UNIVERSITY OF CAPE COAST

# MUSIC PERFORMANCE AND BRAIN RESPONSES: THE CASE OF MUSIC AND DANCE STUDENTS OF UNIVERSITY OF CAPE COAST

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Thesis submitted to the Department of Music and Dance of the, Faculty of Arts, College of Humanities and Legal Studies, University of Cape Coast, in partial fulfilment of the requirements for the award of Doctor of Philosophy degree in Music Education

JUNE 2020

# DECLARATION

## Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere

Candidate's Signature………………………………. Date…………………......

Name……………………………………………………………………………

## Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature………………………….……Date…………..

Name……………………………………………………………………………...

Co-Supervisor's Signature…Maria Witek…………………..…Date…15.10.2021…

Name: Maria Witek………………………………

# ABSTRACT

This study was about investigating music performance and brain responses among undergraduate students of the Music department of University of Cape Coast. The purpose of the study was to investigate the following: possible statistically significant differences in brain response to reading of song lyrics and singing of song as well as brain response among student with long exposure and limited exposure to music. Further, the study sought to investigate possible statistically significant differences in responses to singing by the four lobes of the brain; frontal, parietal, temporal and occipital. Census method was used with a total of fifty respondents (N=50). Data for the study was collected using Electroencephalogram (EEG) machine. The data was computed and analysed using quantitative techniques. Two statistical tools were employed in testing the hypothesis formulated; the t-test for hypothesis one and two while the two-way ANOVA was used to analysed hypothesis three. Within subject dependent variables, a Repeated Measures ANOVA with a Greenhouse-Geisser correction, Wilks' Lambda statistical tests were observed during computation of data. Result show that there was no statistically significant evidence of difference in the brain responses when respondents read or sing lyrics of a song ($p>0.873$). Also, there was no evidence of statistical difference in the brain responses to singing and reading by students with long period of exposure or limited exposure to lyrics of a song ($p>0.394$). Finally, there were statistically significant differences in responses of the four brain lobes (frontal, parietal, temporal and occipital lobes) to singing among the study participants ($p<0.025$).

## KEY WORDS

Cognitive

Musical performance

Neuroanatomy

Neurological

Physiognomies

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## DEDICATION

To God Almighty, Professor Amuah, Dr. Eric Debrah Otchere, my family, and my dear wife Diana Mawufemor Amedzro-Dzakey.

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| | |
|---|---|
| **EEG -** | Electroencephalogram |
| **TMS -** | Transcranial Magnetic Stimulation |
| **MEG -** | Magnetoencephalography |
| **fMRI -** | Functional Magnetic Resonance Imaging |
| **PET -** | Positron Emission Tomography |
| **SPECT -** | Single-Photon Emission Computed Tomography |
| **CNS -** | Central Nervous System |
| **SES -** | Socio-Economic Status |
| **IT -** | Information Technology |
| **CRDD -** | Curriculum Research and Development Division |
| **ICT -** | Communication Technology |
| **BCI -** | Brain-Computer Interface |
| **CSV -** | Comma-Separated Value |
| **SPSS -** | Statistical PaKage for Social Sciences |
| **B.I -** | Brain Index |
| **SPS -** | Samples Per Second |
| **BR -** | Brain Response |

# CHAPTER ONE

# INTRODUCTION

Throughout my studies in the field of music education and psychology, I became exposed to cognitive psychology of music. In reading towards my doctoral studies, I became aware of the relationship between music and the brain. This realisation triggered my interest in finding out in detail how the brain reacts to the singing and reading of lyrics of songs. I was, therefore, motivated to investigate the difference between brain responses to singing and reading of lyrics by students with long period of exposure to music and those with limited exposure to music. I therefore, finally, investigate also, the significant differences in brain response of the various brain lobes to singing.

## Background to the Study

This study is about music, performance and brain responses in humans. In terms of music, there are numerous definitions of the word "music" from various backgrounds, disciplines and in different contexts. However, one fundamental word that runs through all of them is sound. It is therefore justifiable to say that music is sound (Rodgers, 2010). Meanwhile, not every sound is music unless it is organized with the intention of making it music. As a result, one may surmise that music is sound that is organized. So far, researchers have not confirmed that the sound generated by specific nonhuman living creatures such as apes and birds is music (Heinsohn, Zdenek, Cunningham, Endler, & Langmore, 2017). So, it is obvious that music is an attribute of humans. Peretz, (2006) confirms that "music is generally regarded as an exquisite art form, a refined product of human culture." She continues that other cognitive scientist also say that "music is cognitive architecture.

Music is an intangible that induces different kinds of feelings in humans and for that matter it is also defined as an intangible object with an affective domain. Peretz, (2006: p22) explains further that:

> "Emotion is an integral part of the music experience. This emotional power is something of a mystery or paradox because of the abstract, nonrepresentational nature of music. Yet, music is a powerful tool for emotion and mood modulation, as further discussed in (Peretz, 2006). Movement is a key component of emotional reactions to music. Much music is composed with very specific action tendencies in mind getting people to sing, to dance, march and fight, or work and play together." Peretz, (2006: p22).

This is true and evident in some phenomena such as people listen to music and the consequent reaction is weeping and other drastic change of behaviour.

Performance

Performance is an activity found in the various disciplines under the humanities with diverse forms of the arts as well as aspects of life in socio-cultural contexts (Bunt & Stige, 2014; Gade, & Jerslev, Eds. 2005). Performance raises fundamental issues about bodily praxis, human agency, temporality, and discursive knowledge, conventional understandings of tradition, repetition, mechanical reproduction, and ontological definitions of social order and reality. According to scholars "performance is a contested concept," meaning that it is bound up in disagreement about what it is, and that disagreement over its essence is itself part of that essence" (Drewal et al. 1991). In other words, performance has no precisely agreed upon definition. Rather it varies in scope and import from one academic discipline to another and from one practitioner, or human agent, to another." For example, socio-culturally in the African context, if you visit a workplace and find a person "shouting" above everyone's voice and giving orders, it is a "performance" that shows that he/she is in charge or in a position as the head. It is also a psychological phenomenon that has to do with neuro-cognitive consciousness of the person's psyche. There is performance in linguistic verbal art and also in the performing arts which include music, dance and drama (theatre arts).

In spite of the numerous concepts of performance, Drewal defines performance as the practical application of embodied skills and knowledge to the task of taking action in everyday social life, Drewal et al. (1991; Allen, Anderson, Andrade, Angrosino, Appadurai, Appadurai, & Ashkenazi, 2012). This definition is open-ended by embracing performance in many disciplines. After considering the controversies in other disciplines, she explains further that:

> "In the broadest sense, performance is the praxis of everyday social life; indeed, it is the practical application of embodied skill and knowledge to the task of taking action. Performance is thus a fundamental dimension of culture as well as the production of knowledge about culture. It might include anything from individual agents'

> negotiations of everyday life; to the stories people tell each other, popular entertainments, political oratory, guerrilla warfare, to bounded events such as theater, ritual, festivals, parades, and more." Drewal et al. (1991).

Drewal et al's explanation clarifies performance in general terms. In poetry, Bauman and Briggs (1990) call it "the enactment of the poetic function" as well as the authoritative display of communicative competence, features of performance that have been of particular concern in sociolinguistics and folklore. This means that every performance is preceded by rehearsal for mastery and competence, and this principle applies to performance in music.

Music performance cuts across the vast scope of the music practicum from instrumental to vocal dimensions and also from solo to group performances (Gohlke, 1994). Scholars found out that each of the music performances involve skill training, practice, mastery and professional competence (Hambrick, Oswald, Altmann, Meinz, Gobet, Campitelli, 2014). Music performance involves both physical and mental pragmatics: physically, the body muscles and posture must be acclimatized to the act to permit flow and this is attained by several hours of rehearsal each day for months or years depending on the particular musical activity (Lambert, Viljoen, Bosch, Pearce, & Sayers, 2008). Mentally, it requires a lot of cognitive processes attained also by repetition of each concept until it is registered in the subconscious mind to make way for flow. These culminate into the achievement of high sense of creativity exhibited through embellishments and improvisation which are all dependent on that assemblage of all the previous cognitive ideas and experiences of learning and rehearsal phenomena.

Music Performance

Music performance is the platform for exhibiting one's musical achievement. It is preceded by a lot of preoperational process of learning and rehearsal. The questions to consider however are what happens to the brain before, during and after the learning process. Furthermore, does neuroscience supports the idea that musical achievement is attained by how gifted and talented the musician is, and also whether by now, the practice of neuroscience has benefited musicians by way of helping them to develop their musical learning, skill and performance to the greatest height. We are aware that neuroscience provides deep insight into the vital processes that advances knowledge particularly in training, rehearsal or practice in order to attain musical excellence. Perfection comes out of practice, they say, but has neuroscience researches actually proved that "practice truly makes perfect"? It is true with many other endeavors in life but how perfect is perfect? This study goes a long way to find out how the brain works during multiple practice, reading music and singing.

What has been done with Music Performance and its effects on the Brain

The pioneers in music performance research including other scholars concentrated on music reading and its effective use which is just an aspect of musicianship as the knowledge of music. They conducted the study by comparing a group of musicians and another set of non-musicians and found out that after taking three months of piano lessons, the brains of the set of non-musicians showed a different pattern of activation in response to musical notation differently from before the study. According to them, they developed different learning-related patterns with melody from rhythm in music notation. This means that, their brain firing pattern differs with melody reading from rhythm reading during the experiment. They indicated that the brain changes after learning to read and play music**.** They also observed that musicians who continue to perform regularly develop higher intuition, and that, "the melodic and rhythmic information contained within single notes are processed simultaneously." This suggests that they depend on different specializations within the brain for the two musical exercises.

That which is interesting about the study is that, the changes in the brain's response to notation occurred just after a short period of the training, and at this early stage of the learning process, the brain conditioned itself to process music notation automatically. Sight reading modifies spatial mapping in pianists, (Perception and Psychophysics, 66: 183–195.) Scholars confirmed from the neuroimaging data observed.

Brain Responses

Studies about music and brain responses have been evidenced as growing interest of research in recent years. (Fujioka, Ross, Kakigi, Pantev, Trainor, 2006). However, investigating the phenomena of music performance and brain responses has also become an interesting concern for scholars (Amaducci, Grassi, and Boller, 2002; American Psychiatric Association, 2013; Ashoori and Jankovic, 2007; Bandettini, 2009 Bäzner, Hennerici, 2010). For example, Thaut (2005) reports about the fact, and how music has received an exceptional research focus in brain-based investigations in the past years. In his study, he observed that music has established a high relationship with brain-based studies.

Scholars in recent years have perceived a significant upsurge in the number of scientific investigation and periodicals within the field of neuroscience and music education that facilitate the relationship between music and the brain**.** This current study examined brain responses to music as students engaged in music reading and singing performances in the Ghanaian context.

It is evident in this 21st century the need for the evolution of neuroscience which cannot be overemphasised over the brain-based investigations which are ingress to the field of music and neuroscience research. In other developments, neuroscience researchers have interest in the understanding of neural induction and pattern formation, sensory system, cellular components of nervous tissues, intracellular signaling, brain energy metabolism, nervous system development, among others. The use of various gadgets such as Diffusion tensor imaging (DTI), Positron emission tomography (PET), and Single photon emission computed tomography (SPECT) among other gadgets have accelerated the generation of knowledge beneficial for understanding the function of the brain. The neuroanatomy of musical expectancy, emotion, listening and performance are discussed and how music exploits these cognitive processes. It is observed that progressions in neuroscience illuminate the traditional understanding of the human mind, many of the new insights are also of relevance to musicians as well as to music pedagogy (Abraham, 2015; Altenmüller & Schlaug, 2015; Ashoori & Jankovic, 2007; Bandettini, 2009 & Hodges, 2010).

Moreover, it is an indubitable fact that the greater understanding of how inter-subjective processes are integral to the development of the right brain has shown how, according to the neuropsychoanalyst Schore (2012), right-brain models can bridge the fields of psychiatry, music and trauma. However, George Bush's project 'the Decade of the Brain', spanning the years 1990–1999, has already acknowledged the need to 'enhance public awareness of the benefits to be derived from brain research. However, research instruments such as Electroencephalogram (EEG), Functional Magnetic Resonance Imaging (fMRI) and Magnetic resonance imaging (MRI) are among other modern neuroscience technological approaches that support research in measuring brain activities.

As neuroscience is gaining prominence around the globe with empirical research, it has been revealed that cerebral cortex self- organises as we engaged with different musical participations. Skills in these areas may then transfer to other activities if the processes are comparable. Some of these skills transfer automatically without our conscious awareness.

However, some skills transfer automatically without our conscious awareness, notwithstanding, a required reflection on how they might be utilised in a new situation is yet to be addressed (Pantev et al., 2000; Albright, Kandel, & Posner, 2000).

**Statement of the Problem**

The cognitive neuroscience of music according to scholars is the scientific study of brain-based mechanisms involved in the cognitive processes underlying music (iller et al, 2011). These behaviours include music listening, performing, composing, reading, writing, and ancillary activities (Rose, 2016;

Hahne, & Friederici, 1999). The brain is composed of three parts; the brainstem, cerebellum, and cerebrum (Duvernoy, 2012; Dobbing, Hopewell, & Lynch, 1971; Winick, Rosso, & Waterlow, 1970). The cerebrum is divided into four lobes: frontal, parietal, temporal, and occipital. Scholars agree that the cerebrum is the largest part of the brain and is composed of right and left hemispheres (Hagmann, Cammoun, Gigandet, Meuli, Honey, Wedeen, & Sporns, 2008; Bokde, Teipel, Schwarz, Leinsinger, Buerger, Moeller, & Hampel, 2005; Raz, Gunning-Dixon, Head, Rodrigue, Williamson, & Acker, 2004; Cohen, Dehaene, Naccache, Lehéricy, Dehaene-Lambertz, Hénaff, & Michel, 2000). It is also upheld that cerebrum is a large, folded mass of nervous tissue that makes up the majority of the human brain. Many ridges of cerebral tissue, called gyri (singular: gyrus), extend from the surface of the cerebrum and are bordered by grooves in the cerebrum. The brainstem includes the midbrain, pons, and medulla. In the study, the use of Electroencephalogram (EEG) has been significantly functional and that the instrument (EEG) was determined as one of the major data collection instruments (Edlow, McNab, Witzel, & Kinney, 2016; Guérit, Amantini, Amodio, Andersen, Butler, de Weerd, & Lamblin, 2009; Carrion, Weems, Watson, Eliez, Menon, & Reiss, 2009).

Scholars have found that music highly contributes to the development of various disciplines offered in schools.

In terms of discipline, scholars found out that having some experiences in music and neuroscience, appreciate the interdisciplinary approach as a way to capture learners' interest and to reflect the integral link of neuroscience (Jones, 1994). Though considerable research has emerged in the field of music education over the past half of a century, studies in brain responses to music have been in its developing stages in the field of music education (Mark, & Madura, 2013; Schippers, 2009; Fujioka, Ross, Kakigi, Pantev, & Trainor, 2006; Thaut, & Thaut, 2005; Swanwick, 2003; Jorgensen, 2003; Green, 2002). Most of the researches in this area has been done in Western and Asian countries. In Africa as a whole it is very difficult to trace research in the field of music and neuroscience most especially, in Ghana (Schippers, 2009 & Bruer, 1997).

My engagement with the literature in the field of music and neuroscience have shown that little or no research in the area of music performance and brain responses in the field of music education has been conducted in Africa and for that matter in Ghana. In addition, performers' brain response as they engage in reading and singing performances of music has not been given enough attention in the literature. This research therefore aimed at examining brain responses as students engage with musical performance, particularly music reading of song lyrics and singing of a song).

**Purpose of the Study**

The purpose of this study was to examine brain responses to the reading of lyrics and singing performance.

**Objectives of the Study**

The specific objectives of this study were:

1. To investigate the extent to which brain responses of students engaged in reading activity differ from the brain responses of students engaged in singing activity.

2. To examine the differences in brain response to music between students with long exposure to music and those with limited exposure to music before entry into a university music programme
3. probe the differences in brain responses to a singing activity among the four brain lobes.

**Research Hypothesis 1**

$H_0$: there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity

$H_1$: there are statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity

**Research Hypothesis 2**

$H_0$**:** There are no statistically significant differences in brain response to music between students with long period of exposure to music and those with limited exposure to music before entry into a university music programme

$H_1$: There are statistically significant differences in brain response to music between students with long period exposure to music and those with limited exposure to music before entry into a university music programme

**Research Hypothesis 3**

$H_0$: There are no statistically significant differences in brain response to singing among the four brain lobes.

$H_1$: There are statistically significant differences in brain response to singing among the four brain lobes.

**Significance of the Study**

The overall rationale of this research was to bring to the attention of educational practitioners the relevance of music in the cognitive and intellectual development of learners. Particularly the results will aim at gaining better understanding of a subject (The Cognitive Neuroscience of Music), and will primarily focus on the advancement of knowledge rather than solving a specific problem. It is believed that the data emerging from the results of the study will serve as vital information for music educators who may incorporate lessons learned from the study into the design of pedagogical activities with the view to optimizing learning outcomes and making learning more exciting especially among young learners.

This study will also create awareness for both music teachers and students about how musical exposure can inform the practices and procedures of teaching and learning of music.

**Delimitation of the study**

This study is delimited in terms of geographical and content scopes. Regarding geographical delimitation, only music and dance students within the Department of Music and Dance of the University of Cape Coast in the Central Region of Ghana were involved in the study. This is because, there were reasonable number of music and dance students within the music and dance department of the university from which a large sample can be drawn for a meaningful quantitative study. Furthermore, the content of the study was limited to brain response to reading of song lyrics and singing of a song. Other forms of music performance such as playing of musical instruments, dancing fall outside the scope of this study.

**Limitation of the study**

Like any other one, this study has its own limitations. Study limitations largely tend to arise from the methodology used, so is the case of this study.

Scholars have proposed that the larger the sample size the more accurate results can be, as this may help reduce statistical uncertainty. It is believed that with a sample size of about 30, the result of a study on students' brain responses to music can be more reliable.

In the case of this study, even though a total of 50 students were used as respondents, a much larger number would have been preferred since such a number has a greater statistical potential to generate results with higher precision.

The respondents were pre-informed about the due data collection process after which agreement form was given to them to be filled. On the day (day 1) scheduled for the data collection, only 7 out of 32 of the first years were present between the hours of 6am and 7pm within the university premises. This was actually a great challenge to me during this Novel Corona virus pandemic era due to the increasing nature of the said pandemic. On some two occasions, I could not meet even a single student to collect data on.

**Theoritical Framework**

SHAW'S THEORY:

The framework below explains how our daily music performance activities are been supported by Shaw's theory. Shaw postulate that neural firings are triggered by singing and playing music (Shaw et al, 2005)

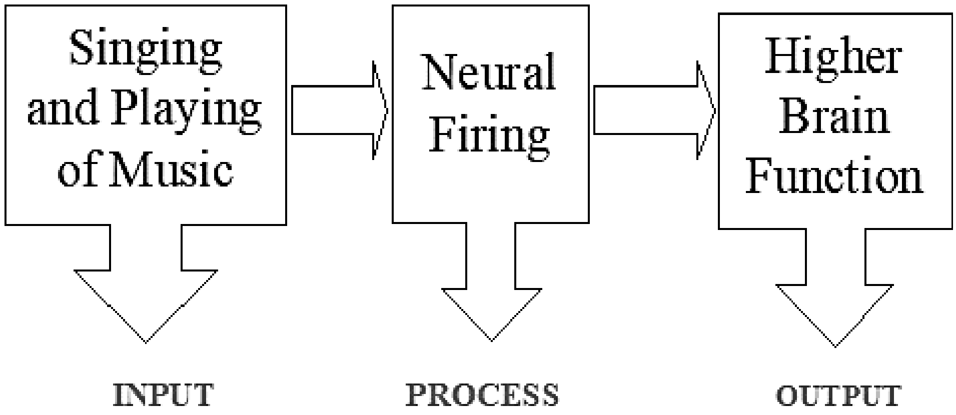


***Figure 1:*** **Shows a framework of Gordon Shaw's model of music processing in the brain**

Shaw's Theory in Figure 1 can be explained as a three-stage phenomenon. The first stage labelled as singing and playing of music can be likened to a stimulus applied to the brain while stage two, neural firings, represents the brain's response to or interaction with the stimulus. The third stage presented in the model as higher brain function is referred to as the effect on the brain after interacting with the stimulus. In effect, the theory suggests that the human brain achieves higher brain function when subjected to musical stimulus such as singing and playing of music.

The focus of the study was to investigate the possible relationship between music performance and brain response of student's engagement with reading of song lyrics and singing of a song. Shaw's (2005) theory which expounds singing of music thus provides a theoretical basis that underpins the study.

