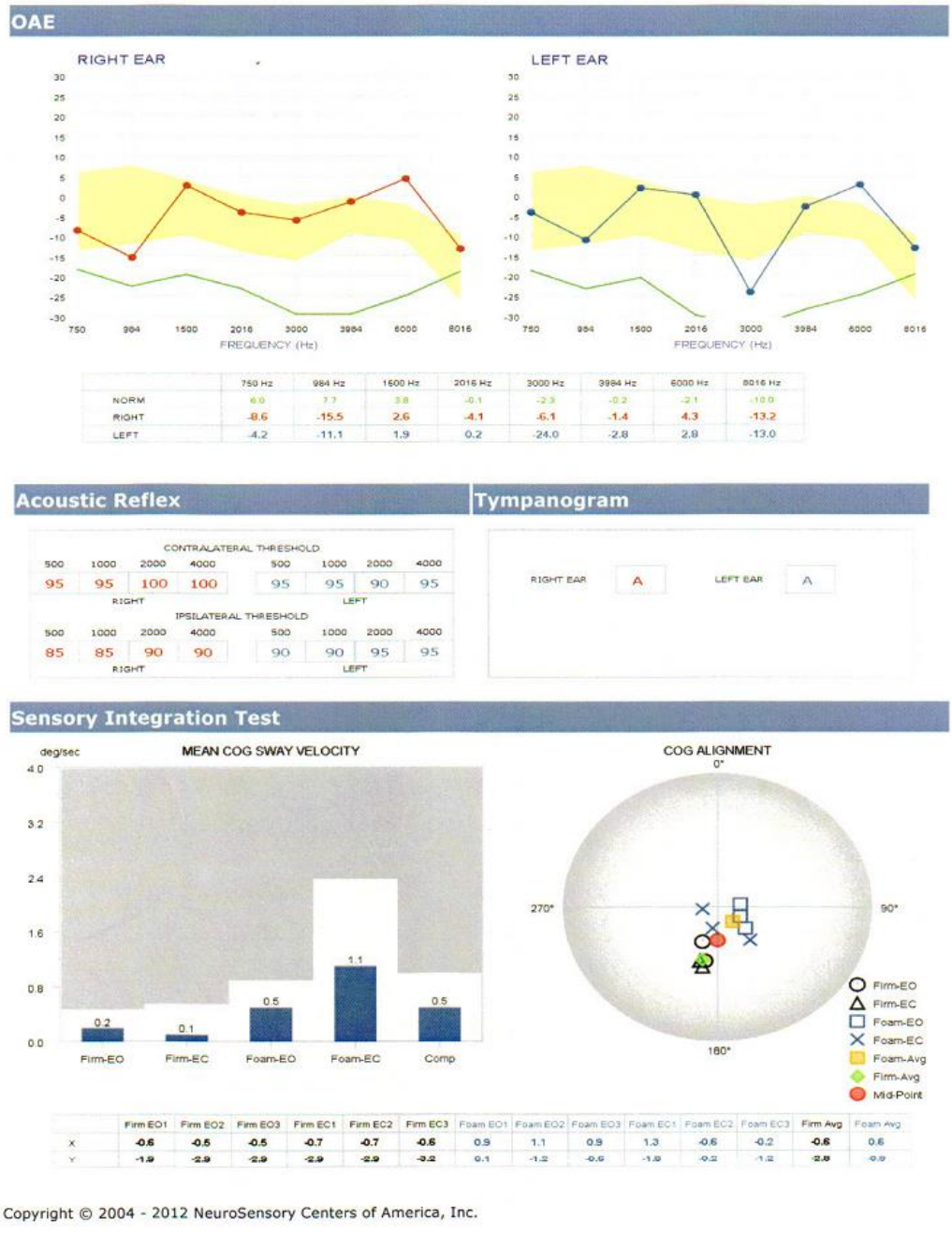


Figure 7. Complete acoustic test results (Stewart, K., Gonzalez, J., & Haynes, S. (2004-2012). Reprinted with permission.

For the CAR measurements, the normal measurement test threshold should be somewhere around 75 to 80 dB for tones, and 70 to 75 dB for general noise (Hain, 2014). From the example above, taken from a patient with depressive symptoms, abnormally high CAR measurement results were evident in both ears, with levels of 95 and 100 dB. The measurements in this study were like this example, with an average CAR measurement value presented for each ear of each patient. These measurements were tested against known published medically considered normal CAR measurements of patients with no depressive symptoms.

In this secondary quantitative data research, the test results consist of the OAE test for the right and left ears, the tympanogram, the CAR, the ipsilateral acoustic reflex, and the sensory integration test. These tests provide a complete functional depiction of the vestibular process for a test subject. The tympanogram results ensure proper middle ear functioning, without which the other test results would be inaccurate. The other tests, other than the acoustic reflexes, reveal whether there is a hearing loss other than in the middle ear. In our data analysis, we are only considering the CAR measurements, consisting of an average measurement from the four tests in each ear. All of the other measurements and test results from the audio testing are necessary to eliminate hearing loss as the cause for an abnormal CAR measurement.

