THE BRAIN SYMPHONY FOR POST-STROKE REHABILITATION – A PILOT RANDOMISED CONTROLLED STUDY WITH P.RAMLEE SONGS

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ABSTRACT

The interaction between music and the brain involves a complex process, triggering a large network of neurons that includes motor actions, perceptions, and emotions; each part working to process the different aspects of the tune. In terms of the motor areas in the brain, studies revealed that processing music pulses intertwines closely with movement. This research investigates how much effect music has to the brain, in terms of neuroplasticity (where nerve cells adapt to compensate any damage to the brain), especially amongst stroke survivors. The research was conducted in two phases: 1) songs selection process, and 2) medical procedure, in the Department of Rehabilitation University Malaya Medical Centre (UMMC). In the first phase, surveys were conducted to determine the spectrum of popular local songs for subjects aged 55 years old and above, and a playlist of these songs to be played in the second phase. It was discovered that the songs that almost every subject is familiar with and enjoyed are by P. Ramlee. A list of his music was selected to be used for this experiment to test if his songs could have an effect to the subjects. The second phase is an experimental design using music listening on a small sample of 20 subjects aged 55 years old and above and were sorted into stroke survivors and healthy individuals. The subjects were further randomized into two groups: Control group (without music) and Experimental group (with music). The second phase is divided into three stages: Stage one is to pre-screen and select potential subjects before the experiment. The second stage seeks to find the effect of the music selected in phase one on stroke survivors through augmenting the subjects' brain neuroplasticity through measurement of the mean evoke potential (MEP) using Transcranial Magnetic Stimulation (TMS), and the final stage compares the effects of brain neuroplasticity between lesion and non-lesion areas in the patients. The assessment showed that P.Ramlee's music does enable brain neuroplasticity. This

proves a potential in using music as an adjuvant healing tool for cognitive clinical settings like stroke.

ABSTRAK

Interaksi antara muzik dan otak melibatkan proses yang kompleks, mencetuskan respon kumpulan besar neuron yang meliputi aksi motor, persepsi dan emosi; setiap bahagian berfungsi untuk memproses aspek berlainan dalam nada. Dari segi sistem motor dalam otak, kajian menunjukkan bahawa pemprosesan nadi muzik berkaitan rapat dengan pergerakan. Kajian ini bertujuan mengkaji keberkesanan muzik terhadap otak, dari segi neuroplastisiti (di mana sel saraf disesuaikan untuk memulihkan kerosakan pada otak), terutamanya antara pesakit strok. Kajian ini telah dilaksanakan dalam dua fasa : 1) proses pemilihan lagu, dan 2) prosedur perubatan, di Jabatan Rehabilitasi Pusat Perubatan Universiti Malaya (PPUM). Dalam fasa pertama, kaji selidik telah dijalankan untuk menentukan spektrum lagu popular tempatan di kalangan subjek berumur 55 tahun dan ke atas, dan juga senarai lagu yang akan dimainkan di fasa kedua. Didapati bahawa lagu ciptaan P. Ramlee paling dikenali dan digemari oleh majoriti subjek. Satu senarai lagu P. Ramlee telah dipilih untuk menguji keberkesanan ke atas subjek dalam eksperimen ini. Fasa kedua merupakan satu reka bentuk eksperimental yang menggunakan pendengaran muzik ke atas sampel kajian seramai 20 subjek berumur 55 tahun dan ke atas, yang dikategorikan kepada bekas pesakit strok dan individu yang sihat. Seterusnya, subjek-subjek ini dikategorikan lagi kepada dua kumpulan: kumpulan kawalan (menggunakan muzik) dan kumpulan eksperimental (tidak menggunakan muzik). Fasa kedua dibahagikan kepada tiga tahap: Tahap pertama adalah untuk pra-saring dan pemilihan subjek berpotensi sebelum eksperimen. Tahap kedua meneroka kesan muzik yang dipilih dalam fasa pertama ke atas bekas pesakit strok melalui penambahan neuroplastisiti otak pesakit melalui pengukuran *mean evoke potential (MEP)* menggunakan stimulasi magnetik transkranial (TMS), dan fasa terakhir merupakan perbandingan kesan neuroplastisiti otak antara kawasan luka dan tidak luka pesakit. Keputusan menunjukkan bahawa muzik ciptaan P. Ramlee mendorong

neuroplastisiti otak. Ini membuktikan potensi penggunaan muzik sebagai alat perubatan yang penting dalam bidang klinikal kognitif seperti strok.