Operational Framework

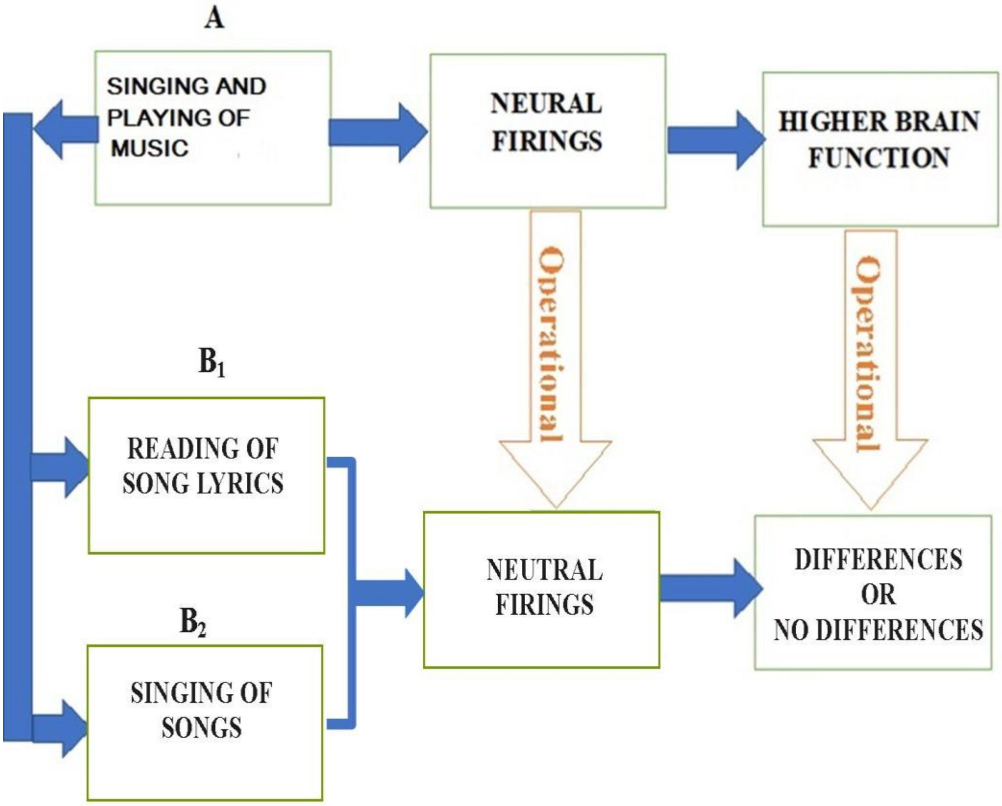


**Figure 2: Operational Framework**

Shaw's theory of human brain in music was adapted for this study. In the present study I employed Shaw's theory and expanded it as an operational framework in testing student performance ability in music reading and singing. Scholars report that reading strengthens one's ability to process information by creating new connections between the synapses in the brain (Zull, 2002). For singing, behaviour is said to be multi-sited neurologically and networked across many different brain areas. According to scholars, these include the development and interaction between parts of the brain that are dedicated to music. Such as pitch, rhythm and timbre; language (lyrics and speech), fine motor behaviour etc. in this case, a respondent performed two behavioural tasks (Altenmuller 2006).

**Definition of Terms**

Some key terms were used in the study and are all clearly defined. The terms are; music performance, Brain responses and Music stimulus, cognitive neuroscience of music, Electrical signals, Neurotransmitters and Neuroethics.

**Music performance**

Music performance is the platform for displaying one's musical achievement. It is preceded by a lot of preoperational process of learning and rehearsal in this context.

**Brain Response**

Brain response is defined by scholars as an action or movement due to the application of a stimulus. Therefore, looking at it from the Neuro-biological perspectives brain response may be that behaviour exhibited by the brain from the application of a stimulus.

**Music Stimulus**

This is said to be a component of music or occurrence that arouses a specific functional reaction in an organism or tissue. However, scholars propose that stimulus is that which evokes activity or vigor in a person. It also occurs mostly in the brain areas which respond to music.

**The cognitive neuroscience of music**

The term cognitive neuroscience of music was proposed by George Amitage Miller and Michael Gazzaniga in the year 1976 to mean the scientific study of brain-based mechanisms involved in the cognitive processes in the field of Music Education (Gazzaniga, 2014). The following are said to be musical behaviours which include: music listening, performing, composing, reading, writing, and ancillary activities. It is also defined as increasingly concerned with the brain basis for musical aesthetics and musical emotion with a specific focus on the neural connections in the brain which are involved in mental processes.

**Electrical signals**

They are signals that generate information and pass on through neurotransmitters

**Neurotransmitters**

These are chemical substances that are released at the end of a nerve fibre by the arrival of a nerve impulse and, by diffusing across the synapse or junction, affects the transfer of the impulse to another nerve fibre, a muscle fibre, or some other structure. A neurotransmitter is defined as a substance such as norepinephrine or acetylcholine that transmits nerve impulses across a synapse.

**Neuroethics**

This is a disciplinary term used for ethical concerns in brain research and which has been fortified from its rise as a new discipline.

**Organization of the Study**

Chapter one introduces the background to the study, statement of the problem, purpose of the study, objectives of the study, research hypothesis, significance of the study, delimitation of the study, limitation of the study, theoretical framework, operational framework, definition of terms, organization of the study and chapter summary. Chapter Two presents the review of related literature to the study. Some of the materials discussed are a brief history of the music and neuroscience education specifically about the use of EEG, historical relevance, music educational relevance, the progress of verification towards the current trends in education, music processes in the brain, specifically, music reading and music singing, issues concerning musical experience, musical performance and neurological organisation of music, the interconnection of neurons and synapses in the brain, and their response in the human brain. Chapter Three outlines the methodology adopted for the study. Chapter Four details the statistical analysis and results from the data. This includes, hypotheses testing and discussion of results. I also discussed the future directions and the way forward for this study. Chapter Five, presents the summary of the findings including conclusions and outcomes from the analysis as well as the recommendations and suggestions of the study.

**Chapter Summary**

This chapter provides background to the study. It discussed music, performance, music stimulus and brain response and the role neuroscience in Music Education. I then proceeded to state the problem being investigated as I established a niche and proposed two research questions that would help in gaining insight. Also, two hypotheses were developed since quantitative research more often than not test hypothesis. This chapter also contains the theoretical framework and practical significance of the study. Finally, I provided some working definitions for some key terms and also presented the delimitation, limitations and organisation of the study.

# CHAPTER TWO

# REVIEW OF RELATED LITERATURE

The review of related literature for this study is to provide a consistent, coherent and systematized overture to the reader on this music and neuroscience phenomenon. Though it had been quite gratifying achieving quality related literature, the researcher noticed that it worth researching on the lacuna in the literature and as a whole and to unveil the interdisciplinary in the area of music education and neuroscience. The review of related literature included various phenomena such as neuroscience and education, neuroscience research and education, brain emerging theories, synaptogenesis, Synapse, myelination, music as the main resource for neuroscience, music performance and brain responses, music education, music education and the young adolescent, biological/sex differences in brain response of adult, music education in Ghana, music education and its pedagogical practices in Ghana, benefits of music to education, music versus reading, similarities between music and language, current developments in the human brain in music, music reading: sight reading /sight singing and performance, steady involvement in reading and sing of music, music cognition and cognitive procedures in adults, formal trends in adult education.

## Neuroscience and Education

There are many sides to neuroscience from different points of view (Michael, Newman, Vuorre, Cumming, & Garry, 2013; Stuss, & Knight, (Eds.) 2013; Senge, Cambron-McCabe, Lucas, Smith, & Dutton, 2012; Schore, 2003; Changeux, & Ricoeur, 2002; Finger, 2001). Usually, neuroscience is an interdisciplinary methodical study of the nervous system involving the nerve cells, their anatomy, physiology, and brain activity such as that involved in vision, hearing and other senses (Bear, Connors, & Paradiso, 2020; Verkhratsky, & Butt, (Eds.). 2013; Squire, Berg, Bloom, Du Lac, Ghosh, & Spitzer, (Eds.). 2012; Rosenbaum, 2009; Martin, & Pechura, (Eds.). 1991). Neuroscience is practiced under numerous scientific fields such as computer science, chemistry, cognitive science, engineering, linguistics, medicine, biology, genetics, psychology and physics (Barsalou, 2014; Gallistel, & King, 2011; Fischer, Goswami, Geake, & Task Force on the Future of Educational Neuroscience. 2010; Fischer, 2009; Houdé, Kayser, Koenig, Proust, & Rastier, (Eds.). 2004; Harré, 2002).

Neuroscientific activities date back to the era of the Egyptian civilization and the period of the Greek philosophers of 1600BC and 400BC respectively (Hanna, 2013; Kiliari, 2011; Shlain, 1999). Experiments on musical behaviours using the electroencephalogram (EEG) were first conducted in the 1970s according to Wagner and Hannon, (1975). Since then, neuroscientific development activities have continued around the world in various disciplines of study, including music as therapeutic treatment of neurobehavioral disorders. Technical neuroscience measurement techniques have been developed for various functions including Transcranial magnetic stimulation (TMS), Magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), single-photon emission computed tomography (SPECT) and others. These have improved neuroscience activity in recent times (Ilmoniemi, Ruohonen, & Karhu, 1999, Shibasaki, 2008; Kober, Nimsky, Möller, Hastreiter, Fahlbusch, & Ganslandt, 2001). Brief description of the Structure of the Nervous System and their Functions.

Fung, Yu, & Petropoulou, (2015; Olesen & 2009) explains that the structure of the Central Nervous System (CNS) refers to all the parts involved in the functions of the nervous system. The human nervous system is a vast communicating network. (See the structural table below.)

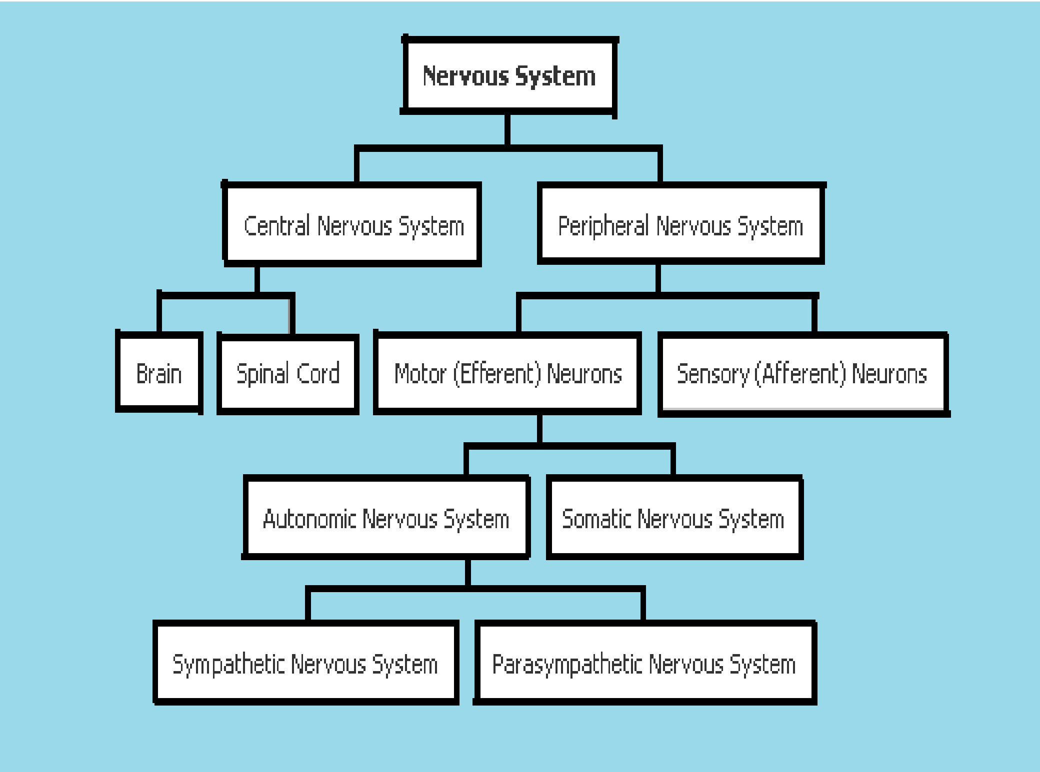


***Figure 3:*** **Structure of the Human Nervous System**

*(Figure adapted from Encarta, (2009) for academic purposes*

The nervous system comprises of the Central nervous system and the Peripheral nervous system (Hess, Rambukkana, 2019; Schafer, & Stevens, 2015; Insausti, 1994). The central nervous system, includes the brain and the spinal cord. They process and coordinate all the incoming sensory information and the outgoing motor commands through the muscles to the body parts, and are also the seat of complex brain functions such as the memory, intelligence, learning, and emotion (Claxton, G. 2015; Carter, 2019). The peripheral nervous system includes all neural tissue outside the central nervous system, this provides sensory information to the central nervous system and carry motor commands out to the body's tissues (Furness, Callaghan, Rivera, & Cho, 2014; Micera, & Navarro, 2009; Horuk, Martin, Wang, Schweitzer, Gerassimides, Guo, ... & Parker, 1997; Navarro, Krueger, Lago, Micera, Stieglitz, & Dario, 2005; Brodal, 2004). Voluntary motor commands, such as moving muscles to walk or talk, are controlled by the somatic nervous system, while the involuntary motor commands such as the digestion and heartbeat, are controlled by the autonomic nervous system. The autonomic nervous system; comprises two systems the sympathetic nervous system is responsible for stimulating the body tissue preparing the body for quick responses to sudden attack and similar situations (Schauer, & Elbert, 2015; Collet, Di Rienzo, Hoyek, & Guillot, 2013; Morrison, & Blessing, 2011; Chapman, 2004; Schore, 2001; Porges, 1998; Robert-McComb, & Young, 2000; Henry, Ely, & Stephens, 1972, January); the parasympathetic nervous system also called the "rest and repose" system, conserves energy and controls sedentary activities, such as digestion, (Mettler, 2009).

The brain comprises the cerebrum, cerebellum, corpus callosum, thalamus, ventricles, hypothalamus, the pituitary glands, pons, medulla, midbrain and the brain stem **(**Pace-Schott, Amole, Aue, Balconi, Bylsma, Critchley, & Jovanovic, 2019; Dobolyi, Palkovits, & Usdin, 2010; Fernández-Gil, Palacios-Bote, Leo-Barahona, & Mora-Encinas, 2010, June; Ek, Arias, Sawchenko, & Ericsson-Dahlstrand, 2000**).**

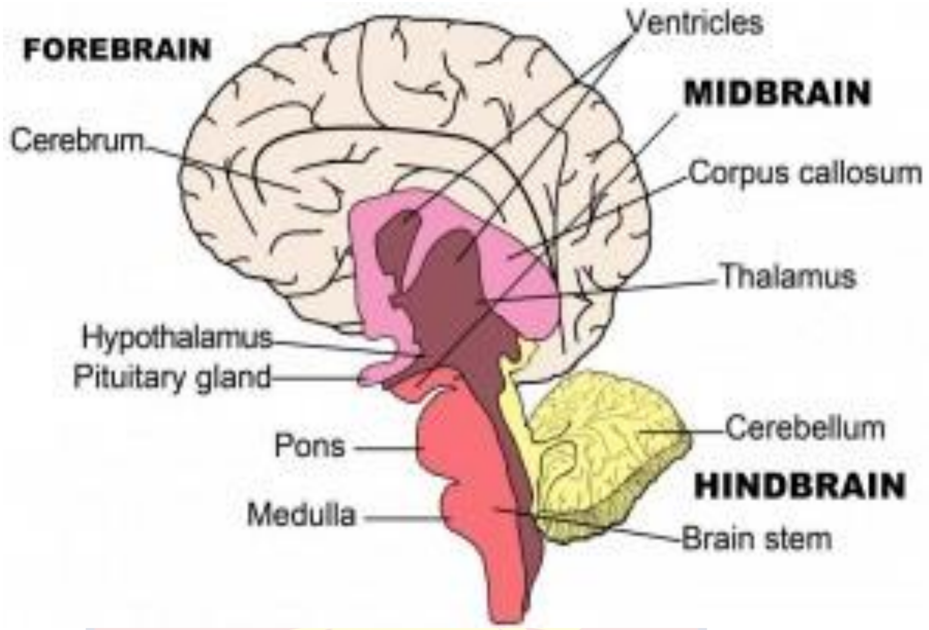


***Figure 4:*** **The human Brain**

*(Figure adapted from Encarta, (2009) for academic purposes)*

The nerve cells, also known as the neurons receive stimuli and transmit nerve impulses to other parts of the body (Farley, Johnstone, Hendry, & McLafferty, 2014; Cantor, & Cantor, 1995, May; Stevens, 1979).

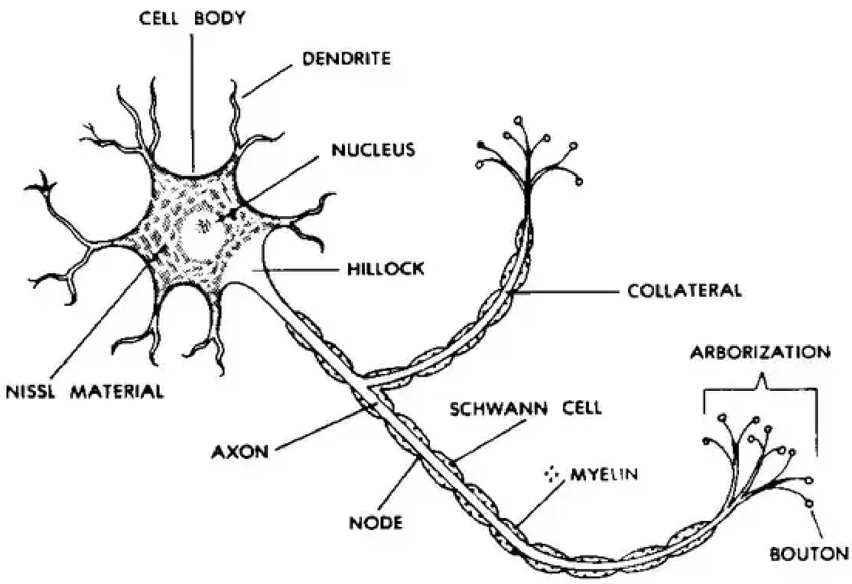


***Figure 5:*** **A Nerve cell**

*(Figure adapted from students' Encarta, 2009)*

Mettler, (2009) further explains that the structure of the nerve cell consists of a central portion containing the nucleus, known as the cell body, and one or more structures referred to as axons and dendrites. The dendrites are short extensions of the cell body involved in the reception of stimuli (Grudt, & Perl, 2002; Han, Zhang, & Craig, 1998; Light, Trevino, & Perl, 1979; Felt, & Vande Berg, 1976; Morest, Kiang, Kane, Guinan Jr, & Godfrey, 1973). The axon, is a single elongated extension which is important in the transmission of nerve impulses from the region of the cell body to other cells.

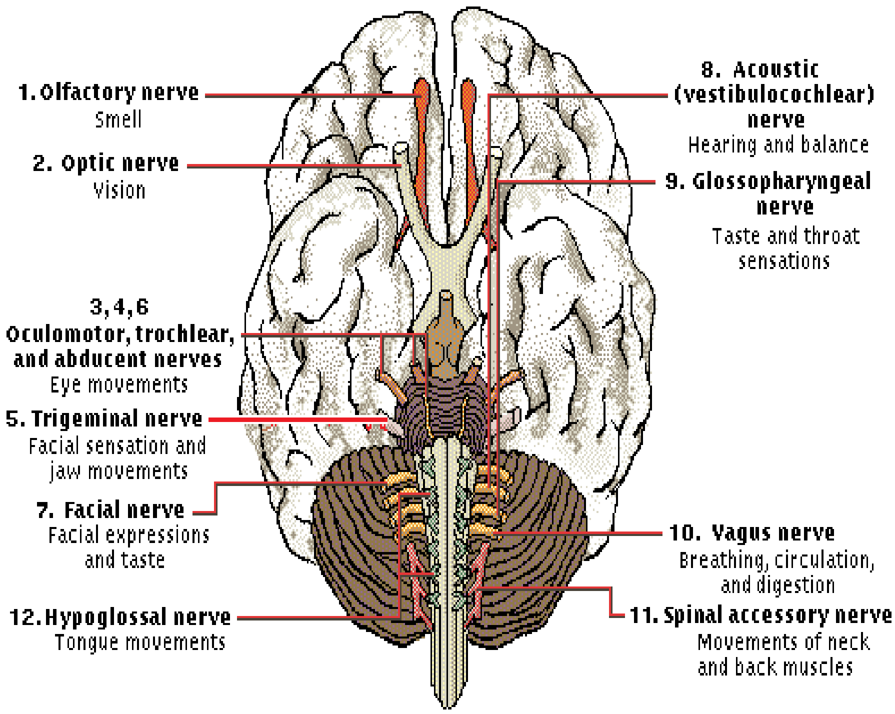


***Figure 6:*** **The Nerve Network Components**

*(Figure adapted from students' Encarta, 2009*

The brain consists of three major divisions: the forebrain, midbrain and the hindbrain **(**Kiecker, & Lumsden, 2005**;** Jarvis, Güntürkün, Bruce, Csillag, Karten, Kuenzel, & Striedter, 2005**;** Rhinn, Dierich, Le Meur, & Ang, 1999; Mastick, Davis, Andrew, & Easter, 1997; Parr, Shea, Vassileva, & McMahon, 1993**).** The forebrain is the largest portion of the brain which is responsible for behaviors, long and short-term memory, learning, motor skills, vision, hearing, affective responses, creativity, and decision-making. It is divided into two hemispheres right and left. It communicates with the other parts of the body through the corpus, callosum (the thick connecting cord). The midbrain which is whole and not subdivided into any regions is the main connection area between the motor neurons and the higher-order processes of the forebrain (Choe, Sanchez, Harris, Otis, & Mathews, 2018; Budinger, Laszcz, Lison, Scheich, & Ohl, 2008; Sen, Theunissen, & Doupe, 2001; Thomas, Sing, Belenky, Holcomb, Mayberg, Dannals, & Welsh, 2000). The hindbrain is divided into the cerebellum, pons, and medulla oblongata and it is responsible for naturally occurring processes such as breathing, blood circulation, metabolism, digestion and constant systematic heartbeat. The limbic system lies directly under the cerebrum. It is responsible for the important human activities referred to as the Four Fs of human survival: Feeding, Fighting, Fleeing, and Flirting (Van Daele, & Cassell, 2009; Vogt, & Laureys, 2005; Reiner, Yamamoto, & Karten, 2005).