To reiterate the reason for this, from Chapter 1, the dopaminergic pathways are those that carry signals in the brain to the basal ganglia using the neurotransmitter dopamine, which is connected to depression. The CAR, which directly connects physiologically with the stapedius muscle in the inner ear, also uses these pathways,

passing through the central nervous system from the ear on one side to the ear on the other. The stapedius involuntarily contracts in reaction to acoustic stimuli. This offers a chance to test the dopaminergic pathway to attempt to detect any depressive influence on that pathway, and thereby answer this study's research question: Do patients with depressive symptoms present abnormal CAR?

In summary, the other tests and their results were necessary to ensure that hearing loss did not cause the abnormal acoustic reflexes. The research question here deals only with the CAR, not with the other test results, however, as a secondary research study, all the testing and results were explained, as they were necessary for the reliability and purposes of testing the possible relationship between the CAR and depression.

Data Analysis Plan

The data was analyzed using Minitab, comparing the secondary test data to published and accepted normal CAR measurements of patients with no depressive symptoms (Hain, 2014). The null hypothesis was that depression is not related to the CAR measurements, while the alternative hypothesis was that patients with depressive symptoms do exhibit significant differences in the CAR when compared to those patients who do not present such symptoms.

The statistical method used was a single sample t-test, one for each ear, using the CAR measurement data discussed above, looking for a difference in CAR measurements in patients with depressive symptoms compared to the same CAR measurements in people with no such symptoms. The data also included other incomplete demographic data. The only commonality among those randomly selected for this study was some

type of depressive symptom(s) reported. The other demographic characteristics are also found in the population of non-depressed contralateral acoustic reflex data, against which this study's data was compared, and were not controlled in this study. There was no ability to correlate the results with the other demographic information, but there was some insight into future research that came out of that information.

Threats to Validity

The acoustic testing instrumentation and equipment used in this study have been extensively tested in the medical field and have proven their accuracy in the measurement of acoustic reflexes, thereby eliminating internal threats of instrumentation validity. Additionally, NSCA took the measurements for each patient once only, and in the same sitting, eliminating the internal validity threats of history, maturation, selection-maturation, and experimental mortality. Each of the vestibular functions that can be tested in this process are triggered by involuntary muscular responses, requiring no participation or response from the patients, and the CAR is an accurate test at multiple frequencies, and is easily quantifiable. Since the patients have no ability to affect the measurements voluntarily, the testing threat is a non-factor, as is the John Henry effect of an awareness of being tested. NSCA eliminated selection threats by randomization of normal patient protocols. External validity threats of reactions to pre-testing and experimental setups are not applicable to this testing method, and multiple treatment interference is likewise not a threat. Randomizing patients with some depressive symptoms enhances the external validity and the appropriateness of applying these results to patients with depressive symptoms in general.

Ethical Procedures

The secondary data was taken from The Neurosensory Centers medical practice patients and those patients gave permission for the data to be statistically analyzed with no revelation of identities of the individuals included in the random selection of data used in this study. Data is being kept in The Neurosensory Centers medical practice and is protected using medical industry standard methods. No ethical concerns are present in this study.

Summary

The purpose of this study was to determine the varying degree of acoustic abnormality in patients who present with depressive symptoms, and to attempt to link objective CAR to depression diagnosis. This chapter reviewed the research question in light of the physiological concepts and phenomenon behind the acoustic testing and its link to dopamine functioning in depressed patients. It also described the acoustic testing methods physiology, patient selection, acoustic testing instrumentation, patient data collection prior to testing, acoustic test data collection formatting, and discussed example acoustic test results. Chapter 4 presents the test results from the 52 participants.

Chapter 4: Results

Introduction

The purpose of this quantitative study of secondary data was to examine the relationship between CAR abnormality and depression in patients diagnosed with depressive symptoms. This relationship is significant because dopamine nigrostriatal pathways in the human brain share connections to both depression and the CAR. In this study, I worked to determine if there is a relationship between the independent variable of depression and the dependent variable of the CAR. If confirmed, further data studies can be conducted to establish a measurable relationship between CAR abnormities and markers for dopamine based on autonomic muscle reflexes. The primary research question and associated hypotheses were as follows:

RQ: Do patients with depressive symptoms present abnormal CAR?

H_0: There is no relationship between the CAR and depression.

H_1: There is a significant relationship between CAR and depression.

In this chapter, I review the data collection methods, the data, and the results of the hypothesis testing of the secondary data.

Data Collection, Demographics, and Screening Results

I randomly selected 52 participants, both male and female, from the secure medical database files of patients at the NSCA in Austin, Texas between 2012 and 2014. This database contained information from all patients who had received medical assessment, treatment, or consultations from Dr. Kendal Stewart, Chief Medical Doctor, or Wally Taylor M.D. These patients were diagnosed as depressed. Demographic

information included age, gender, depressive symptoms, and anti-depressants prescribed. Therefore, the sample provided a wide range of depressed patients, with no loading of any particular diagnosis and their corresponding CAR measurements. The overall auditory test results consisted of the OAE test for the right and left ears, the tympanogram, the CAR the ipsilateral acoustic reflex, and the sensory integration test. These tests were used to confirm that the basic auditory capabilities of all participants fell within normal ranges. As I explained in Chapter 3, these tests provide a complete functional depiction of the vestibular process for a test subject. The tympanogram results ensure proper middle ear functioning and the other tests, other than the acoustic reflexes, reveal whether there is a hearing loss other than in the middle ear.

