UNIVERSITY OF CAPE COAST

BRAIN RESPONSE TO MUSIC AMONG PUPILS IN THE UNIVERSITY OF CAPE COAST BASIC SCHOOL

BY

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Thesis submitted to the Department of Music and Dance, Faculty of Arts of the 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

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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. 29-09-21

Name. Wise Wunu Colette

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.

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ABSTRACT

Progress in neuroscience has quickly increased knowledge of neural insights with musical participation. Researchers have endeavoured to identify brain responses that are related to experiences of music participation. However, interest in neuroscientific study of music is hard to find in Ghana. There seems to be a paucity of research on brain response to music stimuli as well as its relationship to brain development. The objective of this study was to investigate brain responses to music stimuli. The study was conducted within the framework of brain stages of human development theory. A mixed factorial ANOVA and hypothesis testing were conducted. One hundred students (N=100) were randomly sampled to participate in the study. Data for the study were collected using the EmotivEPOC+ EEG and EmotivPRO interface. A one-way repeated measures ANOVA was conducted to investigate the significance of main effect of brain lobes in responses to music among respondents (N = 100). The results of the ANOVA indicated a significant effect among brain lobe, which was observed between the Frontal and the Occipital lobes, Wilks' Lambda $\Lambda = .92$ $F(3, 97) = 2.87$, $p = .040$.

KEY WORDS

Neuroscience of Music

Musical engagement

Neural Correlates

Myelination

Synaptogenesis

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DEDICATION

To God, Professor Isaac Amuah, Dr. Maria Witek, Dr. Eric Debrah-Otchere, Head of Department and my siblings-Phanuel, Ernest, Edith, Evans and Geoffrey. I also dedicate this work dearly to my friend and sister Dorcas Salamatu.

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CHAPTER ONE

INTRODUCTION

In this study, I investigated brain response to music towards the understanding of neural processes of music participation in music education. By identifying myself as a music educator, I found that it is intrinsic to learn about music and neural correlates. I was happy that I came to the realisation of an old dream about interdisciplinary research in the neuroscience of music.

My interest in interdisciplinary research is based on the combination of neuroscience and music. This interest has been sustained since its emergence during the early years of my undergraduate education. Researchers note that interdisciplinary and multidisciplinary research engagement support novelty (Altenmüller, *et al*., 2012; Peterson, 2011; Stewart & Williamon, 2008). Since interdisciplinary studies about music and neuroscience have not been much investigated in Ghana, it is assumed as a gap in literature. There is a lot of rich music in Africa, especially in Ghana where I conducted this study. I believe that there is a lot to explore about the music of Africa through the lens of neuroscience in these new trends of academic investigations. I therefore, always yearned and looked forward to seeing how music educators in African could fit into interdisciplinary and multidisciplinary studies such as cognitive neuroscience of music, neurophysiology, developmental biology of music, psychoneuroendocrenology (PNE), and psycho-neurophysiology. I therefore embraced this study as a unique opportunity to conduct research in neuroscience of music, focusing on brain responses to music among children in the University of Cape Coast Basic School.

Background to the Study

Thaut (2005) reports that music has received an exceptional research focus in brain-based investigations over the years. He also observes that this position has not been attained in any other art form or that no other art form can be compared to the position of music in a brain-based investigation. It cannot, therefore, be overemphasised that the need for brain-based investigations is important in the field of music research. Current investigations aimed at understanding neural induction and pattern formation, sensory system, cellular components of nervous tissues, intracellular signalling, brain energy metabolism and nervous system growth has been conducted (Squire, Berg, Bloom, Lac, Ghosh, & Spitzer, 2008). The use of various tools such as Diffusion Tensor Imaging (DTI), Positron Emission Tomography (PET), and Single Positron Emission Computed Tomography (SPECT) have accelerated the investigation of knowledge beneficial for understanding the functions of the brain (Davis, Iverson, Guskiewicz, Ptito and Johnston, 2009). Electroencephalogram (EEG) and magnetic resonance imaging (fMRI) are among other modern neuroscience technological approaches that support research into brain activity (Hodges & Sebald, 2011). Scholars inform that Adolf Berk is the pioneer in electroencephalogram (Coenen, Fine & Zayachkivska, 2014; Coenen & Zayachkivska, 2013). The existing literature provides records of research endeavours that have acquiesced interest in the practices of neuroscience and investigations involving brain mechanism in recent years (Avanzini, Faienza, Minciacchi, Lopez and Majno, 2003), and these reports provide significant evidence of the development of music and neuroscience research practices at the global level.

The goals for engaging in neuroscience research, inter alia, include the quest for understanding neural oscillation and learning, brain developmental stage and development stage, memory problems, encephalitis (inflammation of the brain) and encephalopathy (a disease that causes brain dysfunction).

Some researchers who conduct neuromusical studies observed that repeated musical participation optimise neuronal circuits by changing the number of neurons involved. They also note that the timing of synchronization (organisation), the number and strength of excitatory and inhibitory synaptic connections involve also contribute in the determination of a particular level of neural musical response (Weinberger, 2004).

In the past three decades, scholars' attentions have been drawn to current developmental trends in music education. In these trends, they have investigated phenomena that deal with musical engagement in the classroom. Scholars focused narrowly on investigating neurological underpinnings of music (Juslin & Sloboda, 2012; Edwards & Hodges, 2007) while others focus broadly on the interdisciplinary and multidisciplinary examination in neurosciences and music studies (Avanzini, Lopez, Koelsch & Majno, 2005) as well as song system and neural oscillation (Brown, Martinez, Hodges, Fox, & Parsons, 2004). In addition, some scholars investigated neurological responses with passive music listening (Hodges & Hodges, 2007) and neurobiology and musical experience (Peretz, 2001). In many of these investigations, the use of Electroencephalogram (EEG) has been significant (Koelsch & Siebel, 2005). The investigation of right auditory cortex in the involvement of pitch perception, harmony, melody and rhythm was also explored by Jackendoff and Lerdahl, (2006), using positron emission tomography (PET). Burunat, Toiviainen, Alluri, Bogert, Ristaniemi, Sams and Brattico (2016) used fMRI to examine the continuous brain response during a naturalistic way of engaging respondents in music listening. Other studies also use MEG in specific studies in neuroscience of music (Kim, Kim & Chng, 2011; Vuust, Ostergaard, Pallesen, Bailey & Roepstorff, 2009; Tecchio, Salustri, Thaut, Pasqualetti & Rossini, 2000). Significantly, these developments in scholarly investigations inform that neuroscientific studies are important in our current trends of music education and other academic musical practices. I looked at these ongoing neuroscientific practices that were recorded in the literature to be informed about what practices exist and what gaps need to be filled as I conducted my study.

Music participation is a major activity in the music classroom. Music teaching and learning focuses on the enhancement of students' skills and knowledge. Music scholars as well as neuroscientists have conducted investigations that study brain responses to musical behaviours such as music listening, performing, composing and ancillary activity. In one of the studies, the researchers looked at babies' brains and their correlates with early childhood musical experiences (Fox, 2000). The study indicated that active musical engagement is a factor in the development of the brain among children. In another study, the researchers focused on complex neural oscillations that are involve in music processing (Altenmüller, 2001). The study indicated that behaviours associated to the cortical activation during music processing informs about the personal experience of music. Most of these studies aim at engendering information on musical activity that influences brain behaviours to support music learning (Koelsch & Siebel, from music genres, brain responses may be investigated to shed light on the observable neurological behaviours or brain processes. It will provide information which will be of worth to the music teacher. As scholars have dealt significantly with the cognitive and emotional experiences of music, it is important that extra attention is paid to the neurological perspectives of music learning. This is because the studies indicate its significance to educational practices. Such attempts (neuromusical examinations) may pair with available knowledge of emotion, cognition and other psychological investigated phenomena. These among other anticipated investigations have become the driving forces for this study.

Another perspective of relevance to this study was its intention for interdisciplinary research approach. The interdisciplinary approach which my study focuses on is to look at the brain based systems that underline music participation. Some scholars name this interdisciplinary approach as neuroscience of music (Peretz, 2006). Also, the multidisciplinary spectrum between the arts, humanities and the sciences has been evidenced to have captured the interest of the academic research community (Cassidy & MacDonald, 2010) since it is important to the development of new knowledge in academia . This study therefore stakes an interdisciplinary approach to music, education and neuroscience which could be important for the professional practices in music education. One of the significances of this interdisciplinary study is its opportunity for music educators and scholars to learn about neurological processes associated with musical participation.

In another consideration, scholars discuss psychological developmental stage theories such as the emotional and cognitive developmental stages in

Piaget's cognitive-developmental stage theories (Juslin & Sloboda, 2012; Beihler & Snowman, 1990). They propose that there are stages of human development that are closely related to learning. A stage is a period at which an individual may be ready to perform well on a particular type of task. This has been referred to as developmental readiness (Beihler & Snowman, 1990). Scholars have also provided evidence relating to brain developmental stage theories (Banich & Compton, 2018) in the extant literature which may support the investigation of this phenomenon. The focus of this study was to provide findings that can support available information on child neural behaviours that are associated to brain developmental stages in respect to participation in music.

More specifically, this study also investigated how neurodevelopmental stages correlates with musical processing. Since the study of brain developmental stage provides an insight into brain neurulation, proliferation, myelination, synaptogenesis, bran pruning and oscillation, it informs that neural processes involved in learning are associated to specific stages of brain development. With these approaches researchers are able to learn what has been investigated about neural processes associated to musical engagement which can benefit scholars in music education.

Relevance of Neuroscience and Music Research to Music Educational Practices

Whiles some wonder what neuroscientific studies can feasibly do in the music classroom, other scholars respond with great confidence that it can do a lot (Flohr *et al*, 2000). Interest in the investigation of children's music participation and brain response with educational relevance has therefore been in significant development from the review of literature (Ainley & Ainley, 2011; Tallal & Gaab, 2006; Gruhn & Rauscher, 2002).

In a study conducted by Flohr *et al*. (2000) EEG was used to isolate sequences of activity that take place in the brain when children play rhythm with stick. The EEG provided a summary of brain activity during the process of this task among children. The study indicated that children have as twice much neural connectivity as adults do. In other studies, scholars found that there was a predomination of the middle left temporal lobe in the progression of a musical note whereas melody activation was predominated in the middle right of the temporal lobe (Boccia, Piccardi, Palermo, Nori & Palmiero, 2015; Zatorre, Belin & Penhune, 2002). This is to inform music educators that melody and other notes are processed differently in the brain. For example, a study conducted by Meyer, Steinhauer, Alter, Friederici and von Cramon (2004) indicate that brain activity varies in comparing chord progression and melodies in the brain. It can be assumed that melodic processing is quite different from harmonic processes. Flohr *et al*. (2000) also investigated two groups of respondents; musically trained and non-musically trained to examine their level of brain activation to Mozart's string quartet KV 458 music record. It was observed that the musically trained respondents had generalised brain responses whiles the non-trained respondents had specific responses in the bilateral auditory region of the brain. These investigations suggest that musically trained subjects and no-musically trained subjects do not produce the same brain oscillation patterns when exposed to the same music. For this reason, knowledge in this study will benefit music educators to illuminate new understanding in which music participation and experience interact in the human brain.

Other neuroscientific studies point out that EEG studies on the human brain are relevant because they unravel benefits of music training in both children and adults (Acquadro, Congedo & De Riddeer, 2016; Voss, Nagamatsu, Liu-Ambrose & Kramer, 2011). One of these benefits perceived by scholars is that neuromusicological investigations may enlighten ways in which musical interactions are processed in the human brain (Flohr *et al*, 2000). All these perspectives of learning and the educational relevance of investigating musical behaviours in the brain suggest that the importance of neuroscience and music in music educational practices cannot be overemphasised.

Statement of the Problem

Researchers have provided reports on investigations into neural correlates of music participation in performance and composition, and these have supported the relevance of the development of music and brain research (Koelsch, 2014, 2010; Kraus & Chandrasekaran, 2010; Zatorre, Chen & Penhune, 2007; Peretz & Zatorre, 2005). Such investigations have stressed the significance of neuroscientific investigations to the contribution of current trends in music education Jafari, Kolb & Mohajerani, 2020; Flohr *et al*, 2000). Other neuromusicological investigations show how musically trained subjects and non-musically trained subjects generate different brain oscillation patterns when they listen to the same music (Flohr *et al*, 2000).

However, a review of existing literature does not reveal any evidence of such research endeavour (neuroscience of music) in Africa and with

African respondents (Lederman, 2003; Edwards, 2008). This is a gap in music education research in Africa. The available literature on neuroscience can mostly be traced to Europe, North America. Notwithstanding the contexts, their findings are mostly generalised or used as inferential claims in the existing literature.

Furthermore, there seems to be no evidence of neuromusical research on children's music participation and its relationship with brain developmental stages and responses within the African environment. There is no clear evidence of any investigation about musical engagement at the myelination and synaptogenesis stages of brain development. Chow (2014) believes that an attempt at conducting the same study in different environment may provide variety of insights.

There is therefore the need for African scholars to engage the investigations of these scholarly phenomena within the African environment. To contribute towards the solution of this problem, I proposed to conduct my study in the field of neuroscience in music education, by conducting a study to observe brain responses to music participation.

This study will also investigate brain response to music among the lobes of the brain. Since neuroscientists noted that the brain has four lobes (Van Petten, Plante, Davidson, Bajuscak & Glisky 2004; Mort, Malhotra, Mannan, Rorden, Pambakian, Kennard & Husain, 2003), I aimed also at examining differences in brain responses when respondents participate in music listening.

Purpose of the Study

The purpose of this study was to investigate brain responses to music listening among children. This was to find out whether or not there was significant difference between brain responses to music listening and non music listening among children of various brain developmental stages. The study was also to investigate if there was or not any significant difference in brain responses of children of different brain developmental stages when engaged in music listening activity. The purpose of this study was also to examine if there were significant differences in neural activity among the four lobes of the human brain when children are engaged in the music listening behaviour.

Objectives of the Study

The objectives of this study are to:

1. investigate the difference in brain responses of exposure to music stimulus and non-music stimuli
2. examine how brain responses vary during exposure to music stimulus among children of different brain developmental stages.
3. examine if there is any significant difference in the brain responses among brain lobes when exposed to music stimulus.
4. examine if there is any significant difference in the brain responses among brain lobes by brain stages when exposed to music stimulus.

Research Questions

Based on the objectives, the following research questions were constructed to guide the study.

1. What is the difference between brain responses of children exposed to music stimulus and that of those not exposed to music stimulus?
2. To what extent does brain response vary during exposure to the same music stimulus among children of different brain developmental stages?
3. What differences exist in brain responses to music in each of the four brain lobes?
4. Are there any significant differences in the brain responses among brain lobes to brain stages when exposed to music stimulus?

Research Hypotheses

The following hypotheses were developed for the study:

1. H_0: There is no significant difference in brain response of children exposed to and those not exposed to music stimulus.

   H_1: There is significant difference in brain response of children exposed to and those not exposed to music stimulus.
2. H_0: There is no significant difference in brain responses of children of different brain developmental stages exposed to same music stimulus.

   H_1: There are significant differences in brain responses of children of different brain developmental stages exposed to the same music stimulus.
3. H_0: There are no significant differences in brain response of the various brain lobes to music stimulus.

   H_1: There are significant differences in brain responses of the various brain lobes to music stimulus.

4. H_0: There are no significant differences in brain responses among brain lobes at brain stages to music stimulus.

   H_1: There are significant differences in brain responses among brain lobes at brain stages to music stimulus.

The Theoretical Framework

A theoretical framework has been developed to assist in the investigation of the phenomena of this study. In my investigation, I employed the time frame of human brain development theoretical framework. It is a brain stage theoretical framework which was developed by Casey, Tottenham, Liston and Durston (2005) to provide an insight into the development of the human brain across stages of human brain development. Some scholars reported on these brain stages from neurulation (the early period before birth) to adulthood (Banich & Compton, 2018; Casey, Galvan & Hare, 2005; Casey, Tottenham, Liston & Durston, 2005).

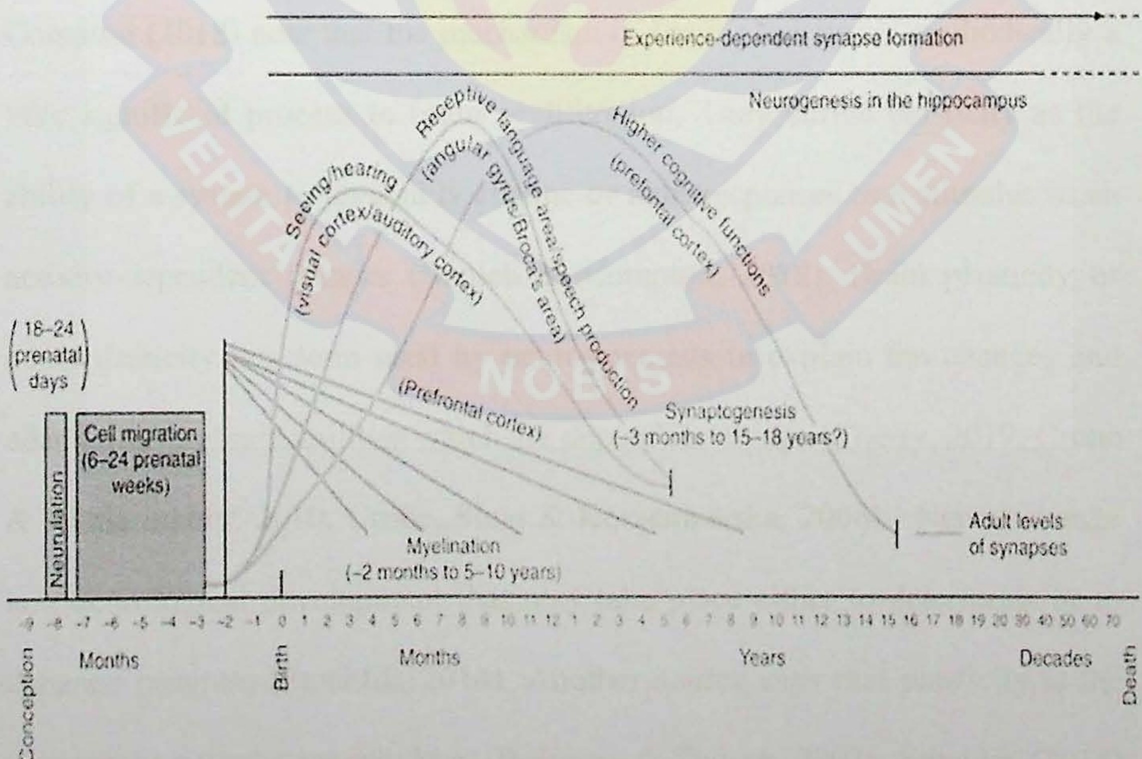

Figure 1.1: A framework of the time course of human brain development (Banich & Compton, 2018)

Figure 1.1 represents the framework of the times in the course of human brain development. This framework has been reported in Banich and Compton (2018). The theory adopted for this study provides some level of descriptions to support brain developmental stage theory. I therefore considered it appropriate for this study. The time course of brain developmental stage as recorded and discussed by Banich and Compton (2018) was the framework that was proposed to support the investigation of brain developmental stage theory to music response in this study. This is because the theory looks at important stages of brain development from conception to younger adulthood and also older years of life after birth. This may then be applicable for observations related to brain behaviours in response to music stimuli as proposed in this study.

In their descriptions on brain developmental stages, Banich and Compton (2018) note that the mechanism of brain plasticity is methodically a very significant process in brain proliferation. They define plasticity as the ability of a system to reversibly change or alter responses to a stimulus in an activity-dependent manner (Banich & Compton, 2018). Brain plasticity or neuroplasticity is a term used by neuroscientists to explain the changes and adaptations in brain abilities which are dependent on age (Cherry, 2019; Crone & Ridderinkhof, 2010; Crone, Sinai & Korzeniewska, 2006). Neural change is a neurological development that may take place either to deteriorate or to enhance progress (Stuchlik, 2014). Another source says that plasticity is the changes in neural connectivities (Delorme & Thorpe, 2003). Stuchlik (2014) specifically stated that neural plasticity is a change in neurons with several billions of connections. Two types of brain plasticity have been observed: (i) functional plasticity and (ii) structural plasticity. Functional plasticity has been explained as the brain's ability to move functions from a damaged area of the brain to undamaged areas while structural plasticity has been explained as the brain's ability to modify its physical structure through learning processes (Cherry, 2019; Cherry, 2017).

Earlier, researchers recorded that brain changes can only take place during infancy and childhood where the physical structure of the brain is still developing (Stanley, Blair & Alberman, 2000; Tayler & Sebastian-Galles, 2007). However, current researchers observe that the brain continues to generate novel neural pathways which modify the existing ones for establishing new experiences, where new information is learnt and new memories are created (Tottenham, N., Hare, T. A., & Casey, B. J. (2009)). In the discussion of brain developmental stages, seven phases have been discussed, specifically in relation to the time course of human brain development by Banich and Compton (2018). These time course stages are 1) neurulation, 2) cell proliferation and migration, 3) development of sensory-motor cortex, 4) development of parietal and temporal association cortex, 5) development of prefrontal cortex, 6) synaptogenesis and synaptic pruning and 7) myelination.

It is observed that these significant 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. However, it has been noted that brain development cannot be thought of simply as a linear progression of growth (Banich & Compton, 2018).

Instead, many physical changes, psychological behaviours and activity take place in interconnected processes.

Neurulation (1-2 months-Prenatal Period)

Neurulation is a stage of brain development identified in the prenatal period of the development of the foetus. What has been referred to as neurulation is simply the stage of neurological development where the nervous system is developed just as a physical hollow tube (Banich & Compton, 2018; Wallingford, Niswander, Shaw & Finnell, 2013; Maden, 2002). This stage is observed to consist of individuals between the ages of the first two months of the period of gestation. Banich and Compton (2018) record that over time the tube goes through other processes like twisting, folding and expanding into a full developed brain.

Cell Proliferation and Migration (3rd to 8th month)

Cell proliferation has been defined as an increase in the number of cells as a result of cell growth and cell division (National Cancer Institute, 2019). It is referred to as the process responsible for the increase of cell numbers. Cell growth and cell division, thus become two significant changes that occur in cell proliferation. It has been observed that in the process of cell growth, syntheses occur as the parent cells divide to produce daughter cells. Banich and Compton (2018) recount that cell proliferation in the brain occurs after the first two months of neurulation to the eighth (8th) month (3rd to 8th month). In the seventh week of gestation, the nerve cells and glia inside the tube are observed to proliferate and to migrate.

Development of Sensory Motor Cortex (2 months to birth and from birth to 10 years)

The sensorimotor cortex brain development stage is another significant stage in the time course of brain development. The development of the sensorimotor cortex begins significantly from two months before birth and continues developing after birth to the eighth year of the individual (Banich & Compton, 2018).

Development of Parietal and Temporal Association Cortex (Birth to 10 years)

The parietal and temporal association cortex is observed to develop within the time course from birth to ten years. Much remains to be studied about this period. However, scholars observe that several higher-order neurological behaviours have been associated with parietal and temporal cortex development (Lau & Rosenthal, 2011; Geschwind & Levitt, 2007; Preuss & Goldman-Rakic, 1991).

Synaptogenesis and Synaptic Pruning

Synaptogenesis is one of the most important stages of brain development (Nieto-Estévez, Defterali & Vicario-Abejón, 2016). Scholars explain that synaptogenesis is a neuroscientific term developed from the word synapse, which means the connection between neurons affording impulses and neural transmissions (Banich & Compton, 2018). The increase in the number of connections of synapses that neurons make with other neurons is a process called synaptogenesis (Javaherian & Cline, 2005). In the synaptogenesis period, there is a significant increase in dendrites (protoplasmic branches of neuronal cells) to provide greater area for synaptic connections (Kim, Kim, Chang, Song, Cho & Jeon, 2001). Dendrites are 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 (Noback, Ruggiero, Demarest & Strominger, 2005; Rubel & Fritzsch, 2002) It has been observed that about 4.3 million synapses are formed every minute at the peak of synaptogenesis development (Silbereis, Pochareddy, Zhu, Li & Sestan 2016). The increase and the pruning of synapses play an important role in neuroplasticity.

Synaptic pruning is a process where axons and dendrites decay and die to eliminate synapses that occur during the early years of life (Selemon, 2013; Chechik, Meilijson & Ruppin, 1998). Neural pruning has been observed to start just after birth and continues to about twenty years in humans. This has been observed from Magnetic Resonance Imaging studies (Iglesias, Eriksson, Grize, Tomassini & Villa, 2005). It has been shown that as the size of infant's brain increases into adulthood, neurons also increase to approximately 86 billion (Azevedo, Carvalho, Grinberg, Farfel, Ferretti, Leite, Filho, Lent & Herculano-Houzel, 2009).

Furthermore, the brain pruning is influenced by environmental factors that are widely thought to represent learning (Craik & Bialystok, 2006). Synaptogenesis seems to be one of the critical stages in brain development and therefore offers a relevant paradigm with which to investigate brain response to music.

Myelination (2 months before birth to 10 years in childhood)

Neuroscientists describe myelination as a process where substances generated by the brain called myelin sheaths are coated around axons in the brain (Banich & Compton, 2018; Crone & Ridderinkhof, 2010). Myelination is a brain developmental period that varies in growth across the various regions of the brain. Myelination stage of human brain development is also a critical period of brain development that is worth investigating in study (Casey et al, 2005). Myelination is identified in human brain development as a stage that starts from the second month in the prenatal period to the tenth year of a child's development. My interest in investigating brain response to music in the myelination period is founded on this brain stage has been more clearly defined than some other brain stages in the neurodevelopmental stage framework. The main developmental stages of focus in this study were myelination and synaptogenesis.

Key Terms

The key terms employed in this study are defined below.

Constitutive Definitions for the Key Terms

1. *The cognitive neuroscience of music:* It is a term proposed by George Armitage Miller and Michael Gazzaniga in the year 1976 to mean the scientific study of brain-based mechanisms involved in the cognitive processes underlying music (Gazzaniga,2002). These behaviours include music listening, performing, composing, reading, writing, and other ancillary activity. The cognitive neuroscience of music is also a phenomenon that deals with brain-base studies relating to musical aesthetics and musical emotion with a specific focus on the neural connections in the brain which are involved in mental processes (Uttal, 2011).

2. *Music Stimulus:* A musical component or event that evokes a specific functional reaction in an organ or tissue. Generally, a stimulus is that which arouses activity or energy in someone or something; a spur or incentive. Areas of the brain which respond to music or other auditory inputs may be an example of stimulus-response.
3. *Music listening*: Listening is to give one's attention to sound and so music listening is the active processes of giving attention to the sound component of music. Listening involves complex affective, cognitive, and behavioural processes (Halone, Cunconan, Coakley & Wolvin, 1998).
4. *Electrical signals in the brain*: They are signals that generate information through neurotransmitters
5. *Cognitive development*: The construction of thought processes, including remembering, problem-solving and decision making from childhood through adolescence to adulthood. Piaget proposes four stages. These stages are sensorimotor, preoperational, concrete operational and formal operational (Beihler & Snowman, 1990).
6. *Developmental stages*: The stages that describe a state of brain development within specified range of ages. Piaget describes these stages as the normal intellectual development from infancy through adulthood. These include thought, judgment and knowledge (Boyatzis, 2008).
7. *Brain responses*: They are brain behaviours resulting from an external or internal stimulus (Pavlov, 2010; Schultz, 2000).

8. *Cognitive Response*: It is a psychological behaviour resulting from external or internal stimulus.

Operational Definitions

Operational definitions for the key terms are also provided to support a clearer definition of the key terms adopted in this study.

i. *Developmental stages*: The various developmental phases that have been proposed by Piaget. They are the sensorimotor stage, preoperational stage, concrete operational stage and formal operational stage. They determine when a child may be ready to attempt a task as in music participation.

ii. *Developmental readiness*: A stage of development where a person is seen as ready to attempt a task, for instance. The phenomenon which is the focus of this study is music listening. At a determined stage, it could be noticed that some transformation of maturity and readiness in personal development may have been established when they participate in music. The perspectives are toward metamorphosis in actions, habits, or competencies associated with effective music engagement.

iii. *Cognitive response*: They are models of behaviours and reactions that may occur when the mind or the brain is being involved, aiming at thought processes such as musical engagement (Ehler & Clark, 2000).

iv. *Myelination and synaptogenesis*: Children from birth up to ten years of age are in the category of myelination stage whiles those from eleven years and above are classified into the synaptogenesis.

It means that the age difference between the two brain stages is that children in synaptogenesis stage are older than those in the myelination stage.

Study Limitation

I recognise that there was one major condition of limitation that I cannot control in the conduct of this study. This condition place some restrictions on the methodology adopted. The condition may also affect data results and conclusions made.

The major limitation of the study is the condition of not being able to sample a larger size of respondents other than one hundred respondents (N=100). The University of Cape Coast Basic School had a population of 2,021 as at the time this study was being conducted. It means that I was supposed to have sampled 323 respondents for the study according to the sample size determination table and the sample size calculator adopted in this study.