There is proof of the value of classroom strategies and approaches aimed at improving students and pupils' attention. Helen Neville's lab is in collaboration with preschool children, giving them attention and training every day. Consequently, the IQ measurements of the pupils have gone up and their attentiveness improved significantly. Research in education has provided positive relationship and coordination between socioeconomic Status (SES) and achievement training pupils to be attentive, low SES pupils were transformed to high SES students in their academic performance. She therefore came to the conclusion that any educational process that invests in solid preschool foundation such as training in attentiveness makes a better investment in terms of funds and the returns on it is better than going through remedial processes later in their education.

It is normal for students to experience anxiety and tension in their teaching and learning process but their educators need to know this phenomenon and how to help the students control such ill-feelings. Many teaching strategies and classroom atmospheres including teacher-learner relationships and rapport exist that psychologically help to relax the learner's anxiety. Scholars in euro-imaging explain how the multiple brain interactions can cause confusion in the learner and the various ways to overcome it during teaching and learning activities. This means that educational neuroscientists can influence educators' activities and guide them to fit or equip the classrooms with the appropriate apparatus for creating the most appropriate learning environment. They can also, suggest the best teacher-temperament, help design lessons appropriately for better understanding and create the best class atmosphere to overcome the anxiety of learners. This means that neuroscience can guide educators in lessons preparation and help them take advantage of the neuroscientific evidence to improve their practice This is one of the ways in which the neuroscientific application can be beneficial to teaching and learning.

Research into music and neuroscience indicates that there could be meaningful connection between neuroscience, music education and pedagogy for improvement due to the recent advancement in understanding the brain functions. It has been argued that all forms of musical training activities are good and beneficial to the enhancement of the brain for greater educational gains. This means that the brain is responsible for both the good and the bad based on what it encounters in its environment, Neuroscience research and Education.

According to Hodges (1997), neurobiological applications to education started in the latter part of the 19th century. Since then, neuroscience activities have continued in the various disciplines under education including psychology. Fischer et al. (2010) define Educational Neuroscience as a new field of study stemming from the interdependency of many other fields of studies but focusing on cognitive neuroscience and psychology in education for research into the neural processes and electrochemical activities in pedagogy. According to Beauchamp and Beauchamp, (2013) some of the first neuroscientists who engaged in Educational Neuroscience include Henry Donaldson and Reuben Post Halleck. In recent times, there have been debates on the feasibility or the usefulness of neuroscience in education but so far, the results have proved to be fruitful. For example, Bruer, (1997, p.4) argued against Educational Neuroscience in his article entitled "Education and the Brain: A Bridge too Far." His main argument was that, not much proof exist that results of experiments conducted on brain development were specifically applied by educational instructional activities (Bruer, 1997).

Bruers' supporting argument in simple terms is that, brain development from infancy through later childhood to adulthood occurs naturally in three stages (Wastell, & White, 2012; Bruer, 1999). This is characterized by development of nerve cells that connect to the neurons of the brain. At the first stage, it makes them psychomotor oriented (Henderson, & Feiner, 2011, October; Oropesa, Sánchez-González, Lamata, Chmarra, Pagador, Sánchez-Margallo, & Gómez, 2011). This is followed by the synaptic elimination and development of new synapses after which the child is able to relate more with his environment by being more sensitive to learn and adjust. From the age of 10, there is rapid development of more synapses caused by enrichment of knowledge (Greenough, & Black, 2013, April; Huttenlocher, & Dabholkar, 1997). This enrichment of knowledge strengthens the synapses, and so if much knowledge is not acquired within this period, his or her potentials are lost forever as some synapses become unused and are naturally pruned away. This affects the person's aptitude as he or she grows. To Bruer (1997), this process is natural and not necessarily induced by formal teaching and learning activities.

Other contenders of Educational neuroscience include Varma, McCandliss, and Schwartz, who argue simply that the timing is wrong to trust the research outcomes of Educational neuroscience because as of now, not enough is known about the brain such that neuroscience can be applied reliably to education However, the logic and reality are that, much has been experimented and achieved in neuroscience with the fMRI, EEG and PET technologies and more knowledge has been acquired in the field of neuroscience to support education.

Educational neuroscience is beneficial to the improvement of education and it is a strong foundation for the future educational achievements. For example, the Centres for Educational Research dotted all around the world rely on neuroscience for research into various brain related situations or conditions. Programme for Neurological Diseases, Neuroscience (World Health Organization), International Bureau for Epilepsy, World Health Organization. Department of Mental Health, ... & International League against Epilepsy. 2005. In fact, new ideas come from neuroscience every day to enhance brain research that is helpful in the educational sector (Tokuhama-Espinosa, 2015; Geake, & Cooper, 2003).

Jenson (cited in Howard-Jones & Fenton, 2012) contends that educational neuroscience has helped and will continue to help many educational institutions in research, and the knowledge acquired from the researches have helped and will continue to inform policies and practices in education. If there is the need to bridge the gap between education and neuroscience, the time is now. The world has moved to a stage of maximizing the abilities of the human brain, and it is believed that, not even half of the brain capacity has been explored. Education and science have stretched the brain very far, and information technology (IT) has opened a new dimension for the human mind There is high probability of augmenting the abilities of the mind. Educational neuroscience is able and should focus on discovering new capabilities within the brain's elasticity.

In brief summary, it is pragmatic that interdisciplinary study of neuroscience in education of music has achieved a significant growth in the western world for which scholars in Africa, since this provocation focusses on cognitive neuroscience and psychology in education for research into the neural brain processes as well as electrochemical activities in pedagogy which is very much related to this study. Hence, needs to be embraced in Ghana and

Africa as a whole. It is also palpable that neuromusicology and the neuroscience of music are important fields of research for music educators.

**Brain Emerging Theories**

In the development of theories related to both cognitive and brain, a theoretical framework has been developed in assisting the investigation. In accessing the researcher employed cognitive development of the human brain developments' time frame. Though it is the brain stage development framework that was developed by Casey, Tottenham, Liston and Durston (2005). According to literature they provided an insight in to the development of the human brain in stage development. Literature also discussed how some scholars reported on the early period before birth (neurulation) to adulthood (Fish, Wieczorek, Rumple, Suttie, Moy, Hammond, & Parnell, 2018; Keunen, Counsell, & Benders, 2017; O'Mahony, Clarke, Dinan, & Cryan, 2017; Silbereis, Pochareddy, Zhu, Li, & Sestan, 2016; Cunningham, Scheuer, & Black, 2016; Dupin & Sommer, 2012; Anderson, Spencer-Smith, & Wood, 2011; Tierney & Nelson III, 2009; Marsh, Gerber, & Peterson, 2008).

Figure 6 signifies the outline of the times in the course of human brain development with some level of descriptions to support brain developmental stage theory, the researcher though realised it was subtle juxtapose this study it gives quite explanation as to how the human brain behaves as discussed by Banich and Compton, 2018; Siegel, & Hartzell, 2013; Deacon, 1998; Bates, Dale, & Thal, 1995; Dumit, 2004; Panksepp, & Panksepp, 2000).

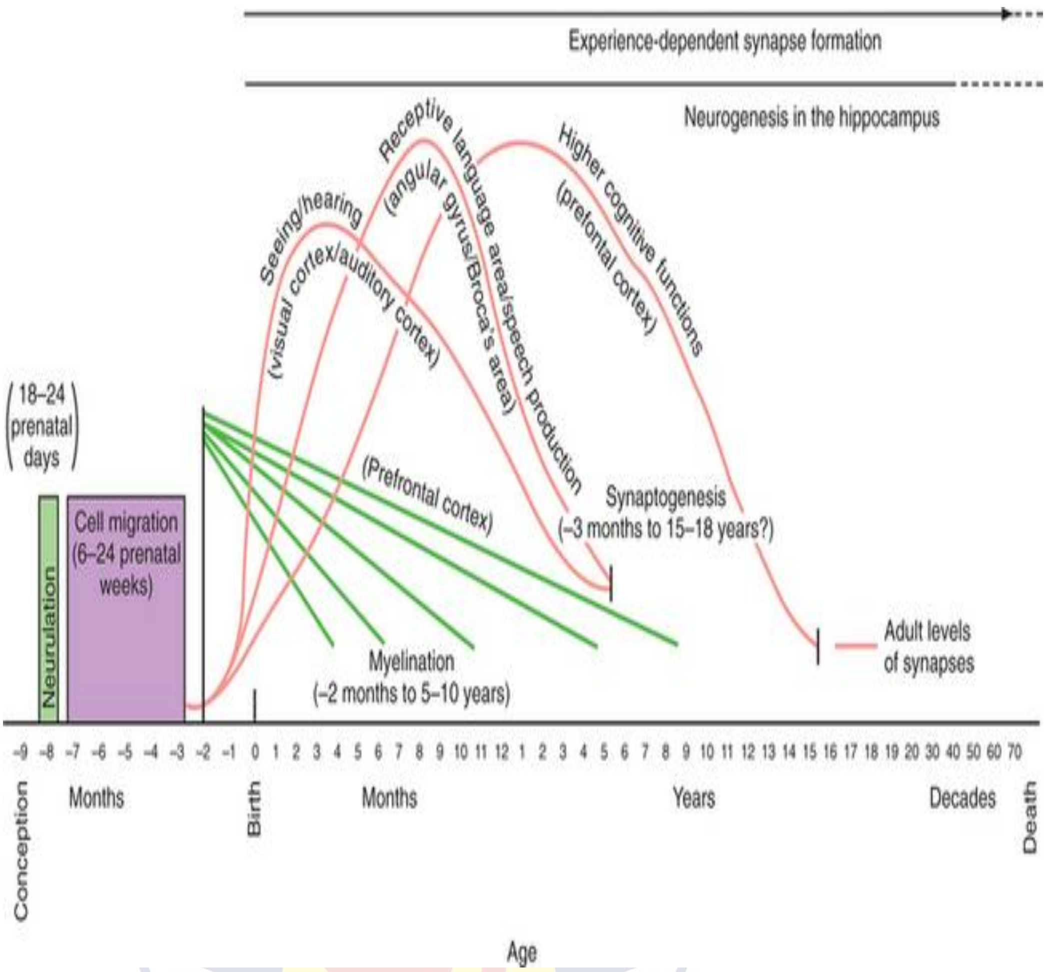


***Figure 7*: Exemplifies the time course of human brain development (Banich and Compton, 2018)**

Banich and Compton (2018) report that report that the mechanism of brain plasticity is methodically a significant process in brain proliferation (Banich and Compton, 2018; Siegel, & Hartzell, 2013; Deacon, 1998; Bates, Dale, & Thal, 1995; Dumit, 2004; Panksepp, & Panksepp, 2000). These scholars define plasticity as the capability of a system to reversibly change or change in responses to a stimulus in an activity-dependent manner (Banich and Compton, 2018; Siegel, & Hartzell, 2013; Deacon, 1998; Bates, Dale, & Thal, 1995; Dumit, 2004; Panksepp, & Panksepp, 2000). Neuroplasticity is a term used by neuroscientists to explain the changes and adaptations in brain abilities which are dependent on age (May, Hajak, Gänssbauer, Steffens, Langguth, Kleinjung, & Eichhammer, 2007). Neuronal change is a neurological development that may take place either to worsen or to enhance development (Manji, Quiroz, Sporn, Payne, Denicoff, Gray, & Charney, 2003; Kleim, & Jones, 2008; Navarro, Vivó, & Valero-Cabré, 2007; Casey, Tottenham, Liston, & Durston, 2005; Manji, Quiroz, Sporn, Payne, Denicoff, Gray, & Charney, 2003; Smith, Roberts, Gage, & Tuszynski, 1999; Jones, & Schallert, 1994; Grossberg, 1976).

Other researchers also affirm that plasticity is the changes in neural connectivity (Guyer, Pérez-Edgar, & Crone, 2018; Li, 2017; Lazzouni, & Lepore, 2014; Fertonani, Brambilla, Cotelli, & Miniussi, 2014; Li, Legault, & Litcofsky, 2014; Engineer, Riley, Seale, Vrana, Shetake, Sudanagunta, & Kilgard, 2011; Draganski, & May, 2008; DeFelipe, 2006; Fritz, Shamma, Elhilali, & Klein, 2003; states that neural plasticity is a change in neurons with billions and billions of connections. Cherry identifies two types of brain plasticity which have been critically observed. These are: (i) functional plasticity and (ii) structural plasticity. Functional plasticity has been elucidated as the brain's ability to move functions from an injured area of the brain to uninjured areas while structural plasticity has been clarified as the brain's ability to adapt or modify its corporeal structure through learning processes (Özsoy, 2012).

Researchers recorded that brain changes can only take place during infancy and childhood where the physical structure of the brain is still emerging (Belsky, & De Haan, 2011; Malina, 2004; Bruer, 1997). Though, recent investigators observe that the brain continues to generate a unique or original neural pathway that modify the existing ones for establishing new experiences, where new information is learnt and new memories are created (Lane, Ryan, Nadel, & Greenberg, 2015; Bar, 2009; Trouche, Bontempi, Roullet, & Rampon, 2009; Begley, 2008; Cozolino, 2002).

Scholars observed that developments of the brain occur within the time course of the first month of foetus conception and continues after birth through childhood, adolescent to early adulthood of about age twenty (20). Hitherto, it has been noted that brain development cannot be thought of simply as a linear progression of growth (Waddell, 2018; Sfard, 2008; Lieberman, 1993).

**Synaptogenesis**

Scholars repot that synaptogenesis is the most vivacious stages of brain development (Shelby, 2014;). According to scholar's synaptogenesis is a neuroscientific term developed from the word synapse, which means the connection between neurons affording impulses and neural transmissions (Banich & Compton, 2018; Conkbayir, 2017; Tau, & Peterson, 2010; Arbib, Numbers, Érdi, Érdi, Szentágothai, Szentagothai, & Szentagothai, 1998). The increase in the number of connections of synapses that neurons make with other neurons is a process called synaptogenesis (Javaherian & Cline, 2005). Scholars explained that during synaptogenesis period, there is a significant increase in dendrites (protoplasmic branches of neuronal cells) to provide greater area for synaptic connections. Other scholars refer to dendrites as dendrones (Goaillard, Moubarak, Tapia, & Tell, 2020). Dendrites are also defined as the branches of protoplasmic extension of a nerve cell that proliferate the electrochemical stimuli that are received from other neural cells to the cell body of neurons (Goaillard, Moubarak, Tapia, & Tell, 2020) scholars report that about 4.3 million synapses are formed every minute at the peak of synaptogenesis development (del Blanco, Guiretti, Tomasoni, Lopez-Cascales, Muñoz-Viana, Lipinski, & Barco, 2019; Swenarchuk, 2019; Virtanen, Lacoh, Fiumelli, Kosel, Tyagarajan, De Roo, & Vutskits, 2018; Hoshino, Ratnapriya, Brooks, Chaitankar, Wilken, Zhang, & Reh, 2017; Hildebrandt, & Dityatev, 2013; Hörnberg, Wollerton-van Horck, Maurus, Zwart, Svoboda, Harris, & Holt, 2013; Bury, & Sabo, 2011; Morgan, Schubert, & Wong, 2008; Collins, Wairkar, Johnson, & DiAntonio, 2006; Contestabile, 2000).

**Synapse**

Scholars identify synapses as the meeting point between two neurons while synaptic pruning is a process where axons and dendrites decay and die to eliminate synapses that occurs during the early years of life (Cheadle, Tzeng, Kalish, Harmin, Rivera, Ling, & Greenberg, 2018; Mullins, Fishell, & Tsien, 2016; Volk, Chiu, Sharma, & Huganir, 2015; Knoblauch, Körner, Körner, & Sommer, 2014; Testa-Silva, Loebel, Giugliano, de Kock, Mansvelder, & Meredith, 2012; Fox, 2009; Lewis, & González-Burgos, 2008; Eckmann, Feinerman, Gruendlinger, Moses, Soriano, & Tlusty, 2007.

**Myelination**

Scholars in the field of neuroscience define myelination as a process where materials or substances are made by the brain called myelin sheaths and are coated around axons in the brain (Fu, McAlear, Nguyen, Oses-Prieto, Valenzuela, Shi, & Barres, 2019; Banich & Compton, 2018; Arancibia-Carcamo, Ford, Cossell, Ishida, Tohyama, & Attwell, 2017; Pamies, Barrera, Block, Makri, Kumar, Wiersma, & Hogberg, 2017; Micheva, Wolman, Mensh, Pax, Buchanan, Smith, & Bock, 2016; Xie, Liang, Fu, Zhang, &

Chen, 2014; Walsh, & Bolen, 2012; Jarjour, Zhang, Bauer, ffrench-Constant, & Williams, 2012; Mistry, Stolnik, & Illum, 2009; Fields, 2009; Fields, 2008). Myelination is a process of brain developmental retro differs in growth across the various regions of the brain. Others also explain that myelination stage of human brain development is also a critical period of brain development (Casey et al, 2005). Myelination is known in human brain development as a stage that starts from the second month in the prenatal retro to the tenth year of a child's development (Vanderah, & Gould, 2020; Van den Bergh, Dahnke, & Mennes, 2018; Raven, 2017; Klase, Khakhina, Schneider, Callahan, Glasspool-Malone, & Malone, 2016; Gesell, 2013; Olusanya, 2013; Friede, 2012; Kurjak, Carrera, Medic, Azumendi, Andonotopo, & Stanojevic, 2005; Ratey, 2001; Bates, 1999).

Consequently, Epstein's brain periodization theory, called *Phrenoblysis Hypothesis* was deliberated upon. Scholars report that in Epstein' brain periodization theory the human brain was observed to develop in spurts where the functions of the mental ages are in correspondence to the chronological age (Kane, 2019; Hodgkins, 2013; Manning, 1993; Fischer, & Bullock, 1984). It is observed that our human brains grow in a meaningfully steady order of spurts and plateaus from infancy through adolescence. Consequently, modelled a healthy claim that neuroscientific research can resolve glitches in our school's systems; problems that deal with the vital domain of curriculum development and problems that deal with pedagogical approaches. Epstein conclusion talks about categories of developmental brain stages correlate well with those of Piaget's cognitive theory. Although this may not be workable in some research Epstein's theory may be apparently applicable in a brain research. These were the discourse that were deliberated upon by Epstein in the developmental processes of both human brain and mind spurts.

Kessler, Hutson, Herman, & Potenza, (2016) report that Epstein's claim on brain periodization theory was believed that what we know about the human brain, as well as what we shall be able to find out in the future shall be able to transform our current state of formal education. For this reason, there is a hope for the progression of nurturing the cognitive neuroscience in Music Education in Ghana and as a whole.

It is obvious that cognitive neuroscience and neuroscience as a whole has gained significance with learning theories, some scholars have characterised this domain of study according to social brain concepts (Mercer, 2013) explained that the term 'social' has been used to highlight the observable concepts of social-emotional connections that exist between neurology and education. Scholars explained that neurology and education is about the various connexion thoughts of learning through our communal setting. According to scholar's social brain concept can also hut light on the developmental neuroscience and human learning (Reeves, Bostock, Ayliffe, Barrows, De Deckker, Devriendt, & van der Kaars, 2013). It is believed that emotions that are generated in our social environment are integral to neuro-cognitive behaviours. The researcher therefore, believes that the replicas or models of social brain concepts are very relevant to music education. This is because we know that our experiences gained from music learning are affected by influences from our social environment.

Other scholars have also drawn conclusion that the interdisciplinary needs of music and the brain is very necessary in our daily activities so long as music education is concerned (McPherson, & Welch, (Eds.). 2012; Abrahams, 2005; Chrysostomou, 2004; Bowles, 2002; Tarnowski, & Murphy, 2002; Ellis, & Fouts, 2001) with this our interest in the field of music should be able to create a suitable room for interdisciplinary research. Concern shared by Levitin in Robert Sopolsky's about his anxiety that a very sore experience for a researcher to find out that people are concerned that, to choose science means one may not be able to combine with music learning and musical arts, that take place in our human domain as compassion, being realised and owned by nature.

As the desire for music learning expands, music educators become more aware that the current trends of music education are rapidly increasing in focusing on neurological and psychophysiological based investigations. This claim has been testified from evidence-based research (Achieng'Akuno, 2019; Nyce, 2012; Miller, 2011; Swart, 2010; Tokuhama-Espinosa, 2010; Bonde, & Wigram, 2002). In higher integrated practices, psychosomatic investigations and its practices are also becoming more relevant to music education and learning, where aggravated mental factors such as stress and internal conflict are dealt with by musical exposure, musical experience and music learning. This is because scholars have observed that long music exposure have a holistic influence on humans: brain, mind, body, emotions, and physical symptoms (Bonde, & Wigram, 2002). For this reason, it is tangible that neurological practices, involving the neurology of music, are becoming more broadening and complex phenomena for investigation. For this reason, these current trends seem to be relevant to issues of our field of music educational practices.