Results and Analysis

The contralateral acoustic data for the right ear results and the left ear results were analyzed and tested separately. For both ears, a CAR score of 77.5 dB, an average of the normal range of 75-80 dB, provided the comparison score for the subject data (see Hain, 2014). The following is a table listing the average CAR scores for the study subjects for both the left and right ears, calculated using scores from each of four frequencies (500, 1000, 2000, and 4000 Hz), for each ear:

Table 1.

CAR Scores for All Test Subjects for Both Right and Left Ear

Right Ear Average CAR (dB)		Left Ear Average CAR (dB)	
97.5	88.75	93.75	87.5
110	100	110	102.5
85	90	87.5	102.5
88.75	102.5	92.5	92.5
90	90	98.75	90
107.5	83.75	110	82.5
98.75	81.25	110	81.25
92.5	86.25	97.5	86.25
97.5	100	98.75	110
98.75	95	105	100
96.25	91.25	87.5	90
90	83.75	96.25	83.75
110	93.75	102.5	90
110	83.75	102.5	86.25
95	88.75	88.75	91.25
105	88.75	100	88.75
98.75	87.5	88.75	85
88.75	92.5	91.25	92.5
87.5	92.5	88.75	88.75
110	92.5	110	91.25
110	90	110	93.75
87.5	97.5	87.5	90
105	96.25	105	83.75
110	93.75	96.25	97.5
93.75	96.25	100	91.25
91.25	106.25	90	110

For the right ear data set, the subjects averaged a 95.14 dB CAR result across the four tone frequencies tested, with a 90% CI of (93.28, 97.01), and a standard deviation of 8.04. Following is a graph of the data used for this test.

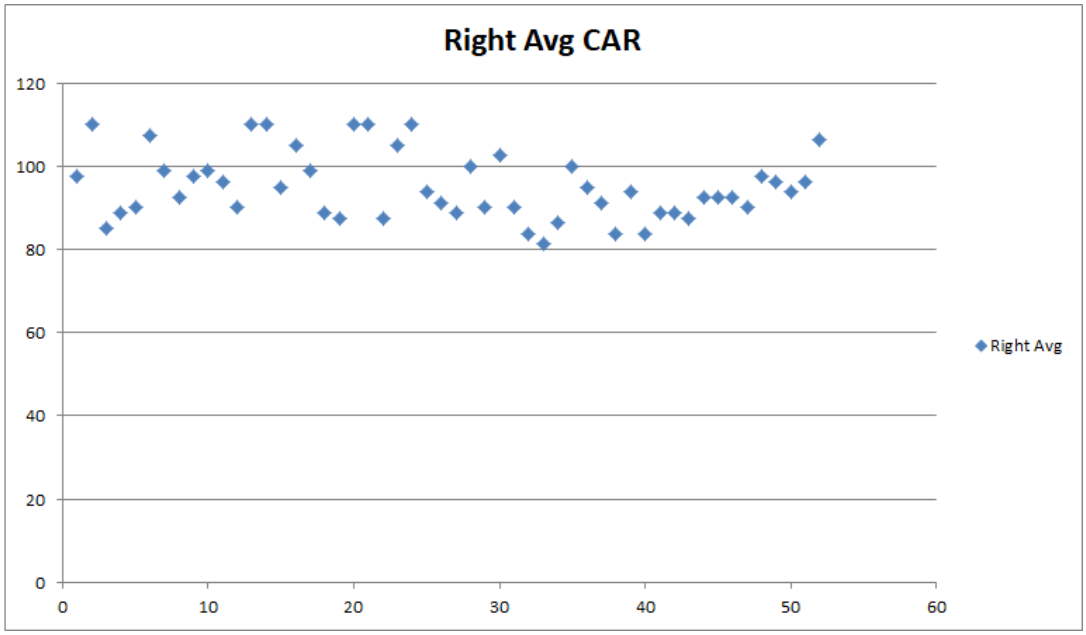


Figure 8. Right ear contralateral acoustic data graph.

I performed a one-sample *t* test with the hypothesized mean of 77.5 dB determined by medically-considered normal (non-depressed) acoustic reflex measurements described by Hain (2014). The population from which I drew the sample is considered normal, and the population standard deviation is unknown. I randomly selected the sample to satisfy the assumptions for running a one-sample *t* test (see Gravetter & Wallnau, 2004). The results of the statistical analysis indicated that the depressed subject scores were significantly higher than the normal average of 77.5 dB, $t(51) = 15.8$, $p < .001$, with a large effect size, $d = 2.19$. The test power result equaled

99.7, indicating a more than sufficient sample size in order to detect a mean difference in CAR results of at least 5.