However, I could not sample 323 respondents, instead, I sampled only 100 respondents. The reason for this sampling challenge was that the data collection process was very tedious. The EmotivEPOC+ was a delicate instrument which could not function efficiently with a large sample size (a sample size over 100).

Some scholars propose that a sampled size of at least 30 can be used for an experimental research (Hertzog, 2008; Osborne & Costello, 2004). It is also proposed that in considering the variability in the size of distribution, larger sample size engenders accuracy in the results. It is believed that since the sample size is larger than 30, the results of the study will produce a reliable information on children's brain response to music (Marino, Hogue, Ray & Kirschner, 2008; Wisz, Hijmans, Peterson, Graham, Guisan & NCEAS, 2008). I believe therefore that the 100 respondents (N =100) which were observed in the study was significant enough for a statistical inference.

The Delimitation of the Study

The population studied in this research was the University of Cape Coast Basic School (UCCBS). I chose UCCBS because it was a gender mixed school where I could observe boys and girls together. The school was also selected because it provided two well defined independent populations that were categorised into Myelination and Synaptogenesis as prompted by the observation of the theoretical framework of the study. Considering the age range of respondents employed in this study, I was also able to select a large range of children that were described within the brain developmental stage framework in the UCCBS. In addition, I selected UCC Basic School by considering my proximity to the school.

The Organization of this Study

This study was conducted according to the 2017 institutional laid down structures of the University of Cape Coast guidelines for thesis preparation and presentation.

Chapter One of this study introduced the reader to the overview of the study. It also provided the purpose, research questions, hypotheses and the definition of key terms. One other very important issue discussed in Chapter One was the development and the discussion of the relevant theoretical framework for the study. A report about the organisation of the study was also provided in this chapter. Since this study was mainly a quantitative research, the development and testing of hypothesis were a principal part of the organisation and the development of this study. Four hypotheses were developed in this study.

Chapter Two presents the literature review. Some of the phenomena discussed are a brief history of the development neuroscience studies specifically about the use of EEG, historical, music educational relevance, the progress of verification towards educational phenomena, music processes in the brain, concerns about children music exposure, musical experience and stage theory, ethical concerns about neurological practices, phenomena of sex differences in brain response, neurological organisation of music, neurons and synapses in the brain, synapses and synaptic response in the human brain, and the processes in the developmental stages of the human brain.

Chapter Three is organised to report on the methodology of the study. The major items developed were the research design and its feasibility for the study, sampling procedures, an overview of the population and the presentation of their descriptive statistics distributions. In this chapter, the development of database and the data setup were also discussed.

In Chapter Four, I provide the statistical results from the data. The analyses of the data, hypothesis testing and discussion of results are also presented in Chapter Four. The discussion includes the significance of results, concerns about stimulus differences, ecological factors as well as issues regarding the theoretical framework of this study and how they may have affected the results and findings that were computed.

Chapter Five presents the summary, conclusion and recommendations of the study. It provided a general summary of the whole thesis, a summary of the data results that were analysed as well as the hypotheses that were developed and tested. The Chapter further provided conclusion on the results and findings. In Chapter Five, recommendations were also offered on the conclusions drawn. Other relevant phenomena were discussed concerning the music stimuli that were employed for data collection, the reassessment of methodology of the study as well as a proposal for new methods in the future investigation of the same study. Finally, I discussed the topic of this study, knowledge acquired and the future directions of this research.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter provides the review of literature for the study. Since this study is an interdisciplinary research, the review of literature addresses issues on neuroscience, music and education. To effectively review literature for the development of this study, a subset of literature has been selected based on children's participation in music, children's music cognition, children's participation in music and affective musical development, children's music participation and psychomotor development, music perception among children, children's musical memory, children's education, music education, children's music education, music education in Ghana and pedagogical approaches in music education in Ghana.

Other related discussions include music processes in the brain, neurological organisation of music, synaptic responses in the brain, processes in the developmental stages of human brain, synapses and synaptic responses in the human brain, processes of the developmental stages of human brain, comparing differences in myelination and synaptogenesis, the significance of myelination in information processing, the significance of synaptogenesis in information processing, the review of other brain based theories and the relevance of neuroscience in education. Though it had been painstaking to achieve a quality literature review, I noticed that the effort has been rewarding in unravelling various phenomena that inform the development of this study.

Children's Participation in Music

As mentioned earlier, this study focuses on examining neural activity that is associated with pupils' participation in music. It has been identified that childhood musical involvement is the genesis of their musical behaviours (Deliège, & Sloboda, 2004; Mithen, Morley, Wray, Tallerman & Gamble, 2006; Cross, 2003; 2001; Sloboda, 1985). Music listening has been identified by scholars as one of the musical behavioural traits found among both adults and children (Sloboda, & O'neill, 2001; Hodges, 1997). In a study conducted by Ilari (2005), it was observed that early childhood exposure to music had considerable impact on musical preference and influenced their music listening behaviour in the last years of their lives.

The literature draws attention to children's mode of music listening. Four of these modes: (1) listening to background music (Radocy and Boyle, 1997; Musselman, 1994). They note that background music does not capture children's attention. Musselman (1994) observed that when children experienced background music, they hear the music but they do not actively or purposely listened to it; (2) listening as an accompaniment to non-musical activity (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). In this mode of listening, children intend listening and may be concentrating, thus, participating mentally in the music. Listening with focused attention may have both cognitive and emotional functions (Boal-Palheiros & Hargreaves, 2004; Hodges, 2009); (4) Listening and performing musical activity (Boal-Palheiros & Hargreaves). Children 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 my study, I adopted the mode of listening activity where children engage in listening to music as a main activity. Since it was my intention to observe children's brain responses to music, I needed them to concentrate on the music to which they listened.

Children's Music Cognition

Cognitive processes involve in music learning is described by Norgaard (2011) as the study of the mental generative progressions and insights that are associated to listening to music, performing music, or any of the behaviours associated with music participation (Picard & Strick, 2011; Juslin, 2003; Hodges, 2010b). The literature reveals that children efficiently process music cognitively (Hanna-Pladdy & MacKay, 2011; Magne, Schön, & Besson, 2006; Trehub, 2003). For example, a group of researchers conducted a study to investigate how young children can detect pitch violation in both music and language through listening. In the study, it was found out that children who had music training perform better than those who did not (Norgaard, 2011; Magne, Schön & Besson, 2006). In another study it was observed that there was a strong relationship between music instruction and improved cognitive abilities of young children's phonemic awareness (Gromko, 2005). The analysis of the data, in the study, revealed that children who received four months of music training performed better on their phoneme segmentation smoothness than children who did not receive the music instruction, $t = -3.52$, $df = 101$, $p = .001$(Gromko, 2005).

The studies therefore show that when children are engaged in active music participation, their cognitive processes are being enhanced. Children's music education is therefore important. This is because it provides opportunity for children to acquire music training and achieve musical experience.

Children's Participation in Music and Affective Musical Development

Music is capable of arousing a variety of emotions within the listener (Cozolino, 2017; Collins, 2013; Huron, 2006; Lavy, 2001; Kandel, 2004). It has been observed that generally, the emotional experiences that are triggered by music listening can educate children's emotion such as the reflection of inner feelings and thoughts (Music, 2016; Lewis, 2012; Peretz, 2001). This experience of music can also support character building (Waksman, 2001). In a study, Panksepp and Bernatzky (2002) recapitulate the possible functions and brain emotional systems in the mediation of music appreciation. In their discussion, they recapitulate a variety of examples of how music may promote behavioral changes. These include effects on music memory, the derivation of mood from musical engagement, brain behaviour and autonomic responses to music.

In one of the studies on the development of affective musical experience, the researchers investigate emotionally salient sound from neural processing to musical exposure, Strait, Kraus, Skoe and Ashley (2009) recorded brainstem potentials to the sound of human voice. In the investigation, results show that musicians develop higher neural response to the stimulus. However, decreased level of brain response was observed to be associated to the less multifarious sections of the sound produced. From the study, it was suggested that higher emotional responses were closely connected to the nature of related acoustical features.

The observations imply that music participation and music learning does a great service to children's development, and that one of the most relevant aspect of affective enhancement for musical engagement is character building. Scholars in field of music education may want to learn from studies that identify ways that music education affects school children or students.

Music Perception among Children

Music perception is described as engaging acoustic examination, auditory memory, auditory scene analysis, processing of interval relations, syntax and semantics, and activation of motor demonstration of behaviour (Koelsch, 2011; Koelsch & Siebel, 2005). Koelsch (2011) provided further details to explain that music perception potentially elicits emotions, thus giving rise to the modulation of emotional affective systems such as those related to subjective feeling and expression of other emotional experiences.

A meta-analysis was conducted to investigate the possibility of separating the perceptual aspects of musical experiences from other aspects of those experiences. It was found out that there was overlapping where the two cannot be separated (Janata, 2015). In another study, researchers examined syntax processing and its relationship to music and language processing (Patel, Gibson, Ratner, Besson & Holcomb, 1998). The findings suggest that music and language can be studied in parallel to address questions related to cognitive and neural processes.

A study was conducted on the perception of music and children musical experience (Līduma, 2016). In this study, Līduma (2016) analysed the succession in the progress of children's musical perception. In the study, the author found out that the perceptual experience of music is developed through everyday engagement in music. In another study conducted to investigate the relationship between auditory perception and musical engagement, Strait, Kraus, Parbery-Clark and Ashley (2010) observed that long term-musical music practice reinforces auditory skills and perception.

Parbery-Clark, Skoe, Lam and Kraus (2009) conducted a study to examine speech and noise to training in music. The investigation indicated that musicians have better perception of speech in a noisy environment than non-musicians. In another study, researchers examine the impact of music training on the development of auditory skills (Kraus & Chandrasekaran, 2010). They observed that music training leads to changes in the auditory system of musicians. The study therefore suggests that music tones the brain for auditory fitness, apart from physical exercise.

The studies therefore suggest that the perceptual abilities of musical experience are closely linked to other human perception that may not be separable. It is also observed that musical perception elicit and modulate emotions. It was also observed that it was possible to learn related knowledge from both cognitive and neural processes which is a novelty in interdisciplinary research. Therefore, studies like this will create avenue for researchers and music educator to identify how perception in music relate to musical participation engagement.

Children's Musical Memory

Musical memory refers to the ability to remember music-related information, such as melodic content and other progressions of tones or pitches (Radocy & Boyle, 2012). It is observed among children that musical memory is functionally unique (Baird & Samson, 2009; Schlaug, 2001; Kandle, 2013; Kandle, 2012). It is noted that musical memory in the brain has the same neural network which is used for all kinds of sounds (Huotilainen, Putkinen & Tervaniemi, 2009; Stanutz, Wapnick, & Burack, 2014). Some studies found that musical abilities and musical experiences that are acquired at childhood years are able to remain in memory in many years of life in adulthood after the training or the experience (Wan & Schlaug, 2010; Ho, Cheung & Chan, 2003)

Barrett (2002) conducted an examination to investigate the extent to which children relate their musical memory to their invented musical symbols. It was noted that children can learn and retrieve music through their own symbolic notations. The investigation therefore suggested that children's invention of musical notation can enhance the mediation of their memory.

In an investigation to explore the cognitive mechanisms in memory processes among young children, Saffran (2003) observed that young children develop structures of neural behaviours that could be closely linked to their musical memory abilities.

In relationship to these observations, it is noted that studies about musical memory are relevant to music educators, by which they can identify ways that music is recalled from its participation and experiences. Stewart and Williamon (2008) also noted that the engagement in musical participation is not enough but also, the understanding of its neurological processes such as musical memory is also relevant to music education.

In brief, musical memories function well to preserve knowledge of our musical learning and experience. It is also noted that the memories and pathways for music are not quite separated from that of other sounds. It is also observed that musical memory is so strong that it is able to save childhood constructed knowledge for use in older years of life. Knowledge about musical memory therefore seems important for musical participation and its associated musical experiences. In relationship to these observations, scholars propose that music education is not only for participating and the development of artistry skills but that the neurological observations are also relevant to music education (Stewart & Williamon, 2008). It therefore seems relevant to my study as it is brain base (neurological) study.

Children's Education

Byram, Gribkova and Starkey (2002) define education as a process of facilitating learning, or the acquisition of knowledge, skills, values, beliefs, and habits which takes place under the guidance of educators. They also note that learners can also educate themselves. Education is a medium for learning, and that, the school system is said to be one of unit for educational practices (Simonson, Zvacek & Smaldino, 2019). A school is also said to provide learning spaces under teachers' directions (Williams & Jacobs, 2004).

School is the leading fountain of knowledge to which children are exposed to. Schooling provides a possibility for them to obtain knowledge on a variety of fields of learning (Perkins, 2008; Hargreaves, 2003). Music knowledge is one of the unique fields of learning that children can acquire in school (Gorbunova & Govorova, 2018).

In brief, education provides opportunity for learning and that the school system is one of the most unique systems where children can learn. In this learning system, teachers play a key role in helping children to learn.

Music Education

Many scholars spoke about the important of children musical engagements (Reimer, 2009; Reimer, 2003; Bowman & Frega, 2012). Music education is a field of study associated with the teaching and learning of music (Volk, 2004). Colwell and Richardson (2002) also discuss 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 conservatory directors. Music teachers teach music theory, harmony and instruments such as piano and voice. Music teachers who teach children, especially those in early grades might need to be knowledgeable in early childhood learning and development (National Research Council, 2012; Morrow, 2001). They might also need to be abreast with psychological, cognitive and neurological processes of children's musical participation and learning (Haskell, 2000; Līduma, 2016; Reimer,2003).

In summary, it is through music education that the phenomena about music learning, relating to both children and adults are discussed. It is also noted that music teachers, unlike other music specialists and scholars such as composers and ethnomusicologists need special music training that can prepare them to be better music educators. Studies therefore about education seem relevant to music educators because the teaching and learning of music are better practiced by music educators in an educational system.

Children's Music Education

Music education for young children is an educational program that helps to bring up children in music participation and learning (Campbell, 2010; Niland, 2009). It is said to be a subarea of music education (Niland, 2009; Reimer, 2009).

Willis (2008) believes strongly that music learning ignites all areas of the development of children. These areas comprise creativity, intellectual, emotional and language acquisition (Oxford, 2015; Kaschub & Smith). In this, children learn to coordinate their body and mind to work together (Collins; 2013; Overy & Molnar-Szakacs, 2009; Sawyer, 2006). Wright and Kanellopoulos (2010) observe that exposing children to musical engagement during their early years of development is a solid approach to early childhood musical experience on which they can build their future on the learning of music.

In a study conducted to find out if music learning has any impact on mathematics score, students from two schools were given the Early Mathematics Ability-3 Test to find out which, between the two schools perform better (Harris, 2007). One of the two schools followed an enriched music curriculum while the other did not. Results from the study show that subjects in the music enriched school had significantly higher mathematics achievement scores than those who were not. The findings suggest that a music-enriched curriculum has a significant impact on children academic achievement.

It is noted that music participation and learning has a significant impact on children development. This suggests that children's musical engagement and learning should be encouraged in schools. Early music learning has also been found to have a long term effect on children's musical experience.

Music Education in Ghana

Otchere, Amuah and Numekevor (2016) believe that the arts, such as music are best suited for the training of the affective domain of an individual, such should be of high priority in the school curriculum. However, this goal has been missed. The authors observed that music teaching in Ghanaian basic schools has not satisfied its right assumed mandate.

Towards a review of the introduction of music education in Ghana, Flolu (1993) noted that there seems to be a conflict of belief system between the curriculum planners and the music teachers. Flolu and Amuah (2003) record that music education in Ghana did not see the achievement it was supposed to attain. In observing that music teaching in Ghanaian basic schools did not accomplish its true purpose, Otchere, Amuah and Numekevor (2016) propose that there is the need to review the music program.

One other issue raised about the underrated music programme in Ghana is the lack of application of information and communication technology (Nyamful, 2016). Nyamful observes that the advancement of information and communication technology in education is rapidly changing the world. Music education in Ghana should therefore not be left behind.

Adjepong (2018) observes that the teaching and learning of traditional Ghanaian music has been given a low priority in the school curriculum. He also noted that the music teachers lack adequate knowledge and skills to provide their music students with musical learning and musical experience in this area of music teaching and learning. In another study Hodari (2013) found out from the study that primary schools have no music subject teachers. The schools also lack facilities such as books and other supportive learning material for the subject.

In all the discussion under music education in Ghana, it is noted that there is a missing link between the status of music education in Ghana and nature of Ghanaian music. It is observed that most often, curriculum planners and the music teachers have discourses about the planning and the teaching of music. The employment of information and communication technology as well as the place for traditional Ghanaian music in the school curriculum has been misplaced. This and other phenomena indicate that the position of music education in Ghana is underrated. This status therefore obviously affects musical participation and learning experiences among children in the school system in Ghana.

As noted earlier, music scholars in Ghana have noted that music education delivery in Ghana has veered away from its goal, that is, the enhancement of the affective experience of children (Otchere, Amuah & Numekevor, 2016).

In a study which explored the pedagogical approaches adopted by music and dance teachers in the primary schools in Ghana, the researchers observed that majority of the teachers who teach the subject in the primary school have obtained college degrees in subjects other than music and dance. This condition has affected their pedagogical approach of the subject (Obeng & Osei-Senyah, 2018). They noted that since the teachers lack professional knowledge and skills of the subject, they fail to interpret the curriculum efficiently.

On the other hand scholars explore the effectiveness of preparing quality music teachers in teacher education programmes (Ballantyne & Packer, 2004). Ballantyne and Packer (2004) observe that when pre-service music teachers go through effective music teacher training, graduates are adequately prepared for classroom music teaching.

In light of the discussion of the pedagogical approaches to music education in Ghana, it is noted that the core goal of music teaching and learning which the enhancement of the affective is experienced of children has not been achieved. One of the major contributing factors for this identified problem is the lack of professional teachers for the implementation of the music curriculum for the primary schools. Also, in this discussion, it was observed that when music teachers acquire quality training, they will be adequately prepared for quality music teaching. Knowledge on the neuroscience of music could also be a vital part of the music-teacher training programmes.

Organisation and Processes of Information in the Human Brain

Scholars noted that the organisation and the processes of information in the human brain is complex to describe (Shapira-Lichter & Cerf, 2017; Coren, 2003). Information processing starts with input from the sensory organs, which transform physical stimuli such as sound waves or light into electrochemical signals (Uttal, 2014; Sadeghi & Thompson, 2010). The messages are then assembled through complex processes to generate meaning and functions (Uttal, 2014).

There are two main areas of the human brain. One of the two is the central nervous system (CNS), which consists of the brain and the spinal cord and the second area is the peripheral nervous system (PNS) which consist of the spinal nerves and the cranial nerves (Bolon, et al, 2013; Catala & Kubis, 2013). One of the major differences between CNS and PNS in information processing is that CNS is the site for information processing while PNS relies on information that is processed by the CNS (Case & Tessier-Lavigne, 2005).

Another aspect of the brain with respect to information processing is the hemispheres of the brain. The brain is divided into two hemispheres--the left and the right. The left hemisphere of the brain controls the right part of the human body while the right hemisphere of the brain controls the left side of the human body (Rogers, Vallortigara & Andrew, 2013; MacNeilage, Rogers & Vallortigara, 2009). During information processing the right hemisphere of the brain controls information processes related to creativity, spatial ability, artistic and musical skills while the left hemisphere controls speech, comprehension, arithmetic and writing (Heilman, Nadeau & Beversdorf, 2003)

Inside the brain, there are information pathways called white matter. Through these information pathways, messages can travel from one gyrus to another as well as from one side of the brain to another (Schmahmann, Schmahmann & Pandya, 2009). Memory processing in the human brain is a complex organisation (Fehr, 2013). Encoding, storing and recalling of information are three main stages of information processing in the brain. There are two types of memory that are organised in the brain. These are short-term memory and long-term memory (Ruchkin, Grafman, Cameron & Berndt, 2003). Short term memory stores information shortly (about one minute). Long term memory is activated for longer term storage of information. Neuroscientists observe that short-term memory occurs in the prefrontal cortex of the brain while long-term memory occurs in hippocampus of the temporal lobe (Squire, 2009).

Lledo, Gheusi and Vincent (2005) noted that ventricles in the brain also play vital role in information processing. Ventricles are brain structures that produce cerebrospinal fluid in the brain (Prins et al, 2005). The ventricle system is a set of communicating cavities within the brain (Prins, et al, 2005). The cerebrospinal fluid created in the ventricle support synaptic transmission and proper functioning of the brain.

Audiologists have noted that when sound is received by the ear, it is converted to an electrical signal which travels to the auditory nerve to the part of the brain that processes sound, the auditory cortex (Ahveninen, Kopčo & Jääskeläinen, 2014; Groopman, 2009). The signals travel throughout the brain, creating a variety of responses. As the hair fibres of the cochlea of the ear send signals to the auditory nerve, impulses are transferred to the auditory centre of the brain (Gubbels, Woessner, Mitchell, Ricci & Brigande, 2008). As stimuli change into the form of electrical properties, they pass through various auditory pathways. Signals are then interpreted into sounds that may make meaning or to communicate (Yu & Goodrich, 2014).

Some researchers have observed that when sound changes into electrical properties and pass through pathways to be interpreted, three new alteration processes occur at new levels in the brain (Dehaene, 2009; Hawkins & Blakeslee, 2007; Doidge, 2007). These alteration processes have spontaneous effects. They unfold the auditory cortex for cognisance insight of sound and then relate the information to other memories (Dehaene, 2009). All these processes occur as voluntary responses through an executive function which has been defined as a set of high-level mental processes that control and regulate abilities and behaviours (Nigg, 2017; Bara, 2010).

Neuroscientists studying about musical processing, through functional brain imaging and electroencephalogram have concluded that the brain is musical and that virtually the whole brain is involved in music processing (Maess, Koelsch, Gunter and Friederici, 2001; Koelsch, Gunter, Friederici, Schröger, 2000; Barber, McKenzie, and Helme, 1995). However, there are specific regions where specific tasks and behaviours could be traced. Barber, McKenzie and Helme (1995) have also observed that music stimuli turn on exclusive neurological processes. They also examined that the brain goes through various neural computations in music processing. The investigation of these neural computational processes seems to be a complex task. However, a conscious attempt of conducting carefully designed empirical investigation can help in explaining these processes (Aru, Bachmann, Singer & Melloni, 2012). From the perspectives of functional approaches of neuroscientific investigations, Mo (2009) noted that the use of neuroscientific techniques such as functional neuroimaging with technical equipment such as functional Magnetic Resonance Imaging (fMRI) is observed as being very suitable if there is the need to do detailed investigations about brain activity and behaviours with stimulus responses.

Byrne (2012) discussed 'mirror effect' as a phenomenon about brain processes of music which are related to mirror effect' to mirror neurons in the brain. Mirror neurons are neurons that fire when the subject observes a similar action performed by another (Keysers & Christian, 2011; Keysers & Christian, 2010). They are also explained as neurons that fire both when an individual acts and when the subject observes the same action performed by another (Rizzolatti, Giacomo, Craighero & Laila, 2004). Brain behaviours relating to mirror neurons are found in motor cortices, the primary cortex and the inferior (Keysers, Christian, 2011). Byrne (2012) reported on a neuroscientific investigation that was carried out to observe the specific neurons that fire when humans and monkeys watch their fellow species when they participate in prescribed activity. In the investigation it was observed that similar brain behaviours were generated by both the observer and the observed. For example in the investigation that was reported by Byrne (2012), some neuroscientists observed that similar brain activity were observed in both the respondent who was engaged in the task and the respondent who was just observing. The responses that were observed in a respondent who was carrying out a specific task were similarly to that of the respondent who was just observing. They noted that when one watches an athlete, for example, neurons that fire from muscles in the athlete during the athletic were found to be similar to the motor neurons that fire in the brain of the spectator (Byrne, 2012).

Byrne (2012) has also confirmed that our responses to music are dependent on these mirror neurons, and that this characteristic trait anthropomorphizes as responses to stimuli, are brought to reality in us.

Thaut (2005) noted that all of our means of musical communications such as audiation, composing, singing, among others, go through motor and muscular activity in the nervous system. The activity associated with that motor activity is connected and affect the behaviours underlying emotions to the extent that our physical states and our emotional states become inseparable. This may in a way explain, for instance, why music inspires us to move in precise ways. It has been observed that music activates an entire host of neurons that are not observed in other artistic participations (Byrne, 2012). Sacks (2010) observed that when we engage in music participation, the firing of neurons in multiple regions of the brain occurs. Sacks (2010) also wrote about a man with a damaged brain. He observed that the man could remember his daily routines by singing a melody. With melodic intonation, he could remember daily activity such as dressing, bathing, eating and washing (Byrne, 2012; Sacks, 2012). From this behavioural experience, Thaut (2005) examined that music can arouse the human spinal motor neurons to set the brain in readiness for the execution of movement to communicate.

In summary, the organisation and the processing of information in the human brain is observably complex. The sensory organs, the white matter and the ventricular system play very vital role in information processing. It is also noted that short term memory and long term memory play unique roles in information processing. The discussions related to the knowledge about 'mirror neurons' and 'mirror effect' also seem interesting for investigation. The discussions indicate that all these reviews are important fields of learning and relevant to researchers and educators studying about the brain in their various fields of disciplines. These related studies can therefore benefit music educators who will want to examine the neurological organisation and the processing of music.

Neurological Organisation and Processes of Music

The learning about the organisation and processing of music in the brain is a major focus of interest in current trends of neuroscientific research (Warren, 2008). As a result of significant development in this field of study, there is an increase in the development of sophisticated tools to investigate neural processes to musical engagements (Warren, 2008). Some of these tools are laboratory electroencephalogram (EEG), EmotivEPOC+, Emotive Insight and fMRI. Hodges and Sebald (2011) noted that music's true value does not lie in the musical structure but in the effects it has on people, in that, the musical processing and the experiences are rather functional than the music itself. Chow (2014) observed that music processes in the brain is a complex phenomenon (Chow, 2014). The study of brain behaviours relating to music participation have developed into an interdisciplinary study called neuroscience of music (Teixeira-Machado, Arida & de Jesus Mari, 2019; Fernandez, 2018). The neuroscience of music is basically defined as the scientific examination of the involvement of the brain in the neural processes of music (Brattico & Pearce, 2013).

Researchers studying neuroscience of music focus on various fields including neuromusicology and psychophysiology of music (Fancourt, Ockelford & Belai, 2014). In the study of the psychophysiological involvement of music, researchers identify tonotopy as the spatial arrangement of where sounds of different frequencies are processed in the brain (Peretz & Zatorre, 2005). Tones close to each other in terms of frequency are represented in topologically neighbouring regions in the brain (Talavage, Sereno, Melcher, Ledden, Rosen & Dale, 2004).

Scholars debate on the cognitive and the neurological relationships that exist between music and language (Philpott & Plummeridge, 2001). These arguments focus on investigations to find out if music and language processing possesses similar characteristics (Sloboda, 1985). Sloboda (1985) pointed out that both music and language are particular to humans, both contain potentials for infinite combinations of possibilities, where both can be learned by listening to models and that both use vocal and auditory sound processes as their natural medium. Sloboda continues to compare music and language and infer that both could have similar processing characteristics because they can both be examined in terms of phonetic, syntactic and semantic structures and that both can be compared in terms of underlying structures over which various transformations can take place.

Contrary to the findings of Sloboda, other investigations provide that music and language do not have similar neurological and cognitive processing characteristics (Philpott & Plummeridge, 2001). Shepard (1987) and Swanwick (1999, 1988) also argue that comparing music and language in similar processing characteristics is questionable. This is because the perceptions that underline the emotional processes of music are perceptually subjective when compared to language. For instance, music composed in major keys could be cognitively processed and perceived by someone as the song being in a minor key. This is subjectivity, a stipulation which is not the same as in the perceptual understanding of language processing. It is also noted that music and its behavioural responses are mostly bonds to emotion (Chow, 2014), while it is not with language. Such psychophysiological studies are admitted to be complex in their explanation (Chow, 2014).

In summary, it is noted that music processing in the brain can basically be studied through cognition and neuroscience. It is learned that both music and language can share some common characteristics to brain behaviours in humans. While both contain potentials for infinite combinations of possibilities; it has also been observed that both music and language can be processed from models of vocal and auditory sound mediums. Therefore, to understand music and brain behaviour, some insights could be linked to language processing as well. All these discussions suggest that the need to be knowledgeable about the neural processes to musical engagement is importance to music educators.

Also, from neuromusical perspectives, it could be deduced that it is worth investigating brain responses to music. This review suggests that the engagement in the interdisciplinary studies of music and its neural correlates will enable music educators to become broadminded about the relationship between brain processes and music. Therefore with respect to this study, it is worthwhile to engage in research that will illuminate our understanding of neural pathways involved in human engagements with music.