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TABLE OF CONTENTS

CHAPTER 3: METHODOLOGY

CHAPTER 5: DISCUSSION & CONCLUSION

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ADHD	:	Attention Deficit Hyperactivity Disorder
AOS	:	Apraxia of Speech
BAMT	:	British Association for Music Therapy
BBT	:	Box and Block Test
CAMT	:	Canadian Association for Music Therapy
CG	:	Mute Music Group
CP	:	Cerebral Palsy
CVA	:	Cerebrovascular Accident
ECRB	:	Extensor Carpi Radialis Brevis
EEG	:	Electroencephalogram
EMG	:	Electromyography
F	:	Female
FDI	:	First Dorsal Interosseus
fMRI	:	Functional Magnetic Resonance Imaging
GIM	:	Guided Imagery and Music
IMI	:	Intrinsic Motivation Inventory
L	:	Left
LH	:	Left Hemisphere
M	:	Male
MCA	:	Middle Cerebral Artery
MEP	:	Mean Evoke Potential
MG	:	Music Group
MMC	:	Mixed Methods Research
MMR	:	Maxillomandibular Relationship

MMTA	:	Malaysian Music Therapy Association
ms	:	Milliseconds
MSMM	:	Malaysian Society for Music in Medicine
MST	:	Music-supported Therapy
NGO	:	Non-Governmental Organizations
NIBS	:	Non-Invasive Brain Stimulation
NMT	:	Neurological Music Therapy
PBA	:	Pseudo-Bulbar Affect
PD	:	Parkinson's Disease
R	:	Right
RH	:	Right Hemisphere
RMT	:	Resting Motor Threshold
rTMS	:	Repetitive Transcranial Magnetic Stimulation
TIA	:	Transient Ischemic Attack
TMS	:	Transcranial Magnetic Stimulation
uV	:	Microvolts
VP	:	Ventriculoperitoneal
WFMT	:	World Federation of Music Therapy

GLOSSARY

- **Attention-deficit/hyperactivity disorder (ADHD)**. is a brain disorder marked by an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development.

- **Aphasia.** An impairment of language, affecting the production or comprehension of speech and the ability to read or write. Aphasia is always due to injury to the brain-most commonly from a stroke, particularly in older individuals. But brain injuries resulting in aphasia may also arise from head trauma, from brain tumors, or from infections.

- **Apraxia of Speech (AOS).** An impaired ability to perform speech movements. It is differentiated from dysarthrias in that it is not due to problems in strength, speed, and coordination of the articulatory musculature. The primary behavioral characteristics of AOS are slowed speech, abnormal prosody, distortions of speech sounds such as sound substitutions and highly inconsistent errors. Individuals with AOS often appear to be groping for the right way to position their mouth, tongue and lips (articulators) when producing words and sounds.

- **Axon.** The lengthy thin straight structure that is part of the neuron body (soma) that conducts nerve impulses away from the cell body to the neuron's terminal buttons.

- **Box and Block Test (BBT).** The Box and Block Test (BBT) measures unilateral gross manual dexterity. It is a quick, simple and inexpensive test. It can be used with a wide range of populations, including clients with stroke.

- **Brain neuroplasticity.** The brain's ability to reorganize itself by forming new neural connections throughout life. Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment.

- **Cerebrovascular Accident (CVA) -** is the medical term for a stroke. A stroke is when blood flow to a part of your brain is stopped either by a blockage or the rupture of a blood vessel.

- **Cerebral Palsy (CP).** is a neurological disorder caused by a non-progressive brain injury or malformation that occurs while the child's brain is under development. Cerebral Palsy primarily affects body movement and muscle coordination.

- **Corpus Callosum.** The commissural plate of nerve fibers connecting the two cerebral hemispheres except for most of the temporal lobes. Also called commissure of cerebral hemispheres.
- **Dendrite.** The tree branch-like structures connected to the nerve cell body (soma) that sends and receives information between cells. Can be thought of as the brain's traffic cops routing messages to their desired cell target.