For the left ear data set, the subjects averaged a 94.95 dB CAR result across the four tone frequencies tested, with a 90% CI (93.00, 96.90) and a standard deviation of 8.39. Following is a graph of the data I used for this test:

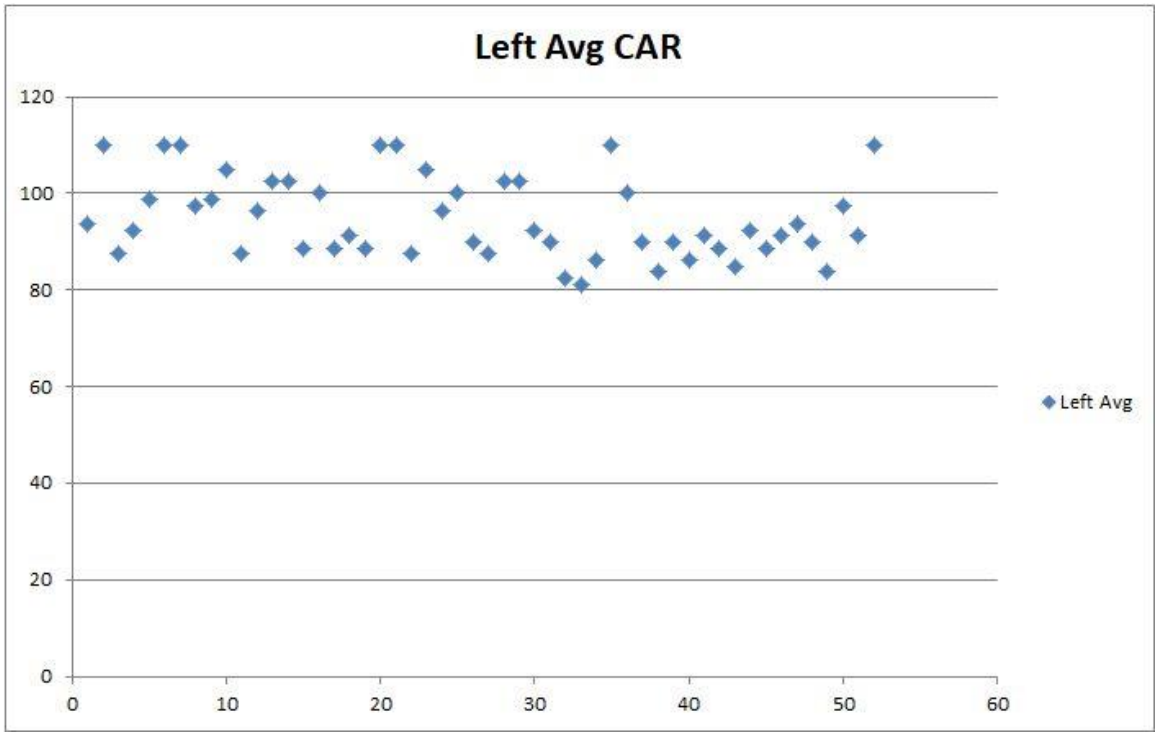


Figure 9. Left ear contralateral acoustic data graph.

I performed a one-sample *t* test, with the hypothesized mean of 77.5 dB determined by medically-considered normal (non-depressed) acoustic reflex measurements described by Hain (2014). The population from which I drew the sample is considered normal, and the population standard deviation is unknown. I randomly selected the sample to satisfy the assumptions for running a one-sample *t* test (see Gravetter & Wallnau, 2004). The results of the statistical analysis indicated that the

depressed subject scores were significantly higher than the normal average of 77.5 dB, $t(51) = 15.0$, $p < .001$, with a large effect size, $d = 2.08$. The test power result equaled 99.5, indicating a more than sufficient sample size in order to detect a mean difference in contralateral acoustic reflex results of at least 5.

Summary

The analysis provided significant evidence to reject the null hypothesis in favor of the alternate hypothesis that there is a significant relationship between CAR and depression. The test statistic was very large and the effect size for each ear was as well. These results indicate the need for further research using the detailed depressive symptom coding for patients and comparing the symptom codes with CAR test results. The data sets I used in this study contained both male and female subjects of all ages, and the data variation was relatively small, though research into differences between genders and any relationship of the results to patient age may still offer some insights. With the power and effect results from the test data, CAR testing is a promising vehicle for further investigation into its use in assisting mental health professionals objectively diagnose depression in their patients, supplementing the more subjective methods in use today.

Chapter 5: Summary, Recommendations, and Implications

Introduction

I conducted this study to analyze abnormalities associated with the CAR in order to see if that may be used to objectively diagnose whether or not patients are depressed, and to what degree. The study of depression in patients who present with depressive symptoms is complex, and lacks specific pathological blueprints that could clearly delineate, for mental health and medical professionals, the degree of patients' depression (Hyman, 2017).

The results of running one-sample *t* tests on randomly selected subjects for both right and left ear CAR scores indicated that depressed patients had significantly impaired thresholds when compared with the normal range of 75 to 80 dB at a confidence level of $p < .001$. The left ear average was 94.95 dB and the right ear average was 95.14 dB.

Interpretation of Findings

These results support my alternative hypothesis that there is a significant relationship between CAR scores and depression. This correlates with the idea that the vestibular system, of which the CAR is a component, can be seen as a modulating neural network complex that is involved in behavioral functions (Meli et al., 2007). Although researchers have not investigated the CAR as a potential aid in diagnosing depression, there has been research showing relationships between involuntary physiological responses and psychological behaviors. Bar-Haim (2002) found a link between physiological noise-sensitivity in adults and their insecure behaviors in social interactions. Although I make no specific suggestions for biological measurements, my

findings open the promising idea that the involuntary muscle responses the neurotransmitter dopamine provides within the human body's acoustic network may hold a key to using physiological measurements to diagnose depression (Bar-Haim, 2002). In addition, Alghowinem et al. (2013) reported encouraging findings relating acoustic features in spontaneous speech characteristics with effectiveness at detecting and classifying depression. These research results lend credible evidence of the potential relationship between the CAR and depression.