Synapses and Synaptic Responses in the Human Brain

The word 'synapse' is derived from the Greek word *synaptein to* mean joining or binding together (Verkhratsky & Butt, 2007). The binding is observed to happen at a location where two neurons meet to communicate (Kandel, 2006). The synaptic responses are observed to be such that when neurons meet they do not completely touch each other but can do transmission through signals from dendrites branches (Wu, Ghosh-Roy, Yanik, Zhang, Jin & Chisholm, 2007; Kandel, 2006; Nimchinsky, Sabatini & Svoboda, 2002).

Through synapses, neurons can do complex entities of interconnections of outputs-inputs for learning and modifications of strength (Kock, 2004).

Chemical synapses and electrical synapses are two major synapses that are discovered by neuroscientists (Kolb & Whishaw, 2011; Patestas & Gartner, 2006). Chemical synapses are observed to be the type of synapses that release molecules when they receive stimulations from action potentials (Kolb, & Whishaw, 2011). Electrical synapses, on the other hand, are synapses that control the movement of molecular icons from one cell into another (Patestas & Gartner, 2006). It is observed that presynaptic and postsynaptic membranes allow action potential to pass electrically charged signals from one neuron to the next to coordinate effective information transmission (Kolb & Whishaw, 2011).

Kandel (2004) defined presynaptic neurons as the neurons that send signals to other neurons at synapse while post-synaptic neurons are the neurons that receive signals from other neurons at synapses. When music stimulus is generated, it is the pre-synapses that receive the musical signals and transmit it to the post-synapses for further transmission and decoding. Neurologists observe synaptic cleft as another significant feature of synapses (Kandel, 2013; Kandel, 2012). Synaptic clefts are observed as the micro gaps between axons and dendrites (Kandel, 2006).

In brief, the neuronal organisation of synapses and synaptic responses in the brain depends on the interconnections of neurons by which signals are generated in thousands and millions. Since presynaptic neurons are responsible for receiving incoming stimuli, they seem to be important in stimuli application and brain response. Insight into the presynaptic and

Neurons fire between 5 to 50 times per second in which information is processed and transmitted (Cordelia, 2008). Vesicles contain thousands of neuron transmitters for signal and information relay between neurons and other cells (Kennedy, 2000). Neuroscientists continue to report that neurotransmitters are stimulated by electrical impulses to cross cell membranes into synaptic gaps (Fields & Stevens-Graham, 2002; Roerig & Feller, 2000; Lodish, Berk, Zipursky, Matsudaira, Baltimore & Darnell, 2000). Synaptic gaps are defined as gaps that exist between neurons which contain charge particles of ion, sodium, potassium and chloride for information transmission signals (MacGregor, 2012; Pereira & Furlan, 2010). Three specific events are involved in the processing cycle: from an electrical signal to a chemical signal and back again. All these processes are observed to happen in less than five-hundredth of a second (Cordelia, 2008). Though neuroscientists are still investigating to enhance their understanding about the structures and functions of neurons, they have identified three categories of neurones: sensori neuron, motor neuron and interneuron (Fukuda, 2007; Steriade, 2004).

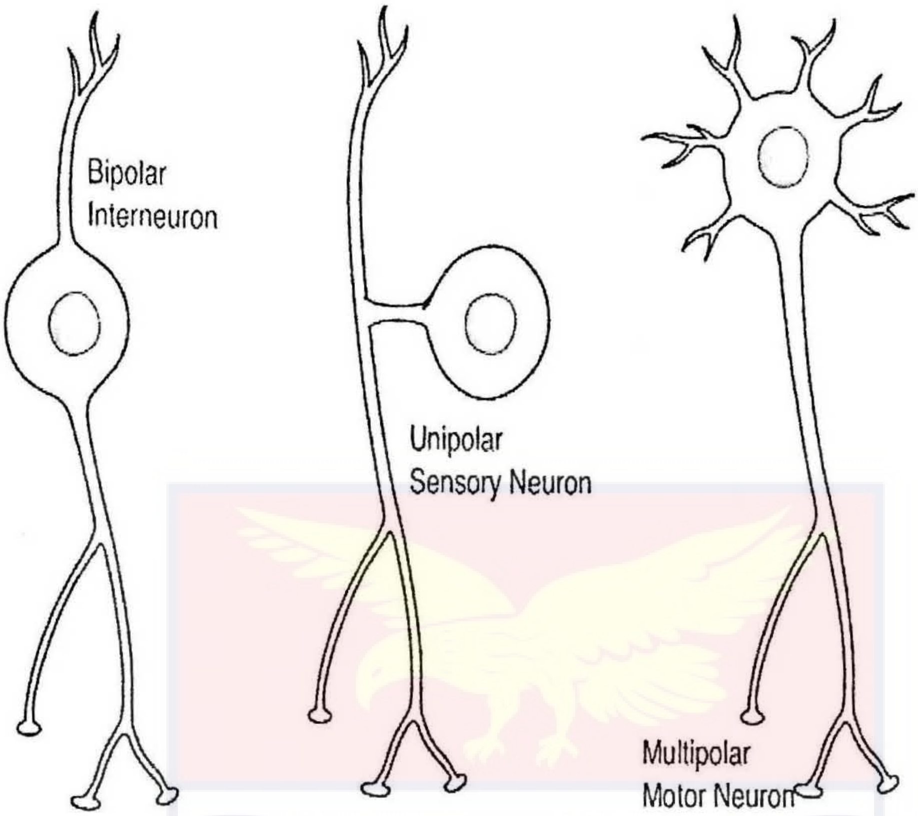

Figure 1.2: The three classified types of neurons as to their functions as in Vieira, Pinaya & Mechelli, (2017)

It is discussed in some investigations that neurons can be classified according to the tasks they perform (Vieira, Pinaya & Mechelli, 2017). Sensory neurons control information from the sensory organs while motor neurons emit signals from the brain and spinal cord to the muscles (Nielsen, 2003). They are mainly responsible for controlling movement while an interneuron functions as a bridge between two neurons (Menelaou & McLean, 2019). The length of the axons of any neuron is observed to vary according to their distance from other neurons in their continuous transmitting processes. It is observed that neurons discharge neurotransmitters with chemical receptors and this condition accounts a lot for their high influence on one another (Corner, van Pelt, Wolters, Baker & Nuytinck, 2002; Bunzeck, Wuestenberg, Lutz, Heinze & Jancke, 2005). These neurological behaviours are such that the neurotransmitters emitting are very important in the organisation of oscillation and neural transmission (Lewis, Volk & Hashimoto, 2004). The neurotransmitters behave like the door for blocking or allowing for the passageway (.King, Blair, Mitchell, Dolan & Burgess, 2006). During the emitting of neurons, there are pre-synaptic neurons and post-synaptic neurons that perform nervous impulse emitting and nervous impulse receiving respectively Huh & Sejnowski, 2018).

I have noted that neuronal behaviours in information processing in the brain are a complex phenomenon. Since scholars observe that humans' psychological processes of communications go through motor and muscular activity in the nervous system it could be concluded that both cognition and neurology cannot be completely separated. In this discussion, it is noted that neurons are the key subjects in brain behaviours and functions, and that they play roles in every affair of brain function. The observation of neuronal behaviours in this study therefore seems very vital.

Processes in the Developmental Stages of Human Brain

Casey et al., (2005) provided a human brain developmental stage theory that describes details of identified stages of human brain development. A study carried out by Epstein (1986) to investigate stages of human brain development indicate that there are statistically significant peak in brain growth rate among the ages of seven, eleven to twelve and fifteen years for males. Right from cortical folding in neurodevelopment, physical forces play a vital role in cellular mechanisms. During developmental stages neuronal differentiation, migration, myelination and connections are among the anatomical changes that are observed in the brain (Stiles & Jernigan, 2010). One other significant anatomical change during the development of the brain is the occurrences of certain physical and functional changes that lead to configuration of the brain (Li, Legault, & Litcofsky, 2014). These changes are referred to as neuroplasticity (Li *et al*., 2014).

The stages and the processes involve in the development of the human brain have been studied from the disciplinary branch of developmental neuroscience (Schore, 2015; Chiao, 2009). Scholars explain that developmental neuroscience is a field of study that helps to examine and to explain how the brain changes, right from the period of gestation; that is foetus development, childhood, and through adulthood ((Munakata, Casey & Diamond, 2004). Kramer, Bherer, Colcombe, Dong and Greenough (2004) provide an observation that, a better understanding of these brain changes are also paired with the interrelationship of the environmental and biological influences. Developmental neuroscience has been noted as an evolving field in the investigation of the connection between neural and cognitive progressions (Munakata, Casey & Diamond, 2004). Most frequent questions asked in this field aim at finding the interrelationships that exist between developmental changes in the brain and the children's developmental behaviours (Munakata, Casey, & Diamond, 2004).

Neuroscience offers a window into the brain to discover many phenomena such as the neurobiological procedures, knowledge about the development, electrical emissions or neuronal plasticity and structures that are developed during specific periods of the brain (Egan, Bloom & Santos, 2010). It is noted that both psychological and biological information are studied to provide a holistic approach in knowledge generation in developmental neuroscience (Zeamer, Heuer & Bachevalier, 2010; Warneken & Tomasello, 2006; Johnson, Munakata & Gilmore, 2008). Scholars note that education and knowledge acquisition have an interrelationship with brain development, neurological structures and behaviours (Zeamer, Heuer & Bachevalier, 2010).

The discussion provides an insight into the developmental stages of human brain that seems relevant to this study. Various scholars associate certain changes to specific stages of human brain development. Notwithstanding, the stages and the associated brain processes that were recorded by the researchers vary from one observation to another. However, the discussions seem relevant to this study.

Musical Engagement and Stage Theories

In reflecting on stage theories and musical engagement, it is observed that scholars draw attention to various changing characteristics such as interest, attachment, value, preference and age (Hargreaves & North, 2010; Saarikallio, 2007; Hargreaves, 1986). Bonneville-Roussy, Rentfrow, Xu and Potter (2013) conducted a study to investigate the extent to which age is related to preferences in musical engagement. The study indicates that there is a decline in musical engagement to age: that is as people grow older. They also found out that musical preference can be conceptualised in relation to age.

In another study, researchers investigate the changes that are related to age which can influence the performance abilities of music learning (Reifinger Jr, 2016). The study indicates that music learning takes place at all age levels. However, it happens at slower rate with older adults.

Another study was conducted to investigate the relationship between instrumental musical activity and cognitive aging (Hanna-Pladdy & MacKay, 2011). In the study, musicians were classified into ranges of duration of their lifetime instrumental music participation. It is found that participants with higher duration of music learning performed better. The study therefore indicate that duration of music participation as in age has an impact on musical experience and better music performance (Hanna-Pladdy & MacKay, 2011).

The literature indicates that research activity focusing on musical experiences and age have been extended to include studies that involve pre-schoolers and school children in areas such as singing, aesthetic appreciation, rhythmic and melodic development, and the acquisition of harmony and tonality (Nieminen, Istók, Brattico, Tervaniemi & Huotilainen, 2011; Hargreaves, 1986).

Biehler and Snowman (1990) introduced the reader to various theorists including Erickson (1902-1994), an American developmental psychologist and a psychoanalyst, Jean Piaget (1896-1990), a Swish developmental psychologist, and also Laurence Kohlberg (1927-1987), an American psychologist and educator. These concepts focus on behavioural and cognitive stages of human development. The scholars suggest that there are some indications associated to human development in relationship to age. In this phenomenon, Piaget relates the stage at which an individual can perform a specific task to *developmental readiness*.

However, these theories could not provide clear biological theoretical classifications of brain stages. All their theories are also in the discipline of cognitive psychology. There is, therefore, the need to seek a developmental stage theory lodged in neuroscience. I am referring to brain based research theory.

Erikson, for example, also provided eight stages of equal relationships to specified age ranges. Among these eight-stage theories, some scholars observe that the fifth stage which is identity versus role confusion has been the most complex concern in Erikson's theory with which he has provided more extensive account (Beihler & Snowman, 1990). Significantly, Erikson's theory seems applicable in a perspective to establish that behaviours are of special significance to developmental stages (Hargreaves, 1988). One of the shortfalls noticed about Erikson's theory, however, was that even though he conducted investigations, most of his conclusions were personalised and subjective. As Erikson's theory is more of behavioural psychology, it may not be much suitable for brain based examinations.

Piaget's theory of cognitive development was also reviewed in this study. Piaget's theory included four stages (Biehler and Snowman, 1990). Piaget proposed that children from birth to two years should be categorised into a stage called sensorimotor; children between the ages of two to seven years fall within the category of the preoperational stage; children from seven years to eleven years were classified into the concrete operational stage while those from eleven years and older were classified into the formal operational stage. Piaget's cognitive developmental stage theory seems useful to practitioners including scholars of music educational domains. This is because the theory laminates our understanding of how students organise and synthesize ideas. Nonetheless, Piaget's cognitive-development stage theory has come under criticism.

Notwithstanding, Bainbridge, Maul and McClendon (2019) observed that Piaget's cognitive development stage theory may be feasible to some extent. McLendon looks at his approach from a classroom perspective. Firstly, McLendon looks at how significant Piaget's cognitive stage theory was developed as it was constructed on structures (eg. 0-2, 2-7, etc.). It was noted that these cognitive transitions take place in persons at about 18 months, 7 years and 11 or 12 years. This means that children become capable of acquiring knowledge in certain ways within these specific ages (stages) for which Piaget's cognitive developmental stage theory seems workable in real-life situations such as research purposes. However, the scholarly observation of inconsistency in the categorisation of the stages (cognitive developmental stages) also makes it unadoptable for this study.

Kohlberg's theory of moral reasoning also provides perspectives on stage theories of human development. Kohlberg's proposal provides a classification of six stages of moral reasoning (Beihler & Snowman). Kohlberg's moral reasoning stages have been categorised into three levels according to ages. However, as observed in the case of Piaget's theory, Kohlberg also could not provide specifically defined stages for children of certain ages. For instance, it is difficult to categorize a child of nine years into either level 1 or level 2, and so on. This theory also, has to be reviewed for future development that may enhance practices including those that are being practiced by music educators and scholars.

In summary, the phenomena discussed here were to support the investigation of a feasible theoretical framework which deals with development stage theory. In this endeavour, Kohlberg's theory of moral reasoning, Piaget's theory of cognitive development, Erickson's theory and that of Hargreaves were discussed. However, the theories provided could not offer any clear biological classification of brain stages for investigation. Notwithstanding, they were included in the materials reviewed with the intension of searching for appropriate theory to direct the current study.

Comparing Differences in Myelination and Synaptogenesis

In the discussions of the time course of human brain development, scholars have indicated various developmental processes with specifics to different ages (stages) of human brain development. Among stages of brain development are myelination and synaptogenesis (Banich & Compton, 2018). These two stages appear to be distinctive and worth investigating.

The time course of human brain development in respect to myelination stage has been identified to be between the ages of -2 months before birth to 10 years of the individual after birth, while the synaptogenesis is observed to occur between -3months to 18years (Banich & Compton, 2018). The categorisation of the two stages (myelination and synaptogenesis) is distinguished at age ten and age eleven; that is ten years and below belong to myelination while eleven years and above belong to synaptogenesis. The age difference between myelination stage and synaptogenesis is at least 8years. In this categorisation the clear cut difference between Myelination and Synaptogenesis is that children in the Myelination stage of brain development cannot be found in the Synaptogenesis. The study, therefore, was to investigate whether or not there was any significant change in the age difference between myelination stage and synaptogenesis to music.

Scholars observed that myelination is an enormously synchronized process in the involvement of leading signal in different cell types in the central nervous system (CNS) to the coating of axons by the plasma membranes of oligodendrocytes (OLs) (Blaise, Kneib, Rousseau, Gambino, Chenard, Messadeq & Rio, 2012; Bakhti, Winter, & Simons, 2011; Lee, Gravel, Zhang, Thibault & Braun, 2005;). Oligodendrocytes are said to be the myelinating cells of the central nervous system which go through multifarious timed of proliferation to produce axon sheath (Bradl & Lassmann, 2010; Chang, Tourtellotte, Rudick & Trapp, 2002). This process is noted to help in a spiral fashion to form an alternation of internodal segments; that is to wrap around axons in the brain.

The Significance of Myelination in Information Processing

Researchers observed that myelination forms a significant part of brain function and development (Fields, 2015; Wandell & Yeatman, 2013; Luciano, Gow, Harris, Hayward, Allerhand, Starr & Deary, 2009; Fields & Stevens-Graham, 2002). Two of the unique characteristics observed by scholars about myelination are that children have twice as neurons and twice as many connections and neural activity in their brains than adults (Flohr, Miller & DeBeus (2000). It is also observed that at this stage, the brain appears to be more plastic and malleable, especially during the first decade of life than in adulthood; that is when compared to synaptogenesis (from age eleven and above) (Flohr, Miller & DeBeus (2000). From a documented report by Banich & Compton (2018), researchers have provided the time course of brain development where the time course of myelination has been observed before and after the birth of an individual. Some studies use Diffusion tensor MR imaging (DTI) method for estimating myelination processes in brain development (Assaf & Pasternak, 2008; Schmithorst, Wilke, Dardzinski & Holland, 2002). Myelin sheaths are noted to restrict the diffusion of water transverse to the axons. In a study conducted to examine the progressive myelination of axons, the central white matter of the frontal lobe was observed in seven children who have an average age of ten (10) and also five adults who have an average age of twenty-seven (27). It was observed in the study that anisotropy in the frontal white matter of the children was significantly lower than that of the adults' respondents (Ashtari Cervellione, Cottone, Ardekani and Kumra, 2009; Choi, Jeong, Rohan, Polcari & Teicher, 2009). The scholars therefore note that there is less myelination in children as compared to adults.

However, this observation is actually in contrast to the study of Casey et al. (2005). Casey et al. provided a framework on the time course of human brain development and provided a developmental outline where myelination was significantly higher in children other than adults. Banich and Compton (2018) also gave an account of this observation which was developed by Casey et al (2005). Klingberg (2006) conducted a study to confirm that myelination becomes the basis for the steady development of prefrontal functions such as increased working memory capacity due to its maturation progressions in the time course of the developing brain. Hooper, Luciana, Conklin and Yarger (2004) have also confirmed this observation. Researchers have also observed that myelin sheaths are also significant in higher synaptic processing (Gomez, et al, 2017; Kreshuk, Koethe, Pax, Bock & Hamprecht, 2014). Myelination is therefore very significant in brain development, information processing and human experience.

It could be summarised that, myelination stage of human brain development seems very vital to information processing. One of the very important characteristic that was reported about this stage of human brain development is that it is a stage where myelin sheaths which are responsible for strong synaptic processing are developed. I am interested in investigating measurable brain activity that are associated with the myelination and its capacity to response to music. The study therefore aimed at investigating whether or not there is any significant difference in brain activity between Myelination and Synaptogenesis to music stimuli.

The Significance of Synaptogenesis in Information Processing

In an attempt to specifically focus on the significance of Synaptogenesis in information processing in the brain, researchers have examined learning processes within a physiologically defined medium. Kleim, Barbay, Cooper, Hogg, Reidel, Remple and Nudo (2002) conducted a study to examine the motor cortices in the information processing. In their method, a motor activity task was conducted among rats. The results provided strong evidence that synapse formation supports learning-dependent changes in cortical function. Derksen, Ward, Hartle and Ivanc (2007) have also conducted another study on a similar phenomenon to confirm the verity of the significance of synaptogenesis in brain development and function.

In a brief, it was noted that synaptogenesis is a very significant developmental process for information processing. At this stage, all characteristics about human brain responses and behaviours depend on the extent to which synaptic pruning had taken place in the individual. Synaptogenesis is also observed as a critical stage of human brain development. I am therefore interested in investigating measurable brain activity that are associated to Synaptogenesis and its brain response to music. The study therefore, also aimed at investigating whether or not there is any significant difference in brain response between synaptogenesis and myelination stages of brain development.

Passive Listening Verse Active Listening

Scholars present extensive dialogue on the extent to which the human brain can response to music within the medium of passive and active engagements (Boyd & Ellison, 2007; Jenkins, 2004; Kuhl, Tsao & Liu 2003). Neuroscientists noted that passive and active music engagements differ significantly in specific parts of the brain (Koelsch, 2014; Solé-Padullés *et al.*, 2009; Brown, Martinez & Parsons, 2004).

A study was conducted to investigate differences in brain response between active and passive musical engagement. The study demonstrated that the frontal cortex and superior temporal sulcus are activated when an individual participating in active music engagement (Brown, Martinez & Parsons, 2004). Other studies (Yinger & Gooding, 2014; Caldwel & Hibbert, 002) observed that active music participation engages more parts of the human brain than passive music participation.

Scrine and McFerran (2018) observed that even though one may not be paying attention to a particular sound of music, the ears, however, do constant signals to the brain as long as a person is exposed to the music or sound. This is seen as an automatic behaviour between the ears and the brain. Scholars refer to this listening behaviour as passive listening (Brunetti, Belardinelli, Caulo, Del Gratta, Della, Penna, Ferretti & Torquati, 2005; Lahav, Boulanger, Schlaug & Saltzman, 2005; Bunzeck, Wuestenberg, Lutz, Heinze & Jaencke, 2005). It is observed that these response behaviours also happen with background music.

Burstein (2009) refers to active listening as when there is a focused behaviour during a listening activity. In this endeavour, the individual pays attention to the sound being presented. Scholars have observed that active listening is a key in internalizing sound, such as the sound which the individual perceives for music (Miranda, 2014). Some scholars have noted that active music listening also makes a good musician, a way of developing better musical experience (Pitts, 2016; Goto, Yoshii, Fujihara, Mauch & Nakano, 2011).

From the review of literature on active and passive music engagement, it is noted that active listening might be a better-preferred behaviour for musical experience and support for a more effective observation of brain response to music. It is noted that the kind of listening behaviour that is adopted during an investigation might have a significant impact on the observable insight. When investigating brain response to music listening, it is therefore important to establish which of the two mediums that might produce an effective result for observation; that is active listening or passive listening. This is where the juxtaposing of passive listening and active listening were specifically relevant for review in this study.

Scientific and Technological Approaches to Neuroscience of Music

Current trends of neuroscientific studies are becoming more easily researchable through high scientific practices and technology. Also, a better understanding of the neurological processes of stimuli in the brain has been noted to be more effective through scientific research mediums such as experimental neuroscience, cognitive neuroscience, clinical neuroscience, neurophysiology, neuropsychology, among others (Miniussi, Harris &

Ruzzoli, 2013; Panksepp, 2004). The review of literature has also indicated that the neuroscience of music and cognitive musicology are becoming an integral branch of neurological based research in music education (Gilstrap, 2015; Radocy & Boyle, 2012; Hodges, 2010; Edward, 2008). Some scholars note that neuroscience of music and cognitive musicology are research fields that rely on direct observations of the brain by using techniques including functional magnetic resonance imaging (fMRI), transcranial magnetic stimulation (TMS), magnetoencephalography (MEG), electroencephalography (EEG), and positron emission tomography (PET) (Brattico, Tervaniemi, Naatanen, & Peretz, 2006). Predominantly, most of these techniques used in the investigations are non-invasive, and that their approaches are recommended on the bases of ethical issues (Bergmann, Karabanov, Hartwigsen, Thielscher & Siebne, 2016; Pascual-Leone, Fregni, Steven-Wheeler & Forrow, 2011). Senior, Lee and Butler (2011) explain cognitive neuroscience as a way of understanding neurological processes from the perspective of the relationship that exists between the brain and the mind. In this perspective, they view neurology as a way of information processing to solve problems. From the perspective of experimental neurology, neuroscientific knowledge is perceived from the medium of comparing people with neurological problems with a normal subject where different neurological functions are divided into categories for investigations (Minshew, Sweeney, Bauman, Webb, Volkmar & Paul, 2005; Panksepp, 2004).

Researchers proposed that a holistic approach to knowledge acquisition of neurological insights is to investigate the relationship that exists between studies in brain and mind and to connect the established knowledge that exists between the two great fields (Siegel, 2020; Banich & Campton, 2018; Tommerdahl, 2010). The interconnection of research fields such as neurology, cognitive psychology and neuropsychology encourage interdisciplinary and multidisciplinary approaches in researches (Burgess et al., 2006; Ochsner & Lieberman, 2001). The scholars believe that knowledge about the interrelationships and the connections that exist illuminate our understanding of neurological phenomena (Haward-Jones, 2010; Du Plessis, 2005).

From the discussion it is noted that current trends in brain based investigations are becoming more easily researchable through high scientific practices and technology. A better understanding of the neurological processes involving a stimulus is engendered through scientific research mediums such as experimental neuroscience. It is also noted that various researchable fields that can interconnect, such as neuroscience, music, education and cognition can be explored as interdisciplinary and multidisciplinary fields of studies.

Ethical Issues on Neuroscientific Research

The study also reflects on ethical issues relating to neuroscientific research. The literature informed that ethical matters relating to research in neuroscience are termed neuroethics. International Neuroethics Society defines neuroethics as a field that studies the implications of neuroscience for human self-understanding, ethics, and policy (Racine, 2014; Shook, Galvagni & Giordano, 2014; Illes, 2006a). Neuroethics refers to two related fields of study: the ethics of neuroscience, and the neuroscience of ethics (Roskies, 2002). 'Bioethics' was also developed from neurotics. Bioethics is the biological perspectives of neuroethics (Farah, 2010). Farah distinguished the nomenclature due to philosophical discernment of neuroethics which include the nature of the free will, moral responsibility and personal identity (Farah, 2010).

The expanding brain research in recent years has also added to the concerns about neurotic.. In the current trends of neuroethics, there has been a significant increase in the development neuroscientific research instruments such as Electroencephalogram (EEG), Magnetic Resonance Imaging (MRI) and functional Magnetic Resonance Imaging (fMRI) (Woods, 2007). The safety of the respondents as well as the authenticity of data produced is of high priority to neurotics and bioethics (Vincent, 2011; Fox, Zhang, Snyder & Raichle, 2009; Kainz, 2007). In the interpretations of results, the notions of free will, responsibility, personhood and the exposure of self are properly addressed with respondents (Cohen, Goldman, & Jerome, 2001).

Furthermore, neuroscience raises ethical, social and legal issues concerning the human person and the brain (International Electrotechnical Commission, 2002a IEC, 2002b). In this regard, potential benefits are carefully weighed against the potential harm of respondents and patients.

Research scholars have investigated brain processes relating to experiences and concepts such as free will, agency, moral judgment, self and personality (Baumeister & Monroe, 2014; Gallagher, 2006). At the same time, those processes become progressively more accessible for modifying the techniques.

Some of the frequently asked questions include: what maybe some of the social and cultural consequences of technologies that enable humans to manipulate their minds? What impact will neuroscience have on our self-understanding and our concept of humanness in general? Are we facing an age of a 'technology of consciousnesses (IEC, 2005)? Given these questions, intensive dialogue between neuroscience and the humanities has become more important. Among other historical reports on the growth of this discipline, is the philosophy of neuroscience. In this regard, concerns have expanded from general features of scientific practise to concepts (Bickle, Mandik & Landreth, 2012). Reports indicate that the ethical issues raised by neuroscience have proven to be twofold. On one hand, there are rapid increase of new methods and techniques. On the other hand, the results of neuroscience tend to support reductionist concepts of free will, autonomy and the self-awareness (Fuch, 2006; Peretz & Zatorre, 2003).

Since this study dealt with respondents who are children, it also looked at some scholarly concerns about neuroscience research with children (Coch, 2007). Children constitute a special and vulnerable population in the involvement of neuroscientific investigation (Coach, 2007). Research scholars are raising new ethical questions which seem relevant to ethical issues (Ackerman, 2001; Illes, 2006a; Gazzaniga, 2005). It reported that to date, very little of the discussion concerning ethical issues in the neurosciences has centred on questions related to the involvement of children (Editorial, 2003).

As the result of the advancement of neuroscientific research endeavours, various brain-based technologies have been made available and amenable to be used with children, and among them, electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) have been quite popular (Casey & de Haan, 2002). Some researchers have adapted this technology for use with children as a way of making tasks easier, shorter, age-appropriate and more engaging. They acclimate participants to the unfamiliar research environment before collecting data (Coch, 2007). Approaching these types of developmental studies as an opportunity for children to learn about their brains also helps to address issues about the benefits of participants (Coch, 2007).

Other practical issues of ethical concern are about incidental findings. In this regard, researchers are advised to involve skilled clinicians in some special studies who will take responsibility for identification and clarification of incidental findings (Grossman & Bernat, 2004).

The review on neuroethics and bioethics explore issues on the levels of practical bases as well as conceptual ethics. I agree with scholars on this phenomenon that ethical concerns of neuroscience-based studies are importance. Also, neurotics are vital in every research endeavour, especially when the respondents are humans. Neurotics and bioethics pay special attention to children's safety about their engagements. It is important, therefore, to ensure that children's safety is guaranteed to a very high extent about their engagement. There is the need to place neurotics at the forefront, without which its practices may be unethical. The arising phenomenon of technological development and the use of modern complex instruments in neuroscience also vehemently reinforce the need for ethical clearance before conducting research. In all, the researcher might bear in mind that the health of their respondents is rather the most important issue.