- **Dysphagia.** Difficulty swallowing (dysphagia) means it takes more time and effort to move food or liquid from your mouth to your stomach. Dysphagia may also be associated with pain. In some cases, swallowing may be impossible.

- **Down syndrome**. is a condition in which a child is born with an extra copy of their 21st chromosome. Hence it has other name, trisomy 21. This causes physical and mental developmental delays and disabilities.

- **Electromyography (EMG).** A diagnostic procedure to assess the health of muscles and the nerve cells that control them (motor neurons).

- **Electroencephalogram (EEG).** A test used to evaluate the electrical activity in the brain. Brain cells communicate with each other through electrical impulses. An EEG can be used to help detect potential problems associated with this activity.

- **Epilepsy.** A central nervous system (neurological) disorder in which brain activity becomes abnormal, causing seizures or periods of unusual behavior, sensations, and sometimes loss of awareness.

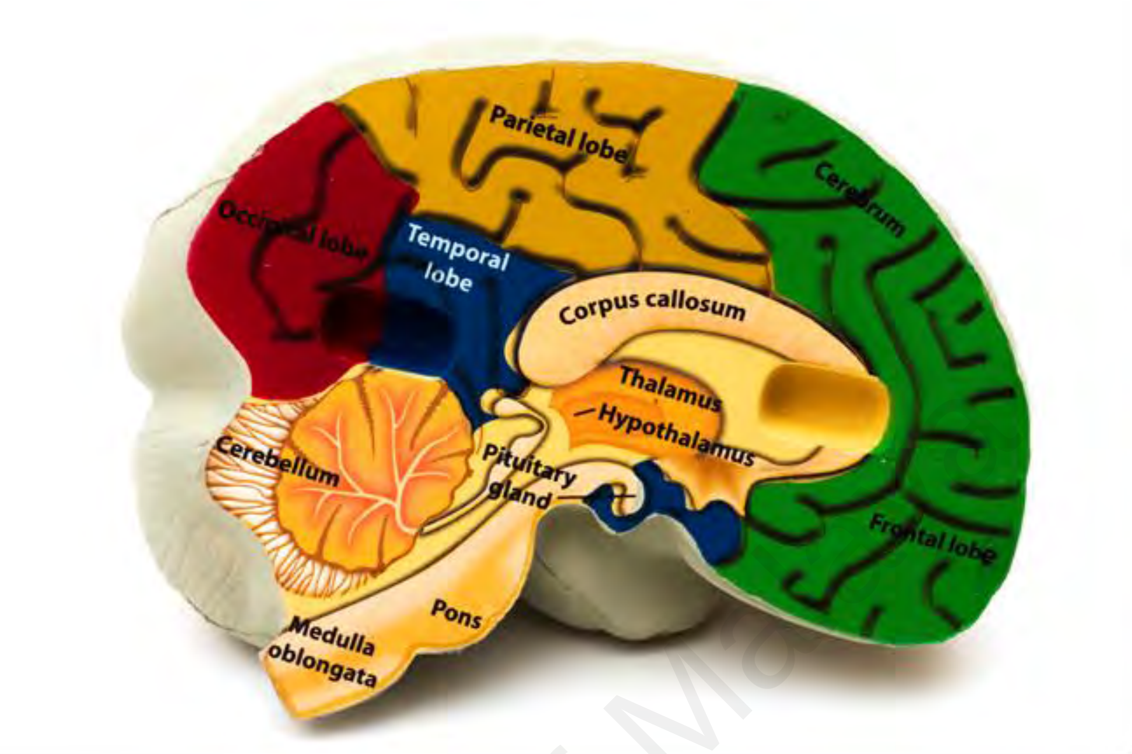
- **Extensor Carpi Radialis Brevis (ECRB).** A muscle in the forearm that acts to extend and abduct the wrist. It is shorter and thicker than its namesake extensor carpi radialis longus (ECRL) which can be found above the proximal end of the ECRB.

- **Frontal Lobe.** Located at the front of the brain stretching roughly from one side of the temple to the other side of the temple. It is the most dopamine-sensitive area of the brain and houses functions like emotions, personality, problem solving, sexual and social behaviour, as well as judgment, language, and problem solving abilities.