With the acoustic reflex neural network located in the lower brainstem and the CAR pathway passing through the central nervous system, there is a connection between the CAR and dopamine pathways in the brain. Researchers have described dopamine as a neurotransmitter playing a role in human functions such as cognition and motivation and have provided detailed examinations of the underlying biological mechanisms, including dopamine receptors, which cause this connection (Song, Li, & Arvey, 2011). Lewis (2011) reported dopamine's importance to the neuromodulator and goal-related behaviors, which are connected with an individual's motivation. Neuroimaging research on both human beings and animals has shown that a dopamine reduction appears to play a profound role in depression (McManamy, 2007). Nutt (2008) found a relationship between dopamine and norepinephrine (a product of dopamine) and MDD symptoms. He found that the increase or the decrease of neurotransmitters (e.g., dopamine) are associated with certain symptoms of depression (Nutt, 2008). All these results point to the possibility that abnormally high CAR thresholds indicate a problem with dopamine pathways and thus mark a link between the involuntary responses of the inner ear

stapedius muscle and depressive symptoms. The CAR takes a sound in one ear along the contralateral acoustic neuropathway from the inner ear to the cochlear nucleus of the central nervous system. It then travels to the opposite side superior olivary complex and facial nerve nucleus and nerve, enabling that stapedius muscle to contract enough to pull the stapes bone down and out, away from the middle ear (Emanuel, 2009). The results of my one-sample *t* tests on both the right and left CAR support the hypothesis that a depression-related lower presence of dopamine and dopamine receptors can potentially lessen the strength of signal provided to the stapedius muscle. That would then cause a rise in the baseline sound magnitude needed to reach the threshold of sound for a CAR response to occur, which would then be higher than a normal CAR threshold.

Limitations of the Study

The limitations of this study rest in four areas. The first includes varying patient demographics such as racial, ethnic, and gender. Most of the patients were White or Caucasian. There were no patients of African descent. According to The National Health and Nutritional Examination Survey III findings, African Americans and Mexican Americans present lower rates of depression than do White Americans. It is important to note that though African Americans and Mexican Americans have lower rates of depression, both groups have a higher lifetime rate of dysthymic disorder than do Whites (Riolo, et al, 2005). Results from survey studies do not allow for specific investigations into individual degrees of depression. Researchers can use the information from these results to be more aware of specific findings of ethnic/racial groups that begin to expose an individual's ability to recognize depression symptoms. The subjectivity of health

professionals in their diagnoses of depressive symptoms mark the need for a quantitative basis for diagnosis, which I sought to establish the groundwork for in this study.

The second, limitation of this study rests in the small number of male participants. This is important to note given the large amount of secondary data I collected for this study. According to Addis (2008) there are two differences that are consistently found in research between men and women regarding depression. First, men are less likely to focus on a depressed mood and are more likely to distract themselves. Second, women are more likely than men to seek help for depression. The differences between men and women are inconsistent and are mostly based on professional judgment.

The third limitation can be found in the wide span of depressive diagnoses of the patients who are treated in the medical practice where I conducted the research. The secondary data I used for this study was collected based on disclosure of depressive symptoms found in the patients' medical histories and charting. Though this was valuable information, patients were treated for a multitude of types of depression diagnoses, and I did not attempt to assess any associations between detailed depression diagnoses and CAR scores.

The fourth limitation of this study is the efficacy of dopamine in each individual patient in this study. Dopamine efficacy may be influenced by biological processes that may change daily, as well as by external stimuli such as weather, sounds, medication, and so on—none of which were controlled for the patients in this study. Research has shown that the density of dopamine receptors and dopamine synthesis are both reduced as a person ages, just as many physiological functions behave with aging (Mobbs & Hof,

2009). I did not take that into account in this study. Genetics also plays a part in dopamine receptors, as described by Pearson-Fuhrhop et al. (2013). These variations, along with the other limitations listed above, would be additional considerations for control in future studies of the CAR and depression.

This study attempted to test patient data to see if there is a relationship between the CAR and depression. The results supported the idea that there is such a relationship, and such a relationship may help researchers find an objective diagnostic process that health professionals in the field of psychology can use to make consistent diagnoses of depression.

Recommendations for Future Research

Vestibular System

Abnormalities in the acoustic reflexes of patients with depression provide one physiological response that health professionals can use to gain a better understanding of a patient's degree of depression. The entire vestibular system presents a unique area of study that may lead to quantifiable findings researchers can use to develop more specific guidelines for medical diagnoses of depression. I thus recommend carefully detailed and controlled studies of the possible matrix of relationships between the CAR and degrees of depression using a wide cross-section of patient demographics and varied degrees of depression. Future studies could also benefit by testing with groups of subjects with homogenous depression diagnoses, with subjects undergoing treatment with the same antidepressant medication, and by separating test subjects into age group clusters.