A Comprehensive Summary of the Review of Literature

Generally, the review of literature provides an overview of the current trends in neuroscientific studies. The arising phenomena provide broadminded knowledge from which new approaches could be drawn. The review also support in exposing the existing gap as well as appropriate methodology that might be suitable for the current study.

Furthermore, the review of the related literature on neuroscience and music education has supported the investigation of this study. The phenomenon discussed also shared an interest in the interdisciplinary need of the neuroscience of music research in regard to the conduction of this study. The literature inform that there is a significant growth in the practice of neuroscientific research, and specifically, the neuroscience of music in the Western world for which scholars in our part of the world, Africa, for that matter Ghana, might need to embrace.

Also, counter arguments were raised about the relevance of other cognitive and behavioural stage theories to the development of this study. The review of developmental stage theories informed the decision for selecting a feasible theoretical framework for this study. Even though Phrenoblysis hypothesis, Piaget's cognitive developmental stage theory and other developmental theories were projected, the consistency of their claims was not clear for adaptation for this study.

In the review of literature on children's music cognition, the studies therefore show that when children are engaged in active music participation, their cognitive processes are being enhanced. Also, in the discussion of children's participation in music and affective musical experience, the observations imply that music participation and music learning does a great service to children's development, and that one of the most relevant aspect of affective enhancement for musical engagement is character building.

Dialogues about music participation and psychomotor development among children were also discussed. Studies about this phenomenon indicate that stages of cognitive development play key role in the learning experiences of music, which music educators might need to pay serious attention to.

In the discussion of music perception among children, the studies suggest that the perceptual abilities of musical experience are closely linked to other human perception that may not be separable. It is also observed that musical perception elicit and modulate emotions. It was also noted that it is possible to learn related knowledge from both cognitive and neural processes through music and language alike. Also, in the discussion of children's musical memory, the research scholars noted that the memories and pathways for music are not quite separated from that of other sounds and that musical memory is so strong that it is able to save childhood constructed knowledge for use in older years of life. Knowledge about musical memory therefore seems important for musical participation and its associated musical experiences.

It is noted that music participation and learning has a significant impact on children development. This suggests that children's musical engagement and learning should be encouraged in schools. Early music learning has also been found to have a long term effect on children's musical experience. The scholars also noted that it is through music education that the phenomena about music learning, relating to both children and adults are discussed. It is also noted that music teachers, unlike other music specialists and scholars such as composers and ethnomusicologists need special music training that can prepare them to be better music educators. In this regard, discussions about music education in Ghana were also presented. It is noted that there is a missing link between the status of music education in Ghana and nature of Ghanaian music. The inconsistency between curriculum planners and the music teachers were also noted. Also, the employment of information and communication technology as well as the place for traditional Ghanaian music in the school curriculum has been misplaced. These are some of the problems highlighted by scholars which have affected children's music education in Ghana.

In the matters arising from the pedagogical approaches to music learning in Ghana, scholars noted one of the major problems is the lack of professional teachers for the implementation of the music curriculum for the primary schools. It is believed that when music teachers acquire quality training, they will be adequately prepared for quality music teaching. Knowledge on the neuroscience of music could also be a vital part of the music-teacher training programmes.

The review of literature for this study also looked at information processing in the human brain. In brief, it is noted that the sensory organs, the white matter and the ventricular system play very important role in information processing. Short term memory and long term memory also play unique roles in information processing. These dialogues also seem to be important to researchers and scholars studying about the brain in their various fields of disciplines. Furthermore, dialogues on music processing in the brain were also reviewed specifically. This review suggests that the engagement in the studies of music and neural correlates will enable music educators to become broadminded about the relationship between brain processes and music. In addition, it is worthwhile to engage in research that will illuminate our understanding of neural pathways involved in human engagements with music.

The neuronal organisation of synapses and synaptic responses in the brain depends on the interconnections of neurons by which signals are generated in thousands and millions. Since presynaptic neurons are responsible for receiving incoming stimuli, they seem to be important in stimuli application and brain response. Insight into the presynaptic and postsynaptic neurons responses therefore seem worthy of exploring in the study of brain response to music. These were some of the discussions presented under the phenomenon of synapses and synaptic responses in the human brain. It was also discussed that since scholars observe that humans' psychological processes of communications go through motor and muscular activity in the nervous system it could it was concluded that both cognition and neurology cannot be completely separated. In this discussion, it is noted that neurons are the key subjects in brain behaviours and functions, and that they play roles in every affair of brain function. The observation of neuronal behaviours in this study therefore seems very vital.

Processes in the developmental stages of the human brain were another important dialogue that was reviewed in the study. The studies related to this phenomenon indicate neuroscience offers a window into the brain for many discoveries. These include knowledge the neurobiological procedures, electrical emissions or neuronal plasticity as well as structures that are developed during specific periods of the brain. In this discussion, various scholars associate certain changes to specific stages of human brain development. However, the stages and the associated brain processes that were recorded by the researchers vary from one observation to another. Notwithstanding, they were included in the materials reviewed with the intension of searching for appropriate theory to direct the current study.

In further discussions, a dialogue was presented on the comparison of neural processes between two brain stages-myelination and synaptogenesis. Myelination stage of human brain development seems very vital to information processing. One of the very important characteristic that was reported about this stage (myelination) was about the significant function of myelin sheaths which are developed. The myelin sheaths are responsible for strong synaptic processing. For which this current study is focused on investigating measurable brain activity that are associated with the myelination and its capacity to response to music.

For synaptogenesis, it is noted that all information processes in the human brain depends on the synapses and synaptic pruning which are spontaneously developed at synaptogenesis. The relevance of literature review on synaptogenesis is to address its nature which can support in investigating measurable brain activity and to investigate whether or not there are any differences between synaptogenesis and myelination in brain response to music.

A discussion was also presented on passive music participation and active music participation. From the review, it is noted that active listening might be a better-preferred behaviour for musical experience. It is noted that the kind of listening behaviour that is adopted during an investigation might have a significant impact on the observable insight. When investigating brain

CHAPTER THREE

METHODOLOGY

Introduction

Chapter three presents the methods adopted for the collection and analysis of data. It addresses the research approaches such as research design, statistical design, research instrument, sampling and sampling techniques, data setup and computation. The chapter also describes how the analyses of the data were conducted. Research scholars have noted that inaccurate data collection procedures can impact the results of a study and lead to spurious results. For this reason, the data collected for the study was carefully managed to be clean and accurate for analyses.

Research Paradigm

The research paradigm adopted for this study was quantitative. A quantitative method is a type of research method that focuses on the objective measurement of statistical, mathematical or numerical data statistically, mathematically, or numerically (Babbie, 2010). A quantitative research method focuses on gathering numerical data which can be generalised across groups of people (Muijs, 2010). It was adopted as the research tool for this study because the data collected for the study were numerical measurements captured from brain (Llinas, 2014). During recording, the computer stores data in the form of brain waves. These waves can be categorised into beta, alpha, theta and delta (Fell, 2011; Fries, 2005; Schnitzler, 2005; Gaser & Schlaug, 2003).

Research Design

In the process of selecting a suitable research design for the study, available research designs were critically evaluated. The research designs reviewed were randomised experimental design, quasi-experimental design, natural experimental design and nonexperimental design. I evaluated these designs because Cook, Campbell and Shadish (2002) note that these are the modern designs for experimental research.

Experimental Designs

An experimental design facilitates the generation and analysis of supporting, refuting, or validating a hypothesis (Squire, *et al.*, 2008). Scholars have explained that experiments provide insight into what outcome occurs or could respond to when a particular factor is manipulated or a stimulus is applied (Squire, Berg, Bloom, du Lac, Ghosh, and Spitzer, 2008).

Cook, Campbell and Campbell (2002) also discussed experimental research design as a test under controlled condition that is made to demonstrate a known truth and that it examines the validity of a hypothesis to determine the efficacy of something untried (Cook, Campbell & Shadish, 2002).

Randomised experimental, also referred to as true experimental design was one of the experimental designs reviewed in this study. Scholars explained randomised experimental design as a research design that goes through a process of randomly selecting subjects to treatments (Everitt and Skrondal, 2010: Cox, 2015).

However, from the review I noted that randomised experimental design did not provide a suitable condition for adoption. The lack of compatibility stems from the fact that my study did not involve respondents randomised into treatment groups. The randomised experimental design was, therefore, not appropriate for adoption for my study.

Also, I looked at the characteristics of the natural experimental design. A natural experiment was described as an empirical study in which individual or units are assigned to experiment and control condition that are determined by nature or factors outside the control of the investigator (DiNardo & Lee, 2011). For example, in a study, a natural experimental design was adopted to determine whether the brain activity of a human subject in response to a stimulus is characteristic of a state of interest, such as a deceptive state or a truthful state (Shastri, Nelson, Bohning, George & Kozel, 2011).

Other scholars view this design as a potentially manipulable (Shadish, Cook and Campbell, 2002). However, the nature of the natural experiment and its design also obviously seems not suitable enough for adaptation as the research design for my study.

For nonexperimental design, it is believed to have a process of measuring presumed cause and effect, but without random assignment. Anderson and Bushman (2001) characterized it for a hypothesis dealing with single variables rather than a statistical relationship between two variable and that it is suitable for non-causal statistical relationships (Fabrigar and Wegener, 2014; Johnson, 2001; Wegener and Fabrigar, 2000). Since nonexperimental design deals with only a single variable, it was also observed as not suitable for this study.

Finally, I reviewed literature on ex post facto design. Ex post facto design is a quasi-experimental study that examines an independent variable that is present prior to the study in the respondents (Leutwyler & Meierhans, 2016; Williams-Brown, 2016; Campbell & Stanley, 2015; Montero & León, 2007). The term quasi means 'resembling' or looking like (Price, Jhangiani & Chiang, 2015) A quasi-experimental study simply means participants are not randomly assigned to treatments (Gefen, 2002; Shadish, Cook & Campbell, 2002). For example, in an experimental research where the respondents are randomly sampled into control and experimental groups and assigned to specific tasks (treatments), quasi-experimental design (ex post facto) cannot be adopted. Scholars have noted that the ex post facto design is one of the suitable designs for experimental research (Campbell & Stanley, 2015; Gersten, Fuchs, Compton, Coyne, Greenwood & Innocenti, 2005). A quasi-experimental design was noted to have been popularised by Don Campbell and Stanley Morgan in the 1960s and was referred to as 'queasy' experimental (Trochim, Jorgenson, Prakash & Kane, 2016). Observably, quasi-experimental appeared to be suitable for studies with non-randomised experimental design characteristics.

For example, in a study conducted by Flohr and Miller (1995), the researchers investigate differences in brain response among three conditions of psychomotor response to music, using a 21 electrodes EEG for the data recording. The conditions were two minutes of sitting quietly, one minute engagement in tapping to the rhythm of an excerpt of classical music. The third condition was one minute engagement in tapping to an Irish folk song. For every condition, 30 seconds of artifact-free data was edited for each respondent.

After the pre-processing of the data, one-way ANOVA was performed for data engendered from each of the electrodes. The results show that there were significant differences among the three conditions. This was one of the examples of the experimental research that was studies in the process of developing the experimental design for the current study.

In the review I noted that ex post facto design was the suitable design for this study. As already noted, the ex post facto experimental design does not involve random assignment; and since my study does not involve random assignment of respondents into treatments groups I adopted it as the design that guides the conduct of my study.

For example, I worked with two populations (Primary School and Junior High School). In each population, I conducted a simple random sampling to select participants for the study. There was therefore no involvement of random assignment.

Data Collection Procedures

Research proposal development and defence precedes the main data collection. The study was initiated after an approval to undertake the study was received from the Institutional Review Board of the University of Cape Coast (UCCIRB). A positive response was also received from the management of the participating school.

One of the conditions carefully observed was the vulnerability of the respondents. Since the respondents were minors (basic school children), a comprehensive ethical procedure was paramount. Many protocols were therefore observed at this stage of the data collection process. A lot of time was spent on the scheduling of period for data collection.

The basic school from which the respondents were sampled consisted of the Primary School and the Junior High School (JHS). Since the JHS children were older than the primary school children, the data collection process started with the Junior High School respondents. This procedure was employed to help me develop my research skills in the interaction with the older children before meeting the more vulnerable ones in the primary school.

Data collection procedures for this study were in two categories; primary data collection procedures and secondary data collection procedures. Primary data collection is defined as a category of data collection process of gathering data directly from sources other than collecting data from an already done research (Polkinghorne, 2005). In this case, I had a proposed population which served as the field (University of Cape Coast Basic School) where the primary data collection was done (with the various proposed instrument). Primary data is also understood as data that has been collected from first-hand-experience and which has not yet been published (Kimball, Ross, Thornthwaite, Mundy & Becker, 2008). It is believed to be more authentic and reliable.

Secondary data are data from extant literature; they are data from a source that has already been published. In the process of accessing these data, there is no specific method because the data is just ready for access (Calantone & Vickery, 2010). Secondary data may be obtained from sources such as books, newspapers, biographies, data achieves, internet articles, database, among others (Kabir, 2016). In this study, therefore, the use of secondary data was reviewed to guide the study as well as to illuminate our understanding of the results.

In this study, data was collected on brain activity to stimuli responses. The focus of the study was to examine data emerging from brain activity stimulated by music. The initial data generated in the form of EEG waves was mined and processed in comma-separated values (CVS) format. The CSV data were converted into SPSS data format for analysis.

A pilot test was also conducted before the final data collection. A pilot test has been defined as an initial investigation purposed to assess feasibility, time, and cost, among others to improve upon the study design preceding the conduct of a complete investigation (Kesler, Sheau, Koovakkattu & Reiss, 2011). The pilot test was meant to support the verification of results which were computed and analysed from the data results. In this study, the purpose of ex post facto design was to examine differences in brain response to music stimuli and non-music stimuli. The first involvement was to record data of brain activity when the respondents were engaged in non-music listening activity after which the respondents were exposed to the music stimulus.

Data Analysis Procedure

In the analyses of data, four hypotheses were developed, investigated and tested. The data analyses were computed using SPSS (SPSS version 20.0). In the various analyses, independent T-Test, dependent paired-sampled T-Test, repeated measures ANOVA and a 2 x 4 factorial ANOVA were conducted.

In hypothesis one, data test and analyses was conducted to investigate whether or not there is any statistical significant difference in brain response between music and non music stimuli. In the testing of hypothesis one a student t-test was conducted.

Data tests and analyses were conducted for hypothesis two to investigate whether or not there are any significant differences in brain response to music in the brain stages of Myelination and Synaptogenesis. In this endeavour an independent T-Test was conducted.

In hypothesis three, data tests and analyses were conducted to examine the extent to which brain activity vary in the four brain lobes of the brain when the respondents listen to music. In this endeavour, a repeated measures ANOVA test was conducted.

Data tests and analyses were conducted for hypothesis four to examine whether or not brain responses vary in the four brain lobes of the brain at two selected stages of brain development-myelination and synaptogenesis when the respondents listen to music. In this endeavour, a mixed repeated measures ANOVA test was conducted.

Mixed Factorial ANOVA Design for Hypothesis Four

A 2 x 4 mixed factorial ANOVA design was adopted for data computation and analyses to test hypothesis four. A mixed repeated measure ANOVA is a factorial ANOVA design to compare the mean differences between groups that have been split into two factors (also known as independent variables), where one factor is a within-subjects factor whiles the other factor is a between-subjects factor (Kinnear & Gray, 2006; Olejnik & Algina, 2003). Glenberg and Andrzejewski (2008) further explain factorial design as a statistical design that examines variables of two or more factors from a population and is designed to ask a series of questions. It is an expanded development in statistical research of one factor ANOVA, which is also an advance over a T-Test. It is therefore clear that mixed factorial ANOVA for repeated measures ANOVA is more robust for the testing of hypothesis four. This is because hypothesis four (4) has one between subject factor of brain stages (myelination and synaptogenesis) and a within-subjects factor (brain lobes). Statistician propose that once there are two or more factors with each factor having at least two levels, it is advisable to employ factorial ANOVA for data computation and analysis (Glenberg and Andrzejewski, 2008) In the current study therefore, assumptions about factorial ANOVA were met with the involvement of two factors- brain lobes and brain stages. With these characteristics, a 2 X 4 mixed repeated measure ANOVA was adopted for analysis and hypothesis testing for hypothesis four.

Table 1.1

2 x 4 Factorial ANOVA Design

	Brain Lobes				
Brain Stages	L_1	L_2	L_3	L_4	
B_1	B_1L_1	B_1L_2	B_1L_3	B_1L_4	$\mu =$
B_2	B_2L_1	B_2L_2	B_2L_3	B_2L_4	$\mu =$
	$\mu =$	$\mu =$	$\mu =$	$\mu =$	

Table 1.1 displays the two-way mixed factorial ANOVA that was adopted for the study where:

L_1 = Frontal lobe

L_2 = Parietal lobe

L_3 = Temporal lobe

L_4 = Occipital lobe

B_1 = Myelination stage of brain development

B_2 = Synaptogenesis stage of brain development.

In the development of the two-way mixed factorial ANOVA, the brain stages and the brain lobes columns serve as the factors. Under the brain lobes factor are four levels while there are two levels under the factor of brain stages. The levels therefore generate the statistical treatments at every intersection column of the two factors in the factorial design.

Quantitative Model Adopted in the Study

Sovacool (2014) observed that methods that are mostly used in the disciplines of social science remain underutilised due to lack of sufficient and appropriate approaches of examinations. Some other scholars propose that a good research is supposed to follow a systematic and well structured scientific model (Jensen, Goggins, Fahy, Grealis, Vadovics, Genus & Rau, 218; Bennett *et al*, 2017; McKechnie & Pettigrew, 2002). Therefore, in my study, I discussed my quantitative approach model that was employed in the study.

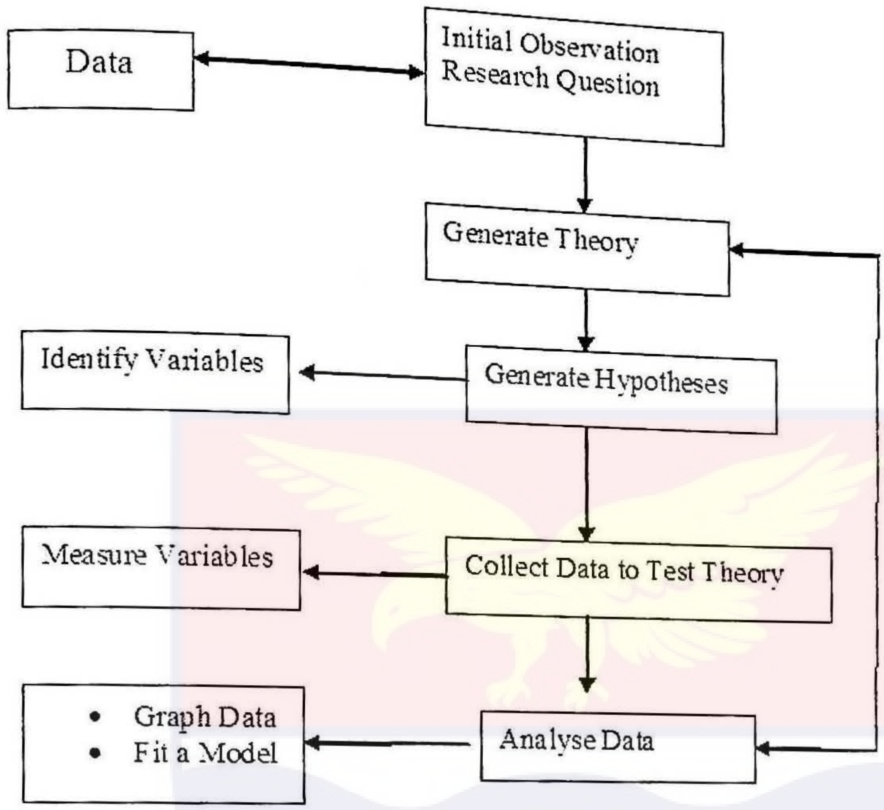

Figure 1.3: Field's Model for conducting quantitative research (Field, 2009)

Quantitative method of research is noted to be a robust method that can support quality research in social science disciplines (Sovacool, Axsen & Sorrell, 2018; Zainal, 2007; Amaratunga, Baldry, Sarshar, & Newton, 2002). I therefore adopted a quantitative model for investigation in this study. Field (2009) provides a model that can support a comprehensive approach in quantitative research (Figure 1.3). Field's model was therefore adopted for this study.

From the author's point of view, Field (2009) notes that the kind of data to be collected is the first most important aspect of research. This is because the nature of data to be collected informs the development of the theoretical framework of the study. In this, I noted that my data would need a brain base theoretical framework to guide the investigation. For this reason, I adopted Casey *et al.* (2005) human brain developmental stage framework.

Identification of variables was another important aspect in the model of quantitative research approach. Statisticians define variable as any characteristic or distinction that can be measured in an investigation. Variable is also defined as an observed value that changes in data units in a population over time (Willenborg & De Waal, 2012; Mitnitski, Mogilner & Rockwood). The identification of variables has prompted the development of the hypotheses for this study.

As suggested by Field (2009) model, I measured the variables that were generated from the data collected. The measurement of variables in this study was enhanced by data computation and analyses. The measurement of variables also enhanced the hypotheses testing.

Andy Field's quantitative model suggested that any variable intended to be measured should be derived from the collected data which would then be used to test the proposed theory. This procedure was therefore adopted in this study. In this regard, I identified the variables from the data as the dependent variables while the pre-existing variables in the participants are independent variable

Procedures for Hypotheses Testing

There are two types of hypothesis. They are null and alternative hypotheses. The difference between the null hypothesis and the alternative hypothesis is that null hypothesis establishes a position that there is no relationship between two phenomena while the alternative hypothesis takes a position that there is a relationship (Banerjee, Chitnis, Jadhav, Bhawalkar & Chaudhury, 2009). The alternative hypothesis was developed to examine difference in brain activity with respect to music listening behaviour and non-music listening behaviour. In the development of alternative hypotheses, non-directional hypotheses were adopted because, positive or negative test statistic may result from the analysis of the data. The hypotheses of this study are presented in Chapter One.

Research Tools

The major data collection tools employed in this study were EmotivEPOC+, electroencephalogram (EmotivPRO), Sample Size Determination Table, Sampling calculator and Audio player.

How EEG was used in Data Collection in this Study

An electroencephalogram was employed as a suitable and a key instrument for data collection. EmotivEPOC+ is a modernised and portable type of electroencephalogram (EEG) for data collection of brain responses. Researchers identified EmotivEPOC+ as a non invasive Brain Computer Interface (BCI) (Stach, Browarska & Kawala-Janik, 2018; Niedermeyer, 2004).

EEG measures voltage fluctuations produced from ionic current within the neurons of the brain. In clinical and non-clinical contexts, EEG refers to the recording of the brain's spontaneous electrical activity over some time as recorded from multiple electrodes placed on the scalp (Niedermeyer, 2004). In this study, the electrodes of EmotivEPOC+ were placed on the scalp of the respondents. The wireless device was connected to a computer through a flash drive before data collection.

EmotivPRO software was installed on a computer to transform the electrical activity generated in the brain into waves and stored in the computer. The data were later mined into CSV files for data set up and computing.

The Reliability of the EmotivEPOC+ Instrument

Since EmotivEPOC+ was the major data collection instrument, it was necessary to discuss its reliability that justifies its adoption for data collection in this study. Scholars explain that reliability is the total consistency of measurement for an observation (Varni, Burwinkle, Seid & Skarr, 2003). In a measurement process, a significant reliability is said to be observed when similar results occur under the condition of continuous occurrences (Kaljurand, Kütt, Sooväli, Rodima, Mäemets, Leito & Koppel, 2005).

Allen, Coan, and Nazarian (2004) reported that the reliability coefficient for EEG is 0.9 ($r > 0.9$). The literature reports that the reliability coefficient for EmotivEPOC+ is r =.82 (Thatcher, 2010; Corsi-Cabrera, Galindo-Vilchis, Del-Río-Portilla, Arce & Ramos-Loyo, 2007), suggesting a high reliability.

Wave Signals Recording with Electrodes

In EEG recording process, the electrodes receive the activity from neurons (Aurlien, Gjerde, Aarseth, Eldøen, Karlsen, Skeidsvoll & Gilhus, 2004). These neurons generate two hundred and fifty six samples per second of synaptic potentials (256 SPS) (Ito, Masuda, Shinomiya, Endo & Ito, 2013; Trappenberg, 2009) and this knowledge has inform the management of data samples that was used for the data set up and computation. Initially, the EEG data collected were in the form of waves-alpha, beta, delta, and theta. Research scholars inform that these waves are measured in frequency hertz (Hz or cycles/sec) and amplitude (Britton, Frey, Hopp, Korb, Koubeissi, FANA, Lievens, Pestana-Knight & St. Louis, 2016). Therefore, after collecting the initial data in the form of waves, the performance of data mining to transform the waves into comma separated values (CSV) which served as continuous for the purpose of the SPSS data setup and computation was necessary.

Population

In the study, I used University of Cape Coast Basic School children as my population. The school has a total population of two thousand, one hundred and twenty pupils. The primary school had a total population of 1435 pupils as at the time of this investigation. The population consisted of six hundred and ninety-five (695) boys and seven hundred and forty (740) girls. The Junior High School has a total population of six hundred and eighty-five (685) as at the time of this investigation. This consisted of three hundred and twenty-six (326) boys and three hundred and fifty-nine (359) girls.

Table 1. 2

Frequency Distribution Table for the Population

Primary	Frequency	Percent	Valid Percent
Primary School	1435	67.7	67.7
Junior High School	685	32.3	32.3
Total	2120	100.0	100.0

Table 1.2 displays a frequency distribution of the population adopted for the study. The primary school was adopted as the population that represents the myelination stage of brain response while the J.H.S represents the synaptogenesis stage.

Table 1.3

Frequency Distribution of Gender of the Primary School Pupils

	Frequency	Per cent	Valid Percent
Boys	696	32.8	48.5
Girls	739	34.8	51.5
Total	1435	67.7	100.0

Table 1.3 shows a frequency distribution for the total population for the primary school

Table 1.4

The Frequency Distribution of Gender of the JHS Population

	Frequency	Per cent	Valid Percent
Boys	326	15.4	47.6
Girls	359	16.9	52.4
Total	685	32.3	100.0

Table 1.4 shows a frequency distribution for the total population of the JHS.

Sampling Technique

This study adopted a multifaceted sampling technique for participant selection. This includes simple random sampling and stratified sampling techniques. I adopted this sampling technique to study the population in the University of Cape Coast (UCC) Basic School. The design for a stratified sampling is demonstrated in Table 1.4

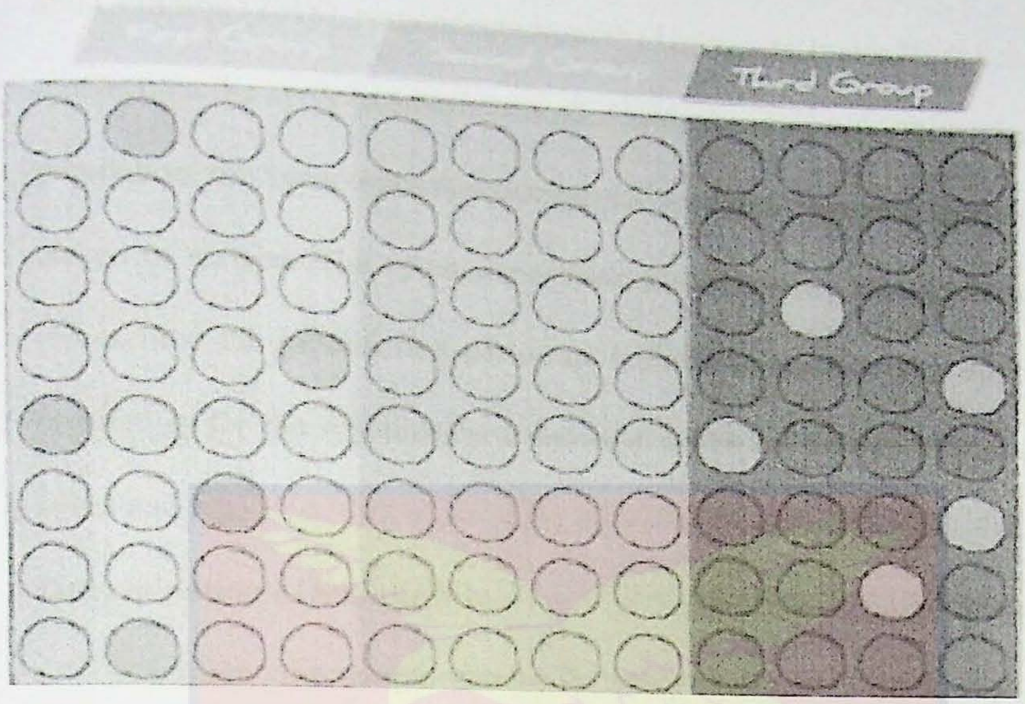

Figure 1.4: Distribution table of a stratified sampling

After the random selection was done to select classes through stratified sampling, random sampling was done in the selected classes to obtain the respondents for the study. In the University of Cape Coast Junior High School (JHS), for example, there were three main strata from which the respondents were selected using the random sample strategy. These were the three main year groups (JHS 1, JHS 2 and JHS 3) of the JHS education system in the school. Also, for the upper primary classes in the University Basic School there were three strata (primary 4, 5 and 6 classes).