- **Functional Magnetic Resonance Imaging (fMRI).** A technique for measuring and mapping brain activity that is non-invasive and safe. It is being used in many studies to better understand how the healthy brain works, and in a growing number of studies it is being applied to understand how that normal function is disrupted in disease.

- **Guided Imagery and Music (GIM).** GIM is a music-assisted therapy used to explore one's own inner world and help clients to work on significant life issues, for instance, disturbing old memories, losses, traumata, bothering health conditions, and relationship issues. While being guided, strong emotions are released and the client finds helpful resolutions.

- **Human Brain.**



The anatomy of the human brain (Healthline Medical Team, 2015).

- ***Temporal Lobe*** - The temporal lobe is located around the ears on both sides of the head and stops just before the rounding of the back of the skull. The temporal lobes house many of the brain's important functions such as auditory interpretation, speech and visual processing, spatial memory as well as short and long-term memory.
- ***Parietal Lobe*** - The parietal lobe is located behind the frontal lobe and above the temporal lobe. The parietal portion of the brain contains the areas that are vital for processing sensory information from different areas of the body, our spatial sense, as well being tied to the functioning of solving mathematic problems, reading and writing processes.
- ***Occipital Lobe*** - The occipital lobe houses the visual cortex of the brain, which contains our visual map of the world we live in.

- ***Cerebral Cortex*** - Is the neural tissue located around the top front portion of the brain. The cerebral cortex is a very important area of the brain and has a vital role in thought, language, memory, attention, and consciousness.
- ***Cerebellum*** - Known as the portion of the brain that helps with control of skeletal muscles and in coordination in voluntary motor skills.
- ***Hippocampus*** - The portion of the brain that is part of the limbic system and located in the medial temporal lobe of the human brain. The hippocampus plays roll in spatial navigation and in establishing new long-term memories.
- ***Medulla*** - The small area at the base of the brain that plays a role in the autonomic functioning of the nervous system. It is responsible for automatic functions of the body below the thought process such as respiration, blood pressure, heart beating, and more.
- ***Thalamus*** - Located in the mid-brain area. The thalamus is responsible for processing of sensory data such as visual and auditory information. It is also involved in consciousness and levels of arousal.
- ***Hypothalamus*** - Portion of the brain that is part of the endocrine system. It is responsible for metabolic processes such as hunger, thirst, body temperature and more. The hypothalamus is also responsible for neuro-hormones that influence the pituitary gland.
- ***Pituitary Gland*** - An incredibly important pea sized organ that protrudes at the base of the hypothalamus, and is located at the base of the brain. It is responsible for regulation of body homeostasis. It does this through secreting hormones that regulate body growth, sexual function, metabolism, blood pressure, temperature, and thyroid gland function.

- ***Pons* -** The Pons serves as a message station between several areas of the brain. It helps relay messages from the cortex and the cerebellum. Without the pons, the brain would not be able to function because messages would not be able to be transmitted, or passed along. It also plays a key role in sleep and dreaming, where REM sleep, or the sleeping state where dreaming is most likely to occur, has been proven to originate here, in the pons.

- **Intrinsic Motivation Inventory (IMI).** The Intrinsic Motivation Inventory (IMI) is a multidimensional measurement device intended to assess participants' subjective experience related to a target activity in laboratory experiments.

- **Maxillomandibular Relationship (MMR).** A critical step to establish the new occlusion in implant supported complete mouth rehabilitation.

- **Mean Evoke Potential (MEP).** Single or repetitive-pulse stimulation of the brain causes the spinal cord and peripheral muscles to produce neuroelectrical signals known as motor evoked potentials (MEPs). Clinical uses of MEPs include as a tool for the diagnosis and evaluation of multiple sclerosis and as a prognostic indicator for stroke motor recovery.

- **Middle Cerebral Artery (MCA).** The largest of the three major arteries that channels fresh blood to the brain. It branches off the internal carotid artery. It supplies blood to lateral (side) areas of the frontal, temporal, and parietal lobes. The frontal, temporal, and parietal lobes control the sensory functions of the arms, throat, hands, and face.