In sum, it is observed that interdisciplinary research of the music and neuroscience had achieved a significant development in the Western world for which scholars in Africa, for that matter Ghana, need to hold. Consequently, neuromusicology and the neuroscience of music are important fields of research for music educators which not be over emphasis.

**Music as the main resource for Neuroscience Research**

Scholars revealed that music is a mystical and magical art. It could make people relaxed, happy, cheerful, exuberant or even delirious, or moody, sad, tearful, grief or even suicidal. That means music has been shown to be able to influence the wellbeing and health of human nervous system."

Music is studied in neuroscience as part of the field of cognitive neuroscience. Cognitive neuroscience according to Levitin and Tirovolas, (2009) include music, psychology, education, and aspects of philosophy, music education, chemistry, linguistics, engineering, biology, medicine, physics, mathematics and, genetics. Accordingly, all these subject areas are integrated with neuroscience and are sometimes used interchangeably. For example, neuromusical science is used interchangeably with cognitive neuroscience of music which is the study of the cognitive processes of the brain in relation to music (Brattico, 2006).

Another reason why the use of music in neuroscience is common according to Miranda and Overy (2009) is that: (1) Music listening and music performance presents better understanding of multiple neural processes such as auditory, fine motor skills, short-term memory, emotional responses, cognitive prediction, and social communication. Collins (2013) also explains that there is significant difference between music behaviours and creating. These echo two of the main areas of enquiry in music and neuroscience, music performance and brain research.

Musicians' brains are physically and functionally different from others particularly in the auditory and motor processes. This suggests that musical experience is able to change the structure of the brain, a function known as neuroplasticity.

Zatorre (2005) explains that listening to and producing music involves a tantalizing mix of all the human cognitive functions. According to him, even a simple activity such as humming a familiar tune invokes complex auditory pattern-processing mechanisms such as attentiveness, memory storage and retrieval, motor programming, sensory-motor integration, etc., (Zatore 2005:312).

Music activities generate high performance in cognitive tasks (subject areas). It means that music activities help in enhancing other non-musical activities for example other classroom work in other subjects. This alludes to the benefits of music in education (Wan, & Schlaug, 2010 & Jones, 2009**).**

Moreover, Miranda and Overy (2009) clarify further how some neural processes engaged by music affect human intelligence including speech, and emotions. This supports the argument that neuroscientific research can inform music education.

In sum, the phenomena reflected were to support the investigation of the viable theoretical framework of this study which deals with music singing and reading engagement. It is also, in particular relates to brain's responses to music as a special or vital imperceptible object for specific purpose (educational) from other objects (tangible or intangible) that can be used in cognitive neuroscience researches. It also, talks about the engagement in music activities that it generates high performance in human reasoning.

**Music Performance and Brain Responses**

According to Brouette, (2016:39). an African American elementary school music teacher, 'Singing has a profound effect on a child's psycho-social development as well as the intellect. Singing with movement opens even more neural pathways to enhance brain development. As Gerald, an African American student in my second-grade music class at St. Peter Martyr school wrote when asked how music made him feel, "I love to sing and dance. I just can't stop my feet from moving. "

According to Bartlett, "music has a wide range of emotional and physiological effects on the human body including changes in heart rate, respiration, blood pressure, skin conductivity, skin temperature, muscle tension, and biochemical responses," conducted research which shows that music and imagery can fortify the human immune system. Tanioka et al., 1987). Tsao et al., (1991) explain that in the brain, musical signals cause the "release of neurotransmitters.

It is not surprising that anatomical differences have been found between musicians' and non-musicians' auditory and motor cortices and the neural connectivity linking these areas. Adult instrumental musicians, for example, have more gray matter in somatosensory, premotor, superior parietal, and inferior temporal areas of the cortex and these expansions correlate with their levels of expertise (Gaser and Schlaug, 2003). Musicians also have enlarged cerebellar volume, coupled with the lifelong intensity of musical practice, which has been proposed to be due to the role of the cerebellum in motor and cognitive skill rehearsal. However, the level of musical accomplishment likewise correlates with more gray matter volume in Heschl's gyrus, an area of the auditory cortex linked to abilities in pitch discrimination and detecting tonal patterns. In a study investigating non-musicians, amateur musicians, and expert musicians increased musical expertise correlated with gray matter density in areas involved with higher order cognitive processing and auditory processing. Interestingly, high proficiencies and dexterity in musicians was also linked to a decrease in gray matter density in areas related to sensorimotor function, proposed to be due to an increased automatization of motor skills or higher motor efficiency. In conglomeration, these findings imply that changes in the brain's auditory and motor areas relate to active music-making.

Similar structural brain distinctions have been found in child musicians in the early stages of honing their musical skills. Scholars tracked 5–7-year-old children as they progressed with their musical studies. While they observed no preexisting cognitive, musical, motor, or structural brain differences between the subsequently musically trained and control groups, children who studied music for 12 months developed enhanced activation of the bilateral temporal lobes and superior temporal gyre during rhythmic and melodic discrimination tasks. After 15 months of piano lessons, children further showed training-related changes in the motor cortex, the corpus callosum, and the right Heschl's gyrus compared to controls (Hyde et al, 2009) the same areas of the brain that are enhanced in adult musicians.

Meyer raised an important question (1956) what is so special about music that people respond to it emotionally and with actions? What aspect of music is responsible for moving the hearers to respond as they do? He explained that a lifelong exposure to the music of one's culture makes the hearer become sensitive to the regularities used by the composers of different genres and so effortlessly and unconsciously the hearer can predict how the music being listened to will unfold. He says, the skills of the composer in the music are important in crafting the hearer's expectancies, and music being a multidimensional stimulus, the expectancies can be formed at many different levels of the music including the pitch and rhythm being two obvious examples. Apart from this, some people have to hear or listen to a piece of music over and over again, a good number of times before they become moved.

**Music Education**

Music education is a field of study associated with the *teaching* and learning of *music (*Barrett, 2014Colwell, R., & Richardson, (Eds.). 2002*)*. Scholars again confer that music education is a field of practice in music in which scholars, researchers and educators are trained for careers in music teaching and research as well as music conservatoire executives. It may also be necessary that they might need to be abreast with mental, reasoning and neurological information of young adult musical involvement and learning (B King, 2017; Charcot, 2013; Heath, & Wolf, 2012; Ravitch, 2010 Swanwick, 2002).

In summary, it is through music education that the significance of music learning relate to both children and adults are conferred. Hence, it is also well-known that music teachers, unlike other music doyens and researchers such as composers and ethnomusicologists need special music training that can impart knowledge in them so they could be better music educators.

**Music Education and the young Adolescent**

Music education for young progenies is an instructive program that enhances, or brings up children in music involvement and learning (Lebo, 2012; Henderson, Mapp, Johnson, & Davies, 2007; Borgo, 2007; Scales, Benson, Roehlkepartain, Sesma Jr, & van Dulmen, 2006; Peacock Hill Working Group. 1991). It is said to be a subarea of music education (Humphreys, 2004 & Green, 1990).

Music learning ignites all areas of the development of children (Scripp, Ulibarri, & Flax, 2013; Willis, 2008). These areas include creativity, intellectual, expressive and language acquisition (Runco, & Pritzker, (Eds.). 2020; Runco, 2014; Beghetto, & Kaufman, 2009; Folsom, 2005). They report that, children learn to coordinate their body and mind to work together (Overy & Molnar-Szakacs, 2009; Kim, 2006; Duffy, 2006) observe that exposing children to musical behaviours such as singing engagement during their early years of growth is a solid method to early childhood musical experience on which they can shape their upcoming on the learning of music.

It is noted that music participation and learning have a significant impact on children growth. This suggests that musical engagement and learning should be encouraged in schools. More so, initial music learning has also been found to have a long-term effect on children’s musical knowledge.

**Biological/Sex Differences in Brain response of adults**

This study observes some conscious effort of influences about sex differences connecting music and brain responses and also to acme other conceivable features that may influence or cause differences in brain activities from statistical fallout, which perhaps seem significant for enquiry. Differences in brain response between opposite sexes (male and female) were evident in the literature (Ehlers & Kupfer, 1997). Researchers have found out that significant differences exist between males and females in the peering of brain responses (Halpern, 2013). Females among most other mammalian species display a similar tendency, though investigators have not yet settled on an exact motive why. An evidence-based investigation that was made earlier found out that women have more delta wave activity. This has been confirmed across most mammal species **(***Ehlers & Kupfer, 1997).* Though, this inconsistency documentation has not been found out to be apparent until early adulthood (in the '30s or '40s, in humans), with men showing greater age-related reductions in delta wave activity than women **(***Ehlers & Kupfer, 1997).*

In sum, the discussion was focused on some influences about sex differences in connection with music and the brain and its responses as well as some considerable features that may affect their differences. Also, this could be enough apparent to worth examining to find out the degree to which brain responses may vary in both sexes in future such as males and females in a university music programme.

**Music Education in Ghana**

In the 21st century and initial emerging phases of music education in Ghana, Flolu (1993) report about the illogicality of belief system amid the Curriculum Research and Development Division (CRDD) and the music educators. Flolu and Amuah (2003) repot that music education in Ghana did not gain the attainment that was supposed to achieve. Taking critical look at the music teaching in Ghanaian basic schools did not realise or attain its factual resolution. In 2016, scholars anticipated that there is the need to review the music program (Debrah-Otchere, Amuah and Numekevor 2016).

They have a robust believe system that the arts, such as music are finest suitable for the drill of the affective domain of an individual, therefore, high level of precedence is needed to support the school curriculum. However, their goal has not been met. They also observed that music teaching in Ghanaian basic schools has not fulfilled its true presumed directive.

Scholars observe that the progression of material and communication technology in education is speedily altering the world. Nyamful report that music education in Ghana should not be left overdue.

In all, it is eminent that there is a mislaid between music education in Ghana and nature of Ghanaian music. Another observation made is that there is a battle between Curriculum Research and Development Division (CRDD) and the music educators. The employment of information and communication technology (ICT) and the indigenous traditional Ghanaian music in the school curriculum has also been erroneous. This position perceptibly touches musical contribution and learning practises among youth in the school system in Ghana.

**Music education and its pedagogical practices in Ghana**

Scholars of music in Ghana have noted that music education transfer in Ghana has swayed of been attaining its goal, thus, the augmentation of the emotional knowledge of children (Debrah Otchere, Amuah & Numekevor, 2016).

For a pedagogical approach presumed by music and dance educators/ teachers in both tertiary and basic schools in Ghana, the researchers observed that majority of the teachers who teach the subject at the basic level have obtained college degrees in subjects other than music and dance. This issue has pretentious their educational approach of the subject and again noted that once the teachers lack professional knowledge and skills of the subject material, they were unable to interpret the curriculum inventively.

In line with the argument of the pedagogical approaches to music education in Ghana, it is observed that the core goal of music instruction and learning which is the enhancement of the affective practiced of children has not been attained.

One causal issue for this recognised problem is the lack of specialised or professional teachers for the implementation of the music curriculum for the basic school levels. More so, it was observed that when music teachers acquire quality training, they will be sufficiently equipped for an effective music teaching in the classroom. Finally, instruction on music and neuroscience could also be vibrant portion which could also be futured in the Ghanaian colleges of education music programmes.

**Benefits of Music to Education**

Neuroscientific research has provided support for the assertion that music education is beneficial to education in the sense that it helps improve performance of the student in other subject areas, supports the individual in respect of self-discipline, efficiency and emotional control, as well as promotes benefit to society as a whole. Some of these benefits are visible in the following: (1) Musical activities (Hyde et al. (2009). (2) Students' have improved ability to develop vocabulary and reading skills (Tsang and Conrad, 2011). (3) Musical experience raises IQ (Schellenberg, as cited in Hyde et al., 2009). (4) Music directly alleviates learning disabilities, such as dyslesia. (Flaugnacco et al., 2014) (5) Music activities improve attention and memory recall (Posner & Patoine, 2009). (6) Music is a less expensive and simple method of early screening in children for reading disabilities. For example, according to Zuk et al. (2013). (7) Playing of music instruments helps intellectual development and increases confidence, self-esteem, strong will to overcoming frustrations when learning is tough, self-discipline; and promotes means of self-expression (Hallam, 2010). (8) Students who participate in high-quality music programmes scored higher marks in reading and spelling tests (Hille et al. 2011).

Hodges' (1997) philosophy that "only humans have music; birds' songs are "more" communication than music, and that the musical aspect of the human brain starts working from the womb" raises the important question or concern of whether human foetus that is exposed to considerable amount of music during the gestation period may produce a person of higher intelligence than the foetus with little or no music background sound during pregnancy.

In summary, the literature relates to the study since it discussed efficacy and emotional control in the brain. It also indicates that musical activities develop the brain. The study again reports that student's vocabulary and reading skills are developed by engaging oneself into a musical activity.

**Music versus Reading**

The fact that music enhances the knowledge and understanding of other subjects cannot be underestimated. According to Dee Hansen and Elain Bernstore, “Music educators struggle with the sometimes-contradictory philosophies of the study of music for its own sake versus the study of music in support of other nonmusical skills.” James Catterall's analysis of the Department of Education's National Education Longitudinal Study of 1988 (NELS:88) reveals that “musical learning has positive effects on mathematics and reading skills,” Hansen and Bernstore, (2002:17)

In 1997, the U.S. Department of Education established "America Reads Challenge" with the goal of developing all adult literacy starting with children Millions of dollars were set aside for the reading programs through the federal state funds. This affected other disciplines’ instructional time especially music educators as well as the arts and physical education. However, improvement was minimal. The National Research Council published its findings entitled "Starting Out Right" warnings that" after several days of too many hours of reading every day, the reading experience becomes distasteful for children, and if music programs are discontinued, students will be deprived of potential aural, oral, visual, and emotional experiences that should bring reading and writing texts to life.

The researchers advised that "learning to read and write is a complex and multifaceted process that requires a wide variety of instructional practices." Therefore, instruction in music can be a rich source of support for achieving reading literacy. They explained that many basic skills used in text reading or decoding reading symbols i.e., breaking the visual code of symbols into sounds are more in music reading than text reading because instrumentalists and vocalists read music symbols. More specifically, in choral music, one must additionally read lyrics alongside to the musical symbols. Furthermore, “choral students demonstrating fluency perform precise attack-and-release of beginning and ending consonants to emphasize key words in lyrics while singing on the vowel.” This is a commonly used technique to achieve accurate intonation and blend in music reading that can influence reading of text. Above all, “children learning music-text reading skills in music class at the emerging level choose movements, pictures, or graphic representations to represent sounds while Students at the decoding stage sight-read text and music simultaneously, attending to the syllabic or melismatic relation of the text to pitch or rhythm changes; use articulation of individual consonants and vowels as they relate to specific musical pitches and rhythms in the musical context; and make appropriate adjustments to the text of additional verses of a song to fit the music.” These are the highly technical activities that go on in music lessons that at the same time are fun.

Music pedagogy activities also influence fluency in reading. According to Theodore Harris and Richard Hodges, “fluent readers are those who are capable of reading text with speed and accuracy.” They also define fluency as “expressing oneself smoothly, easily, and readily, having freedom from word identification problems,” Harris and Hodges, (1981).

**Similarities between Music and Language**

Over the years various academic discourse by scholars concerning similarities about music and language was discussed (Berkowitz, 2010; Patel, 2010; Bloome, Carter, Christian, Otto, & Shuart-Faris, 2004; Bourdieu, Passeron, & de Saint Martin, 1996; McKay, & Wong, 1996). Others argue that it is important to focus on investigational dialogues to find out if music and language processing possesses similar characteristics (O'Kelly, & Magee, 2013; Hollien, 2013; Oldfield, 2006; Rod Watson, Swain, & McRobbie, 2004; Black, Harrison, & Lee, 2003; Oldfield, 2003; Freimuth, Quinn, Thomas, Cole, Zook, & Duncan, 2001).

In connection with the above deliberation, it can be inferred that it is worth to examine the brain base apprehensions of the relationship between the brain processes when engaged in singing and reading activities (Brain, 2015; Satel, & Lilienfeld, 2013; Bagozzi, Verbeke, Dietvorst, Belschak, van den Berg, & Rietdijk, 2013; Franks, 2010; Wagner, 2010; Feinstein, (Ed.). 2009). This study therefore, is believed to have provided a verity and to enable researchers to the establishment in the field of music and neuroscience practices in Ghana and Africa as a whole. According to Sloboda (1985) in his argument, music and language are specific to humans, both comprise potentials for immeasurable combinations of potentials both can be learned by listening to replicas and that both use vocal and auditory sound processes as their natural medium.

He continued to compare music and language that it could have similar processing characteristics because they can both be scrutinised in terms of phonetic as in language acquisition, syntactic and semantic structures and that both can be comparable (Khurana, Koli, Khatter, & Singh, 2017; Meisel, 2011; Abrahamsson, & Hyltenstam, 2008; Brown, 2005; Brown, 2000; Petitto, Zatorre, Gauna, Nikelski, Dostie, & Evans, 2000; Postma, 2000).

However, some scholars also report that music and language do not have similar processing characteristics (Sun, Lu, X., Ho, Johnson, Sammler, & Thompson, 2018; Schön, Gordon, Campagne, Magne, Astésano, Anton, & Besson, 2010; Steinbeis, & Koelsch, 2008; Tallal, & Gaab, 2006; Koelsch, Kasper, Sammler, Schulze, Gunter, & Friederici, 2004; Peretz, & Hyde, 2003). others argue that comparing music and language in similar processing physiognomies are questionable because insights that highlight the emotional processes of music are of personal perception as compared to language (Welch, Hallam, Lamont, Swanwick, Green, Hennessy, & Farrell, 2004; Philpott, 2001; Spruce, McCormick, & Paechter, 1999; Westerlund, 1999).

Jackendorf (2009) provided a framework of some differences that occur in the brain developments/processes of music and languages, For Jackendorf, music processes enhance result or effect while language processes transport relative thoughts (Jackendorf, 2009). Though, their inquiries were not able to define the various regions of the brain that may be explicitly responsible for language processing which may be compared to music processes.

In sum, the argument was clear that both music and language could have some mutual physiognomies to brain actions in humans. While both comprise abilities for endless blends of potentials, more so, both music and language can be processed from replicas of spoken/vocal and auditory sound means. Therefore, to understand music and brain behaviour, some consciousness could be allied with those of language processing.

## Current Developments in the Human Brain in Music

Scholars discussed about how music is been processed in the human brain (Patel, 2010; Särkämö, Tervaniemi, Laitinen, Forsblom, Soinila, Mikkonen, & Hietanen, 2008; Molnar-Szakacs, & Overy, 2006; Koelsch, & Siebel, 2005; Peretz, & Zatorre, 2005; Levitin, & Menon, 2003). Others observed that we often listen to one sound almost every day such as someone's voice, in a background of competing sounds (LaBelle, 2015; Johnsrude, Mackey, Hakyemez, Alexander, Trang, & Carlyon, 2013; Dole, Hoen, & Meunier, 2012; Levey, Levey, & Fligor, 2011; Prochnik, 2011; Cameron, & Dillon, 2007; Gatehouse, & Noble, 2004; Kalikow, Stevens, & Elliott, 1977).

It is obvious for as to listen from our musical background and must assign concurrently occurring frequency component to the correct source, and to organise sound appropriately over time (Johnsrude, Mackey, Hakyemez, Alexander, Trang, & Carlyon, 2013).

The establishment of the discourse reveals that physical signals that we exploit to do so are deep-rooted; additional new research has engrossed on the fundamental neural bases, where most progress has been made in the study of a form of sequential organization known as 'auditory streaming' (Stuart-Hamilton, 2012).

Researchers report that listeners' sensitivity to streaming cues can be captured in the responses of neurons in the primary auditory cortex, and in electroencephalogram (EEG) wave components with a short latency (<200 ms). However, cyclosis can be powerfully affected by care, signifying that this early processing either obtains input from non-auditory areas, or feeds into processes that do. This has become very necessary that the true value of music does not necessarily depend on its musical structure but in the effects, scholars suggest that the musical processing and experience is rather functional than the music itself.

Consequently, it is reasonable enough that investigating into the brain responses of the music including various aspects of performance structures might be of significant value to scholars and can also be useful for pedagogical purposes (Green, & Bavelier, 2012). Tonotopy as in psychophysiological studies seems to be an important feature of the expedition for musical investigations in music and brain-based study. It is very probable that Psychophysiological studies identified tonotopy is the spatial preparation of where sounds of varied frequency are processed in the human brain (Rauschecker, & Tian, 2004).

This study therefore, relates to this research because, there is the need to understand the tonotopy (the spatial arrangement of where sounds of different frequency are processed in the brain) processes of musical tones dynamics as well as other musical activities can be of importance to us as music educators in Ghana (Marsh, & Young, 2006; Swanwick, 1999).

**Music Reading: Sight Reading/Sight Singing and Performance**

According to Gabrielsson, (2003, p. 243), "sight reading means performing from a score without any preceding practice on the instrument of that score, that is to perform *a prima vista*. Sight reading involves a combination of reading and motor behaviour, that is, to read note patterns coming up in the score while performing others just read." Pike and Carter, (2010) hint that "sight-reading is a complex process that engages numerous skills like perception, memory, problem solving and concentration while Risarto and Lima, (2010) adds audiation and motor coordination to the process. Piano sight-reading is a multisensory activity according to Le Corre, (2002). Lehmann and McArthur, (2002) also say it combines both interpretation of sensorial information from the musical score with pre-held musical knowledge and instructing the fingers to select specific corresponding keys of the piano to achieve the desired sounds.