The strata adopted during the sampling procedures were the categorisation of all students into the three-year groups (JHS1, JHS2 and JHS3). After this stratified sampling, simple random sampling was then conducted to select participants from each stratum. In all a total of 50 respondents from the Junior High School and also 50 respondents from the Primary school were involved in the study. Consistent with the brain developmental stage theory espoused by Casey *et al.* (2005) and Banich and Compton (2018), respondents from the University Junior High School represented the synaptogenesis period of brain development. The sampled population for synaptogenesis consists of children between the ages of eleven to sixteen. The respondents from the University Primary School represented the myelination period of brain development. The sampled population for the myelination consists of children between the ages of seven and ten.

Determination of Sample Size

Initially, the sample size for the study was determined through the application of the 'sample size calculator', and information obtained from the literature. The calculator was also used to calculate the alpha level and confidence interval in the study.

Apart from a sample size calculator, the sampling size distribution table is also recognised as helpful in determining a sample size base on the size of a particular population. This method was explained by research scholar (Burk, 2000). I used a sampling size determination table adopted from Krejecie and Morgan Sample Size Determination Table. Chuan and Penyelidikan (2006) discussed the authentication of Krejecie and Morgan sampling size determination table when collecting data in a specific population. This sampling size table is said to be designed based on a confidence level of 95%. Chuan and Penyelidikan (2006) recommend that in situations where researchers cannot have access to an entire statistical population a sampling size determination table such as that of Krejecie and Morgan can be employed.

A sample size of 100 respondents was used in this study. This was due to the nature of the study which is explained in detail later in the sampling procedures and techniques sections of the report.

Table 1.5

Krejecie and Morgan (1970) Sample Size Determination Table

N	S	N	S	N	S
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

In the Krejecie and Morgan Sample Size Determination Table as displayed in Table 1.5, *N* stands for population size, while *S* stands for Sample size.

Distribution of Ages of Respondents

Table 1.6 shows the age distribution of students involved in the study. The range of age distribution of sample size is between seven and sixteen. From Table 1.6, children of age twelve have higher number in the sampled population in the distribution as compared to the other ages whiles age sixteen has the lowest number in distribution.

Table 1.6

Frequency distribution of age

	Frequency	Per cent	Valid Percent
Seven	8	8.0	8.0
Eight	17	17.0	17.0
Nine	12	12.0	12.0
Ten	13	13.0	13.0
Eleven	5	5.0	5.0
Twelve	21	21.0	21.0
Thirteen	6	6.0	6.0
Fourteen	8	8.0	8.0
Fifteen	6	6.0	6.0
Sixteen	4	4.0	4.0
Total	100	100.0	100.0

Sampling

As noted earlier, in this study, a sample size of 100 respondents was used. This consisted of fifty boys and fifty girls in the reasoning of experimental design. Random sampling method was designed and employed to select twenty-five boys and twenty-five girls from the Primary school as well as twenty-five boys and twenty-five girls from the Junior High School.

Five classes were sampled from the Junior High school and five classes from the primary school. From each of the successful sampled classes, random sampling was conducted to select respondents for the study. Stratified sampling was done by categorising the respondents into two statistical populations of Myelination and Synaptogenesis. This stratification was informed by the brain developmental stage theoretical framework proposed for this study. From the Primary school, pupils of age ten and below were stratified into Myelination brain developmental stage whiles pupils from age eleven and above were stratified into synaptogenesis brain developmental stage as described by Banich and Compton (2018).

Five children were sampled from each of the five sampled classes from the primary school and the Junior High School of the University of Cape Coast Basic School. Fifty children were selected from the JHS to represent the population of Myelination. Fifty children were also selected from the primary school to represent the population of synaptogenesis.

From a total population of 2120, a sample size of 322 was determined as the sample size according to the formulae laid down by scholars in a sample size distribution table and a sample size calculator. However, since it was experimental research (Quasi-experimental), scholars suggest that a sample size of at least 30 is good for inferential statistics (Airth, 2019; Field, 2009; Kelley & Maxwell, 2003). Scholars therefore propose that a sample size of 30 and above is enough to achieve an exact enough mean and deviation estimation (Airth, 2019; Suresh & Chandrashekara, 2012; Hertzog, Kramer, Wilson & Lindenberger, 2008; Boyle & Radocy, 1987). This proposition has been established from the central limit theorem to approximate experimental results distribution (Airth, 2019).

Other statisticians including Glenberg and Andrzejewski (2008) believe that a small sample from random sampling that is accurately guided is better than a huge biased one. A good sampling was therefore employed for an accurate result. A sampled size of 100 was therefore reliable for this study.

The Recording Process

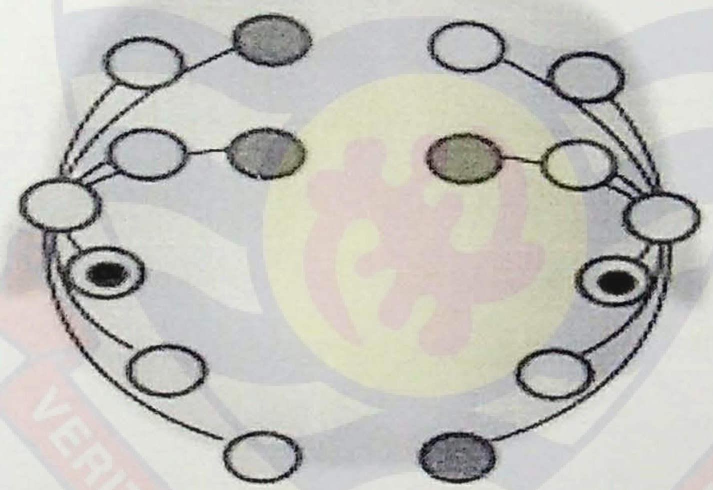

Figure 1.5: Connection sensors of EmotivEPOC+ during data collection

Sensors of the EmotivEPOC+ are monitored by the EmotivPRO. The EmotivPRO is the computer interface developed for its data collection. There was the need to carefully work to get the EmotivEPOC+ headset in good connection before recording. To ensure this, the EmotivPRO has been programmed to display the connectivity status. From the EmotivPRO interface, three colours serve as indicators of the connectivity status. 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 disconnection of that electrode. A deep yellow signal was indicated that there was a connection but that it was not strong enough for recording for that specific electrode. However, the display of green was a signal for the strong connectivity of the specified electrode for quality recording. When all sensors show green as shown in Figure 1.6, it was a signal of good connectivity for recording.

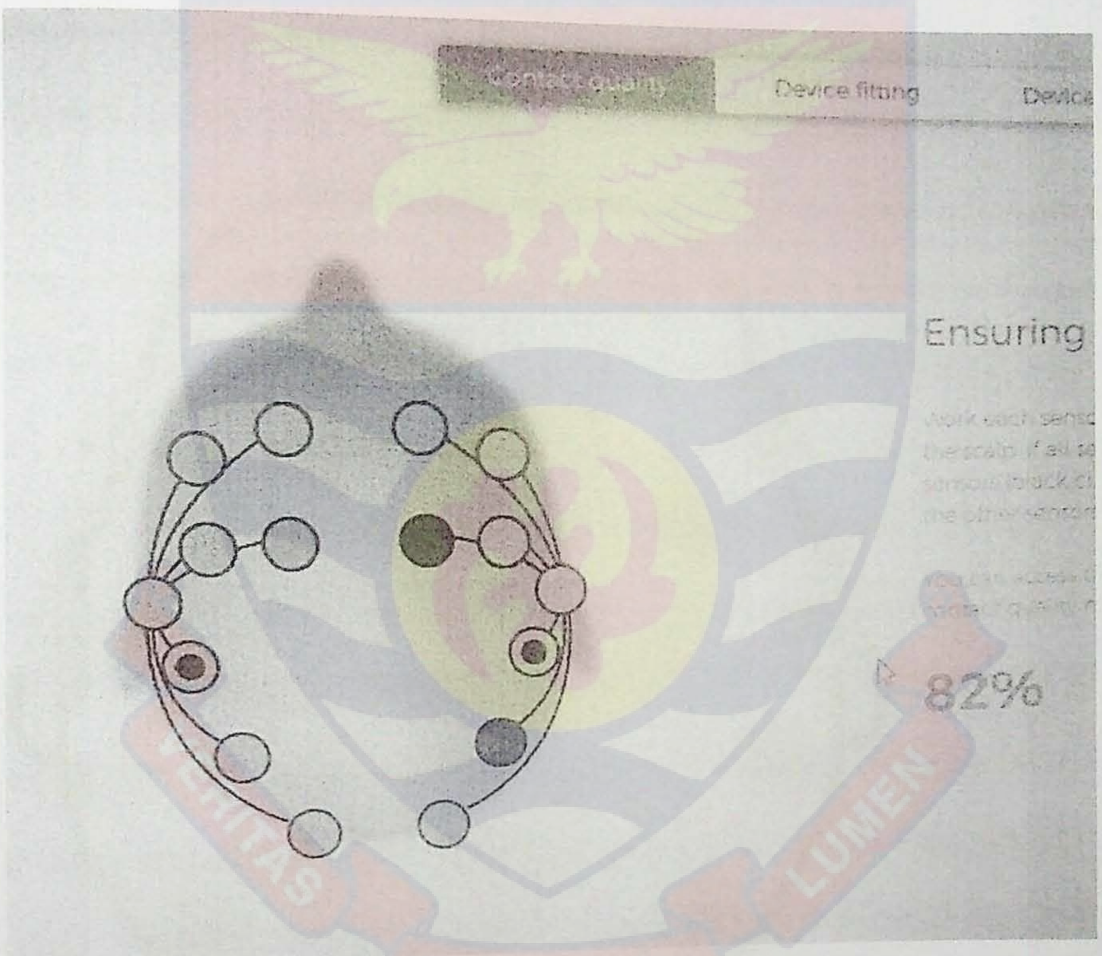

Figure 1.6: Connection status of EmotivEPOC+ displayed by the EmotivPRO interface

As shown in Figure 1.6, the status of the connectivity of the various sensors during setup for recording can be viewed and monitored from the EmotivEPOC+ interface. The connectivity status is that when sensors signal black, they indicate no connectivity status. When they signal red, it means that there is a poor connectivity status whiles blue signal indicates full connectivity of the electrode. Also any sensor that signals green-black status indicates that the connectivity is unstable; that is; that particular sensor is shifting between disconnection and connectivity. This helped me to work out a good connection at about 89% before recording brain responses to both non-music stimuli and music stimuli. At most times, Emotive connection was able to reach 100% before recording. The EmotivEPOC+ was fixed on the scalp of respondents to enable it record brain activity. The EmotivEPOC+ was monitored by an EmotivPRO which is brain-computer interface installed software.

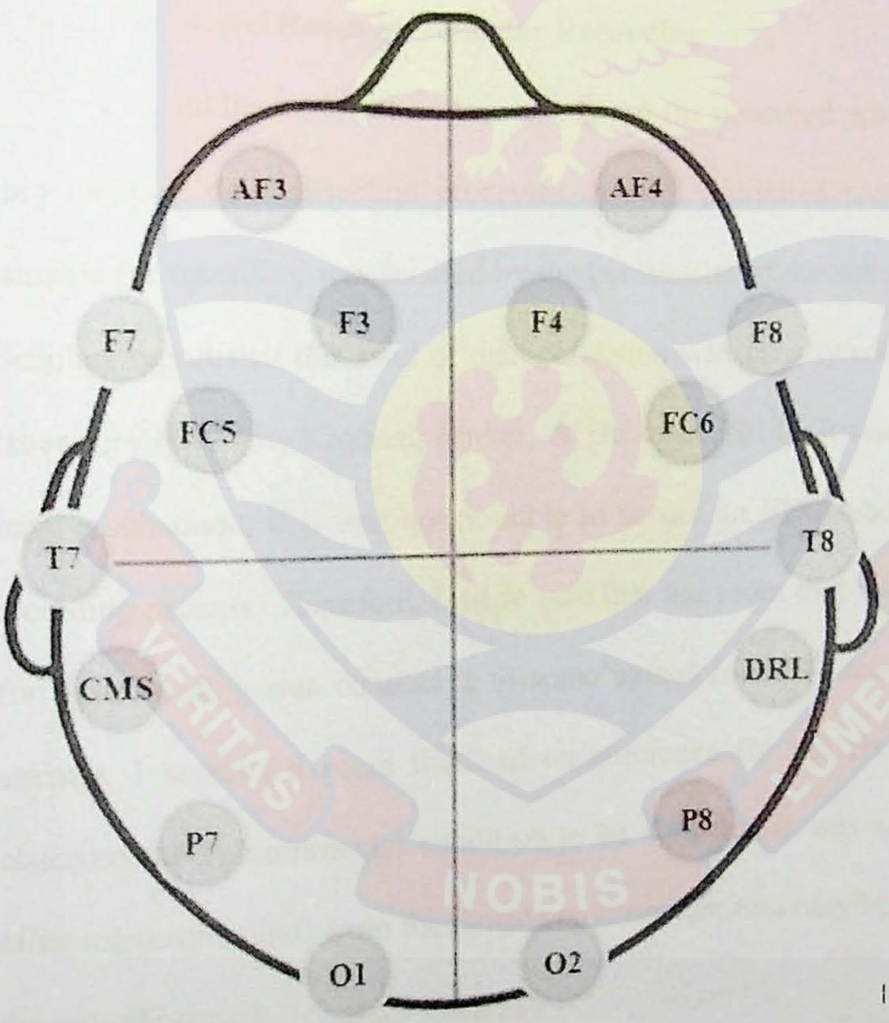

Figure 1.7: EmotivEPOC+ channels in the EmotivPRO interface

I ensured that all the electrodes turn green on the computer screen before I started recording brain responses to the stimuli. Notwithstanding, some of the children had long, bushy or thick hair, a condition that could not make it possible for good scalp contact and connectivity. For those children in the selected sample who could not respond well for data collection, a random sampling is conducted to select another respondent.

Basic Protocol for Recording Setup

Some protocols were observed before recording. These include a well-ventilated room that was suitable for recording, an installed EmotivPRO on a computer, music player software that was installed on a computer, recorded music, earphone headset, and pocket or face tissues paper and snack.

A Well Ventilated Room Suitable for Recording

I would like to briefly report on each of the observed protocol and how they enhance data collection processes. A well-ventilated room which was suitable for recording was secured by the permission of the school's authority. Scholars report that this kind of data collection was usually conducted in the laboratory (De Vos, Kroesen, Emkes, & Debener, 2014). It was necessary to have a substitute, if it was not possible to secure an EEG laboratory for the recording process. Therefore, I made sure that the room that was given to me for the recording was conducive to some extent for EEG recording. In this attempt, I secured a room that had an ambience for the recording. I also observed the environmental condition to be sure that it was secured against other music or sounds from the outside environment that may be obstructive to the recordings.

Computer for Reproduction of Recorded Music

While data collection was being done on a laptop computer with an installed EmotivPRO interface it was not possible to use the same computer for the replay of the recorded music. Another laptop computer therefore was used for the replay of the recorded music. The laptop computer was used to replay the music record because of its capability of tracking the duration of the performance task.

Recorded Music

In this study, recorded music was used as the music stimulus. The intension for adopting recorded music listening was to enable the respondent to focus on the music listening and avoid being disrupted by the activity of performing musicians. It was also less expensive to use recorded music other than life performance of the music. Moreover, it was easier to do data collection with the recorded music than it with live performance. I intended to use a piece of traditional Ghanaian music that was familiar to the children in the University of Cape Coast Basic School (UCCBS). As part of my deliberate attempt to select the specific music stimuli, I visited UCCBS occasionally to observe their musical participating activity to be informed about the popular traditional music that is mostly performed by the school children.

In one of the school children's musical participation activity, I observed them singing *Yaa Asantewaa Adowa*. *Yaa Asantewaa Adowa* is one of the traditional Ghanaian music that is performed among the Twi speaking communities in Ghana. In the University of Cape Coast Basic School, music teachers use the song as one of their music teaching materials. The school music teachers teach many Ghanaian traditional songs in the school. By the time the children graduate from primary school to JHS, they have learnt many traditional musical repertoires such as the one adopted for this study. Since it was one of the songs I had observed them performed, decided to select this particular music (*Yaa Asantewaa Adowa*) for the stimulus among other songs that were proposed for the study.

I used *Yaa Asantewaa Adowa*, a popular traditional Ghanaian music for the listening engagement. The traditional song is highly rhythmic and arranged for singing with the accompaniment of other traditional music instruments such as *dawuro* (bell), *apentima* and *firikyiwa*.

Figure 1.8: Excerpt of the opening notes of Yaa Asantewaa Adowa

Figure 1.8 shows an excerpt of the *Yaa Asantewaa Adowa* music which was used as the music record for the study. Looking at the rhythmic nature of the music, it was difficult to restricted participants completely from their responses of bodily movements.

One can, therefore, note that the bodily movement or the dancing nature of the traditional music of Africa cannot be separated from the other properties of the music. For this reason, participation in the traditional music of Africa such as the *Yaa Asantewaa Adowa* music as used during data collection for this study was not possible to prevent participants from responding to the musical properties appropriately.

The Adoption of Headphone for the Music Listening Activity

Headset, headphone, earphone are devices that look similar in form and function. However, there are key differences that were considered in choosing a suitable device for music listening activity during the data collection.

EmotivEPOC+ Setup for Recording

During the EmotivEPOC+ setup process before data collection, a green signal that indicates that the gadget was well charged was observed. Bluetooth connection was also observed to be sure that all sensors signal active status of good connectivity. The hydration of the sensors was also done to enhance connectivity.

As the headset was being fixed carefully on the head, the EmotivPRO interface displayed the status of connectivity of all the sensors as discussed earlier. After successful connectivity between the EPOC+ and the EmotivPRO by the support of the USB, the headset was carefully fixed on the head of the respondent. After observing a signal of good connectivity it was also important to name and register files before recording starts. During my data collection, I had to deal with many respondents who were in the cluster of two independent populations (Myelination and Synaptogenesis). A large data for non-music stimuli records and music stimuli records was collected during the data collection activity. For this reason, each data file was carefully labelled before recording in order to control for data mess up and misrepresentation.

Identification and Separation of Baseline Data

The cutting off of the baseline data was an essential aspect of data normalization. Baseline data is as a set of information often collected and employed to compare to other data acquired afterwards (Shuan, 2019). It serves as the foundation of most research projects (Shuan, 2019). Baseline data is a measurement of behaviour taken before interventions are started. Baselines data is important because it allows the researcher to compare the behaviour before and after the implementation of behaviour plan to determine if the interventions are working (Shuan, 2019). The baseline CSV data for this investigation is therefore baseline electroencephalogram data. As discussed earlier, the baseline contains forty seconds (40sps) of every data record of every respondent. The non-music brain response was the initial data collected which serve as a basis for comparison with subsequently acquired data-music stimulus.

Active Listening and Passive Listening

As discussed in the review of literature for this study, scholars discuss differences between active listening and passive listening (Boyd & Ellison, 2007: Kuhl, Tsao & Liu 2003). Passive listening and active listening are two main mediums of participating in listening activity (Boyd & Ellison, 2007). Since this study was meant to observe brain activity and behaviours to stimuli (non-music stimulus and music stimulus), the music listening procedure that was adopted was carefully examined. Some scholars observe that active listening is key to internalizing sound, especially in this case about the sound which the individual perceives for music (Reybrouck & Brattico, 2015).

The view that active music listening makes a good musician is shared by many scholars (Pitts, 2016; Goto, Yoshii, Fujihara, Mauch & Nakano, 2011). For this reason, I adopted active listening for the listening participation activity for my study.

Data Mining

The raw data collected during the music participation and brain activity were in the form of waves. A sample of the waves is displayed in Figure 2.1.

Figure 1.9: Emotive brain waves generated by the brain from a stimulus-response

Figure 1.9 represents recorded generated brain waves from the EmotivEPOC+ interface. The first line of waves is named by AF3 which represents brain waves generated from a section of the left hemisphere of the frontal lobe and recorded by the electrode AF3. The next line of waves were also generated from a section of the left hemisphere of the frontal lobe and recorded by the EmotivEPOC+ sensor F7. The brain waves named T7 are waves generated from a left hemispherical section of the temporal lobe. The forth line of waves is named by P7 which represents brain waves generated from a section of the parietal lobe of the left hemisphere and recorded by the electrode P7. The brain waves named O1 are waves data generated from a left hemispherical section of the occipital lobe. The brain waves at O2 represent data collected from a

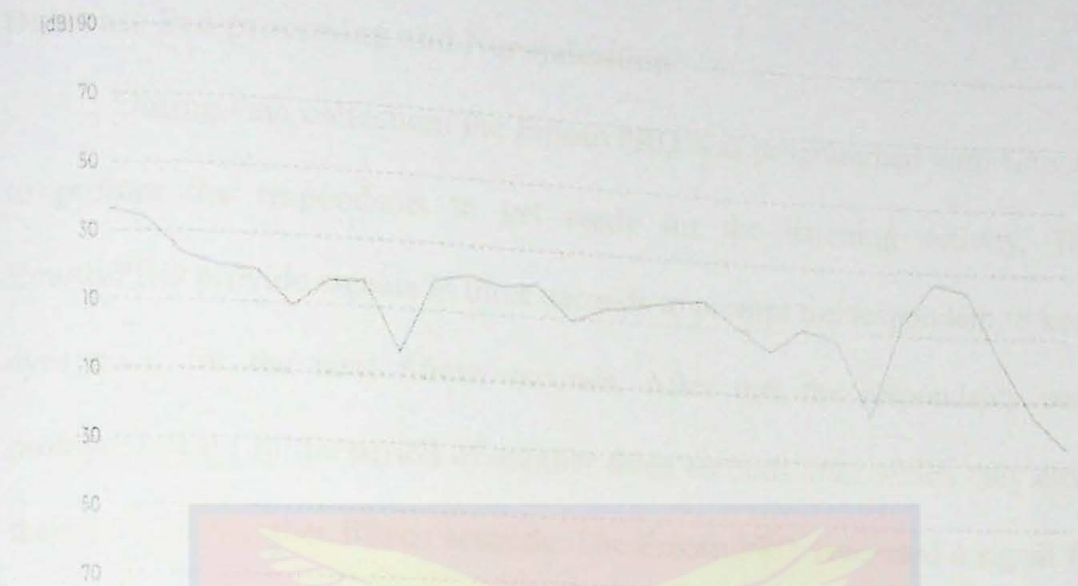

Figure 2.1: Emotive data in-band power from the interface

An EmotivPRO interface displays five kinds of waves from its interface as shown in Figure 2.1 above. The waves generated by EmotivPRO are Theta (4-8Hz), Alpha (8-12Hz), Low Beta (12-16Hz), High Beta (16-25Hz) and Gamma (25-45Hz). Other scholars have had discussed on brain waves (Coenen, Fine & Zayachkivska, 2014; Coenen & Zayachkivska, 2013; Cohen, Goldman, & Jerome, 2001)

To provide better statistical meaning to the data collected, there was the need to engage in data mining to regenerate the recorded data which brain waves into another form for more meaningful and significantly quantifiable information. In the process of data mining the data of each respondent was selected. From the cloud icon in the EmotivPRO interface, CSV, which is defined by scholars as comma separated value (Arenas, Maturana, Riveros & Vrgoč, 2016; Mitlöhner, Neumaier, Umbrich & Polleres, 2016) option was clicked from the data formatting panel to mine the Emotive data. 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.

Database Pre-processing and Normalisation

During data collection, the EmotivPRO was programmed with activity to prompt the respondents to get ready for the listening activity. The EmotivPRO provide signals in three seconds to prompt the respondent to keep eyes open for the next fifteen seconds. After that the respondents were prompted again in the period of another three seconds after which they close their eyes for another fifteen seconds. The EmotivPRO generated a signal for an extra four seconds to normalise the data recording. A total of 40 seconds duration was involved in the data normalisation process when recording was ongoing. The data collected within the first 40seconds therefore was named baseline data as described by scholars (Brefczynski-Lewis, Lutz, Schaefer, Levinson & Davidson, 2007). The data flaws caused by the equipment, programmes, techniques or other conditions were therefore captured in the baseline data.

In the process of removing artefacts, a careful calculation was needed to determine the amount of data that consisted of the abnormal data. The attainment of EEG data onto a digital storage medium was calculated at the sampling rate of 256 samples per second (256sps) (Halford, Sabau, Drislane, Tsuchida & Sinha, 2016). Hindarto, Muntasa & Sumarno (2018) also confirmed the verity that EEG brain signals are recorded by 256 Hz sampling rate non-invasively.

The input of data was conducted after a successful collection and pre-processing of data into SPSS as the database for computation. This other process of handling my data is referred to by scholars as data entry (Kumar, 2009; McLoone, 2005). During my data entry process, I considered various characteristics of the nature of data collected and its use.

Data Cleaning

There was the need for data cleaning after data collection was done in this study. This was necessary because scholars consider data from the real world as being messy (Parkinson, 2006; Green, Kim & Yoon, 2001; Hernández & Stolfo, 1998). When a researcher or a data analyst goes through the process of detecting and correcting corrupt or inaccurate records from a record or identifies 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 (Lu, Hales, Rew & Keech, 2016; Haiby, Ziklik, Hudis & Peleg, 2013). The data cleaning activity in this study therefore was that after the successful entry of data into SPSS, the 'Analyze' option in the SPSS interface was selected. 'Descriptive Statistics' menu was then selected where I was able to access the 'Crosstabs' option. In the 'Crosstabs' I was able to compute a crosscheck to ensure that there was no extra or missing case. Any missing is corrected and any unwanted extra case observed is removed from the database and crosschecked again before data computation was conducted. The case processing summary of the data setup for the testing of hypothesis one is presented in Table 1.7.

Table 1.7

Summary of Case Processing for the Data Setup for Hypothesis One

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
MUSIC NON-MUSIC	100	100.0%	0	.0%	100	100.0%

Table 1.7 indicates that there is no invalid case in the data setup for the computation and testing of hypothesis one. The table also indicate that there is no missing case that may negatively affect data computation and the testing of hypothesis one.

Table 1.8

Summary of Case Processing for the Data Setup for Hypothesis Two

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Stages of Brain * Aggregate	100	100.0%	0	0.0%	100	100.0%

It is also observed in Table 1.8 that there is no invalid case in the data setup for the computation and testing of hypothesis two. The table also did not indicate any missing case that may negatively affect data computation and the testing of hypothesis two.

Table 1.9

Summary of Case Processing for the Data Setup for Hypothesis Three

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Brain Stages * Ages	100	100.0%	0	0.0%	100	100.0%

It is also observed in Table 1.9 that there is no invalid case in the data setup for the computation and testing of hypothesis three. The table also did not indicate any missing case that may negatively affect data computation and the testing of hypothesis three.

Table 10

Summary of Case Processing for the Data Setup for Hypothesis Four

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Brain Stages * Frontal MUS	100	100.0%	0	0.0%	100	100.0%
Brain Stages * Parietal MUS	100	100.0%	0	0.0%	100	100.0%
Brain Stages * Temporal MUS	100	100.0%	0	0.0%	100	100.0%
Brain Stages * Occipital MUS	100	100.0%	0	0.0%	100	100.0%

Table 2.0 shows that there is no invalid case in the data setup for the computation and testing of hypothesis four. The table also did not indicate any

missing case that may negatively affect data computation and the testing of hypothesis four.

Test of Significance for Hypothesis One

In this study, the within-subject variables that supported analysis and the testing of hypothesis one were non-music stimulus and music stimulus.

Test of Significance for Hypothesis Two

The between-subject data presentation was conducted for the testing of hypothesis two. Data analyses for the two independent populations were represented by Myelination and Synaptogenesis which are the brain stages selected for investigation.

Data Presentation for Hypothesis Three

To support data computation and analyses for hypothesis three the data presentation was described. There are four classifications of the lobes of the human brain (Nopoulos, Flaum, O'Leary & Andreasen, 2000; Mesulam, Guillozet, Shaw, Levey, Duysen and Lockridge, 2002; Toga, Thompson & Sowell, 2006). Analysis of brain lobe one consisted of aggregating data from the following sensors AF3, F7, F3, FC5, FC6, F4, F8 and AF4. These sensors (electrodes) have been identified as belonging to the Frontal lobe. The analysis of brain lobe two consisted of the data from electrodes (sensor) P7 and P8. These lobes have been classified as belonging to the Parietal lobe. The analysis of brain lobe three consisted of the data generated from electrodes (sensors) T7 and T8.