- **Motor Threshold (MT).** MT is a patient specific value for each subject or patient which is demined before the TMS session. When a magnetic coil is discharged over the motor cortex and the discharge energy is over threshold value neurons are activated and the targeted muscles might twitch.

- **Neuron**. A neuron is the functioning cell unit in the nervous system that is also known as a nerve cell. Neurons are responsible for sending impulse messages to other neural cells. Impulse messages in a neuron are sent via the release of neurotransmitters. The neuron's cell body is called the soma. The neuron cell consists of 3 main sections a soma, axon, dendrite.

- **Non-Invasive Brain Stimulation (NIBS).** A new therapy involving delivery of a weak electrical current through the skull and into the brain while images of the body schema in movement are displayed.

- **Pacemakers.** A medical device that generates electrical impulses delivered by electrodes to contract the heart muscles and regulate the electrical conduction system of the heart.

- **Polytherapy.** Therapy with two or more drugs used at the same time to treat a condition. The term is used most often to describe treatment of seizure disorders with more than one drug; however, it is also used to describe multidrug therapy in Parkinson's disease, schizophrenia, and other brain diseases.

- **Pseudo-Bulbar Affect (PBA).** A condition that causes uncontrollable crying and/or laughing that happens suddenly and frequently. It can happen in people with a brain injury or certain neurologic conditions.

- **Psychotherapy.** A way to help people with a broad variety of mental illnesses and emotional difficulties. Psychotherapy can help eliminate or control troubling symptoms so a person can function better and can increase well-being and healing.

- **Repetitive Transcranial Magnetic Stimulation (rTMS).** A non-invasive and relatively painless tool that has been used to study various cognitive functions as well as to understand the brain–behavior relationship in normal individuals as well as in those with various neuropsychiatric disorders.

- **Rhythmic Auditory Stimulation.** Technique by which a series of auditory stimuli are presented at a fixed rhythm, so that patients have to synchronize their movements to the rhythms. Learn more in: The Role of Sensory Rhythmic Stimulation on Motor Rehabilitation in Parkinson's Disease (PD)

- **Synapse**. The structural space between neurons in the nervous system that is the conduit for a neuron to send a chemical message signal to the targeted neural cell. A synapse is also known as the terminal button. Once a message is received at the postsynaptic cell an electrical message is released and passes through the adjoining neuron to the next presynaptic cell that releases another chemical message. The process will repeat itself until the message reaches it desired target. The word synapse is Greek in origin and means point of contact.

- **Spasticity.** A condition in which certain muscles are continuously contracted. This contraction causes stiffness or tightness of the muscles and can interfere with normal movement, speech and gait. Spasticity is usually caused by damage to the portion of the brain or spinal cord that controls voluntary movement. The damage causes a change in the balance of signals between the nervous system and the muscles. This imbalance leads to increased activity in the muscles.

- **Ventriculoperitoneal Shunt.** A ventriculoperitoneal (VP) shunt is a medical device that relieves pressure on the brain caused by fluid accumulation.

- **Vertigo.** A sense of rotation, rocking, or the world spinning, experienced even when someone is perfectly still.

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Music is a mix of rhythmical, harmonic and melodic sounds that engages with the minds of listeners in all levels. It brings in representations of passions and fears, and emotions relating to experiences which encourages potential therapeutic opportunities. Throughout history, many people have believed in the power of music that affects each person differently. In fact, it is found that music stimulates more parts of the brain than any other activity does (Mannes, 2013). With such potential, music has often been used therapeutically and there are plenty examples across different cultures of music's curative and preventative powers (Gaynor, 2002).

The idea of using music as a healing tool has gone through some shifts, with research in music moving from social science towards therapeutic medicine. It uses an interesting approach whereby the therapist aids the patients in improving their health by applying the musical experiences that they have and the relationships that develop through them. The process is considered multidisciplinary whereby one uses music as the main element of work (Hanser, 1999; Mcintosh, Brown, Rice & Thaut, 1997). It has shown to be beneficial to people of all ages from children to adults, and the elderly. It helps those with the conditions concerning the brain such as mental health needs, developmental and learning disabilities, Alzheimer's disease and other aging related conditions. Therapy with music is also part of the rehabilitation programs for those with brain injuries, stroke, physical disabilities, substance abuse problems, and acute and chronic pain like mothers in labour (American Music Therapy Association, n.d.).