Assessment of the entire vestibular system could provide a more inclusive level of assessment for patients. Patients that may be deaf, blind, or disabled could then be included, due to the vast quantifiable responses the vestibular system as a whole provides the health professional.

Genetics

The research and analysis of antidepressant drugs has resulted in some depressed individuals having some success with medications and psychotherapy, but those treatments often fall short of the desired results. Discoveries regarding the molecular mechanisms of depression have led researchers to conduct further investigations into the genetics of depression using new DNA sequencing technologies to help identify mental disorders. The studies of the molecular mechanisms of autism and schizophrenia have led to new avenues of research into diagnosing types of depression, along with more targeted treatments (Hyman, 2017). These new lines of research may be coupled with the research of using CAR testing for depression, offering even more possible objective measures of depression for mental health professionals to use.. It is important to note that the spectrum of depression is vast in its scope of diagnosis and new research into the molecular mechanisms behind various mental disorders may help researchers understand depression at a deeper level.

Implications for Positive Social Change

Primary care physicians are the providers most often prescribing antidepressant medications to patients. This is concerning given their limited training in treating mental health disorders. Prescriptions for antidepressants are second only to prescriptions for drugs that lower cholesterol (Smith, 2012). Therefore, acoustic reflex abnormalities and their connection to depression would provide these professionals a more objective diagnostic method than solely relying on complex and unreliable symptom-based assessment of a depressed patient's reported self-perception.

Psychotherapy may be considered just as effective for depression as antidepressants. However, just like primary care physicians, psychotherapists rely heavily on professional judgment when diagnosing a patient's depression. Prescription privileges have been approved for psychologists in a few states. The APA has been communicating with a number of other states regarding these privileges, but the American Medical Association and APA oppose these privileges out of concerns for patient safety. A number of mental health professionals believe that a combination of psychotherapy and appropriately trained psychologists may provide the best treatment outcome for prescribing antidepressants to patients. Assessment and study of quantifiable findings regarding markers for dopamine could present quantifiable outcomes regarding patients' mental states. This presents a significant implication for positive social change that very well may influence which medical and/or therapeutic options are best for individual patients presenting depressive symptoms (see Smith, 2012).

Finally, this research offers individuals a better understanding of their present state of mind in real time. Educating patients and quantifying their depressive states may help them gain some understanding of their depression and better grasp the degree of their depression.

References

Addis, M. (2008). Gender and Depression in Men. *Clinical Psychology*, *15*(3), 153-168. doi:10.1111/j.1468-2850.2008.00125.x

Alghowinem, S., Goecke, R., Wagner, M., Epps, J., Breakspear, M., Parker, G. (2013, October). *Detecting depression: A comparison between spontaneous and read speech.* Paper presented at the Acoustics, Speed and Signal Processing (ICASSP) IEEE International Conference, Vancouver, BC. doi:10.1109/ICASSP.2013.6639130

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, D.C: Author.

Armstrong, D., Meenagh, G., Bickle, I., Lee, A., Curran, E., & Finch, M. (2006). Vitamin D deficiency is associated with anxiety and depression in fibromyalgia. *Clinical Rheumatology*, *26*(4), 1-4. doi:10.1007/s10067-006-0348-5

Bar-Haim. (2002). Introversion and individual differences in middle ear acoustic reflex function. *International Journal of Psychophysiology*, *46*, 1-11. Retrieved from www.elsevier.nl/locate/ijpsycho. doi:10.1016/S0167-8760(02)00036-3

Baloh, R. W., & Honrubia, V. (2001). *Clinical neurophysiology of the vestibular system* (3rd ed.). New York, NY: Oxford University Press.

Barbui, C., Esposito, E., & Cipriani, A. (2009). Selective serotonin reuptake inhibitors and risk of suicide: a system review of observational studies. *Canadian Medical Association*, *180*(3), 291-297. doi:10.1503/cmaj.081514

Drevets, W., Price, J., & Furey, M. (2008). Brain structural and functional abnormalities in mood disorders: implications for neurocircuitry models of depression. *Brain Structure and Function, 213*, 93-118. doi:10.1007/s00429-008-0189

Emanuel, D. C. (2009). Acoustic reflex threshold (ART) patterns: an interpretation guide for students and supervisors. Retrieved from http://www.audiologyonline.com/articles/acoustic-reflex-threshold-art-patterns-875.

Gensichen, J., Michael, K., Peitz, M., Muth, C., Beyer, M., Guthlin, C., . . . Peterson, J. (2009). Case management for depression by health care assistants in small primary care practices. *Annals of Internal Medicine, 151*(6), 369-378. doi:10.7326/0003-4819-151-6-200909150-0-00001

Gierek, T, Slaska-Kaspera, A. (2007). The stapedius muscle – the present opinions about anatomy and physiology. *Otolaryngologia Polska, 61*(1): 29-32. doi:10.1016/S0030-6657(07)70379-7

Gravetter, F. L., & Wallnau, L. B. (2004). *Statistics for the behavioral sciences*, (6th *ed*.). Belmont, CA: Wadsworth/Thomson Learning.

Hain, T. C. (2014). Acoustic reflexes. Retrieved from http://www.dizziness-and-balance.com/testing/acoustic_reflexes.htm.