These lobes are classified as belonging to the Temporal lobe. The data for brain lobe four (Occipital lobe) were represented by the data collected from electrodes (sensors) O1 and O2. The electrodes O1 and O2 are identified and classified as belonging to the Occipital lobe. The data generated from all the electrodes have been statistically aggregated into their identified lobes to enhance computation and analyses.

The intention of this section was to provide a clearer description for the brain lobes which support the identification of data categorisation. It was therefore vital to clearly identify the various parts of the brain that belong to a specific brain lobe during categorisation. The identification of the brain lobes was also to support the clarification of the grouping of data that was to be analysed to represent every specific lobe of the brain. As noted earlier, neuroscientists have classified the human brain parts into four lobes (Hammers *et al*., 2003). These lobes are frontal, parietal, temporal and occipital.

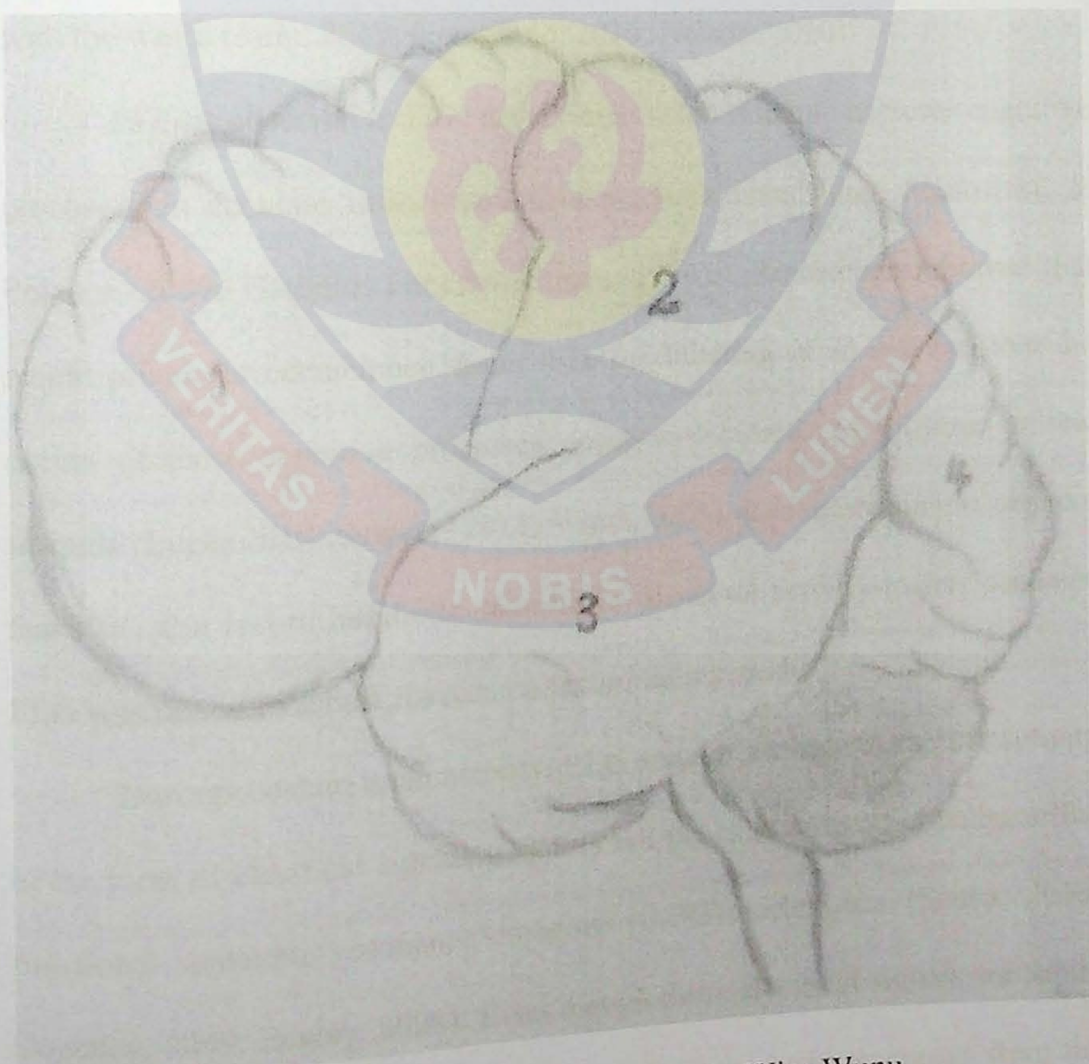

Figure 2.3: A Sketch of the Human Brain Lobes by Wise Wunu

Figure 2.3 represent a sketch of the human brain lobes as classified in neuroscience. The part of the sketch numbered '1' represents the frontal lobe, the part of the sketch numbered '2' represents the parietal lobe, the part of the sketch numbered '3' represents the temporal lobe and the part that sketch numbered '4' represents the occipital lobe of the brain.

Comparing EEG to other Brain Computer Data Collection Technologies

The data collection approach in this study involves a non-invasive process of observation. For this reason EmotivEPOC+ EEG was employed. EEG has been noted to be one of the most versatile brain imaging techniques (Arbib, 2013). It was observed to be ideal for probing into the function of our human brain to see how it can shape our perceptual abilities and interactions with the world (Jahn, 2019; Greenfield, 2016; Nelson, 2010).

EEG is observed to have a very high resolution and captures cognitive processes in accurate time frame (Makeig, Gramann, Jung, Sejnowski, & Poizner, 2009; Hatfield, Landers & Ray, 1984). Researchers observe that neural processes occur much faster than the blinking of an eye and that the events of these cognitive processes occur in hundreds of millions in few seconds (Luck, 2014; Sawyer, 2011; Ward, 2003). It is interesting to observe that EEG can record hundreds of millions of neural activity in few seconds. EEG was therefore robust for data collection in my study.

During constant brain activity, EEG gadgets are able to capture activity in the form of electrical signals which is not possible with other gadgets like functional magnetic resonance imaging (fMRI) techniques (Sousa, 2016; Sweeney, 2009; Begley, 2008). Even though these electrical signals are subtle and very tinny, EEG sensors are able to pick up the brain responses from the scalp surfaces. Apart from the observation and recording of data for the physiological neural activity in the brain, EEG is also able to monitor cognitive-affective behavioural responses. From the EmotivPRO interface of EmotivEPOC+ recording, affective status such as level of stress or attention to stimuli responses were recorded. This data can be used in the future for other research investigation apart from the neurophysiological data that were the focus of attention in this study.

Though magnetoencephalography (MEG) records neural activity like EEG with excellent time resolution and captures deeper neural activity much better than EEG (Barkley, 2004), it is an immobile data collecting instrument which cannot be moved easily about for data collection out of the laboratory like the EmotivEPOC+ equipment. MEG was therefore not suitable for employment in the data collection activity for this study. MEG scanners are also huge and expensive which demand heavy technological maintenance resources. EEG was therefore ideal, compared to MEG for data collection with respect to this study.

Functional Magnetic Resonance Imaging (fMRI) was also compared to EEG regarding the efficacy for data collection for this study. fMRI records brain activity by measuring changes in blood flow (Kwong, 2012; Bonmassar, Schwartz, Liu, Kwong, Dale & Belliveau, 2001; Dai, Liu, Sahgal, Brown & Yue, 2001). These changes are associated with neural activity. fMRI was observed to have excellent spatial resolution (Hall, Robson, Morris & Brookes, 2014; Logothetis, Merkle, Augath, Trinath, & Uğurbil, 2002). However, fMRI lacks the motion of time as measured by EEG. Since this study was to measure brain activity in motion fMRI was also not suitable for data collection, as compared to EEG.

Scholars define positron emission tomography (PET) as a nuclear imaging technique based on gamma radiation caused by decaying radionuclides which are injected into the body of the respondent (Dagliyan, 2017; Yeong, Cheng, & Ng, 2014; National Research Council, 2012). With PET, you can monitor metabolic activity (for example, glucose metabolism) of neurons during cognitive activity. While PET scans are much more robust towards motion artifacts, they are lacking the high time resolution of EEG recordings.

Many researchers who are interested in developmental neuroscience recommend the use of EEG when discussing methodologies for examining neurophysiological and psychological processes in brain and cognitive studies (Lin, Cross, Jones & Childers, 2018; Dimoka, Davis, Gupta, Pavlou, Banker, Dennis & Kenning, 2012; Gevins & Smith, 2003). The electroencephalogram (EEG) is a competent and comparatively reasonably priced system for the study of developmental changes in brain-behaviour relations (Lind, Moustgaard, Jelsing, Vajta, Cumming & Hansen, 2007; DiPietro, 2000). I reviewed literature on some of these advantages of using EEG in brain research to inform my decision of employing EmotivEPOC+ EEG instrument for data collection. It can be noted therefore that EEG is efficient and suitable for the study that I proposed to do.

CHAPTER FOUR

DATA ANALYSES AND DISCUSSION

Chapter Four presents the results of the study. The results are presented in response to the research questions. The Chapter also presents the results that emerged from the testing of hypotheses generated for the study. Finally, Chapter Four also presents the discussion of results and findings that were generated from the analyses of data.

Advance Organiser

According to the University of Cape Coast Graduate Students handbook, there is the need to present 'advance organiser' in Chapter four of thesis. In the presentation of the *advance organiser'* of this study, I restate the purpose of the study, the summary of methods and analytical techniques that were employed in the development of this study.

As already presented in Chapter One, the purpose of this study was to investigate brain responses to music listening. This was to find out whether or not there was a significant difference between brain responses to music listening and non music listening. The study also investigated if there was any significant difference in brain responses among children of different brain developmental stages when engaged in music listening activity. In addition, the study examined neural activity among the four lobes of the human brain when children were engaged in music listening musical behaviour.

One hundred respondents were sampled out of the total population of two thousand, one hundred and twenty for data collection. From the two categorised populations, fifty respondents were sampled to represent the statistical population of myelination whiles the other fifty respondents were sampled to represent the synaptogenesis stage of brain development. Brain response data was collected when respondents were exposed to at least 60 seconds each of non-music activity and music listening activity, using the EmotivEPOC+ instrument and EmotivPRO software.

The test of significance for each of the hypotheses needed a specific type of data computation and statistical test. Independent variables and dependent variables were observed in the data. Therefore, the nature of variables observed determined the specific tests that were to be conducted. A Repeated Measures ANOVA with a Greenhouse-Geisser correction, Wilks' Lambda and Tukey's statistical tests as well as student's T-Test was computed. Bonferroni correction test was also computed as a suitable and robust test for checking the occurrences of errors or false in statistical analyses.

Since 256 samples were generated in every second during data collection process, a total of 15360 sps were generated in every 60 seconds. The first 40 seconds of 10240 sps were cut off from the total data of every respondent. As explained in the methodology chapter of this study, the first 10240 sps represent artefacts associated with the initiation of the experiment for every respondent. The artifacts were therefore cut off to enable the desired clean data access. After the cut off of the artifacts of every respondent, a total of 5120 sps data which represent 20 seconds data records were then extracted from the remaining data of every respondent and imputed into the data base for computation and analyses. In the process of analyses of data for this study, SPSS version 20.0 was the main computation tool.

Hypotheses One Data Analyses

The data for the study were analysed to test the veracity of the first null hypothesis of the study.

Analyses of Data on Brain Response to Music and non-Music Stimuli

This section of the report presents the computed results of the analysis of data obtained from brain activity engendered by the brain's reaction to music stimulus and compared to non-music stimuli. The first hypothesis that was tested is:

H_0: There is no significant difference between brain responses of exposure and non-exposure to music stimuli.

H_1: There is a significant difference between brain responses of exposure and non-exposure to music stimuli.

Table 2.1

Descriptive Statistics of Data on Brain Response to Music and Non-music Stimuli

	Mean	N	Std. Deviation	Std. Error Mean
MUS	4190.12	100	35.20650	3.52065
NONMUS	4200.93	100	19.37447	1.93745

The descriptive statistics generated in response to the testing of hypothesis one are displayed in Table 2.1. It is worth mentioning that the mean difference between brain response to music stimuli and non-music stimuli is $u = 10.80$

Statistical Test of Significance of the Mean Difference between Brain Responses to Music Stimuli and Non-music Stimuli

Table 2.2 displays the results that emerged from the application of the paired sample T-Test statistical model. The paired sample T-Test was computed to examine the significance of the mean difference in brain activity between music and non music stimuli.

Table 2.2

Test Statistics of the T-Test on Brain Response to Music and Non-music Stimuli

	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
MUS < NON-MUS	-10.80	37.25	3.72	-2.90	99	.005

Observation of the results indicates that brain activity was higher when respondents were not exposed to music (u = 4200.93) and was lower when the respondents were exposed to music listening (u = 4190.12). The results emerging from a paired-sample T-Test analysis indicated that there was a significant difference in brain activity between respondents exposed to music and those who were not.

It is therefore noted that the test report for the paired-samples t-test on brain response to music and non-music indicates significant difference (M= 4190.12, SD = 35.20) and non-music stimuli (M =4200.93, SD = 19.37) conditions; t (99) = -2.90, $p = 0.005$.

Even though results show significant difference in brain response between non – music and music stimuli, research scholar noted that a statistical significance of a test is not enough for real life implication (Han, Hsu & Sheu, 2010; Barrett, 2007). There is the need to further compute a Cohen's d test which measures the magnitude of significance (Middel & Van Sonderen, 2002). A Cohen's d test for the paired sampled T-Test was therefore computed. The Cohen's d test is thus computed as:

$$\text{Cohen's d} = \frac{\text{Mean difference}}{\text{Standard deviation difference}}$$

$$\text{Cohen's d} = \frac{10.81}{15.83} = 0.68$$

The computation indicates that there is a medium size Cohen's d test. This implies that the magnitude of the significant difference that was computed for brain response between non – music and music stimuli was moderately impressive; that is moderately practical.

Paired-Sample T-Test Analysis of Brain Response to Music and non-Music Stimuli in the Frontal Lobe

Brain activity in the Frontal lobe were also analysed to test the null hypothesis of hypothesis one. Table 2.3 shows the descriptive statistics for brain activity in the Frontal lobe.

Table 2.3

Descriptive Table for Paired Sample on Brain Response to Music and Non-music Stimuli in the Frontal lobe

	Mean	N	Std. Deviation	Std. Error Mean
MUSIC	4198.66	100	58.91	5.90
NON-MUS	4195.52	100	33.82	3.38

of 0.05. The analysed data could not generate enough evidence to reject the null hypothesis-p-value generated was 0.645.

It was observed that brain activity was higher in children when they listen to music (u = 4198.66) than when they did not (u = 4195.52). Notwithstanding, the mean difference was not significant to reject the null hypothesis (H_0).

In summary, the paired-samples T-Test showed no significant difference in the scores for the MUS (M= 4198.66, SD = 58.91) and the N0NMUS (M =4195.52, SD = 33.82) conditions; t (99) = 0.462, $p = 0.645$ in the Frontal lobe. Paired Sample T-Test on Brain Response to Music and non-Music Stimuli in the Parietal Lobes

Table 2.5 displays the descriptive statistics of brain response in the Parietal lobe to music and non-music stimuli.

Table 2.5

Descriptive Statistics Table for Paired Samples on Brain Response to Music and Non-music in the Parietal lobe

	Mean	N	Std. Deviation	Std. Error Mean
MUSIC	4186.87	100	31.97	3.197
NON-MUS	4197.78	100	43.47	4.347

The mean difference for the pair sampled T-Test on brain response, in the Parietal lobe to music and non-music stimuli was $u = 10.92$. Analytically, the means indicated that there was higher brain activity in the Parietal lobe, when the respondents did not listen to music than when they did.

Analysis of Test Statistics on Brain Response, in the Parietal Lobe, to non-Music Stimulus and Music Stimulus

Table 2.5 displays the results of the paired sample T-Test computed to investigate whether or not there was significant difference in brain activity in response to music and non-music stimuli in the Parietal lobe.

Table 2.6

Test statistics of paired-sample T-Test on Brain Response, in the Parietal lobe, to Music Stimulus and Non-music Stimulus

	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
MUSIC< NON-MUS	-10.92	49.98	4.97	-2.20	99	.030

Observation of the analysed results of brain responses to music and non-music in the Parietal lobes indicates that brain activity was higher in children when they were not exposed to music than when they were exposed to music.

A paired-samples T-Test was computed to compare brain response to music and non-music in the Parietal lobe. The computed test statistics to examine the level of significance of the difference between brain responses in the Parietal lobe, to music stimulus and non-music stimuli showed that there was a significance difference between brain response in the Parietal lobe to music (M= 4186.87, SD = 31.20) and non-music (M =4197.78, SD = 43.47) conditions; t (99) = -2.195, p = 0.030.

Paired Sample T-Test on Brain Response to Music and non-Music in the Temporal Lobes

Table 2.7 displays the computed descriptive statistics for the brain response to music and non-music stimuli in the Temporal lobe.

Table 2.7

Descriptive table for paired samples on brain response to music and non-music stimuli in the Temporal lobe

	Mean	N	Std. Deviation	Std. Error Mean
MUSIC	4188.94	100	56.01	5.601
NON-MUS	4213.42	100	45.60	4.56

The mean difference for the pair sampled T-Test for the stimuli responses in the Temporal lobe of the brain was calculated as 24.48 (u = 24.48). The computed means in Table 2.7 indicates that there was higher brain activity when respondents were not exposed to music than when they were.

Analysis of Test Statistics of Brain Response, in the Temporal Lobe to Music and non-Music

Table 2.8 presents the results of the test statistics for examining the significance of the difference between brain response in the Temporal lobe, to music stimulus and non-music stimuli.

Table 2.8

Test statistics of paired-samples T-Test on Brain Activity to Music and non-Music in the Temporal lobe

	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
MUSIC < NONMUS	-24.48	71.21	7.12	-3.438	99	.001

The results of the paired-sample T-Test showed that there was significant difference between brain responses, in the Temporal lobe, to music stimulus and non-music stimuli.

The observation of the results engender by the test statistics indicate that brain activity, in the Temporal lobe, was higher when children were exposed to non-music than to music.

In summary, the report on the paired-samples t-test on brain activity, in the temporal lobe indicate that there was a significant difference in the scores engendered from brain response to music (M= 4188.94, SD = 56.01) and non-music (M =4213.42, SD = 45.60) conditions; t (99) = -3.38, p = 0.001 in the Temporal lobe.

Analysis of Paired Sample T-Test on Brain Response to Music and non-Music in the Occipital Lobe

Analysis of paired-sample T-Test on brain response to music and non-music stimuli in the Occipital lobe was also conducted. Table 2.9 displays the descriptive statistics of brain responses, in the Occipital lobe to music and non-music stimuli.

Table 2.9

Descriptive Statistics Table for Paired Sample on Brain Response to Music and Non-music of in the Occipital lobe

STIMULI	Mean	N	Std. Deviation	Std. Error Mean
MUSIC	4182.031	100	43.76	4.38
NON-MUS	4196.98	100	42.00	4.20

The mean difference between brain responses, in the Occipital lobe, to music and non-music stimuli was 24.48 (u = 24.48). The means indicated that there was higher brain activity when children were exposed to non-music stimuli than to music stimulus in the Occipital lobe.

Analysis of Test Statistics of Music and non-Music Brain Response in the Occipital Lobe

Table 3.0 displays the paired-samples T-Test on brain responses to music and non- music stimuli in the Occipital lobe. The paired-sample T-Test was computed to investigate whether or not there was significant difference between brain activity to music and non-music stimuli in the Occipital lobe.

Table 3.0

Test statistics of paired-sample T-Test on Brain Reponses to Music and non-Music Stimuli in the Occipital lobe

	Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
MUSIC < NONMUS	-14.95	60.50	6.05	-2.47	99	.015

The analysis of the data generated by brain response in the Occipital lobes, to music and non-music suggests that brain activity was higher when children were not exposed to music (u = 4196.98) than when they were exposed to (u = 4182.031).

In summary, the test report for the paired-samples t-test on brain response to music and non-music in the occipital lobe is that there was a significant difference in the scores generated from brain responses to music stimulus (M= 4182.031, SD = 43.76) and non-music stimuli (M =4196.98, SD = 41.99) conditions; t (99) = -2.95, $p = 0.015$ in the Occipital lobe.

Analysis of Data in Respect to Hypothesis Two

It was observed that the student T-Test was the appropriate statistical model for the second hypothesis. Hypothesis two was designed to examine the extent to which brain activity engendered by music stimuli differ between the two stages of brain development-myelination and synaptogenesis

Hypothesis two involves an independent between subject variables with two levels and a dependent variable (brain response). The two levels of the independent variables are myelination and synaptogenesis stages of brain development. The hypothesis two is stated as follows:

H_0: There are no significant differences in brain responses of children of different brain developmental stages exposed to the same music stimulus

H_1: There are significant differences in brain responses of children of different brain developmental stages exposed to the same music stimulus.

Since the testing of the hypothesis involved two independent variables and one dependent variable, the student *t*-test was employed for the analysis of the data. SPSS (version 20.0) was adopted for data setup and data computation in this study.

T-Test Results on Brain Response to Music at the Myelination and Synaptogenesis of Brian Development

Table 3.1 presents the results of descriptive statistics on brain responses to music at the two brain developmental-myelination and synaptogenesis

Table 3.1

Descriptive Statistics on Brain Responses to Music at the Myelination and Synaptogenesis Stages

Brain Stages	N	Mean	Std Deviation	Std. Error Mean
Myelination	50	4201.08	24.50	3.46
Synaptogenesis	50	4179.08	40.73	5.76

Table 3.1 shows that the mean difference between brain responses to music at the myelination and synaptogenesis at the brain developmental stages is 21.91.

Analysis of Test Statistics of Brain Responses to Music at the Two Brain Developmental Stages

The results presented in Table 3.2 indicate that brain activity is higher in myelination stage (4201.08) than in at the synaptogenesis stage (4179.17).

Table 3.2

Student t-test results on brain activity at the myelination and synaptogenesis stages of brain development

	t	*df*	Sig, (2-tailed)
Equal variances assumed	3.260	98	0.002

The results of analysis indicated that there was a significant difference between scores generated by brain response to music at the myelination stage (M= 4201.08 SD = 24.50) and synaptogenesis stage (M =4179.17, SD = 40.73) conditions; t (98) = 3.260, $p = 0.002$.

However, the statistical significant difference that is observed in brain response to music between brain stages – myelination and synaptogenesis is not enough evidence in real life condition (Han, Hsu & Sheu, 2010; Barrett, 2007). There is the need to further compute a Cohen's d test which measures the magnitude of significance (Middel & Van Sonderen, 2002). A Cohen's d test for the independent sampled T-Test was therefore computed, using the Cohen's d test formula as:

$$\text{Cohen's d} = \frac{\text{Mean difference}}{\text{Standard deviation difference}}$$

$$\text{Cohen's d} = \frac{22.00}{-16.23} = -1.36$$

A Cohen's d test that is 0.8 or above indicates a large effect size. The computation which generates -1.36 for brain response between myelination and synaptogenesis therefore indicates that there is a very high size Cohen's d test. This implies that the magnitude of the significant difference that was computed for brain response between myelination and synaptogenesis was highly impressive. Therefore the results can be highly accepted practically.

Analysing the Descriptive Statistics for the T-Test of Myelination and Synaptogenesis Stages of the Frontal Lobes

The data on brain responses in the Frontal lobe was analysed to further investigate the extent to which brain responses at myelination stage was different from that of synaptogenesis stage. The descriptive statistics test results have been displayed in Table 3.3.

Descriptive Statistics on Brain Responses to Music Stimuli in Myelination and Synaptogenesis Stages of the Frontal Lobe

A descriptive statistics was computed on brain responses, in the Frontal lobe, to music stimulus at the myelination and synaptogenesis stages of brain development.

Table 3.3

Descriptive Statistics on Brain Responses to Music at the Myelination and Synaptogenesis Stages in the Frontal lobe

Brain Stages	N	Mean	Std. Deviation	Std. Error Mean
Myelination	50	4206.23	43.22	6.11
Synaptogenesis	50	4191.09	70.89	10.03

Table 3.3 shows that the mean difference in brain activity in the Frontal lobe between myelination and synaptogenesis is 15.14. In the Frontal lobe, brain activity was higher at the myelination stage than at the synaptogenesis. However, there was the need to examine the significance of the difference.

Test Statistics on Brain Responses to Music at the Myelination and Synaptogenesis Stages of the Frontal Lobe

Table 3.4 presents the results of the T-Test performed on the data generated from the brain responses, in the Frontal lobe, to music at the myelination stage and synaptogenesis stage of brain development.

Table 3.4

Tests Statistics on Brain Response in Myelination and Synaptogenesis to Music Stimulus in of Frontal Lobe

	F	Mean Difference	t	df	Sig. (2-tailed)
Equal variances assumed	.028	15.14	1.29	98	.200

The results in Table 3.4 suggested that there was no significant difference between brain activity between brain activity at the myelination and synaptogenesis stages of brain development in the Frontal lobe. Since the *p*-value was not significant, it could not suggest the rejection of the null hypothesis (H_0).

Statistical Tests on Brain Responses to Music in the Frontal Lobe, at Myelination and Synaptogenesis Stages

Independent-samples T-test was conducted to compare brain responses to music stimuli between the two brain stages-myelination and synaptogenesis in the Frontal lobe. The results indicate that there was no significant difference in the scores generated by brain responses to music at the myelination stage (M= 4206.23, SD = 43.22) and synaptogenesis stage (M = 4191.09, SD = 70.90) conditions; t (98) = 1.29, $p = 0.200$.

Descriptive Statistics of Brain Response to Music, in the Parietal Lobe, at Myelination and Synaptogenesis Stages

The results for the descriptive statistics of brain response to music in the Parietal lobe at the two brain stages were computed and displayed in Table 3.5.

Table 3.5

Descriptive Statistics on Brain Responses, in the Parietal Lobe, to music at the Myelination and Synaptogenesis Stages

Brain Stages	N	Mean	Std. Deviation	Std. Error Mean
Myelination	50	4195.06	4.142	5.96
Synaptogenesis	50	4178.67	12.36	1.75

The mean difference in brain activity between the two brain stages of myelination and synaptogenesis in the Parietal lobe as presented in Table 3.4 is 16.39 ($u = 16.39$).

Table 3.6

Test Statistics on Brain Responses to Music in the Myelination and Synaptogenesis in the Parietal lobe

Variances	F	t	df	Sig. (2-tailed)
Equal variances assumed	38.284	2.64	98	.010

The results in Table 3.6 indicate that brain activity at the myelination stage were higher than brain activity at the synaptogenesis stage.

Results of a Statistical Test on Brain Responses to music between Myelination and Synaptogenesis Stages in the Parietal Lobe

A test statistics was computed on the data generated from brain activity in the Parietal lobe. The analysis established the level of significance of the differences between responses to music at the myelination and synaptogenesis stages. The results of the computation are displayed in Table 3.6.

The results of the student t-test computed indicated that there was a significant difference between the scores generated by brain responses to music at the Myelination stage (M= 4195.06, SD = 42.14) and that of the Synaptogenesis stage (M = 4178.67, SD = 12.36) conditions; t (98) = 2.64, p = 0.010 in the Parietal lobe.

T-Test Results on Brain Responses to Music in the Temporal Lobes at the Myelination and Synaptogenesis Stages

The results of the analysis of data indicated that brain responses, in the Temporal lobe, to music differed at the myelination stages from the synaptogenesis stage.

Descriptive Statistics for Myelination and Synaptogenesis in the Temporal Lobe

The descriptive statistics data analysed for brain responses to music stimulus in myelination and synaptogenesis in the Temporal lobe was also conducted. The results of the analysis are shown is Table 3.7.

Table 3.7

Descriptive Statistics of Brain Response to Music in the Temporal lobe at the Myelination and Synaptogenesis Stages

Brain Stages	N	Mean	Std. Deviation	Std. Error Mean
Myelination	50	4201.77	48.44	6.85
Synaptogenesis	50	4176.11	60.46	8.55

The mean differences in brain activity between the two brain stages of myelination and synaptogenesis is 22.66 (u = 22.66). The mean difference reflect differences in brain activity, in the Temporal lobe, between myelination and synaptogenesis stages.

Table 3.8

Results of a Statistical test on Brain Responses to Music in the Temporal lobe at the Myelination and Synaptogenesis Stages

	F	Sig.	t	df	Sig. (2-tailed)
Equal variances assumed	.908	.343	2.341	98	.021

A test statistic was computed to test the null hypothesis which states, regarding the temporal lobe, that there is no significant difference in brain response to music between children of the myelination stage and synaptogenesis stage.

The results indicate that there was a significant difference between brain responses to music at the myelination stage (M = 4201.77, SD = 48.44) and the synaptogenesis stage (M = 4176.11, SD = 60.46) conditions; t (98) = 2.34, $p = 0.021$) in the Temporal lobe.

Results of Statistical Test on Brain Responses to Music in the Occipital Lobe at the Myelination and Synaptogenesis Stages

The results of the analysis of data indicate that there was a difference between brain responses to music at the myelination stage and the synaptogenesis stage.