Music reading and performance cut across the lengths and breadths of music practicum involving solo or group works such as orchestra, piano, strings, brass, organ, singing, jazz band and choral music. According to Gabrielson, (2003, p. 223), music reading and preparation for performance involves the following series of musical tasks:

- Practicing - *Sight reading, Dynamics and other technicalities*
- Learning the general characteristics
- Eye movements
- Sight reading and memorizing
- Identification of musical structure
- Improvisation - Motor processes in performance
- Some general background knowledge of the musical piece and the composer
- Motor exercises
- Theories of motor skills
- Empirical investigations
- Expressive movements

- Measurements of performance - Measurement procedures and data analysis
- Early investigations
- Contemporary investigations
- Comments - Models of music performance
- Models based on measurements
- Models based on intuitions
- Comments - Physical factors in performance
- Medical issues – Healthy sight, Hearing and whole body fitness
- Stress factors
- Psychological and social factors – Development, Personality and Performance anxiety.

According to Gabrielsson, all the above considerations go into music reading and preparation for performance. However, McPherson et al. (1997, p. 51) cited in Gabrielsson, (2003, p. 246), outlines five types of performance as performing rehearsed music, sight reading, playing from memory, playing by ear and improvising. Pressing (1998) defines improvisation as "a system of expertise, relating to standard expertise theory with its emphasis on deliberate practice and development of domain specific skills, in this case skills such as real-time perceptual coding of events, optimal attention allocation, decision making, prediction of the action of others, error correction, movement control and others, moreover the ability to 'integrate these processes into an optimally seamless set of musical statements that reflect both a personal perspective on musical organization and a capacity to affect listeners." One can perceive that the definition pertains most specifically to jazz band performance because there are different kinds of improvisations and their context. For example, an organist can improvise on a hymn and the process will be different from the specifications in Pressing's definition.

**Steady Involvement in Reading and Singing of Music**

This study focuses on examining neural activities that are associated with the young adult's involvement in music among students of a University music programme. Scholars report that steady involvement of musical activities is the origin that underpins musical behaviours.

Scholars reveal that active involvement in music behaviours has been branded as one of the qualities found among both adults and children (Sloboda, & O'neill, 2001). In the year 2005, a study has been conducted and was observed that long exposure to music had significant influence on musical preference and also, influenced their music listening behaviour at the later part of their lives.

It is undeniable fact that the literature draws more attention to both young adults who are steadily engaged in musical activities. Some of these modes were (1) singing/listening to background music (Radocy and Boyle, 1997; Musselman, 1974). Scholars again observed that background music does not arrest the attention of many young adults however, does not help them develop much musical interest. Another study also mentioned Muselleman that according to him when children experienced background music, they hear the music but they do not actively or purposely listen to it; (2) listening as an accompaniment to non-musical activities (Larson & Kubey, 1983; Sloboda, et al., 2001). In this situation music is more often used as a secondary, than as a main, activity, by adolescents and young adults; (3) listening as a main activity (Boal-Palheiros & Hargreaves, 2004). Scholars view in the mode of listening in this context, both children and young adults aim heeding and whitethorn be focused, thus, during the mental process or participating mentally in the music. Again, music participation with full focused may have both cognitive and emotional functions (Boal-Palheiros & Hargreaves, 2004); (4) Listening or engagement of musical performance activities. Both children and young adults engaged in this mode of listening, according to Boal- Palheiros and Hargreaves, "listen attentively and respond physically to music (e.g. singing, and dancing to a song)."

In summary, it is observed focused on the adoption of mode of singing and reading activity where young adults engage in music singing and reading activity. The purpose was to observe or focused on young adult's brain response to music when engaged in both music singing and reading.

**Music Cognition and Cognitive Procedures in Adults**

Cognitive processes in music education is describe as the study of the mental reproductive developments and ideas that are allied to musical behaviors such as singing, listening, reading, performing, or any other behaviours associated with music participation. In the study, it is revealed that young adults proficiently process music in a cognitive means. In addition, some scholars conducted a study to investigate how young children and adults can perceive pitch destruction in both music and language. In the study, it was found out that children who are musicians perform better than those that are non-musicians. Another study also reports that there was a strong relationship between music instruction and improved cognitive abilities of young adults' phonemic awareness in music. The study is therefore, relavant to Shaw's theory which I used as theoretical framework that engagement in an active musical behaviour enables cognitive processes being boosted.

**Formal Trends in Adult Education**

Education as a process of enabling learning, or the gaining sort of knowledge, skills, values, beliefs, and habits which takes place under the guidance of educators (Ertmer, & Newby, 2013; Mezirow, 2009; Doyle, 2008; Wilson, Ludwig-Hardman, Thornam, & Dunlap, 2004). They again observed that learners can also teach or educate themselves (Schweisfurth, 2011; Fleming, & Baume, 2006; Illeris, 2003). Scholars report that education is a intermediate for erudition, and that, the school system is said to be one of unit for educational practices (Gay, 2018; Ball, 2012; Diekelmann, & Diekelmann, 2009). A school is also said to offer learning spaces under instructors' directions (Long, & Ehrmann, 2005; McArthur, 2015; 2004; Barr, & Tagg, 1995).

Other scholars also report that school is the leading spout of knowledge that young adult are bare to. Schooling provides likelihood for them to attain information on a diversity of grounds of learning (Hargreaves, 2003; Mertens, 2014) Music knowledge is one of the unique fields of knowledge that learners can acquire in school (Conley, 2008; Green, 2008; Green, 2008).

In brief summary, education offers prospect for learning and that the school system is one of the most sole systems where children can learn in a conducive environment. In this erudition scheme, teachers play a key role in helping learners to study.

## Chapter Summary

The second chapter of this study focused on the conceptual and empirical review of related literature. In this chapter, I discussed neuroscience and its application in education, specifically Music Education. Some neuromusical studies were also presented and discussed. The nervous system, its parts and functions were also analysed to help understand the parts of the brain responsible for music appreciation and as well as tonotopy. Other thematic areas such as: sex differences in adults, music reading; sight reading/sight singing and performance; benefits of music to education; the potency of music in neuroscience achievements were also elaborated and supported with empirical studies from the field of neuroscience and music education.

Other studies also focused on the adoption of mode of singing and reading activity where young adults engage in music singing and reading activity. The purpose was to observe or focused on young adult's brain response to music when engaged in both music singing and reading. Another study also focuses on a study that was relavant to Shaw's theory of which I used as theoretical framework that engagement in an active musical behaviour, enables cognitive processes being boosted.

Other scholars discussed that education offers prospect for learning and that the school system is one of the most sole systems where children can learn in a conducive environment. In this erudition scheme, teachers play a key role in helping learners to study.

For music education, scholars provided evidence that it is eminent that there is a mislaid between music education in Ghana and nature of Ghanaian music. Another observation made is that there is a battle between Curriculum Research and Development Division (CRDD) and the music educators. The employment of information and communication technology (ICT) and the indigenous traditional Ghanaian music in the school curriculum has also been erroneous. This position perceptibly touches musical contribution and learning practises among youth in the school system in Ghana.

It was also noted in the literature that music participation and learning have a significant impact on children growth. This suggests that musical engagement and learning should be encouraged in schools. More so, initial music learning has also been found to have a long-term effect on children's musical knowledge.

Finally, report show that one causal issue for this recognised problem is the lack of specialised or professional teachers for the implementation of the music curriculum for the basic school levels. More so, it was observed that when music teachers acquire quality training, they will be sufficiently equipped for an effective music teaching in the classroom. Finally, instruction on music and neuroscience could also be vibrant portion which could also be futured in the Ghanaian colleges of education music programmes.

# CHAPTER THREE

# METHODOLOGY

## Introduction

This chapter broadly describes the methodology that was adopted in carrying out the study. Notably, it addresses the research design, population, instrument which was used for data collection. Other things which were also taken consideration in this chapter include data collection statistical design, sampling and sampling procedure and analysis procedures.

Neuroscience is an exciting and emerging discipline which seeks to understand the most complex organ in the body and the nervous system; the brain. EEG can capture and record human brain waves-neural oscillations- (Llinas, 2014) that are traced from brain responses to various musical stimuli. In another development, brain waves are said to produce computer generated frequency ranges that are categorised into beta, alpha, theta and delta-four types, which are all generated at all times (Fries, 2005; Gaser & Schlaug, 2003).

## Research Design

The quantitative research method was adopted for this study. This method of research has been explained by scholars as a type of research method which focuses empirically on the measurement of data, mathematically, statistically or numerically.

Quantitative research method focuses on gathering numerical data which can be generalised across groups of people or to explain visible behaviour.

According to Llinas, (2014) suitable method was designed purposely to capture the brain activity which couple with brain waves or neural oscillations.

For the collection of data, in this chapter, various neural waves were varied by observing various stimulus responses that were generated.

According to scholars, numerous designs were discussed in adopting suitable research designs in this study.

**Experimental Design**

Researchers report that an experimental design simplifies the multitude and analysis of supporting, refuting, or validating a hypothesis (Philippe, Poustka, Chiodin, Hoff, Dessimoz, Tomiczek, & Kuhl, 2019; Callen, 2015; Crismond, and Adams, 2012). They again report that the preface *quasi* means “resembling.” Therefore, quasi-experimental research is research that look like experimental research but is not true experimental research. Though the independent variable is operated, respondents are not randomly allotted to conditions or instructions of conditions. Because the independent variable is manipulated before the dependent variable is measured, quasi-experimental research eliminates the directionality problem. But because participants are not randomly assigned making it likely that there are other differences between conditions quasi-experimental research does not eliminate the problem of confounding variables. In terms of internal validity, therefore, quasi-experiments are generally somewhere between correlational studies and true experiments.

Quasi-experimental research design is similar to experimental research in that there is manipulation of an independent variable. It differs from experimental research because either there is no control group, no random selection, no random assignment, and/or no active manipulation.

Scholars acknowledged that research design is an overall plan for collecting data in order to tackle the objectives of a study. It is therefore envisaged that understanding the adopted design aided the examination and the analytical development of data that was collected empirically. Therefore, the researcher decided to use music reading and singing to probe the various brain responses which may be generated and statistically analysed as proposed in the hypotheses of this study. The researcher employed inferential observation but not causation. This is because quansi-experimental design does not employ random assignment.

Previous research on similar experimental design guided the researcher on the type of data to collect, how to collect, process and analyses them in order to answer the research questions or test the research hypothesis (Sahu, 2013; Wahyuni, 2012; Ellis, & Levy, 2009; Gelo, Braakmann, & Benetka, 2008).

Researches have shown that a treatment in a factorial design is the possible units of combinations. Again, a factorial design may also be called a crossed design. A researcher, Ronald Fisher also, argued about the fact that complex designs such as factorial designs were more efficient than studying one factor at a time (Gilbert, & Fisher, 2006; Box, Hunter & Hunter, 2005; Anderson, & Whitcomb, 2000; Fisher, & Yates, 1953). Repeated measures are said to be powerful for factors that cause variability between subjects (Bakeman, 2005; Morris, & DeShon, 2002; Keselman, Algina, & Kowalchuk, 2001).

**The Statistical Design of the Study**

This research employed factorial design due to its applicability to probing into music performance and brain responses focusing on two or more factors.

Glenberg, & Andrzejewski, (2008) on the other hand explain that all possible blending of all levels across factors. This occurs within the experimental units. It is evident that a factorial design is more efficient and complex than studying one factor simultaneously. Glenberg and Andrzejewski (2008) propose four main principles which charaterise the application of factorial design in statistics:

A factorial design/experiment must have two factors, and each of the factors must have at least two levels.

Each treatment is formed by merging one level from each of the factors but never by combining levels from the same factor.

The total number of treatments is equal to the product of the levels of all of the factors.

Each sample, one from each treatment must contain at least two observations.

This study therefore, proposed to employ Shaw (2005) theory which also demands the use of factorial design as it has the characteristics of multiple factors. A factorial design expounds the design having multiple factors. Hence, unlike one factor with different treatment which uses one-way ANOVA, these multiple factor designs, therefore use factorial ANOVA as explained by Glenberg and Andrzejewski (2008). This study was conducted at the premises of the music and dance Department of the university of Cape Coast.

**Table 1: Population**

| | Gender | Frequency | Percent | Cumulative Percent |
|---|---|---|---|---|
| Valid | Male | 32 | 64.0 | 64.0 |
| | Female | 18 | 36.0 | 100.0 |
| | Total | 50 | 100.0 | |

From the table above, it is observed that 64 percent of the population represents male respondents that were used in the study. It is noted that the male respondent constitutes more than half of the population used as participants in the study.

**The Research Design**

**Census Methods**

In this study, census was employed. Census is an effort or an attempt to list all elements in a group and to measure one or more characteristics of those elements. A census can provide detailed information on all or most elements in the population, thereby enabling totals for rare population groups or small geographical areas. Census is also suitable where the field of investigation is small. It is more accurate and reliable and also, rules out the possibility of any personal biases but it also depends on the population Vigilant, McNeilage, Gray, Kagoda, & Robbins, 2009; Smith. By census, 50 respondents which constitute the total population of music students in the department of music and dance, university of cape coast were adopted in the study.

### Rationale for the choice of Quantitative method for this study

Scholars report that different research approaches or method and different analyses have their strength and weaknesses Allen, Clapham, Hammond, Katona, Larsen, & Stevick, 1999; Wright, Boyd, & Tredoux, 2001). Plonsky, 2013; Moher, Liberati, Tetzlaff, & Altman, 2010; Scollon, Prieto, & Diener, 2009; Grant, & Booth, 2009; Wolf, 1986). Again, different methodology and pedagogical strategies be applied in this investigation of as conducted in other studies to authenticate what scholars observed that the change in methodology affects data results and findings (Anney, 2014; Steinert, Mann, Centeno, Dolmans, Spencer, Gelula, & Prideaux, 2006). Confirming the above statement studies showed by Girolametto, Sussman, & Weitzman, 2007) as well as Goldstein, Hubbard, Cutler, Angeli, and Valanides, 2009) have also confirmed this observation.

As a result, it is important that a researcher chooses a research method that suit the purpose of his research. It is vivacious that the nature of this research lends itself better to the quantitative method because of the statistical data that were generated of which my research questions one, two and three are not in exception.

### Data Collection Instruments

The data collection tools of this study are: Electroencephalogram (EEG) machine, questionnaire, Laptop computers and recording technologies.

Questionnaire

Data collection for the study was also carried out by means of questionnaire. The use of the questionnaire became desirable so as to be able to elicit responses regarding students' demographic backgrounds as well as their previous backgrounds in music. Since it was a census study, the questionnaire was administered to 50 undergraduate music students in the Department of Music and Dance of University of Cape Coast.

The questionnaire was structured into two sections, A and B. Section A sought to collect demographic data, notably respondents' academic levels, age and gender. Section B on the other hand was designed to collect data on respondents' degree of exposure to music, that is singing and reading of music before entry into a university programme. The section consisted of four close-ended items that elicited responses on whether the respondents got engaged in singing or reading of music and how long their engagement was before entry into the university music programme.

The four items on the questionnaire are described as follows:

Questions 1 and 3 were made up of 'yes' or 'no' responses while questions 2 and 4 comprised multiple choice options.

(Question 1=A-B): = "Yes" = A; "No" = B. Question 2 was a follow up question and consisted of five items eliciting information on how often respondents had sung before entering into university. (Question 2 = A-E) "Once a week" = A; "Twice a week" = B "Thrice a week" = C; "Four times a week" = D; "Five times or more a week" = E. The question in (Question 3 = A-B): "Yes" = A; "No" = B. Question 4 collected data on how long the respondents had participated in a group singing activity like choir before entry into a university programme. (Question 4 = A-D): “One year” = A; “Two years” = B; “Two and a half years” = C; “Three or more years” = D.

**Data Collection Procedures**

The data collection for this research streamlined various rigorous procedures. After a successful proposal defense, the research proposal went through ethical clearance and later, approval was given from the Institutional Review Board, University of Cape Coast (UCCIRB). I submitted an introductory letter to the head of department of music and dance, University of cape coast for permission for data collection.

I was duly advised by the head of music and dance department to carefully observe the vulnerability of the respondent. In this case, all the respondents were music students from levels 100 to 400 respectively. Though, the respondents were adult between the ages of 17 and 23. Yet still I made conscious effort and provided them (respondents) with a comprehensive ethical and procedural rule which was dully observed by the respondents.

During the data collection process with the respondents at the university premises, the data collection was started with the level students. This was because, some students at that time had little or no exposure to either reading or singing, or some of the students might have not been in any of the choral groups before entry into a university music programme. In all, I first demonstrated what actually the EEG machine does to the student respondent whilst a respondent was exposed to music performance activity regarding reading performance activity and singing performance activity.

**Determination of Primary and Secondary Data Collection**

Data were collected according to two categories in this study; these were; primary and secondary data collection procedures.

Primary data collection is the process of gathering data directly from sources other than collecting data from already done research, such as literature. It is data that has been collected from first-hand-experience and which has not yet been published. It is believed to be more authentic and reliable.

Secondary data is defined as data collected by another person than the researcher, and these data have already gone through post data systematic processes. In accessing these data, there is no specific method because the data is ready for access (Kabir, 2016). Other scholars defined secondary data as data which has already been published (Kabir, 2016).

Scholars described some categories of secondary data as books, newspapers, biographies, data achieves, internet articles, database, among others (Kabir, 2016). Building up on previous chapter of the literature review in this study; two types of stimuli were paramount in this study during data collection. These two types of stimuli were used to examine brain activity of each of the 50 students' respondents. These were reading and singing stimuli. The data was generated in the form of electroencephalogram (EEG) recordings. Following recording, Statistical Package for Social Sciences (SPSS) was used for data analysis and removal of artefacts.

Data collection was first tested in a pilot, and then completed in the final study.

A pilot test is an early enquiry in order to assess feasibility, time, and cost, to improve upon the study design preceding the conduct of a complete investigation. Piloting in this study was to support the verification of outcomes which were computed and analysed from the data results. The main purpose of this study was to examine the significance differences in brain response to reading and singing activities.

After the cut off of the artifacts of each respondent a total of 5120 sps data which represent 20 seconds data records were then cut off from the residual data of each respondent and credited into the data base. These data were computed and analysed.

**Data Processing and Analysis Procedure**

Field (2009) identifies variables in quantitative research model as another the important aspects. According to him, a variable in statistics is defined as any characteristics that can be measured in a study or value that changes in data unit in a population over time.

Field was optimistic that the quantitative model would be more suitable for any variable intended to be measured that must be derived from the collected data which would be used in the testing of the proposed model (Bond, Yan, & Heene, 2020; Vaughan, & Ormerod, 2005).

This study uses a factorial design with four repeated measures factorial ANOVA. Between subjects in a factorial design, different respondents test each condition so that each respondent is only exposed to a single user interface.

Between-subject variables have discrete levels as explained by scholars in the field of quantitative research paradigm (Glenberg & Andrzejewski, 2008).

Within-subjects is also referred to as repeated measures ANOVA. That is if the test sense slightly concluded differences between related means (Glenberg & Andrzejewski (2008; Zimmerman, & Zumbo, 1993).

In the data processing and analysis, the repeated measures ANOVA design was used in analysing the data with three (3) factors. The first factor was brain response with the levels reading and singing. The second factor was exposure with the two levels; long exposure to music and limited exposure to music before entry into a university music programme. The third factor was the brain lobes with four levels. These levels were the Frontal, Parietal, Temporal and Occipital lobe. This follows the direct arrangement of the four brain lobes of the human brain.

Again, APA reporting style and test reporting were involved during data analysis. Both descriptive and inferential statistics were employed for the data analysis. These are mean, standard deviation, paired sample t - test (left with inferential statistics).

**Table 2: A repeated-measures factorial ANOVA proposed in this study**

| | **Lobe 1 (Frontal Lobe) repeated measures ANOVA** | | |
|---|---|---|---|
| **STIMULI** | $S_1$ | $S_2$ | |
| $M0$ | $M_0S_1$ | $M_0S_2$ | $X=$ |
| $M_1$ | $M_1S_1$ | $M_1S_2$ | $X=$ |
| | $X=$ | $X=$ | |

Table 2 illustrates the way the brain behaves or responds to music within the frontal lobe of the brain. This was to compare the brain activity of reading and singing that was discussed earlier in the frontal lobe.

**Table 3 A representation of a 2-way repeated-measures factorial ANOVA design**

| | Lobe 2 (Parietal Lobe) repeated measures ANOVA | | |
|---|---|---|---|
| STIMULI | $S_1$ | $S_2$ | |
| $M0$ | $M_0S_1$ | $M_0S_2$ | $X=$ |
| $M_1$ | $M_1S_1$ | $M_1S_2$ | $X=$ |
| | $X=$ | $X=$ | |

Table 3 represents four repeated measures ANOVA which was designed to observe the brain behaviour to reading and singing in the parietal lobe of the brain. Its purpose was to compare brain activity of the two selected activity associated with the brain in the parietal lobe.