Holick, M. F. (2007). Vitamin D deficiency. *New England Journal of Medicine, 357*, 266 -281. Retrieved from www.nejm.org. doi:10.1056/NEJMc072359

Hyman, S. E. (2017). A new hope for biological insights into depression. *Biological Psychiatry, 81*(4), 280-281. doi:10.1016/j.biopsych.2016.12.001

Isacsson, G., Rich, C., Jureidini, J., & Raven, M. (2010). The increased use of antidepressants has contributed to the worldwide reduction in suicide rates. *British Journal of Psychiatry*, *196*, 429-433. doi:10.1192/bjp.bp.109.076166

Jimenez, D., Alegria, M., Chen, C., Chan, D., & Laderman, M. (2010). Prevalence of psychiatric illnesses in older ethnic minority adults. *American Geriatrics Society, 58*(2), 256-264. doi:10.1111/j.1532-5415.2009.02685.x

Lecrubier, Y. (2008). Recognizing and effectively treating depression. *CNS Spectrums, 13*(7), 5-9. doi:10.1017/S109285290002825X

Leon, A., Marzuk, P., Tardiff, K., Bucciarelli, A., Stajic, M., Piper, T., & Galea, S. (2007). Antidepressants in adult suicides in New York City, 2001-2004. *Journal of Clinical Psychiatry*, *68*, 1399-1403.

Leu-Semenescu, S. et al. (2010). Sleep and rhythm consequences of a genetically induced loss of serotonin. *Sleep, 33* (03), 307-314.

Lewis, M. (2011). Dopamine and the neural "now." *Perspectives on Psychological Science*, *6*(2), 150-155. doi:10.1177/1745691611400235

Licinio, J., & Wong, M. (1999). The role of inflammatory mediators in the biology of major depression: Central nervous system cytokines modulate the biological substrate of depressive symptoms, regulate stress-responsive systems, and contribute to neurotoxicity and neuroprotection. *Molecular Psychiatry*, *4*(4), 317-327. doi:10.1038/sj.mp.4000586

McManamy, J. (2007, May 9). Dopamine, serotonin's secret weapon. Retrieved from http://www.google.com/search?sourceid=navclient&aq=2&oq=differences in

dopamine and serotonin&ie=UTF-8&rlz=1T4SKPT_enUS443US444&q=depression serotonin and dopamine&gs_upl=0l0l1l111055lllllllllll0&aqi=s18

Meli, A., Zimatore, G., Badaracco, C., Angelis, E., & Tufarelli, D. (2007). Effects of vestibular rehabilitation therapy on emotion aspects in chronic vestibular patients. *Journal Psychosomatic Research*, *63,* 185-190. doi:10.1016/j.jpsychores.2007.02.007

Mitjans, M., & Arias, B. (2012). The genetics of depression: What information can new methodologic approaches provide? *Acts Españolas De Psiquiatría*, *40*(2), 70.

Mobbs, C. V., & Hof, P. R. (2009). *Handbook of the neuroscience of aging*. Amsterdam: Elsevier/Academic Press.

Nutt, D. J. (2008). Relationship of neurotransmitters to the symptoms of major depressive disorder. *Journal of Clinical Psychiatry*, *69*(suppl E1), 4-7. doi:10.1007/springerreference_116852

Pearson-Fuhrhop, K., Minton, B., Acevedo, D., Shahbaba, B., & Cramer, S. (2013). Genetic variation in the human brain dopamine system influences motor learning and its modulation by l-dopa. *PLoS One*, *8*(4), 1. doi:10.1371/Journal.pone.0061197

Riolo, S., Nguyen, T., Greden, J., & King, C. (2005). Prevalence of depression by race/ethnicity: findings from the national health and nutrition examination survey III. *American Journal of Public Health*, *95*(6), 998-1000. doi:10.2105/AJPH.2004.047225

Smith, B. (2012). Inappropriate prescribing. *American Psychological Association, 43*(6), 36.

Song, Z., Li, W., & Arvey, R. (2011). Associations between dopamine and serotonin genes and job satisfaction: preliminary evidence from the add health study. *Journal of Applied Psychology*, 1-5. doi:10.1037/a0024577

Stewart, K., Gonzalez, J., & Haynes, S. (2013). NeuroSensory Centers of America. Austin, TX.

Substantia Nigra. (2013). Medical Neurosciences. Madison: University of Wisconsin. Retrieved from http://www.neuroanatomy.wisc.edu/virtualbrain/BrainStem/20Substantia.html

Vestergaard, P. (2008). Skeletal effects of central nervous system active drugs: anxiolytics, sedatives antidepressants, lithium and neuroleptics. *Current Drug Safety, 3*(3), 185-189. doi:10.2174/157488608785699432

Wallis, C. (2009). Study: early therapy can save teens from depression. *Time Magazine*. Retrieved from http://content.time.com/time/health/article/0,8599,1902500,00.html