Descriptive Statistics on Brain Responses to Music in Myelination and Synaptogenesis in the Occipital Lobe

Student t-test was computed for the Occipital lobe of hypothesis two. The analysis was conducted to further investigate whether or not there was any significant difference in brain activity to music between Myelination and Synaptogenesis in the Occipital lobe.

Table 3.9

Descriptive Statistics on Brain Responses to Music in the Occipital lobe at Myelination and Synaptogenesis Stages

Brain Stages	N	Mean	Std. Deviation	Std. Error Mean
Myelination	50	4193.27	47.75	6.75
Synaptogenesis	50	4170.80	36.48	5.16

Table 3.9 presents the descriptive statistics of brain response to music in the two brain stages-myelination and synaptogenesis. The mean difference in brain activity between the two brain stages is 22.47 ($u = 22.47$).

Test Statistic on Brain Response to Music at the Myelination and Synaptogenesis Stage

A statistical test was computed to establish the significance of the difference between the brain responses to music at the myelination and synaptogenesis stages.

Table 4.0

Results of Statistical Test on Brain Response to Music at the Myelination and Synaptogenesis in the Occipital lobe

	F	t	df	Sig (2- tailed)
Equal variances assumed	3.72	2.64	98	0.010

Table 4.0 presents the results of the statistical test of brain response to music in the Frontal lobe. The test examines the significance of the difference between brain response to music, in the occipital lobe, at the myelination and synaptogenesis stages of brain development. The results indicate that there was a significant difference between brain responses to music at the myelination stage (M = 4193.27, SD = 47.75) and the synaptogenesis stage (M = 4170.80, SD = 36.48) conditions; t (98) = 2.64, $p = 0.010$).

Statistical Test in Respect of the Third Hypothesis

The third hypothesis for this study was developed to investigate whether or not there is any significant difference in brain responses to music among the four lobes of the brain. The third hypothesis is as follows:

H_0: There are no significant differences in brain responses to music among the four brain lobes.

H_1: There are significant differences in brain responses to music among the four brain lobes.

Descriptive Statistics on Brain response to Music

Table 4.1 presents a descriptive statistics results computed from data that emerged from brain response to music in the four lobes-Frontal, Parietal, Temporal and Occipital.

Table 4.1

Descriptive Statistics of Brain Responses to Music in the Four Brain Lobes

Lobes	Mean	Std. Deviation	N
Frontal lobe	4198.66	58.91	100
Parietal lobe	4186.87	31.97	100
Temporal lobe	4188.94	56.01	100
Occipital lobe	4182.03	43.756	100

Table 4.1 presents the descriptive statistics table for the four lobes that shows the generation of mean differences. However, to find out whether or not these observed differences are significant there is the need to conduct inferential statistics.

Table 4.2

Mauchly's Test of Sphericity among Brain Lobes on Brain Response to Music

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
Brain Lobe	.897	10.617	5	.060

Table 4.2 displays results of Mauchly's test of Sphericity. The computation is effected to assess whether or not the sphericity assumption has been violated. Since the test statistics is not significant, it is assumed that the variances of the treatment conditions are equal, which met the assumption of sphericity

Table 4.3

Test Statistics on Brain Responses to Music in the Four Brain Lobes

Effect	Value	F	Hypothesis df	Error df	Sig.	Observed Power
Wilks' Lambda	.92	2.87	3.00	97.00	.040	.670

Since the equality of variance is assumed, the Wilks' Lambda test statistic was computed to investigate whether or not there were significant differences among the four brain lobes with respect to brain responses to music. The results are represented in Table 4.3. The *p*-value therefore indicates that the null hypothesis was rejected.

Table 4.4

Pairwise Comparisons among Brain Lobes

(I) Brain Lobe	(J) Brain Lobe	Mean Difference (I-J)	Sig.
Frontal lobe	Parietal	11.793	.379
	Temporal	9.719	.541
	Occipital	16.628*	.023
Parietal lobe	Frontal	-11.793	.379
	Temporal	-2.074	1.000
	Occipital	4.835	1.000
Temporal lobe	Frontal	-9.719	.541
	Parietal	2.074	1.000
	Occipital	6.909	1.000
Occipital lobe	Frontal	-16.628*	.023
	Parietal	-4.835	1.000
	Temporal	-6.909	1.000

Table 4.4 shows a Pairwise comparisons table of multiple T-Tests with Bonferroni correction. The Pairwise results in the Frontal lobe between Frontal and Occipital show significant pairings. Also, the pairing of the Occipital lobe with the Frontal lobe was significant. Data results display marginal means of brain activities among the brain lobes. The results indicate that there are significant differences between the Frontal lobe and the Occipital lobes in respect brain response to music.

In summary, the results of one-way repeated measures ANOVA was conducted to investigate the significance of main effect of brain lobes in responses to music among respondents (N = 100). The results of the ANOVA indicated a significant effect among brain lobe, which was observed between the Frontal and the Occipital lobes, Wilks' Lambda $\Lambda = .92$ $F(3, 97) = 2.87$, $p = .040$.

Analysis of Data in Respect of Hypothesis Four

The data for the study were also analysed to test the veracity of the forth null and alternatives hypotheses. The forth hypothesis was developed to analyse and investigate whether or not there is any significant difference in brain responses among the four brain lobes at two brain developmental stages-myelination and synaptogenesis to music listening behaviour. A 2 x 4 mixed factorial ANOVA was adopted for the analysis and the testing of hypothesis four. The forth hypothesis that was tested is:

H_0: There are no significant differences in brain responses among brain lobes at brain stages to music stimuli.

H_1: There are significant differences in brain responses among brain lobes at brain stages to music stimuli.

Descriptive Statistics for Brain Lobes and Brain Developmental Stages

Towards the development of analysis and test for hypothesis four, a descriptive statistics was computed. This is displayed in Table 4.4.

Table 4.5

Descriptive Statistics for Brain Responses to Music among Brain Lobes at Brain Developmental Stages (Myelination and Synaptogenesis)

Lobes	Brain Stages	N	Mean	Std. Deviation
Frontal	Myelination	50	4206.2294	43.22474
	Synaptogenesis	50	4191.0872	70.89356
	Total	100	4198.6583	58.90856
Parietal	Myelination	50	4195.0613	42.14038
	Synaptogenesis	50	4178.6695	12.35501
	Total	100	4186.8654	31.97406
Temporal	Myelination	50	4201.7661	48.44271
	Synaptogenesis	50	4176.1125	60.46219
	Total	100	4188.9393	56.00945
Occipital	Myelination	50	4193.2653	47.74529
	Synaptogenesis	50	4170.7957	36.48325
	Total	100	4182.0305	43.75593

Table 4.5 displays a descriptive statistics table for brain responses to music among brain lobes at brain stages-myelination and synaptogenesis. From the table, the means and standard deviations are provided for each combination of the groups of the independent variables. It is observed from each group of combination that there are differences in the means and standard deviations among the various brain lobes to brain stages. However, there is the need to conduct a test statistics in order to confirm whether the differences are significant or not.

Table 4.6

Mauchly's Test of Sphericity

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
Lobes	.897	10.543	5	.061

The Mauchly's Test of Sphericity as displayed in Table 4.5 has $p > 0.05$, which shows an insignificant difference in the variability in the distributions of the data emerging from the brain lobes. The results show that there is homogeneity in the variances.

Table 4.7

Test Statistics Showing Interaction among Brain Lobes and Brain Stages

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Lobes	Sphericity Assumed	14635.622	3	4878.541	2.899	.035
Lobes interaction with Brain Stages	Sphericity Assumed	1866.244	3	622.081	.370	.775
Error(Lobes)	Sphericity Assumed	494755.428	294	1682.842		

The within–subjects test was computed to allow the comparison of levels of the independent variables-brain lobes. From the computation, it is observed that the interaction among brain lobes is insignificant, [F (3, 294) = 2.899, p > .05]. Therefore there was no interaction between brain stages and lobes. However, there was a main effect among lobes with $p < 0.05$.

Table 4.8

Test Statistics of Between-Subjects Effect for Brain Stages

Source	Type III Sum of Squares	df	F	Sig.	Observed Power
Intercept	7019501842.88	1	1683597.13	.000	1.00
Brain Stages	39657.96	1	9.51	.003	0.86
Error	408596.08	98			

The test of within-subjects was conducted to analyse the variances to account for variation in the dependent variable (Loehlin & Beaujean, 2016). It is displayed in Table 4.8 that the between subject effects of the brain stages is significant, F (1, 98) = 9.5, p = .003, with a high power of 0.86. From Table 4.8, a high statistical power of 1.0 was also generated to indicate that the probability of making a type II error was highly avoided (Foster, 2001; Sandin & Johnson). A profile plot is needed to give clearer description of the interactions.

Interaction between the Two Factors-Brain Stages and Brain Lobes

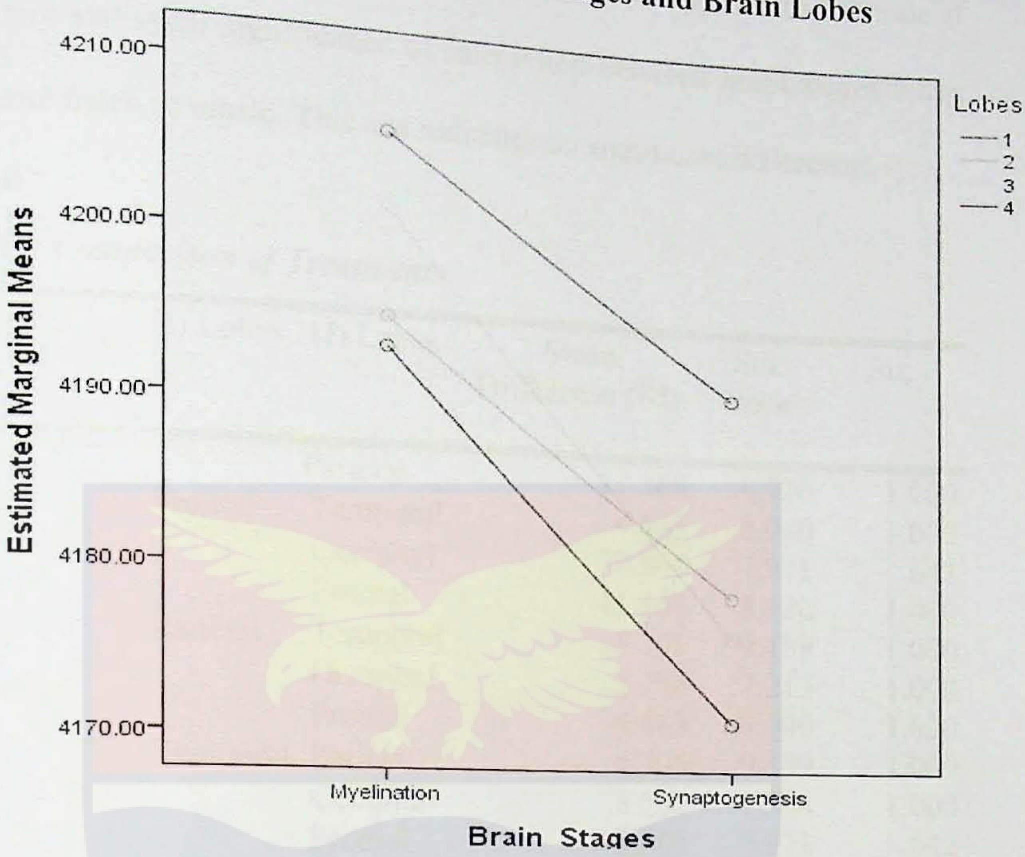

Figure 10: Displays a Plot between the Two Factors

The graph presented in Figure 2.5 was plotted to examine the interaction effect of brain lobes on brain response to music. The graph displays an interaction effect among lobes when respondents listen to music.

Research scholars observe that interaction commonly occurs in ANOVA computations as well (Frost, 2020; Hayes & Preacher, 2014; Fairchild & McQuillin, 2002.). Frost (2020) recommends the computation of an interaction plot to enhance easier interpretation of data results.

Table 4.9

Test Statistics of Multivariate between Brain Stages

Brain Stages		Value	F	Hypothesis df	Error df	Sig.
Myelination	Wilks' lambda	.971	.939	3.000	96.000	.425
Synaptogenesis	Wilks' lambda	.933	2.289	3.000	96.000	.083

Table 4.9 shows a multivariate test statistics computed to examine if there is any statistical significance of interaction between brain stages when respondents listen to music. This test indicates no significant difference.

Table 5.0

Pairedwise Comparison of Treatments

Brain Stages	(I) Lobes	(J) Lobes	Mean Difference (I-J)	Std. Error	Sig.
Myelination	Frontal	Parietal	11.168	8.920	1.000
		Temporal	4.463	8.040	1.000
		Occipital	12.964	7.971	.642
	Parietal	Frontal	-11.168	8.920	1.000
		Temporal	-6.705	9.139	1.000
		Occipital	1.796	7.213	1.000
	Temporal	Frontal	-4.463	8.040	1.000
		Parietal	6.705	9.139	1.000
		Occipital	8.501	7.784	1.000
	Occipital	Frontal	-12.964	7.971	.642
		Parietal	-1.796	7.213	1.000
		Temporal	-8.501	7.784	1.000
Synaptogenesis	Frontal	Parietal	12.418	8.920	1.000
		Temporal	14.975	8.040	.393
		Occipital	20.292	7.971	.075
	Parietal	Frontal	-12.418	8.920	1.000
		Temporal	2.557	9.139	1.000
		Occipital	7.874	7.213	1.000
	Temporal	Frontal	-14.975	8.040	.393
		Parietal	-2.557	9.139	1.000
		Occipital	5.317	7.784	1.000
	Occipital	Frontal	-20.292	7.971	.075
		Parietal	-7.874	7.213	1.000
		Temporal	-5.317	7.784	1.000

A pairedwise comparison test for all treatment conditions was also computed to observe the differences in brain lobes verses brain stages. This is displayed in Table 5.0. From the pairedwise table, the mean differences for all treatment conditions in the brain lobes verses brain stages were statistically insignificant ($p > .05$).

In summary, a 2 x 4 mixed factorial ANOVA was conducted that examined brain responses to music among brain lobes at brain stages. There music stimuli and listening to the music again (second time) to investigate brain response. From their observation, they noted that music listening increases activity in the network of mesolimbic structures such as nucleus accumbens and ventral tegmental area, as well as the hypothalamus (Menon & Levitin, 2005). Abrams, Ryali, Chen, Chordia, Khouzam, Levitin and Menon (2013) also noted that listening to music stir up neural physiological reactions. In another study, Haumann, Kliuchko, Vuust and Brattico (2018) conducted an investigation using music information retrieval (MIR) method to examine musical responses in the auditory cortex. They observed that there were some evoked related brain responses that originated from higher-order cortical structures such as the inferior frontal cortex as a result of the musical engagement. Their study indicates that music stimuli increase neural activity.

The results of data analysis and the testing of the first hypothesis in this current study indicate lower brain activity when the respondents listen to music. This suggests that the music relaxes the brain activity of the respondents during the engagement (Krout, 2007). Another study which investigated brain response to music showed that respondents who were assigned to music listening engagement generate significantly lower theta in the cortical regions of the brain as compared to non-music condition (Jacobs & Friedman, 2004). This study also support a conducted by Jaušovec, Jaušovecn and Gerlič (2006) that indicated that Mozart music generates less complex brain patterns among the respondents than those who were assigned to other tasks. In the case of my investigation, there was no stimulation, where a raised level of physiological nervous response or where an increase in brain activity was noted in the application of music stimuli as compared to the computed results observed with the non-music stimuli. The observation in my study which shows that brain activity was lower with music stimulus but rather higher with non-music stimuli was contradictory to other investigations recorded in the literature (Krout, 2007; Jaušovec, Jaušovecn & Gerlič, 2006; Jacobs & Friedman, 2004). While it is not clearly explained in the available literature, it is probably that, perhaps, the engagement of the music listening participation caused relaxation in neural oscillation, which engendered lower brain responses.

Stimuli Differences in this Study and other Studies

It is probable that the kind of music adopted as the stimulus in this study may have caused an inconsistency in the results and findings. In this study, 'Yaa Asantewaa Adowa'- a traditional Ghanaian Ashanti song was used for the music stimuli. However, in all the studies conducted as recorded in literature, the stimuli applied were different from the one used in this study (my study). Many researchers who conduct studies to investigate brain response to music adopted jazz and classical music as stimuli in their investigations (Tervaniemi, Janhunen, Kruck, Putkinen & Huotilainen, 2016; Limb & Braun, 2008). Other studies report on the use of Rock'n'Roll' to investigate neural correlates to musical engagements (Istók, Brattico, Jacobsen, Ritter and Tervaniemi, 2013; Waylen & Wolke, 2004). In these studies one major difference was that jazz musicians were able to discriminate better than the classical musicians when there was a change or improvisation. So far, it is difficult to trace any study that has adopted any Ghanaian traditional song in similar study. It is likely that differences in stimuli application may have accounted for the differences in results-my study and other studies reported in literature. Also, as comprehensively discussed in the methods of data collection, during the two conditions-musical engagement and non-musical engagement, there was no distracted activity that was possibly perceived to influence the changes.

Discussion of Lower and Higher Brain Activity on the Study

The literature equivocally indicates that music stimuli, in the medium of listening or performance generate significantly increased level of physiological and neurophysiological arousals (Salimpoor, Enovoy, Longo, Cooperstock & Zatorre, 2009; Juslin & Laukka, 2004; Brodsky, 2001). Some researchers also state that music triggers mood and spatial abilities (Lundqvist, Carlsson, Hilmersson & Juslin, 2009; Husain, Thompson & Schellenberg, 2002). A study conducted by Gomes and Conde (2017) also indicated that musical excerpt transmit positive valence emotions (joy) in the parietal lobe of the brain. Other researchers observed how the human brain is stimulated significantly by music (Kreutz, Murcia & Bongard, 2012; Sourina, Kulish & Sourin, 2009). In an interdisciplinary research of stimuli responses and psychoneuroendocrenology (PNE), music had been found to be a psychoactive stimulant (Kreutz, Murcia & Bongard, 2012). Some scholars also observe that music stimulates more parts of the brain than any other human function (Odegaard, 2017). However, it is difficult to trace any consistent study where researchers found low brain activity instead, in the application of music stimuli.

Notwithstanding, some researchers observed that engagement in music can give relaxation to the participant, relief stress and reduce pain (Phillips-Silver, 2012; Bossard, 2011). Also, music has been found to generate relaxed physiological response (Nater, Abbruzzese, Krebs & Ehlert, 2006; Davis, 1989). It is noted that the nature of brain activity that may be generated in moments depend on the neural oscillation that is stimulated in the moment of observation (Ribeiro *et al.,* 2004; Paller, & Wagner, 2002). According to Shah, Lahiri and Sen (2017)., a neural oscillation refers to the rhythmic and repetitive electrical activity generated impulsively which is in response to stimuli by neural tissue in the central nervous system.

Some research scholars note that the mechanisms that occur during the generation and transmission of voltage in the brain rely on specific neural oscillations and these oscillations also depend on the stimuli that are received (Ben-Ari, 2014; Gerstner, Kistler, Naud & Paninski, 2014; Steriade, 2003). In other words, responses to stimuli determine neural oscillations and that the oscillations determine the nature of voltage that is transmitted. Therefore, it is likely that the generation of lower or higher brain activity is determined by the type or the nature of stimuli that is received by the brain. Yoto, Katsuura, Iwanaga and Shimomura (2007) also report that oscillatory electrical activity occurs in the brain when groups of neurons synchronise their firing activity. Therefore, it is unlikely that the brain activity that was generated during the engagement in music listening participation may have influenced the changes. This observation is support by some scholarly investigations. For instance, in a study conducted by Vuust Brattico, Seppänen, Näätänen and Tervaniemi (2012) respondents listened to three different types of music-classical, jazz and rock or pop. Their findings indicate that the characteristics of the specific music serving as the stimulus generate differences in their neural activity significantly. This suggests that the brain behavioural differences are embedded in the nature of music stimulus applied in the study.

The Results and Finding with Respect to Hypothesis Two

The results showed that there was a significant difference in brain activity between the two brain stages-myelination and synaptogenesis. The analyses reveal that brain activity in response to music were higher in myelination stage than the synaptogenesis stage.

The results of hypothesis two support other findings in the literature that inform that the state of neural development of an individual also affect changes in brain responses (Zamm, Schlaug, Eagleman & Loui, 2013; Parani, 2012). For example, Parani (2012) conducted a study to investigate the functional and structural connectivity on music processing. The study indicated that neural architecture underlying music processing in children is sensitive to changes in tonal key. The study conducted by Zamm, Schlaug, Zamm, Schlaug, Eagleman & Loui, (2013). also indicated that the synchronisation of music is determined by the pre-developed or the configured musical perception of the individual. However, it is not very clear whether the changes in brain responses to music between the two brain stages as examined in this study were determined by the developmental configurations at the specific stages.

As noted earlier, children from birth up to ten years of age are in the category of myelination stage whiles those from eleven years and above are classified into the synaptogenesis. It means that the age difference between the two brain stages is that children in synaptogenesis stage are older than those in the myelination stage. This has been operationally defined in this study.

The observation of brain responses according to the chronological development of brain stages (Casey *et al.*, 2005) was not consistent with findings reported in the literature. Banich and Compton (2018) observed that synaptogenesis is a stage of brain development where a dramatic increase in neural connections called synapses take place. It was also noted that at the stage where myelination ends, synaptogenesis increases and continue into older years. Even though there is no available literature that compared brain activity between myelination and synaptogenesis, some studies indicated that there is a significant increase in brain activity in the synaptogenesis which was not reported about myelination (Chung, Allen & Eroglu, 2015; Cline, 2001). It is therefore expected that brain responses to music should have been higher at the synaptogenesis stage than the myelination stage, since studies demonstrated that dramatic increase in neural connections are observed synaptogenesis stage. These observations should be further investigated in the future.

Inconsistency in Brain Developmental Stage and Developmental Ability as an Influencing Factor

Results and findings from some studies indicate inconsistency in developmental readiness and developmental abilities. For example, a study was conducted to investigate the relationship between complex executive function and age (Best, Miller & Naglieri, 2011). Respondents who were between the age of 5 and 17 were sampled for the study. In their investigation, they found that the correlation of the developmental pattern of complex executive task did not vary across age. This indicates that older children did not show higher correlation than the younger ones in executive functions as suggested by the theory of cognitive developmental readiness and developmental abilities. In another test, Anderson, Bucks, Bayliss and Della Sala (2011) conducted an investigation among children and older adults across four age groups to investigate age differences on dual performance tasks. In their investigation, they observed the abilities of the respondents to coordinate performance on two tasks that were carried out simultaneously. The researchers observed that there were no significant age related differences in the performance. This is to say that respondents in the older age groups did not show higher performance difference than those in the younger age groups

However, age related investigations that report that younger children generate higher brain responses than older ones on the similar task (same tasks) are difficult to find in literature. This neurological age related investigations report that younger children-children in the myelination stage have higher responses than the older ones-children in the synaptogenesis stage on the same musical engagement activity. In the current study, there was no distracted engagement among children of the two brain stages during data collection procedures that can be perceived as an influencing factor. It was discussed earlier in the methodology chapter of the current study that protocols were observed to avoid any predicted distractive engagement during data. The investigation on myelination and synaptogenesis therefore need further examinations that can provide more explanations on its results and findings.

Discussion of Results and Findings with Respect to Hypothesis three

Results and findings that were conducted to test hypothesis three indicated that there are significant differences in brain response to music among the various lobes of the brain. However, it is noted that the Frontal lobe did not show significant difference according to the test statistics computed.

In the investigation of brain response in the Frontal lobe, the literature indicated that the frontal lobe is accountable for superior cognitive task including memory, impulse control, problem solving and motor function (Tyng, Amin, Saad & Malik, 2017; Szczepanski & Knight, 2014). Zatorre (2005) also noted that the engagement in any form of musical behaviour, including listening to music involve every cognitive function. However, the cognitive function of the Frontal lobe during the engagement in music participation was not significant. Further investigation is therefore need about this observation.

To highlight the clarity of the engagement activities during data collection, there was no group engagement, instead, each respondent was engaged separately in a well ventilated and isolated room to control against any destructive activity engagement or sound that may draw the attention of the respondents. Every participant responded only to the activities that were engaged for the data collection. It is therefore not clear whether the respondents were responding to something internally (in the brain) that involved the frontal lobe or that there was an involvement of some mind-wondering or day dreaming behaviours which may probably have influence on the generation of the data.

Also, Geroldi, Metitieri, Binetti, Zanetti, Trabucchi and Frisoni (2000) conducted a study to investigate changes in the frontal lobe to musical engagement. However, the study conducted by Geroldi *et al*. (2000) did not report that the change in the frontal lobe was compared to brain activity in the other lobes of the brain. Even though a study indicate that there is a change in neurological behaviours in response to music in the frontal lobe (Geroldi *et al.*, 2000), changes in brain response to music in the frontal lobe was not significant in this study (my study). This study therefore needs further investigation on the phenomenon.

It is interesting to note that brain response to music stimuli was not found to be the same in all brain lobes as investigated among school children in the University of Cape Coast Basic School in this study. The results show that there were differences in brain response to the same music stimulus among the Parietal, Temporal and Occipital, but not in the Frontal lobe. Knowing that the Frontal lobe engages in superior cognitive task (Geroldi *et al.*, 2000), it probably seems congruent to note that it generated the highest mean of response to the music.

One other striking observation which was noted in the testing of hypothesis three is that, the Temporal lobe was not found to generate the highest mean difference; instead, the highest mean difference was generated by the Frontal lobe. One would have thought that the Frontal lobe would have generated the highest significant mean in brain response because of its related cortex that is associated to musical processing. The literature indicates that Temporal lobe contains the auditory cortex that is responsible for music processing (Rogalsky, Rong, Saberi & Hickok, 2011; Warrier, Wong, Penhune, Zatorre, Parrish, Abrams & Kraus, 2009).

The results and findings which showed that responses in the four lobes differ, provide an insight that neural activity or neural behaviours are not the same in all lobes of the human brain in respect to music listening. Further explanation of the specific brain functions among the various brain lobes can give further insight in the discussion of the hypothesis three findings.

In brain anatomy, the Frontal lobe is noted as the biggest lobe of the brain and that it occupies approximately one-third of the cerebral hemisphere in humans (Valentin, Alarcon, Garcia-Seoane, Lacruz, Nayak, Honavar & Polkey, 2005; Sowell, Delis, Stiles & Jernigan, 2001; Mesulam, 1986). For its function, the frontal lobe has been observed to be involved in motor function, reasoning, emotion and language. It is observed to contain the motor cortex which is involved in planning and coordinating movement (Scott & Schoenberg, 2011; Faw, 2003; Ardila, 2008). Apart from the probabilities discussed earlier about the insignificant of results computed for brain response in the Frontal lobe, the finding may also suggest that the function of the Frontal lobe is probably not noted for responding to music stimuli in respect to the data results of hypothesis three.

The Parietal lobe is posterior proximal to the Frontal lobe and superior to the Temporal lobe. Scholars inform that the Parietal lobe contain the somatosensory cortex for processing sensory information. Some of its sensori information processing is touch, temperature, and pain (McGlone & Reilly, 2010; Dijkerman & De Haan, 2007; Carlsson, Petrovic, Skare, Petersson & Ingvar, 2000). Though the Parietal lobe is not particularly noted for processing music information, it however interesting to note that it responded significantly to music stimulus according to the results computed by the test statistics computed for the Parietal lobe.

The Temporal lobe can be describes as being inferior distal and anterior to the parietal lobe, posterior distal to the Frontal lobe and anterior to the Occipital lobe. The temporal lobe is observed to contain the auditory cortex (Arnott, Binns, Grady & Alain, 2004; Scott, Blank, Rosen & Wise, 2000). The auditory cortex is the main area for processing auditory information (Patterson, Uppenkamp, Johnsrude & Griffiths, 2002; Recanzone, Guard & Phan, 2000). Also, notably, scholars have observed that the auditory cortex is responsible for music processing in the brain (Zatorre, Belin, & Penh, 2002; Schneider *et al.*, 2002) and this cortex is located in the Temporal lobe. That might assume that higher brain responses should be observed in the Temporal lobe. However, the data computation and analyses did not support this.

Occipital lobe lies posterior distal to the Parietal lobe and posterior proximal to the temporal lobe. It contains the primary visual cortex, which is responsible for interpreting incoming visual information (Sousa, 2016; Wolfe, 2010; Constantinidou, Thomas and Best, 2004). In the Occipital lobe, brain activity to musical engagement (music listening) were observed to be the lowest in respect to the data results. There is therefore the need for further probing about brain response to music in the Parietal lobe.

Discussion of Results and Findings with Respect to Hypothesis Four

Hypothesis four was developed from research question four to investigate whether or not there is any significant difference in brain response to music among brain lobes at brain stages. The results that were analysed to test hypothesis four indicated that there were significant differences in the main effect. However, there was no significant interaction effect in brain lobes verses brain stages ($p > 0.05$).