**Table 4: A 2-way repeated-measures factorial ANOVA design used for this study**

| | Lobe 3 (Temporal Lobe) repeated measures ANOVA | | |
|---|---|---|---|
| STIMULI | $S_1$ | $S_2$ | |
| $M0$ | $M_0S_1$ | $M_0S_2$ | $X=$ |
| $M_1$ | $M_1S_1$ | $M_1S_2$ | $X=$ |
| | $X=$ | $X=$ | |

Table 4 the fourth design represents a repeated measures factorial

ANOVA to examine brain activity to reading and singing in the Temporal lobe of the brain. This was to compare differences in the brain lobes.

**Table 5: A representation of 2-way repeated-measures ANOVA for Occipital lobe**

| | **Lobe 4 (Occipital Lobe) repeated measures ANOVA** | | |
|---|---|---|---|
| **STIMULI** | $S_1$ | $S_2$ | |
| *M0* | $M_0S_1$ | $M_0S_2$ | $X=$ |
| $M_1$ | $M_1S_1$ | $M_1S_2$ | $X=$ |
| | $X=$ | $X=$ | |

Table 5 presents a repeated measures factorial ANOVA to examine brain activity to reading and singing within the Temporal lobe of the brain. This was purposely designed to compare differences in the lobes of the brain.

Quantitative Research Model

Scholars report that some approaches related to disciplines such as social sciences are insufficient in their potential due to insufficient and appropriate slants of investigations (Sovacool, 2014).

Other scholars are of the view that good research should trail a well-defined, systematic and well-structured scientific model. In this study, I therefore adopt the quantitative model for this research.

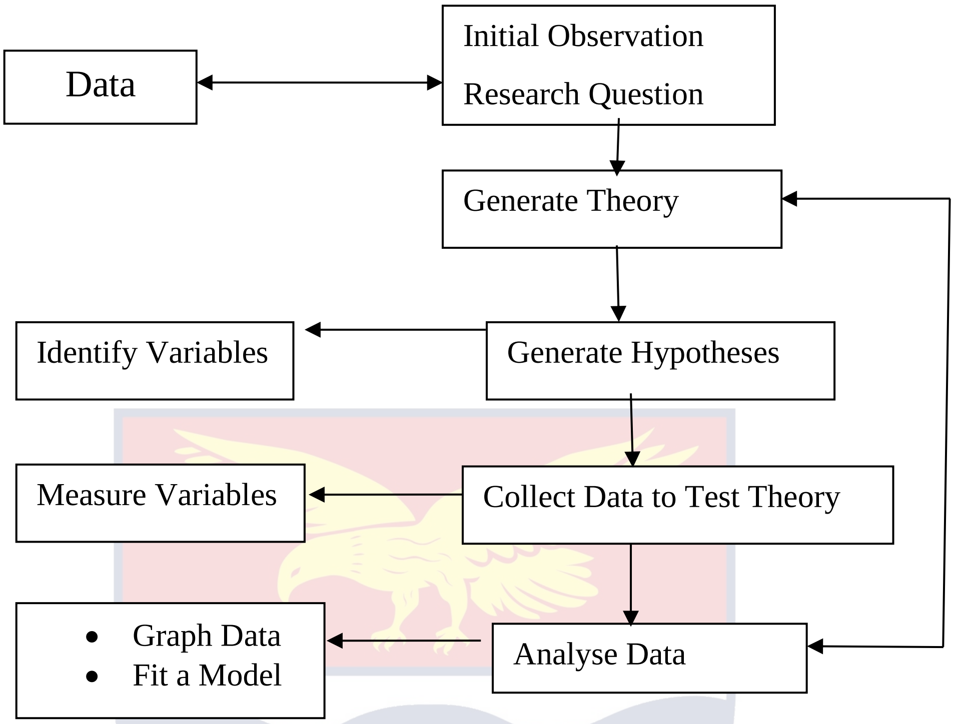


***Figure 8*: Model in quantitative research (Field, 2009).**

Field (2009), explained in his model that the kind of data to be collected is the most important aspect of research. This is because the kind or nature of data that is to be collected pre-informs the development of the theoretical framework of the study. This study aimed to investigate brain responses to music when engaged in music performance activity.

The electroencephalogram (EEG) is the most common tool used in brain research. It is an electrophysiological monitoring method using a machine to record electrical activity of the brain (Niedermeyer, 2004). EEG measures voltage fluctuations resulting from ionic current within the neurons of the brain. In clinical and research contexts, EEG refers to the recording of the brain's spontaneous electrical activities over a period of time as recorded from multiple electrodes placed on the scalp (Niedermeyer, 2004). This gives a brief description to the methods for recording and analysing the EEG. Detailed protocols describe recorder calibration, electrode application,

Scholars report in the process that the EEG machine will be placed, fixed with the electrodes on the scalp they will be connected to a monitory device (a computer) that transforms the electrical activities going in the brain into waves that can be used for data and interpreted for its relevant and useful meaning. In this study therefore the electrical activities, the ionic currents, the voltage fluctuations, the neuron synapses and their related behaviours shall be tracked from the application of various music stimuli as prompted in the hypotheses of this study (Bronzino, 1995).

Scholars also inform that it is only when the participation to a region is synchronized with electrical activity occurring at the same time that you begin to distinguish simple periodic waveforms in the EEG. Four simple periodic rhythms recorded in the EEG are *alpha, beta, delta, and theta.* These rhythms are identified by frequency in hertz (Hz or cycles/sec) and amplitude (Britton et al. 2016). The amplitudes recorded by scalp electrodes are in the range of microvolts (μV or 1/1,000,000 of a volt). Figure 7 provides a table of alpha wave rhythms that seem suitable in the rhythmic, performing and the scientific investigations and data collection of this study.

**Table 6: EEG waves (rhythms), frequencies and amplitudes that can be generated from brain responses.**

| Rhythm | Freq (Hz) | Amp(μV) |
|---|---|---|
| Alpha | 8-13 | 20-200 |
| Beta | 13-30 | 5-10 |
| Delta | 1-5 | 20-200 |
| Theta | 4-8 | 10 |

**How EEG was used in Data Collection in this Study**

Emotiv EPOC+ is a non-invasive brain recording technology which is a Brain-Computer Interface (BCI) system developed from modern technological advancement of the electroencephalogram. Electrodes are placed on the scalp they are then connected wirelessly to a monitoring device (a computer) that transforms the electrical activity in the brain into waves that can be used for data and interpreted for its relevant and useful meaning. In this study therefore the electrical activity, the ionic currents, the voltage fluctuations, the neuron synapses and their related behaviours were tracked during the reading and singing of music as prompted in the hypotheses of this study.

**Recording Procedure during data collection**

Below are the EmotivEPOC+ connection sample.

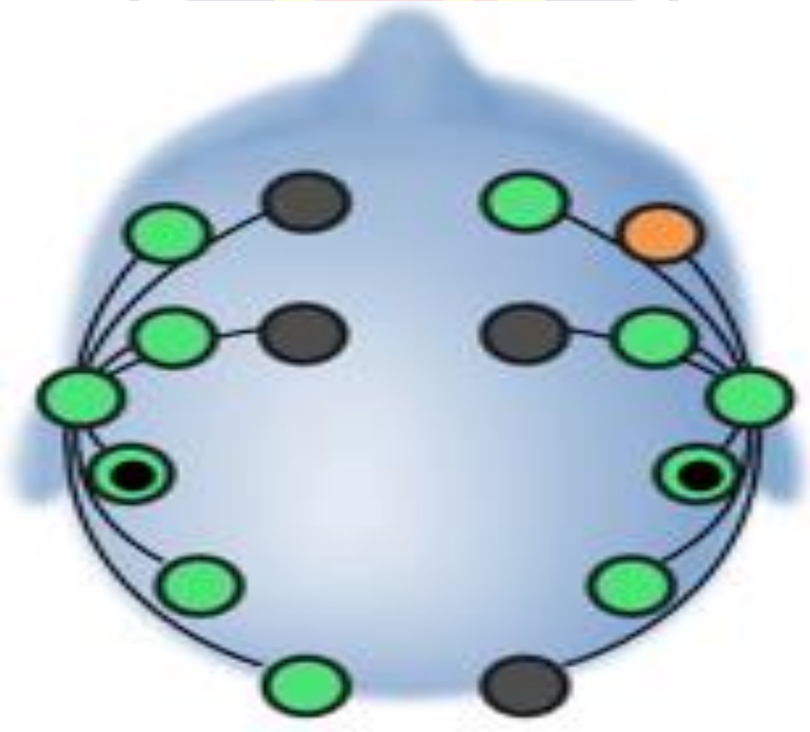

*Figure 9*: **EEG connection sensors of EmotivEPOC+**

Sensors of the EmotivEPOC+ are electronic machines that are monitored by the EmotivPRO whilst the EmotivPRO is the computer interface developed for its data collection.

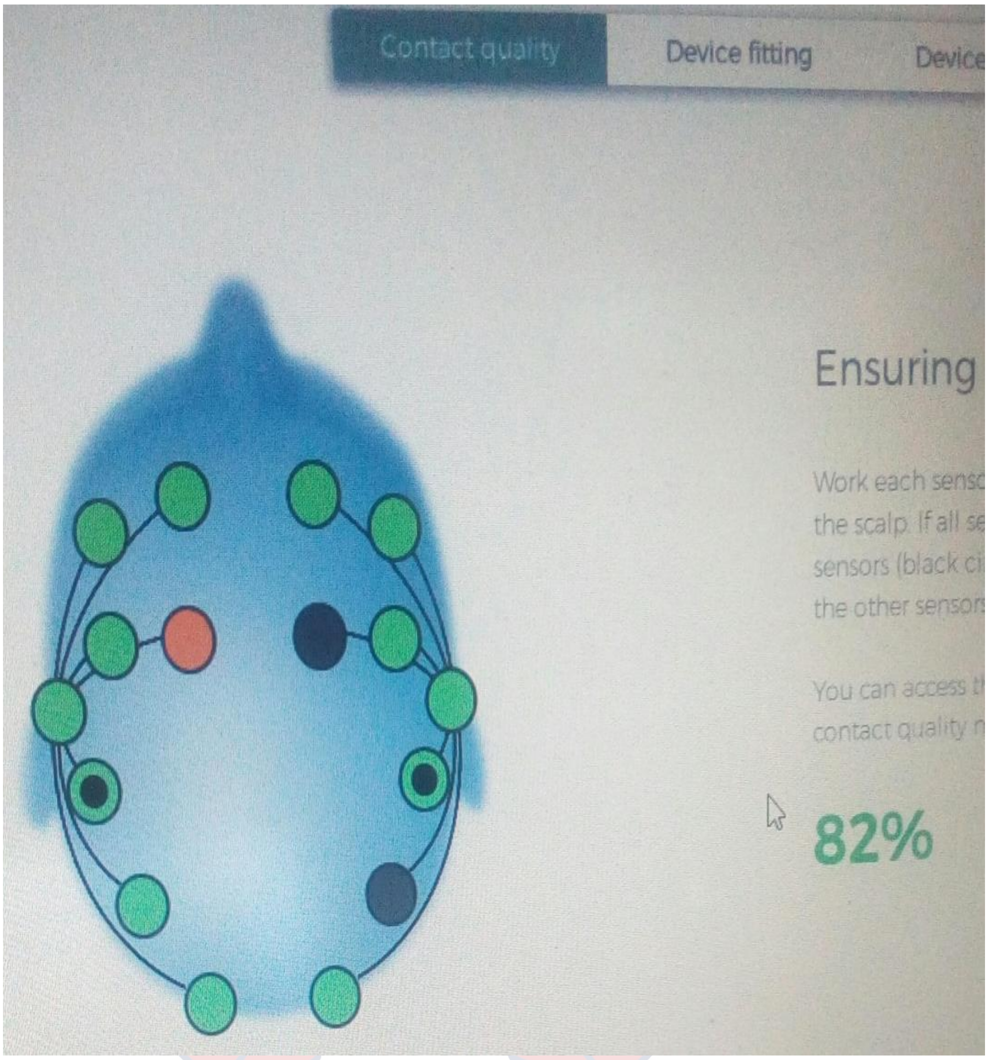


*Figure 10:* **The EmotivEPOC+ displayed by the EmotivPRO interface**

Figure 3.1 presented the various sensors used throughout the data collection setup for recording which can be viewed and monitored from the EmotivEPOC+ interface.

The EmotivEPOC+ was fixed on the scalp of respondents for the recording of brain activities.

There must be a good connection to get the EmotivEPOC+ headset at maximum percentage in connection before recording. In ensuring this, the

EmotivPRO had been programmed to display the connectivity status. From the EmotivPRO interface, three colours serve as indicators of the connectivity status. Scholars are of the view that these colours are black, deep yellow and green. Black is shown by any sensor in the interface on the computer screen to signal that there was no connection or a total interruption of that electrode. A yellow signal highlighted that there was a connection but was not adequate for recording for such identified electrode. The exhibition of green signal was an indication for a strong connectivity of the specified electrode that worth recording in this study. But when the sensors demonstrate a green signal then this suggests that there is a good connectivity for recording during the whole recording process as demonstrated in figure 2.8. The Emotiv connection was at times able to reach 100% before recording.

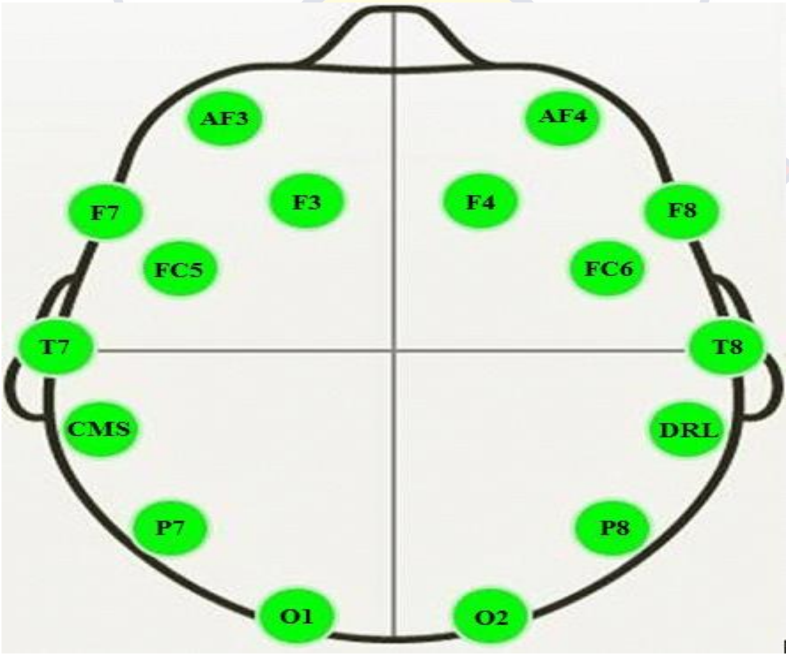


***Figure 11*: Demonstrating good connectivity before and during data collection**

**Table 7: Names of the above human brain lobes**

| | |
|---|---|
| AF3 = Frontal lobe | CMS = Temporal lobe |
| AF4 = Frontal lobe | DRL = Temporal lobe |
| F3 = Parietal lobe | T7 = Temporal lobe |
| F4 = Parietal lobe | T8 = Temporal lobe |
| F7 = Temporal lobe | P7 = Occipital lobe |
| F8 = Temporal lobe | P8 = Occipital lobe |
| FC5 = Parietal lobe | O1 = Cerebellum |
| FC6 = Parietal lobe | O2 = Cerebellum |

**Recording setup protocol during data collection**

During the process (setup), some preliminary measures took place before recording was done. They include: well-ventilated room (Lab) suitable for recording; an installed EmotivPRO on a computer fixed on an office table, the indigenous 'Yebo to Ebenezer' lyrics on a piece of paper was read and sung.

*Yɛ bɛ to Ebenezer*

*nyame n'adom ara kwa*

*kae 'nea nyame ayɛ ama wo*

*Na fa nnaasɛ ma no*

*Ebenezer nyame n'adom ara kwa*

*Yɛ bɛ to Ebenezer na yɛatrotrom Awurade*

***Figure:12:*** **Demonstrates the lyrics of the music for reading.**

*Yɛ bɛ to Ebenezer*

*nyame n'adom ara kwa*

*kae 'nea nyame ayɛ ama wo*

*Na fa nnaasɛ ma no*

*Ebenezer nyame n'adom ara kwa*

*Yɛ bɛ to Ebenezer na yɛatrotrom Awurade*

***Figure 13*: Demonstrates the lyrics of the music for singing**

The EEG machine then processed their neural corelate, whilst, brain responses were recorded.

***Figure14:* The environment for collection of data**

EEG recording was done in a serene environment with some snacks and face tissues available to the participant and researcher.

Laboratory (Room) Suitable for Recording

The Head of Music and Dance Department, furnished us with a well-ventilated room which was suitable for recording.

Another important factor was an environmental condition with no other sounds from external sources that could be disruptive to the recordings.

**EmotivPRO (Computer)**

The electrical impulses in an EEG recording look like wavy lines with peaks and valleys (Llinas, 2014). These lines allow doctors (researchers) to quickly assess whether there are abnormal patterns. Any irregularities may be a sign of seizures or other brain disorders (Gaser & Schlaug, 2003).

In this study, Electroencephalogram (EEG) machine software used This interface have been provided by EmotivPRO made it suitable for transforming the data into a different format before data could be analysed. In the process, the EmotivPRO interface was useful in converting Emotiv wave recordings into a comma-separated value (CSV). The signals then generated a continuous data on a Microsoft Office Excel spreadsheet during data mining process thus' after the data collection was completely done. This data process of transformation of data into a CSV excel spreadsheet enabled a successful transfer of the data into SPSS data.

**Technique for Selecting Stimuli Materials**

In support of the need of selecting stimulus materials, Boyle and Radocy (1987) propose that one must:

Provide a base for planning instructional activities, but in this case selecting materials for generating stimuli Helps in assessing a group's attitude towards a single object or event. In selecting music samples, it will be necessary to study and to establish some level of knowledge and confidence of student's various behavioural responses towards various sample to be sure of selecting appropriate materials that useful response as high confident level. Provides attitudinal data for academic activities. A cumulative scale may be generated through a cumulative scale technique to be able to have some level of confidence in the use of the selected homogeneous items. Help in checking statistical error (Boyle & Radocy, 1987 p.206.)

Boyle and Radocy further inform that these balances provide the response of respondents towards the use of an object, item or a situation to inform the selection of a homogeneous material for a test or other uses. This increasing record could also be done through the process of range arrangement for students to express their level of familiarity relationships from familiar to a non-familiar material. In the selection of these materials, a mood meter could also be used to help in identifying students' (respondents') emotional response towards a particular material (music).

Music (Indigenous) used for collection of data

"Yɛ bɛ to Ebenezer" an indigenous song, popularly known to most Ghanaians. It is often sung in churches and at social gatherings. My main purpose of selecting the music was that the students were likely to be familiar with it. I will be able to have a precise and valuable result.

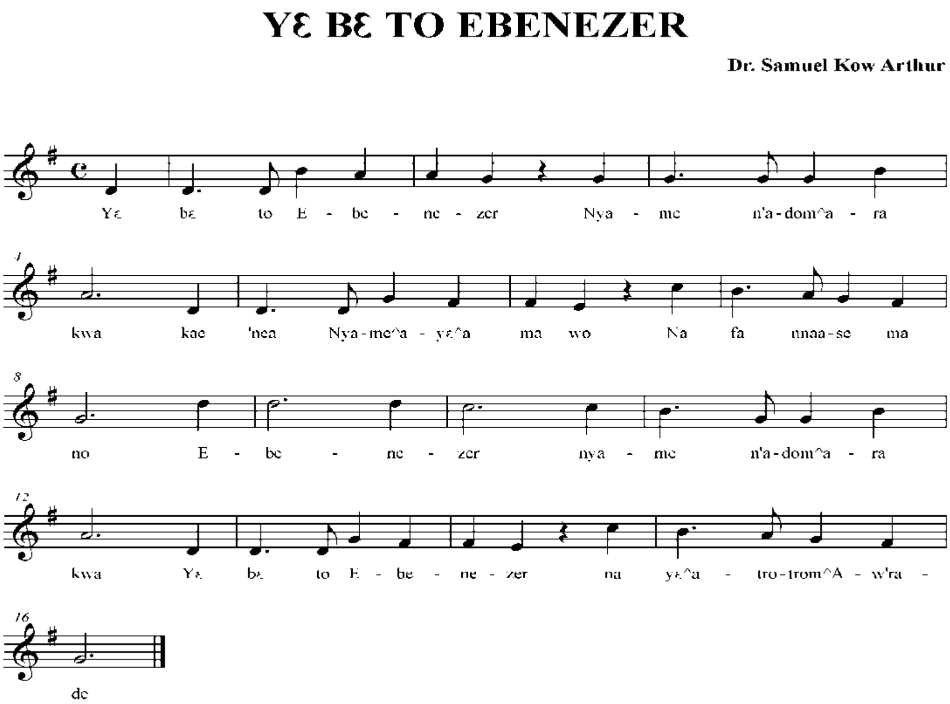


*Figure 1*5: Except of the opening monotone of Yɛ bɛ to Ebenezer

**Procedure**

Before data collection, there was the need to observe a green signal that indicates that the gadget was fully charged. There must also be a Bluetooth connection to ensuring that the sensors' signal is active and also, in good connection. It is very necessary to observe that the hydration of the sensors have been dully applicable to augment connectivity.