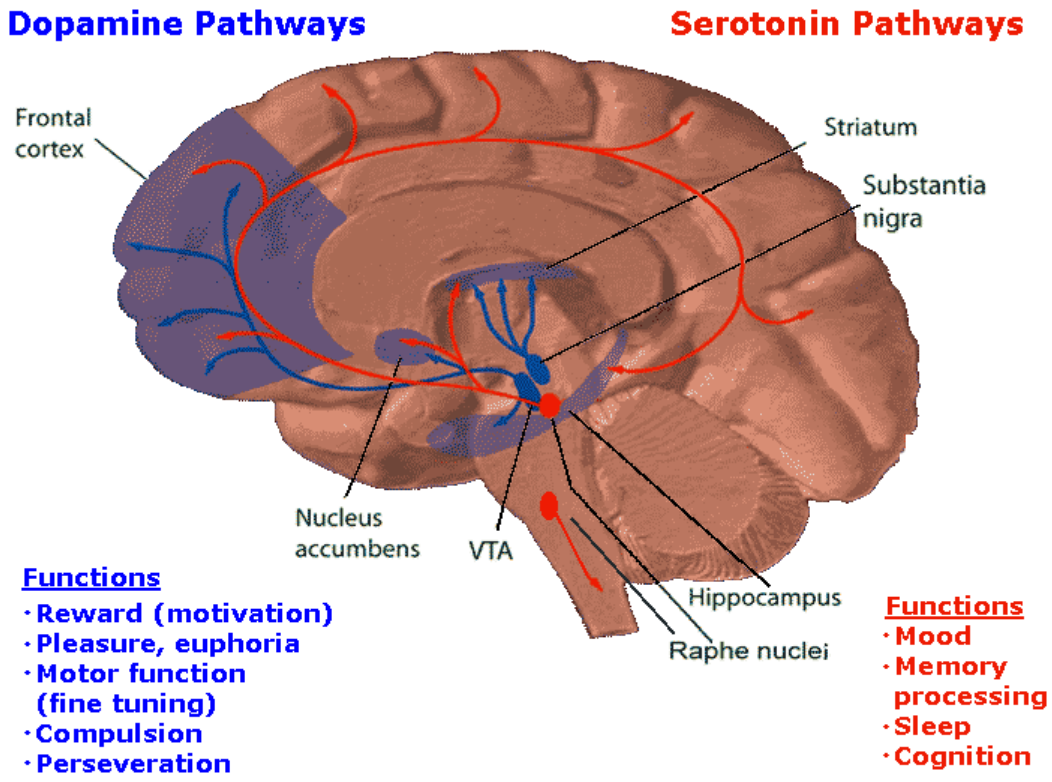
Wallis, C., Cloud, J., Szalavitz, M. (2013). Same genes, multiple disorders. *Time Magazine: 100 New Health Discoveries.* New York: Time Magazine Publishing.

What is depression. (2015). *American Psychiatric Association*. Retrieved from http://www.psychiatry.org/patients-families/depression/what-is-depression

Wilkins, C., Yvette, S., Catherine, R., Birge, S., & Morris, J. (2006). Vitamin d

deficiency is associated with low mood and worse cognitive performance in older adults. *American Association for Geriatric Psychiatry*, *14*(12), 1032-1040. doi:10.1097/01.JGP.0000240986.74642.7c

Appendix A: Dopamine and Serotonin Pathways



Appendix B: NSCA Letter of Permission

NeuroSensory Centers of America
Austin

Kendal Stewart, M.D.
John Gonzales, P.A.C.
Susan Haynes, L.F.N.P

Octavious Bishop
Walden University

April 14, 2018

Re: Use of Sensory-View Graphics

To whom it may concern,

I, Kendal Stewart, MD, as the Director and Chairman of Sensory-View of America and Neuro-Sensory Centers of America, hereby grant to Octavious Bishop the right to publicly display any copyrighted and proprietary materials utilized in his dissertation thesis.

Should you have any questions regarding this release, then feel free to call me.

Sincerely,

Kendal Stewart, M.D.
Neurotology / Neuro-Immune Specialist
Chairman and Chief Science Officer
Sensory-View of America
Neuro-Sensory Centers of America
GX Sciences
Neurobiologix

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Curriculum Vitae

Octavious Bishop

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Director of Player Development (2016-Football)/Director of Student Leadership and Personal Development , Jun 2018 – Aug 2018

- My responsibilities in short was to provide strategy and implementation of programs to support student-athlete development in the Texas Athletics program, a complex and dynamic program with varying needs in a large population of student-athletes.

Professional Football; NFL; XFL, Apr 1999 – Feb 2002

Education

WALDEN UNIVERSITY, MINNEAPOLIS, MINNESOTA
General Educational Psychology Candidate Expected graduation, Apr 2018

- My area of focus is grounded in assessing quantifiable physiological makers for dopamine in individual struggling with depression.

UNIVERSITY OF TEXAS, AUSTIN, TEXAS
Masters in the Science of Social Work, May 2008

UNIVERSITY OF TEXAS, AUSTIN, TEXAS
Bachelor's in the Science of Social Work, May 2001

Work Experience

AUSTIN COMMUNITY COLLEGE, AUSTIN, TEXAS
Associate Adjunct Professor, Jan 2011 – Present

- My responsibilities are to provide a safe, mentally stimulating educational environment that will maximize the cognitive potential of the students exposed to my classroom setting, culture, and teaching philosophy.

Inspirational Speaker, Jan 2015 – Present