In the discussing of results for hypothesis four, it is observed that the treatment conditions among brain lobe at brain stages in the frontal lobe were not significant. It was rather observed that when children of myelination stage and synaptogenesis stage of brain development listen to the same music they generate significant main effect in brain response to the music. Since there was no evidence to show that the cross-over interaction between the two main factors-brain lobes and brain stages were significant, it suggests therefore that the effect of brain stages on the dependent factor-brain lobes are not in convergent. The interaction effects as shown in the brain lobes indicate that a third variable influences the relationship between the independent and the dependent factors (Andersson, Cuervo-Cazurra & Nielsen, 2020).

To clearer understand how significant the interactions are, suggests a comparison of the four brain lobes. As analysed already, the interaction effect was observed in the Parietal and the Temporal lobes only. This means that the interaction was not observed among all lobes of the factor (brain lobes). Towards the goal of a comprehensive analysis of the interaction phenomenon, the analysis of interaction examined the extent to which the cross-over interactions contribute substantially to the generalisation of the results (Lau & Nie, 2008).

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

In this Chapter, I present summary, conclusion and recommendations of the study. The summary will include brief presentation of the purpose of the study, hypothesis tested, methods adopted in the data collection, analyses, findings and discussions.

Purpose of the study

The purpose of this study was to examine brain responses to music listening to investigate differences between non-music and music stimuli.

Research questions

The research questions that this study sought to answer were:

1. What is the difference in brain responses when children are exposed and not exposed to music stimulus?
2. To what extent does brain response vary during exposure to the same music stimuli among children of different brain developmental stages?
3. What differences exist in brain responses to music in each of the four brain lobes?
4. Are there any significant differences in the brain responses among brain lobes to brain stages when exposed to the same music stimulus?

Procedures used

The modus operandi followed in investigating the topic of this study include: the development of objectives, research questions, hypotheses, appropriate theoretical framework, adopting suitable research design, the selection of suitable sample and variables and the adoption of appropriate analytical methods.

The Study Design

The quasi-experimental research design was adopted in examining the problem. The effectiveness of this design in producing reliable results within the framework of traditional research has been argued by many research scholars (Leutwyler & Meierhans, 2016; Williams-Brown, 2016; Campbell & Stanley, 2015; Montero & León, 2007; Cook, Campbell & Shadish, 2002).

Variables and Samples Employed in the Study

The variables I used were categorised under three main areas: stimuli, brain stages and brain lobes. In the case of stimuli, non-music and music stimuli were examined. The brain stages investigated were myelination and synaptogenesis. The four brain lobes were frontal, parietal, temporal and occipital lobe.

A review of literature reveals that larger sample size makes a study more informative and reduces uncertainty (Anderson, Kelley & Maxwell, 2017). Although the sample size from which data was gathered for this study was not so large (N = 100), according to sample size determination calculator adopted, I believe that the results provided meaningful findings and insights for generalisation. My confidence for this claim was based on the conscious attempt of following all the procedures and assumptions set for inferential statistics. I believe that the recommendations derived and addressed shall be relevant for the development of this study.

Data Collection

The procedures followed for data collection include a verification of the reliability of the research instrument-EmotivEPOC+, official approval from the Institutional Review Board of the University of Cape Coast, obtaining permission from the school authorities and parents to involve students in the study, the selection of appropriate music.

I used *Yaa Asantewaa Adowa* as the recorded music in the study. During the data collection activity, an excerpt of the recorded music, lasting 60 seconds was played for the respondents and their brain behaviour was recorded. I also recorded respondents' brain behaviour without music.

Before the main data collection, a pilot test was conducted. The reliability coefficient of the instrument (EmotivEPOC+) used to collect data for the pilot test was .82 ($r = .82$). Research scholars who use EmotivEPOC+ confirm that the reliability coefficient of 0.82 is an indication of reliable instrument (Thatcher, 2010; Corsi-Cabrera, Galindo-Vilchis, Del-Río-Portilla, Arce & Ramos-Loyo, 2007).

Field Work

The study involved one basic school in the University of Cape Coast community. The basic school consists of Primary School and Junior High School. The music teachers in the school, as well as the various class teachers whose classes were involved in the data collection activity, assisted with the organisation of the students for the data collection.

Data Analyses

The data collected for the study were computed and analysed with statistical package for social sciences (SPSS) version 20.0 and Microsoft

Excel version 2016. The SPSS version 20.0 was used to run the statistical procedures, including-mixed repeated factorial ANOVA, T-Test, and repeated measures ANOVA.

Summary of Results and Findings in Respect of Hypothesis One

Hypothesis one was developed to investigate whether or not there is any significant difference in brain response between non-music and music stimuli. The result indicated that there were differences in the means of brain activity between non-music and music stimuli. It indicated that non-music stimulus generates greater mean of brain response than music stimuli among the school children. To verify the significance of the result, a student t-test was computed. Brain activity was higher when respondents were not exposed to music (u = 4200.93) but was lower when the respondents were exposed to music listening (u = 4190.12. The mean difference of 10 (u = 10.08) was significant in the computation of the test statistics.

Summary of Results and Findings in Respect of Hypothesis Two

Research question two of this study was developed into hypothesis two to investigate whether or not there were significant differences in brain response to music between two brain stages-myelination and synaptogenesis. In summary, brain activity to music was higher among respondents who were in the myelination stage (u = 4201.08) than those in the synaptogenesis stage (u = 4190.12. The mean difference of 10 (u = 10.08) was significant in the computation of the test statistics. The results indicated that there were differences in brain activity to music stimuli between the two brain stages (u = 10.96). To verify the reliability of results, a T-Test computation was performed. It was observed that mean brain activity at myelination stage was higher than that of synaptogenesis stage. In other words, children's brain responses to music were different at myelination and synaptogenesis stages.

Summary of Results and Findings in Respect of Hypothesis Three

Hypothesis three was tested as a response to research question three. The research question three was developed to investigate whether or not there were differences in brain response to music among the four brain lobes. The results indicate that there were differences in brain activity among the various lobes. To confirm the reliability of the results, repeated measures ANOVA was computed. The means computed u = 4198.66, u = 4186.87, u = 4188.94 and u = 4182.03 for the Frontal, Parietal, Temporal and Occipital lobes respectively indicated that there are differences in the mean, and that these means were tested to be significant. The results therefore, suggest that brain response to music stimuli is not the same in all brain lobes among the respondents.

Also, since scholars note that each brain lobe engages in specific functions, it was not surprising to observe significant differences in brain response among the lobes. The Temporal lobe is known to contain the auditory cortex which is central to music processing. One would have expected that the Temporal lobe should have generated the highest mean to brain response because of its specific function of engagement in musical processes. However, brain activity to music in the Temporal lobe did not engender the highest response; instead, it was the Frontal lobe that generated the highest brain response. A high mean of 4198.66 (*u* = 4198.66) was generated by the Frontal lobe, and when compared to that of the Parietal lobe for example (*u* = 4186.87), there is a huge mean difference of 11.79 (u =

11.79). However, even though brain response in the Frontal lobe was higher than those engendered by the other lobes, the mean difference of responses in the Frontal lobe was not significant.

Summary of Results and Findings in Respect to Hypothesis Four

Research question four of this study was developed into hypothesis four to investigate whether or not there are any significant difference in brain response to music among the four brain lobes by two brain stages-myelination and synaptogenesis. In the computations towards the testing of hypothesis four, the two factors-brain lobes and brain stages were paired in computation, every level of the factor were computed and the treatment conditions were also computed for analysis. In the pairedwise comparison of results there were no significant main effect among the mean differences computed for myelination and synaptogenesis in pairing with the four brain lobes- Frontal, Parietal, Temporal and Occipital. To confirm the consistency of results for research question four, a two-way mixed factorial ANOVA was computed to test hypothesis four. The results, however, indicated that there was a significant main effect. However, there was no significant interaction in brain responses to music among the brain lobes by brain stages. The multivariate test computed also indicated no significant difference (u = .425 and u = .083 for myelination and synaptogenesis, respectively).

The Theoretical Framework

As explained in Chapter one, the time frame of human brain development (Casey *et al.*, 2005) was adopted as the theoretical framework for this study. The theoretical framework addressed the stages of human brain development and the specific brain developmental functions that are associated to the various brain stages (Banich & Compton, 2018). Two stages of human brain development, namely, myelination and synaptogenesis were investigated in this study. Results of analysis indicated that there was a significant difference between scores generated by brain response to music at the myelination stage (u = 4201.08) and synaptogenesis stage (u =4179.17). The mean difference of 21.91 (u = 21.91) was significant. The results therefore support brain stage theoretical framework which primarily noted that every brain stage behave differently in respect to their neural responses to stimuli (Pantelis, Yücel, Wood, Velakoulis, Sun, Berger & McGorry, 2005). The significant difference in brain response to music between the two brain stages-myelination and synaptogenesis therefore support this priming notion.

Conclusion

I based my conclusions on the findings emerged in response to the research questions and hypothesis outlined in Chapter one.

Hypothesis One

Research question one was developed into hypothesis one as:

$H_{0:}$ There is no significant difference in brain response of children exposed to and those not exposed to music stimulus.

$H_{1:}$ There is significant difference in brain responses of children exposed to and those not exposed to music stimulus.

The results of the study indicate that there are positive differences in brain response between non-musical engagement and musical engagement in the computation of a student's t-test. The results show that there were fewer brain activities when respondents listen to music and when they did not listen to music, there were higher brain responses. These findings were not consistent with results obtained by earlier studies in the area of music and brain response. Many of the studies indicate that music listening increases higher brain activities (Lebedev, Kaelen, Lövdén, Nilsson, Feilding, Nutt & Carhart-Harris, 2016; Sarnthein, VonStein, Rappelsberger, Petsche, Rauscher & Shaw, 1997). It is not very clear whether the low brain responses engendered during the recording of brain responses to music was because the respondents were more focused and thus less distracted during the music listening compared to when they were not listening to the music. It is also not clear whether it is the engagement in the music listening activity that reduced the higher brain response of non-musical engagement or not. Further investigation is therefore needed to clarify the reasons for this generated result. However, based on the analyses and findings, it can be concluded that there are significant differences in brain responses to music stimuli and non music stimuli and that there is the need for further investigation on the observations.

Also, by analysing changing brain behaviours engendered by the engagement in music participation and non-music participation, this thesis has shown how children's brains respond to Ghanaian traditional music compared to when they are not listening to the music.

Hypothesis Two

Research question two was developed into hypothesis two as:

H_0: There is no significant difference in brain responses of children of different brain developmental stages exposed to same music stimulus.

H_1: There are significant differences in brain responses of children of different brain developmental stages exposed to the same music stimulus.

A research question and a hypothesis were set out to make a theoretical argument about the significant difference in brain responses between myelination and synaptogenesis to music participation. The results indicate that the generated brain activity between the two brain stages-myelination and synaptogenesis show differences in the mean results and that the mean difference was significant. Respondents in the myelination stage engendered higher mean brain responses while respondents in the synaptogenesis stage engendered lower mean brain responses during the music listening engagement. Since synaptogenesis increases the efficiency of neuronal network (Kolb & Whishaw, 2009; Zillmer, Spiers & Culbertson, 2007), one may be expecting that the stimulation of music in the brain would be higher at synaptogenesis stage than at myelination stage. The literature also suggests that new synapses (synaptogenesis) occur at older years which generate rapid sensory stimulation (Zito & Svoboda, 2002). It is therefore expected that the rapid sensory stimulation which is associated to synaptogenesis might cause an increase in brain response at synaptogenesis stage than myelination stage. However, the results and finding were contradictory to this-brain response was lower at synaptogenesis than at myelination. There was no possibly or perceived distracted behaviour that children in the myelination stage engaged which could probably cause the change in the generation of high brain response in the myelination stage than in the synaptogenesis stage. It is assumed that there are other factors such as rapid sensory stimulation as mentioned in Zito and Svoboda (2002) that could account for the change in results and findings.

By analysing brain behaviours engendered by brain response between myelination and synaptogenesis, this study has shown how children's brain respond to music between two brain stages-myelination and synaptogenesis.

Hypothesis Three

Research question three was developed into hypothesis three as:

H_0: There are no significant differences in brain response of the various brain lobes to music stimulus.

H_1: There are significant differences in brain responses of the various brain lobes to music stimulus.

Hypothesis three aimed at investigating whether or not there are any significant difference in brain response among the four lobes of the brain when engaged in music listening. The results in respect to hypothesis three indicate that the differences in brain responses engendered by the four brain lobes- Frontal, Parietal, Temporal and Occipital engendered were statistically significant. The significant difference was observed among Parietal, Temporal and Occipital lobes but not in the Frontal lobe. It was, however, not clear why brain response to music in the Frontal lobe was not significant. To better understand the implication of the results generated by the Frontal lobe, future studies could address specific functions of brain lobes and their brain response to music. It is interesting to note that the Temporal lobe generate the highest significant difference in brain response to music. Notwithstanding, the test statistic computed was not significant. Since the auditory cortex, which is noted to process music, sound and language is embedded in the Temporal lobe, it can probably be suggested that its musical function supported the generation of the highest significant differences in brain activity among brain lobe during the physical engagement. Notwithstanding, an examination is needed to further investigate this observation towards a clearer understanding.

By analysing varying computations of brain behaviours stimulated by brain response to music, the investigation has also shown how Ghanaian children respond differently to music among the four lobes of the brain, and specifically by responding to a Ghanaian traditional music. It could be concluded that all brain lobes do not respond the same to the same music stimulus.

Hypothesis Four

Research question four was developed into hypothesis four as:

H_0: There are no significant differences in brain responses among brain lobes at brain stages to music stimulus.

H_1: There are significant differences in brain responses among brain lobes at brain stages to music stimulus.

Hypothesis four aimed at investigating whether or not there are any significant differences in brain response among the four lobes of the brain at two brain stages - myelination and synaptogenesis - when respondents engaged in music listening participation. The results in respect to hypothesis four indicate that there are differences in brain responses among the four brain lobes to brain stages and that, these differences were statistically significant. However, brain activity to music in the Frontal lobe did not indicate statistical significant differences. The computed two-way repeated measures factorial ANOVA generate a robust test result that was able to control for homogeneity and all extraneous variable before computing the statistical differences. It is also observed that there was an interaction effect between the Parietal and the

Temporal lobe, but not in the Frontal and the Occipital lobe in the computation and the testing of hypothesis four. It can therefore be concluded that there is an effect of interaction in the brain lobes on the brain stages in the Parietal and the Temporal lobes. Also, as observed in the analysis, the computed mean generated by the Frontal lobe was not significant. It is probable that the specific functions of the Frontal lobe do not involve musical processing for which it was not able to generate significant brain response to music. To better understand the implication of the results generated by the Frontal lobe, future studies could address specific functions of brain lobes and their interaction with brain stages to music.

By analysing brain behaviours engendered by brain response between brain lobes and brain stages, this study has shown how Ghanaian children's brains respond to music among the four lobes of the brain at two brain stages-myelination and synaptogenesis. In this investigation a statistical interaction effect was observed in the Parietal lobe and the Temporal lobes at the brain stages to also conclude that there was a variable that influenced the homogeneity of the independent and the dependent variables. With hypothesis four, it could be concluded that when children's brains respond to music among the four lobes of the brain at two brain stages-myelination and synaptogenesis, there is no significant interaction in brain activity.

Recommendations

I recommend that a different control than non-music be used for further investigation. This is because the non-music control used in this study did not cause engagement of the respondents in any specific task. Even though the children were still sitting during the participating engagement, it is likely that the respondents may have been doing many different things such as mind-wandering or fidgeting.

Also, in respect to using different methods with the same music stimulus, I recommend that a different methodology be applied in the investigation of the same phenomena studied in this research. This is because scholars have observed that the change in methodology affects data results and findings (Berman, Ahuja & Bhandari, 2010; Ahern & Le Brocque, 2005). Studies conducted by Scott-Little, Hamann, & Jurs (2002) as well as Goldstein, Hubbard, Cutler and Barcellos (2010) have also confirm this observation.

EmotivEPOC+ was adopted for data collection in this study. Instead, another kind of electroencephalogram (EEG) gadget such as EPOC flex, INSIGHT, EPOC X or EmmotivMN8 other than EmotivEPOC+ should be used. Magneto resonance imaging (MRI) or functional magneto resonance imaging (fMRI) method should also be used in investigating the phenomenon in the future. I also suggest that future investigation should focus on different measurement that is generated from the EmotivEPOC+ such as waves – alpha, beta, theta and gamma. This is because these brain waves were not analysed in this study.

Towards a recommendation based on the adoption of a different musical behaviour it is noted that responses generated during musical engagement depends on the specific type of musical behaviour that the individual participate in (McFerran & Saarikallio, 2014; Herholz & Zatorre, 2012; Scherer & Zentner, 2001). In this study, I referred to musical behaviour as a facet of human psychological behaviour through which people interact with musical phenomena (Radocy & Boyle, 2012). Scholars further explain that these musical behaviours can be experienced collectively or as individuals (Radocy & Boyle, 2012; Boyle & Radocy, 1987).

Scholars identify that humans engage musical behaviours (Simones, Rodger & Schroeder, 2015; Boyle & Radocy, 1987). These behaviours include music listening, music performance, such as singing or playing an instrument, reading or writing music, composition, improvisation, moving to music, reading about music, affective or aesthetic response to music and musical analyses (Moran, 2014; Levitin, 2013; Davidson, 2012). This current study was conducted based on music listening behaviour only. This means that there are other musical behaviours that need to be investigated, such as singing, composition and musical analyses. I therefore, recommend that this study should be conducted again by exploring other musical behaviours which were identified by Boyle and Radocy (1987).

In this study, two stages of brain development were investigated in the time course of human brain development theoretical framework. On this basis, future studies should be conducted by investigating brain response to music in respect to the other brain stages which were not explored in the developmental neuroscientific framework in this study. In the review of the time frame of human brain development, seven major brain developmental stages were identified.

The other brain stages - such as neurulation, cell proliferation and migration, the development of sensory motor cortex, the development of parietal and temporal association cortex development and the development of prefrontal cortex - were not investigated in this study. I am therefore recommending that future researchers should endeavour to investigate the remaining brain stages within the framework of time frame (course) of human brain development.

A number of intriguing connections have emerged from the study that provides implications for future studies. Some of them are future invitation to explore different stimuli other than the *Yaa Asantewaa Adowa* which was used in this study. Mostly, researchers in this area of study use jazz, Western classical music and rock'n'roll (Tervaniemi, Janhunen, Kruck, Putkinen & Huotilainen, 2016; Geethanjali, Adalarasu & Rajsekaran, 2012; Vuust, Brattico, Seppänen, Näätänen & Tervaniemi, 2012). It is difficult to trace any study that used Ghanaian traditional music (African music) as used in this study to investigate music engagement. Though the current research shows significant differences in the responses to the mentioned Ghanaian traditional music, there is the need to investigate other traditional music as used in the method of the current study in order to find out was changes that are likely to be generated. Another research question emerging from the findings is: is there any significant difference in brain response between familiar music genre and unfamiliar music genre? This is another possible variable that requires further examination.

In this study active music listening engagement was adopted. This has also raised other questions: will there be any significant difference in brain response to music with the engagement of passive music listening? Do active listening and passive listening to the same music have similar brain response or that there are differences? These questions are relevant and need to be investigated.

Stimulative and sedative music are two major types of music that have been categorised by musicologists. Stimulative music is a type of music that is characterised by fast tempos. Stimulative music also has loud volume and invigorating rhythmic structures (Jiang, Zhou, Rickson & Jiang, 2013). Sedative music mostly has the opposite characteristics of stimulative music. Sedative music is slow, soft and has little rhythmic characteristics (Jiang, Zhou, Rickson & Jiang, 2013; Radocy & Boyle, 2003). These characteristic differences also raise another question: is there any significant difference in brain response to music between stimulative and sedative music? It will be a worthwhile effort to investigate this question. In this regard, Ghanaian traditional music, for example, can be sampled and categorised into sedative and stimulative and used as variable for the study.

In summary, the study investigated brain response to music among children to indicate that there are significant differences in musical participation engagement when compared to non - musical engagement. One of the major recommendations is that a different control condition be used than the non – music that was adopted in the current study for further investigation. Furthermore, since a specific Ghanaian traditional music was used in the current study, another musical genre was suggested for further investigation. Also, a critical look at the method adopted in the current study suggests that a different instrument such as fMRI be employed for future investigation. In all, some of the findings and results computed and analysed in this study were in congruent with available literature while some were in contrary to recommend that there is the need for future investigation on the observations.

Moreover, since the investigation in the current study did not explore all the stages of brain development as discussed in the theoretical framework (Casey *et al.*, 2005), it is recommended that future investigations should explore the other brain stages with music participation engagement. Other stage of brain stages that were not examined in this study include neurulation and brain proliferation.

Finally, since music educators, music scholars and other neuromusical researchers hope that conducting of brain based investigations can uncover strategies that will allow humans to learn music more efficiently (Miller, 20011; Flohr, Miller & DeBeus, 2000).

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APPENDICES

Appendix A: UCC Primary School

Appendix B: Distributions of Sample Population in Age

	Frequency	Per cent	Valid Percent
Seven	8	8.0	8.0
Eight	17	17.0	17.0
Nine	12	12.0	12.0
Ten	13	13.0	13.0
Eleven	5	5.0	5.0
Twelve	21	21.0	21.0
Thirteen	6	6.0	6.0
Fourteen	8	8.0	8.0
Fifteen	6	6.0	6.0
Sixteen	4	4.0	4.0
Total	100	100.0	100.0

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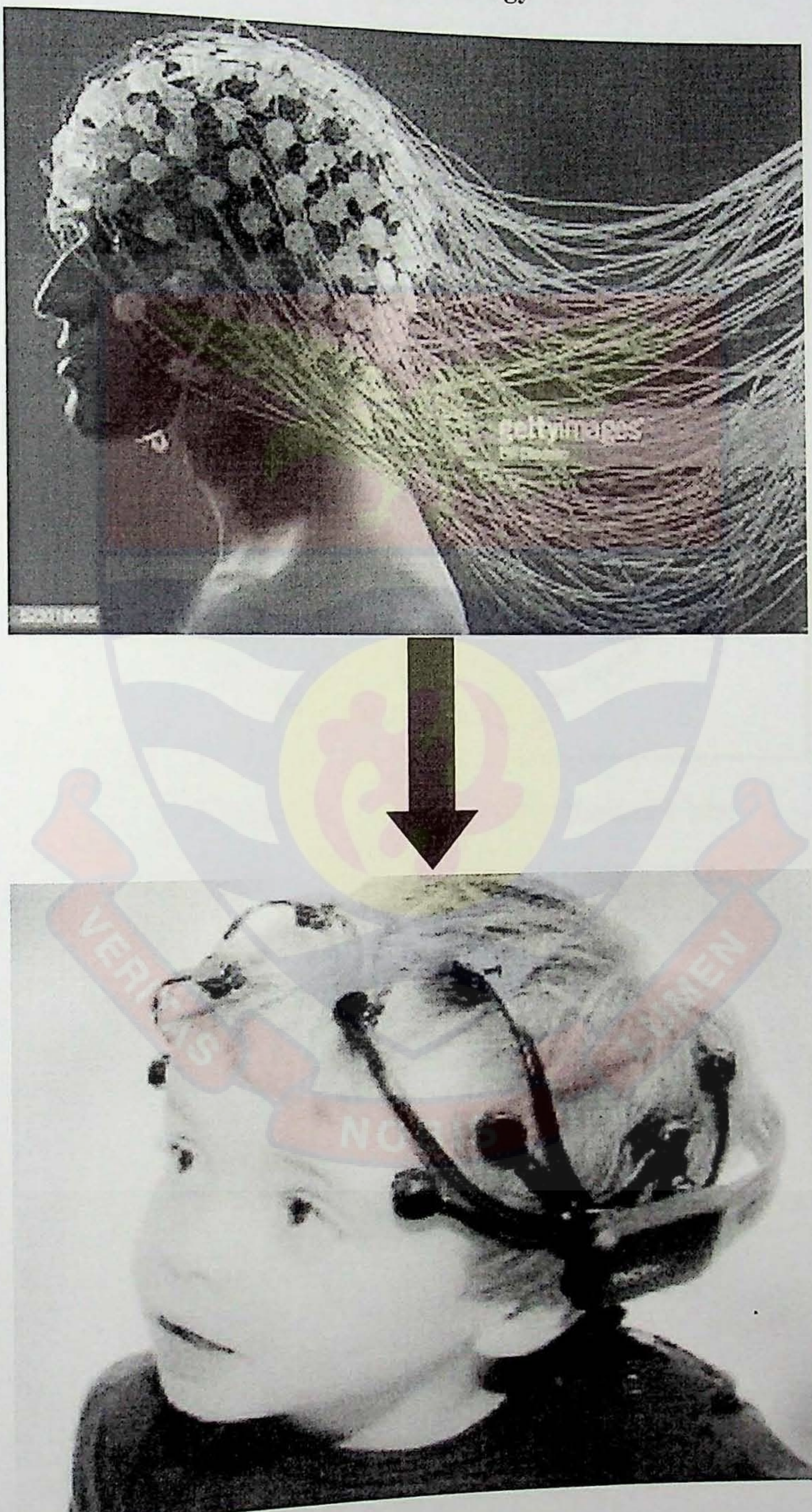
Appendix C: Handing over of Instrument for data collection

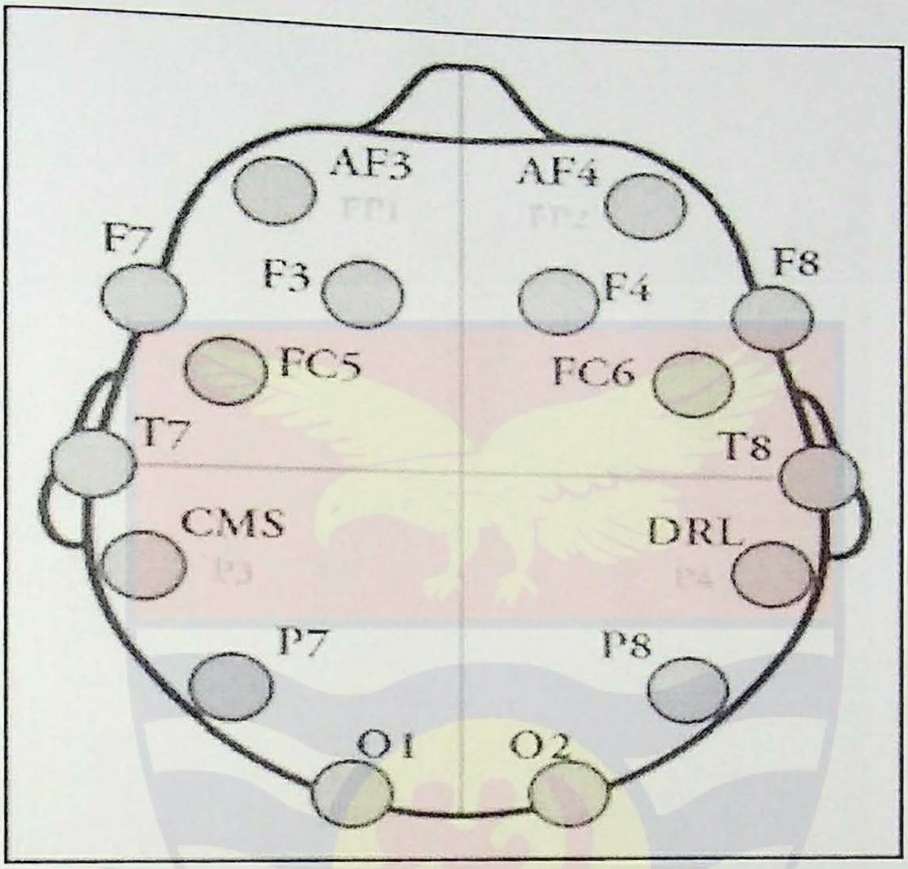
Appendix D: EmotivEPOC+ for Data Collection

Appendix E: Trail of the New EmotivEPOC+ before Data Collection

Appendix F: Modernisation of Laboratory EEG to EmotivEPOC+ Technology



Appendix G: Chart for the 14 Channel EmotivEPOC+ Sensors with 2 Reference Sensors



AF3 = Frontal lobe

AF4 = Frontal lobe

F3 = Parietal lobe

F4 = Parietal lobe

F7 = Temporal lobe

F8 = Temporal lobe

FC5 = Parietal lobe

FC6 = Parietal lobe

CMS = Temporal lobe

DRL = Temporal lobe

T7 = Temporal lobe

T8 = Temporal lobe

P7 = Occipital lobe

P8 = Occipital lobe

O1 = Cerebellum

O2 = Cerebellum

Appendix H: Auditing Neuroscience Model Course

Appendix I: A Respondent Wearing EmotivEPOC+

Appendix J: A Respondent Participating in Music Listening Activity

Appendix L: Diagram of Brain Lobes as Investigated in this Study