The use of a USB Bluetooth transceiver was also important within the setup method before data collection process. during the process the USB transceiver provides signal signifying a connection between the two gadgets by showing a red when it connects to the computer automatically. Hence, the transceiver was suitable for connecting the EmotivEPOC+ headset gadget to the EmotivPRO respectively.

Having fixed the above gadgets successfully, the headset was cautiously fixed on the head of the respondent. The EmotivPRO interface then exhibited a sign of connection within the sensors

During my data collection, respondents were asked to carefully study the material given to them after which each respondent will do the reading and singing performance activity. In order not to misinterpret data, I took record of each respondent for both reading and singing performance activity.

**Separation of Baseline**

Other aspects of collection of this data were to identify the baseline data. Scholars defined baseline data as a set of information often collected and employed to compare to other data acquired afterwards. Baseline data is also defined as measurement of behaviour taken before interventions are started. It is said to be very important in this study because it allows the researcher to compare the behaviour earlier and afterward before the implementation of behaviour plan to determine if the interventions are working.

**EEG Recording and Analysis for this study**

In this study, the electroencephalogram (EEG) was used for recording and analyzing the human brain responses. Though the focus for this study is on Music Performance and Brain Responses, the methods can be adapted for other fields of neuroscience in relation to music. The decorum provides instruction on EEG recorder calibration, electrode application, EEG recording, and spectral analysis of the EEG. EEG amplifiers and recording instruments have changed greatly in the past 20 years. Computer digitization and recording have replaced paper recording, and handheld ambulatory recorders now can replace whole racks of amplifiers. The following protocol describes calibration and EEG recording on an ambulatory recorder, but a clinical recorder in a laboratory could substitute for an ambulatory recorder.

**Data Mining Procedure**

After collection of data, the raw data collected during reading and singing performance-based brain response were recorded in the form of waves (signals).

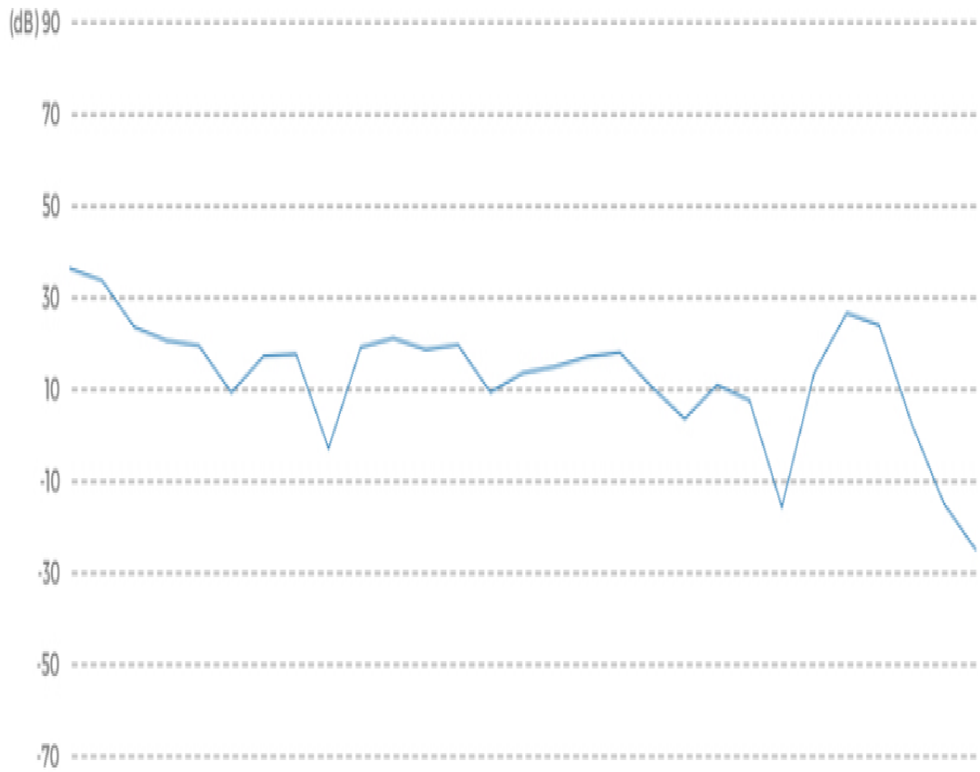


***Figure 16*** **Representation of Emotiv data amplitude from the interface.**

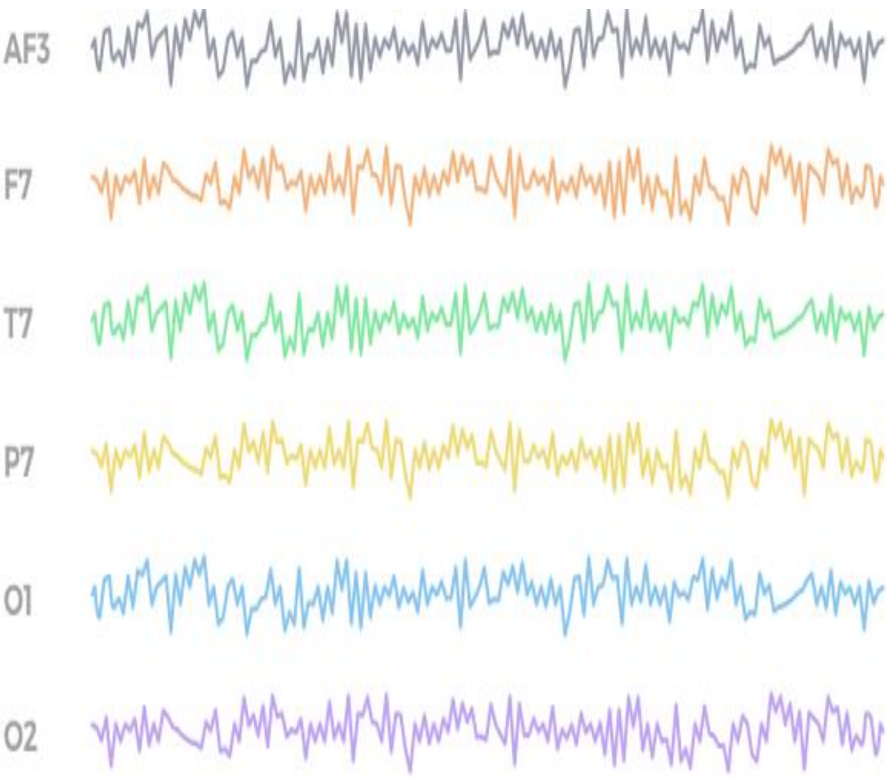


*Figure 17:* **Emotive waves generated by the brain from a performance response (reading and singing)**

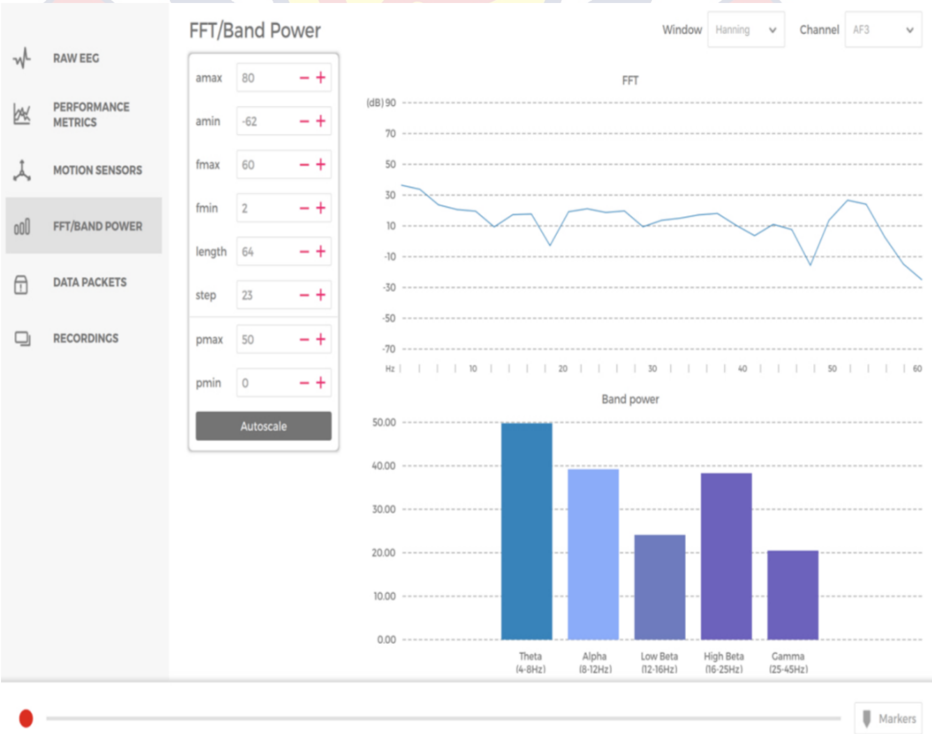


*Figure 18*: **Representation of EmotivPRO interface**

To have accurate and effective data to work with, one needs to be familiar with data mining process in order to regenerate the recorded data with brain waves into another form for a measurable information During this process, the data of each respondent was designated. Since the cloud icon in the EmotivPRO interface, comma-separated value (CSV), there was the need to clicked from the data formatting panel to mine the Emotive data. This was done by clicking on the CSV option, the data began to be reformatted and mined into a spreadsheet of Microsoft Excel data. Once the data was reformatted into an excel spreadsheet, it was then ready for processing, data entry and analysis.

**Data Cleaning**

In this study, it was necessary for data cleaning to be made after a successful completion of data collection. Scholars report that data from the real world as being messy. It is necessary for a researcher to go through these processes so he/she could detect or correct the corrupt or inaccurate records or recognises incomplete or irrelevant parts of the data and then replace, modifying, or deleting the dirty or coarse data, it is referred to by scholars as data cleaning or data cleansing. This process of re-checking of input of data must be done before proceeding to the computation and analysis.

**Data Analysis**

The various computer-generated frequency waves which were analyse statistically. In connection with the various brain responses, this sustains the determination of various brain responses that may be correlated to variables of musical stimuli of the brain electrical activities. Brain cells communicate with each other through electrical impulses (Llinas, 2014).

An electroencephalogram (EEG) used to help detect potential electrical waves and frequencies that are associated with various cognitive activities in the brain (Hodges & Sebald, 2011; Andreassi, 2007) the researcher's focus activity for peering in this study was to investigate various variables of musical stimuli that may have responsive relationship to oscillations (brain waves). Scholars believe that understanding the electrical activities of the brain is as important as understanding the chemical processes when unravelling the mysteries of how our brains tick (Llinas, 2014). This is an indication that the purpose for this study might be statistically significant to the process of data collection and analyses. An example of waves generated by humans is represented in figure.

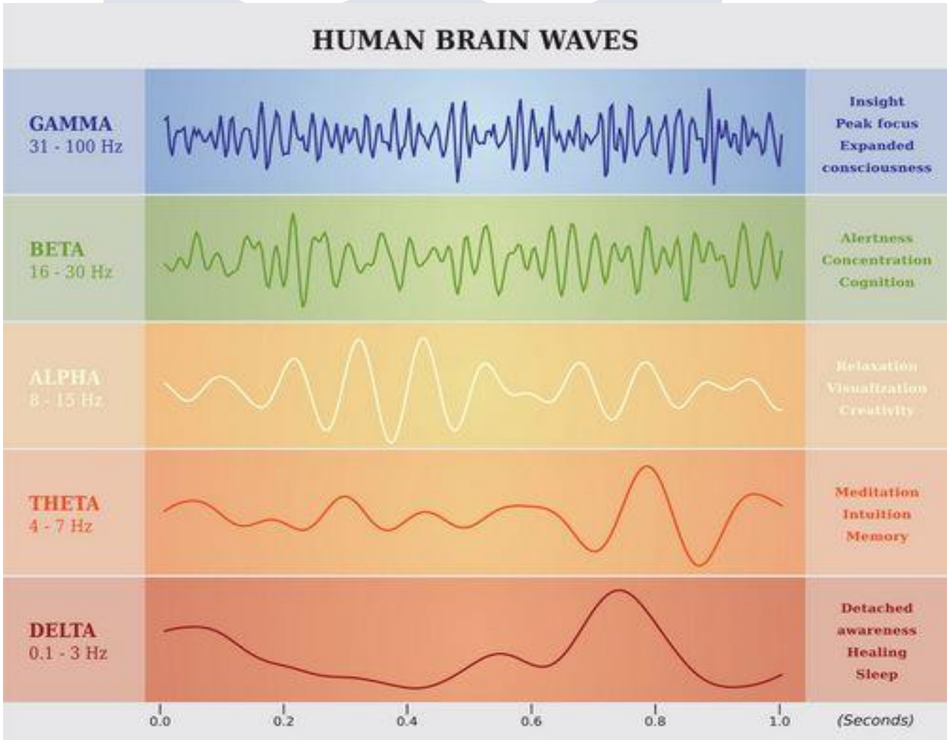


***Figure 19*: Displays the various wave types that can be generated by humans from brain response for data collections and analyses**

Hodges and Sebald (2011), avows that an EEG tracks and records brain wave patterns. Small flat metal discs called electrodes are attached to the scalp with wires (Andreassi, 2007). The electrodes analyse the electrical impulses in the brain and send signals to a computer that records the results. By the use of the EEG instrument, computer generated results of every respondent shall be recorded to create brain index (B.I) that can produce empirical records aimed at monitoring the electrical activities of brain cells of the respondent (Hodges & Sebald, 2011).

The electrical impulses in an EEG recording look like wavy lines with peaks and valleys *Llinas, 2014)*. These lines allow doctors (researchers) to quickly assess whether there are abnormal patterns. Any irregularities may be a sign of seizures or other brain disorders *(Gaser & Schlaug, 2003)*.

Rules for hypothesis Testing in Statistics

Establishing the relationship for the hypothesis testing, the study is mainly fixated on the rules of assumptions which depend on its logical processes (Glenberg and Andrzejewski 2008). These logical processes are: Assumptions about the statistical procedures, generating of the hypotheses; that is the null and alternative hypotheses, Sampling distribution of the test statistics, Setting the significant level and the formulating of decision rule, Random sampling and the computation of the test statistics, Application of the decision rule and drawing of conclusion.

Connecting the assumptions about statistical procedures, scholars have discussed the fact that one's confidence level must be high enough in terms of the characteristics of the various statistical procedures hence, these procedures have to do with the assumption of the population, data and sampling.

## Chapter Summary

This chapter follows discussion on some empirical studies in neuroscience and Music Education, as presented in Chapter Two. In the current chapter, I outlined the methodological processes followed in the conduct of this study. More specifically, I discussed the research design and indicated that the study is situated in the quantitative research paradigm; I also expatiated on processes followed in the sampling (census), collection and treatment of data.

# CHAPTER FOUR

# DATA ANALYSIS AND DISCUSSION

This chapter presents and discusses the analysis of data and presentation of the results. It also presents a discussion on the results that emerged from the analysis of data. The results are presented by briefly reviewing each of the hypotheses and presenting the results of the statistical test results for each of the hypothesis.

## Procedure

EmotivEPOC+ was used to aid perceived potentials of neural waves and frequencies that are associated with various electrical activities in the human brain. The EmotivEPOC+ was used primarily to aid data collection on possible nuanced differences in brain response as students performed the musical activities of reading and singing. The EEG generated frequency waves that were configured and mined into Coma Separated Value (CSV) worksheets as continuous data. The data was then computed and analysed to produce the results and findings for the investigation. The results of the data were used for the testing of the research hypotheses.

Prior to this, data cleansing was also conducted. For data cleaning, inaccurate records from the raw data and database were identified and removed.

For the study, 256 samples per second (sps) were generated in every second during data collection procedure. In all, a total of 15360 sps were produced in every 60 seconds. In the process the initial 40 seconds of 10240 sps were cut off from the total data of all the fifty respondents. The 10240 sps represent the artefacts of the data of each respondent. These artifacts were consequently cut off to allow the anticipated clean data to have free access.

Hypothesis 1

This section of the report presents the results of analysis of data obtained from respondent's brain activity when engaged in reading and singing activity. The brain reaction to music reading was then compared and computed to singing. The hypothesis that was tested is:

$H_0$: there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity

$H_1$: there are statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity

**Results of the Test Statistic for Hypothesis One**

Hypothesis one was developed to investigate whether there were statistically significant differences in brain response between respondents engaged in a reading activity and singing activity.

Brain responses to reading and singing:

Descriptive statistics was computed to summarise the data gathered to test the null hypothesis. The results of the descriptive statistics are displayed in Table 8

**Table 8: Descriptive statistics of brain responses to reading and singing**

| | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Brain response (BR) from reading | 4197.37 | 49 | 62.37 | 8.91 |
| Brain response (BR) from singing | 4195.88 | 49 | 63.68 | 9.09 |

From the results presented in Table 1.1, it is noted that the mean difference between brain responses (BR) to reading and singing is $M$ = 1.49. In order to test whether the mean difference between the brain responses to reading and singing of lyrics (M= 1.49) observed is statistically significant, the researcher conducted paired sample t - test to further analyse the data.

The summary of the result is presented in Table 1.2

**Table 9: Results of Statistical Test of Significance of the difference between brain responses for reading and singing lyrics**

| | Mean Difference | Lower | Upper | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| BR to Reading and Singing | 1.49 | 17.15 | 20.14 | 0.161 | 48 | 0.873 |

The paired sample t test result presented in table 1.2, showed that there is no statistically significant difference, t (48) = 0.161, p = 0.873, at 0.05

levels of significance, between the brain response to reading stimulus (M= 4197.37 SD = 62.37) and singing stimulus (M = 4195.88, SD = 63.68). The results indicate that brain responses are the same when respondents read or sing lyrics of a song.

Hence, the null hypothesis that " there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity, was retained. In effect, the alternate hypothesis that "there are statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity" was rejected.

*Brain responses, in the Frontal lobe to reading and singing activities:*

A descriptive statistics data was computed to investigate the mean differences, standard deviation and the standard error of the data for Frontal lobe of reading activity and singing activity of each respondent. The summary of the result is presented in table 1.3.

**Table 10: Descriptive statistics distribution of total brain responses of Frontal lobe for reading and singing activity**

| | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| B R to reading in Frontal lobe | 4209.00 | 50 | 90.47 | 12.79 |
| B R to singing in Frontal lobe | 4206.71 | 50 | 91.37 | 12.92 |

From the results in Table 1.3, a total mean difference of *M* = 2.29 was calculated from the means of brain response to reading (M=4209.00, SD=90.47) and singing (M=4206.71, SD=91.37) in the frontal lobe. The results showed that there was a difference in the means of the brain response in the descriptive statistic distribution. Yet, there was the need to test the significance of the differences using paired sample t-test. The summary of the paired sample t-test is presented in table 1.4.

**Table 11: The distribution of test statistics results of total brain responses for reading and singing activity**

| | | 95% Confidence Interval of the Difference | | | | |
|---|---|---|---|---|---|---|
| | Mean | Lower | Upper | t | df | Sig. (2-tailed) |
| Brain Response to Reading and singing in Frontal Lobe | 2.2907 | -14.14421 | 18.72563 | 0.280 | 49 | 0 .781 |

In table 1.4, the results emerging from brain response, in the frontal lobe, to reading activity (*M* = 4209.00, *SD* = 90.47) and singing activity (*M* = 4206.71, *SD* = 91.37) indicate that there is no statistically significant difference in brain response $t$ (49) = 0.28, $p$ = 0.78 at 0.05 levels of significance ($p > 0.05$). In effect, the result showed that there was statistically significant difference in the brain response in the distribution. Hence, there is not enough evidence to reject the null hypothesis which states that: “there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity”.

The result therefore shows that there is no statistically significant difference in brain response to reading and singing. The results and findings, therefore, suggest that students' brain responses to reading and singing lyrics are the same.

*Brain responses, in the Parietal lobe, to reading and singing activity:*

A descriptive statistics table was computed to investigate the mean differences, standard deviation and the standard error of the data for Parietal Lobes of reading activity and singing activity of each respondent. The summary of the result is presented in table 1.5.

**Table 12: Descriptive statistics distribution of total Parietal lobes for reading and singing activity**

| | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Parietal Brain Response Reading | 4178.09 | 50 | 33.66 | 4.76 |
| Parietal Brain Response Singing | 4178.24 | 50 | 35.10 | 4.96 |

From Table 12, it is observed that a mean difference of $M$ = -0.15 of brain activity in the Parietal lobe was observed. The result shows that there was a difference in brain response, in the parietal lobe, to music reading and singing. To examine whether the mean difference (M=-0.15) in the brain responses to parietal lobes for reading and singing activity observed is statistically significant, the researcher conducted paired sample t - test to further analyse the data. The summary of the result is presented in Table 1.6.

**Table 13: The distribution of test statistics results of total Parietal lobe brain responses for reading and singing activity**

| | Mean | 95% Confidence Interval of the Difference Lower | Upper | T | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Parietal Brain Response of reading and Singing | -.14917 | 7.03947 | 6.74113 | -.044 | 49 | .965 |

From the test statistics in Table 1.6, the results indicated that the impact of Parietal Brain Response reading activity (*M* = 4178.09, *SD* = 33.66) and Parietal Brain Response singing test (*M* = 4178.24, *SD* = 35.10) to brain response indicate that there is no statistically significant difference in the means of the brain response when the respondents were engaged in the two activities, $t$ (49) = -0.04, $p$ = 0.97 at 0.05 levels of significance. This provides enough evidence to retain the null hypothesis and conclude that there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity”. The negative sign indicates that the mean response from the Parietal Brain Response Reading test was less than that of Parietal Brain Response singing test.

*Temporal lobe brain response to reading and singing activity*

A descriptive statistics data was computed to investigate the mean differences, standard deviation and the standard error of the data emerging from the temporal lobe. The summary of the result is presented in table 1.7.

**Table 14: Descriptive statistics distribution of total temporal lobe brain responses to reading and singing activity**

| | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Temporal Brain Response Reading | 4185.58 | 50 | 74.16 | 10.49 |
| Temporal Brain Response Singing | 4185.10 | 50 | 66.73 | 9.44 |

From the results in Table 14, a mean difference of *M* = 0.08 between brain response to reading and singing activities was observed. To examine whether the mean difference (M=-0.08) in the brain responses to temporal lobes for reading and singing activity observed is statistically significant, the researcher conducted paired sample t - test to further analyse the data. The summary of the result is presented in Table 1.8.

**Table 15: Results of test statistics of brain response to reading and singing activities in the Temporal lobe**

| | Mean difference | 95% Confidence Interval of the Difference Lower | Upper | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Brain Response in Parietal of Reading and singing | .08381 | -14.53 | 14.69 | .012 | 49 | .991 |

From Table 1.8, the results indicate that, in the temporal lobe, there is no significant difference, $t$ (49) = 0.012, $p$ = 0.991, between temporal brain response to reading of lyrics of a song ($M$ = 4185.5804, $SD$ = 74.15768) and between temporal brain response to singing test ($M$ = 4185.4966, $SD$ = 66.73047). The result therefore shows that there is no statistically significant difference in brain response to reading and singing. The results and findings, therefore, suggest that students' temporal brain responses to reading and temporal brain response to singing lyrics are the same. This provides enough evidence to retain the null hypothesis and conclude that there are no statistically significant differences in brain response to music between students engaged in reading activity and those engaged in singing activity".

*Response in the Occipital lobe between reading and singing of lyrics of song;*

A descriptive statistics data of Occipital lobe was computed to investigate the mean differences, standard deviation and the standard error of the data for Occipital Lobes of reading activity and singing activity of each respondent. The summary of the result is presented in table 1.9.

**Table 16: Descriptive statistics of brain response, in the Occipital lobe, to reading and singing lyrics of a song**

| | Mean | N | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|
| Occipital Brain Response reading | 4181.1287 | 50 | 19.31967 | 2.73221 |
| Occipital Brain Response singing | 4178.7987 | 50 | 16.15592 | 2.28479 |

In table 16, we observed that the mean difference between reading and singing of the lyrics of a song is *M*= 2.33. To examine whether the mean difference (M=2.33) in the Occipital Brain Response reading and Occipital Brain Response singing activity observed is statistically significant, the researcher conducted paired sample t - test to further analyse the data. The summary of the result is presented in Table 1.10.

**Table 17: Results of test statistics of brain response to reading and singing activities in the Occipital Lobe**

| | | 95% Confidence Interval of the Difference | | | | |
|---|---|---|---|---|---|---|
| | Mean | Lower | Upper | t | df | Sig. (2-tailed) |
| Brain Response, in the Occipital Lobe, to Reading of song lyrics | 2.33 | -3.68 | 8.34 | .778 | 49 | .440 |

In table 17, the results indicate that there is no significant difference, t (49) = 0. 778, p = 0. 440, between brain response, in the Occipital lobe, to reading of song lyrics (M = 4181.1287, SD = 19.31967) and singing of song lyrics (M = 4178.7987, SD = 16.15592).

This provides enough evidence to retain the null hypothesis and reject the alternate hypothesis. The result therefore shows that there is no statistically significant difference in brain response to reading and singing. The results and findings, therefore, suggest that students' brain responses in occipital lobes to reading and singing lyrics are the same.

**Analysis of Hypothesis 2**

**Table: 18: Descriptive statistics of brain responses to singing of lyrics between students with long and limited exposure to singing**

| | Singing Duration | N | Mean | Std. Deviation |
|---|---|---|---|---|
| Brain responses to singing | Long exposure | 21 | 4193.56 | 42.16 |
| | Limited exposure | 29 | 4182.79 | 45.67 |

From the results in Table 18, a mean difference of M = 10.77 between brain response to reading and singing activities was observed. To examine whether the mean difference (M=10.77) in the singing duration observed is statistically significant, the researcher conducted independent sample t-test to further analyse the data. The summary of the result is presented in Table 2.1.

**Table 19: Test statistics of long exposure and limited exposure of brain responses to singing**

| | | F | Sig. | t | Df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Brain responses singing | Equal variances assumed | .112 | .740 | .850 | 48 | .400 |
| | Equal variances not assumed | | | .861 | 45.147 | .394 |

The results of the analysis show that there is no statistically significant difference in brain response to singing of lyrics between students with long exposure to singing (*M*= 4193.56, *SD*= 42.16) and those with limited exposure to singing (*M* = 4182.79, *SD* = 45.67); *t* (.850) = 0.861, p = 0.394). This provides enough evidence to retain the null hypothesis and conclude that there are no statistically significant differences in brain response to music between students with long period of exposure to music and those with limited exposure to music before entry into a university music programme. The mean difference of M = 10.77 between brain response to reading and singing activities occurred by chance.

The results indicate that, the brain responses are the same when students had long exposure or limited exposure to singing of lyrics. In effect it reiterates that the brain response does not depend on how long students are exposed to music before entry into a university music programme.

Analysis of Hypothesis 3

The third hypothesis for this study was developed to analyse and examine whether or not there was any significant differences in brain response to singing among four brain lobes. The third hypothesis tested with the available data is as follows:

$H_0$: There are no significant differences in brain responses to singing among four brain lobes.

$H_{1:}$ There are significant differences in brain responses to singing among four brain lobes.

**Descriptive Statistics for Hypothesis 3**

Table 20 shows a descriptive statistic result examining brain response to singing among four lobes - Frontal, Parietal, Temporal and Occipital.

**Table 20: Descriptive statistics of brain responses to singing among the four brain lobes**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Frontal Lobe | 4206.71 | 91.37 | 50 |
| Parietal Lobe | 4178.24 | 35.10 | 50 |
| Temporal Lobe | 4185.50 | 66.73 | 50 |
| Occipital Lobe | 4178.80 | 16.15 | 50 |

The computed data table 19 shows the descriptive statistics of brain response to singing in four brain lobes.

**Table 21: Mauchly's test of sphericity for brain response among lobes**

| Within Subjects Effect | Mauchly's W | Approx. Chi-Square | df | Sig. |
|---|---|---|---|---|
| Lobes | .208 | 75.019 | 5 | .000 |

Table 21: displays a Maulchy's test of sphericity to investigate the homogeneity of the variances. The results show statistical significance. This indicates that the assumption of sphericity is violated. Hence there is the need to compute and analyse the significant differences from the Greenhouse Geisser.

Test of within subject analysis on Brain Responses to Singing in Brain Lobes

A repeated measure ANOVA with Greenhouse-Geisser correction was conducted. The results are presented in Table 2.4.

**Table: 22: Test of within subjects on Brain Responses to singing among Brain Lobes**

| Source | | | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Lobe | Greenhouse- | 26716.81 | 1.71 | 15664.19 | 4.10 | .025 |
| Error lobe | Geisser | | | | | |

The results in Table 22 show that there are statistically significant differences in brain response to singing among the four brain lobes, F (1.71) = 4.10, p = 0.025. Though, the mean differences in brain activity to singing did not specify significant difference in all the four brain lobes when Greenhouse-Geisser test was conducted during the analysis process. The mean brain response to the frontal lobe (M = 4206.71, SD = 91.37) is different from that of the parietal lobe (M = 4178.24, SD = 35.10) and the temporal lobe (M = 4185.50, SD = 66.73) as well as the occipital lobe (M = 4178.80, SD = 16.15). These provide enough evidence to reject the null hypothesis and retain the alternate hypothesis which states that "there are significant differences in brain responses to singing among four brain lobes". It means that there are differences in the brain response involving the varying lobes.

**Discussion of Findings**

The findings of the study have shown that the brain response to music between students engaged in reading activity and those engaged in singing activity are the same.

*Brain responses to reading and singing*: No statistically significant difference was found in the brain response to music between students engaged in reading activity and students engaged in singing activity. The mean difference ($m =$ 1.49) obtained was statistically insignificant, (t (48) = 0.161, p = 0.873). Hence there is no statistically significant difference in students' brain response to reading and singing activities.

*Brain responses, in the Frontal lobe to reading and singing activities:* There was no statistically significant difference found in brain response in the frontal lobe to reading and singing, $t$ (49) = 0.28, $p$ = 0.78 at 0.05 levels of significance. The results and findings, therefore, suggest that students' brain responses in the frontal lobe to reading and singing lyrics are the same. The total mean difference, ( $m =$ 2.29), found between the brain response in the frontal lobe to reading and singing occurred by chance.

*Brain responses, in the Parietal lobe, to reading and singing activity:* No statistically significant difference was found in the brain response in the parietal lobe to music between students engaged in reading activity and students engaged in singing activity. The mean difference ($m = -0.15$) obtained was statistically insignificant, ($t$ (49) = -0.04, $p$ = 0.97). The negative sign indicates that the mean brain response obtained in parietal brain response to music in singing test was more than that of reading test.

*Temporal lobe brain response to reading and singing activity:* The results and findings, therefore, suggest that students' temporal brain responses to reading and temporal brain response to singing lyrics are the same. The mean difference ($m = 0.08$) obtained in favour of reading, was statistically insignificant, $t$ (49) = 0.012, $p$ = 0.991.

*Response in the Occipital lobe between reading and singing of lyrics of song: There was* no statistically significant difference in brain response in occipital lobes to reading and singing, t (49) = 0. 778, p = 0. 440. The results and findings, therefore, suggest that students' brain responses in occipital lobes to reading and singing lyrics are the same.

In summary, the results and findings therefore suggest that students' brain responses to reading and singing lyrics are the same.

In addition, the researcher investigates the differences in brain response to music between students with long exposure to music and those with limited exposure to music. It was found that the brain responses are the same when students had long exposure or limited exposure to singing of lyrics, *t* (.850) = 0.861, p = 0.394). In effect it reiterates that the brain response does not depend on how long students are exposed to music before entry into a university music programme.

Finally, the researcher again examined the significant differences in brain response to singing among four brain lobes. There were statistically significant differences in brain response to singing among the four brain lobes, F (1.71) = 4.10, p = 0.025. The students' brain response on varying lobes ranges from frontal lobe, temporal lobe, Occipital Lobe and Parietal Lobe. The highest difference occurred between the frontal lobe and the parietal lobe (M=28.47), followed by the differences in Frontal and Occipital lobes (27.91). The least differences take place between the occipital lobe and parietal lobe. In conclusion, it was found that there are differences in the brain response involving the varying lobes.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## Overview

This Chapter presents a summary of the study including the key findings, conclusions, recommendations as well as suggestions for future research.

## Summary of the Study

The study examined the brain responses in Ghanaian undergraduate music students as they are engaged in musical performance during EEG. Explicitly it explored the differences in the brain response to reading and singing of song lyrics, and differences between brain responses of respondents with long period of exposure and limited exposure to music as they sing song lyrics. The study also examined the brain responses in the four brain lobes when students are engaged in the singing of lyrics.

The quantitative research method was adopted for this study. Census was used as the sampling technique for the study. Fifty students from the Department of Music and Dance, University of Cape Coast were sampled for the study through census.

Electroencephalogram (EEG) equipment, questionnaire, Laptop computers and recording gadgets were the equipment and instruments used in the data collection process.

The quantitative data was obtained. Both descriptive and inferential statistical procedures were used in the analysis through the help of the SPSS Software. The frequencies, percentages, means and standard deviation were the descriptive statistics used. The Inferential statistics were the paired sample t-test, independent samples t-test and ANOVA.

**Summary of Key Findings**

The results obtained from the entire study, analysis and interpretation with reference to the respective research questions and hypothesis sets to guide the study indicate that the brain responses are not significantly different when respondents when reading of song lyrics or singing of a song. The brain responses to singing and reading by students with long or limited period of exposure to lyrics of a song are not significantly different. Also, the brain responses in the various brain lobes of singing are not significantly different when respondents read or sing lyrics of a song.

- **Brain response to music between students engaged in reading activity and students engaged in singing activity**

The research objective 1 sought to investigate differences in students' brain responses when reading and singing lyrics of a song. The hypothesis was subjected to testing with the student t-test statistical model. The test result revealed that there were no statistically significant differences between students' brain responses to reading and singing of song lyrics.

In effect, it suffices to conclude that though reading and singing activities of music vary in the way each is performed; the researcher does not have enough evidence to conclude that the brain responses to these varied activities are different.

- **Brain response to music between students with long exposure to music and those with limited exposure to music**

The outcome of the analysis of the data obtained on duration of students' exposure to music was used to test the hypothesis 2 and also answer the research question 2. The Hypothesis 2 was designed to examine the likely differences between brain responses of students with long period of exposure and those with limited exposure to singing before entry into a university music programme as regards their singing of song lyrics. The independent t-test statistical model was employed to test the hypothesis. The test result showed that there were no statistically significant differences in brain responses to the singing of lyrics between students with long period of exposure to singing and those with limited exposure, $t$ (48) = 0.850, p = 0.40). The results indicate that, the brain responses are not significantly different when students had long exposure or limited exposure to singing of lyrics.

In effect, the researcher concludes that there was no statistically significant difference in brain response to music between students with long exposure to music and those with limited exposure to music.

- **Brain responses to singing in each of the four brain lobes**

Finally, Hypothesis 3 was developed to find out if there were any significant differences in the brain activity among the four brain lobes, thus' frontal, parietal, temporal and occipital lobes as students sing lyrics of a song. Analysis and the test for hypothesis 3 were computed using the SPSS software. The independent variables within subject were frontal, parietal, temporal and occipital lobes. The mean differences in all the brain lobes show significant differences in brain activity. The repeated measure ANOVA model with Greenhouse Geisser correction was used to test the hypothesis. The results established a significant difference among the brain lobes ($F (1.71) = 4.10$, $p = 0.025$). The results therefore, suggest that brain responses to music singing are not the same in the brain lobes (frontal, parietal, temporal and occipital lobes) among the respondents in the university.

**Conclusions**

Based on the findings of the study, the following conclusions are drawn the researcher concludes that:

- there was no statistically significant evidence of difference in the brain responses when respondents read or sing lyrics of a song.
- there was no evidence of statistical difference in the brain responses to singing and reading by students with long period of exposure or limited exposure to lyrics of a song.
- there were statistically significant differences in responses of the four brain lobes (frontal, parietal, temporal and occipital) to singing among the study participants.

**Recommendations**

Based on the findings and conclusions presented, the following recommendations are suggested:

- it is recommended that, using music as a tool to enhances a child's neurological function, music educators may choose singing or reading musical lyrics as musical activities for learners. This is in light of the fact that the response of the brain to these two (2) musical activities does not vary significantly.

- Any future further researcher seeking to investigate relationship between performance of musical activity and brain response, the researcher may choose either singing or reading of musical lyrics. This is hinged on the finding from the study that: there are no significant difference in brain response to musical activity of singing and reading of musical lyrics.
- The study found that no significant differences were observed in brain responses to music between persons with long period of exposure to music and those with limited exposure to music before the study. It is therefore recommended that in selecting music stimuli for students' performance whether reading or singing, a previous background in music may not be a necessary requirement.
- Finally, when subjecting the brain to testing on musical stimulus, caution must be exercised in the choice of a particular lobe of the brain. The rational here is that each lobe of the brain responds to musical stimulus differently

**Contribution to Knowledge**

Based on the research findings, the researcher found that:

- the brain does not discriminate in responding to reading and singing of song lyrics.
- Brain response to music is the same among persons with prolong singing experience and those with little or no such experience
- The lobes of the brain respond differently to singing as a musical stimulus.

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# APPENDIXES

## Appendix A:

## Request for ethical clearance

University of Cape Coast

Department of Music and Dance

November 8, 2018

The Chairman

Institution Review Board

UCC

**REQUEST FOR ETHICAL CLEARANCE**

I wish to apply for ethical clearance to enable me proceed to the next stage of my phD research project.

I successfully defended my phD proposal with the topic "music performance and Brain Responses. The case of Music and Dance students of University of Cape Coast"

This study will involve music students of the University as respondents.

I would be grateful if my permission could be granted.

Thank you.

Yours faithfully,

FRANCIS AFENYO DZAKEY

## Appendix B:

## Ethical clearance

UNIVERSITY OF CAPE COAST

INSTITUTIONAL REVIEW BOARD SECRETARIAT

TEL: 0558093143 / 0508878309/ 0244207814
C/O Directorate of Research, Innovation and Consultancy
E-MAIL: irb@ucc.edu.gh
OUR REF: UCC/IRB/A/2016/665
YOUR REF:
OMB NO: 0990-0279
IORG #: IORG0009096

27TH MAY, 2020

Mr. Francis Afenyo Dzakey
Department of Music and Dance
University of Cape Coast

Dear Mr Dzakey,

**ETHICAL CLEARANCE – ID (UCCIRB/CHLS/2020/10)**

The University of Cape Coast Institutional Review Board (UCCIRB) has granted **Provisional Approval** for the implementation of your research protocol **Music Performance and Brain Responses: The Case of Music and Dance Students of University of Cape Coast.** This approval is valid from 27th May, 2020 to 26th May, 2021. You may apply for a renewal subject to submission of all the required documents that will be prescribed by the UCCIRB.

Please note that any modification to the project must be submitted to the UCCIRB for review and approval before its implementation. You are required to submit periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us in relation to this protocol.

Yours faithfully,

Samuel Asiedu Owusu, PhD
**UCCIRB Administrator**

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

## Appendix: C

**Demonstrates EEG wave signals**

Source: Andrea Danti/Shutterstock

## Appendix: D

**Prof. Amuah handing over instrument for data collection**

# Appendix: E

## Electroencephalogram (EEG) EmotivEPOC+ machine

## Appendix: F

### A 14 channel Emotiv EPOC+ censer

**Appendix: G**

**Testing the EEG machine before actual data collection**

## Appendix: H

## An introduction letter for Neuroscience course auditing at Korle-bu Teaching Hospital

**UNIVERSITY OF CAPE COAST**
**FACULTY OF ARTS**
**DEPARTMENT OF MUSIC AND DANCE**

TELEPHONE: 03321-30947/Ext. 209
EMAIL: music.dance@ucc.edu.gh
WEB: www.ucc.edu.gh

UNIVERSITY POST OFFICE
PRIVATE MAIL BAG
CAPE COAST, GHANA

*In case of reply please quote:*

Our Ref:

Your Ref:

12th November, 2017.

The Head
Neuroscience Department
University of Ghana Medical School
Korle-Bu Teaching Hospital
Accra

Dear Sir,

**LETTER OF INTRODUCTION-DZAKEY FRANCIS AFENYO**

We wish to introduce Mr. Francis Afenyo Dzakey, one of our Ph.D. Candidates in Music Education at University of Cape Coast, to you. Mr. Dzakey is writing his thesis on the topic "Music Performance and Brain Responses: The Case of Music and Dance Students of University of Cape Coast.

He needs some basic education and training in neuroscience and the use of related equipment.

We would be grateful if you could kindly offer him any assistance especially regarding the use of neuroscience equipment for his data collection.

Thank you for your anticipated co-operation.

Yours faithfully,

Eric Debrah Otchere (PhD)
(Head of Department)

HEAD
DEPARTMENT OF MUSIC AND DANCE
UNIVERSITY OF CAPE COAST

## Appendix: I

**The researcher auditing Neuroscience course at the Korle-bu Teaching Hospital with Dr. Adjei, the Head of Neurosurgeon, Korle-bu - Accra**

## Appendix: J

### Questionnaire for Students

### UNIVERSITY OF CAPE COAST

### DEPARTMENT OF MUSIC AND DANCE, UCC

**Introduction**

Dear Respondent,

The researcher is a doctoral student pursuing PhD in Music Education (Music Psychology and Neuroscience) at the University of Cape Coast, Cape Coast. He is undertaking a study on the topic "Music Performance and Brain Responses: The Case of Music and Dance Students of University of Cape Coast"

You are kindly requested to answer the questions on the questionnaire as objectively as possible. Be assured that the questionnaire is meant strictly for academic work and any information you provide will be treated with utmost confidentiality.

Thank you in anticipation of your co-operation.

**SECTION A**

**Read carefully the following information and provide the appropriate responses.**

Level……………….

Age…………………

Gender: Male…………………. Female……………...

## SECTION B

This section talks about the student's degree of exposure to music performance, that is singing and reading of music before entry into a university music programme.

**Questions**

1. Did you get engaged in singing or reading of music before entry into a university music programme?

A. Yes ☐ B. No ☐

**2.** If yes how often do you sing?

A. Once a week ☐ B. Twice a week ☐

C. Thrice a week ☐ D. Four times a week ☐

E. Five times or more a week ☐

**3.** Did you participate in any singing group or choir before entry into a university music programme?

A. Yes ☐ B. No ☐

4. If yes how long?

A. One year ☐ B. Two years ☐

C. Two and a half years ☐

D. Three or more years ☐