Stroke is one of the most significant cause of acquired disabilities in adults (Grau-Sánchez et al., 2013). In 2010, the worldwide prevalence of stroke was 33 million, with 16.9 million people. having a first stroke (Benjamin et al., 2017). From the 2011 report on stroke statistics from American Heart Association, it is estimated that 15 million people are affected with stroke (Mackay & Mensah, 2004), and 5 million of these people ended up having significant disabilities (Rosamond et al., 2007). In Malaysia itself, stroke is among the top 10 causes for hospital admission, with an average mortality age of 80-years-old. (World Health Organisation, 2017). Meanwhile, stroke survivors are left with substantial disabilities which affect their motor, gait, sensory, speech, memory and cognition function. These disabilities have prominent mortality and morbidity among stroke survivors, increasing risks of mood disorder such as depression, anxiety and pseudo-bulbar affect (PBA); which is why therapy given in rehabilitation for post-stroke survivors is the most important phase of recovery (Caswell, 2014).

The usual rehabilitation treatment process utilises a range of traditional therapeutic interventions in their therapy programs to support and improve neurological and functional recovery. Through intensive research and technological improvements on therapies and medications, many experimental treatments have shown benefit to post-stroke survivors. In recent years, research has shown that the adult brain has the capability to reorganise itself by means of stimulation, learning and injury through process known as neuroplasticity (Xu et al., 2015). Neuroplasticity allows the neurons (nerve cells) in the brain to compensate for injury and disease and to adjust their activities in response to new situations or to changes in their environment (Goldstein, 2016). This new emerging concept has proven to be the influential cause for stroke survivors to regain their motor and gait function. It has been verified both in animal models as well as human (Clarkson, Huang, MacIsaac, Mody, & Carmichael, 2010; Karabanov et al., 2013). For example, Grau-Sánchez et al. (2013) found that music-supported therapy (MST) for stroke survivors help to improve their motor cortex. Prior to and after the MST (one-month intense music learning), different behavioral motor tests were used to evaluate these patients.

One of the ways used to assess brain neuroplasticity is the Transcranial Magnetic Stimulation (TMS). It is part of the non-invasive brain stimulation (NIBS) techniques used to test and enhance the recovery of function after stroke. Promising results have been reported with the stimulation modalities in the United States of America (Hummel et al., 2005). TMS of the motor cortex leads to a twitch in the targeted muscle evoking motor-evoked potential (MEP) on electromyograms (EMG). This MEP is used to assess and measure the cortical excitability. As TMS could easily record the MEP with surface electrodes, it becomes part of the regular routine in clinical neurophysiology when assessing the functional integrity of corticospinal and corticobulbar motor pathways neurological disorders like stroke (Rossini and Rossi, 2007). The TMS analysis on the changes in the sensorimotor representations underlying the motor gains observed showed that the patients "obtained significant motor improvements in the paretic hand" along with "changes in the excitability of the motor cortex". This interesting fact showed that TMS works by activating the damaged part of the brain. It is therefore important to extend these investigations to the human brain and music as a therapeutic tool.

Besides that, Jäncke (2009) proved that learning to play new instruments improve structural and functional changes to the brain, hence improving the neuroplasticity of the brain. However, for post-stroke survivors, learning new instruments can be a hard task to complete due to their disabilities that they acquired as well as their motivation to learn new skills. On the other hand, music listening would be a lesser burden. It is as complex as learning an instrument at brain level (Koelsch, 2009). Similarly, it requires wide spread bilateral brain network that includes semantic processing, attention, memory, motor functions as well as emotional processing (Särkämö et al., 2008). From a neuroscience perspective, listening to music engages subcortical and cortical areas of the brain, including the left and right primary auditory cortex, the amygdala, and the medial. geniculate body. in the thalamus (Yinger & Gooding, 2014). However, there is a lack of careful, controlled studies that explore the relation between music rehabilitation for post-stroke survivors with its ability in enhancing brain neuroplasticity in affected patients, which I will elaborate more in Chapter Three. Figure 1.1 shows how the brain processes the complex frequencies of music.

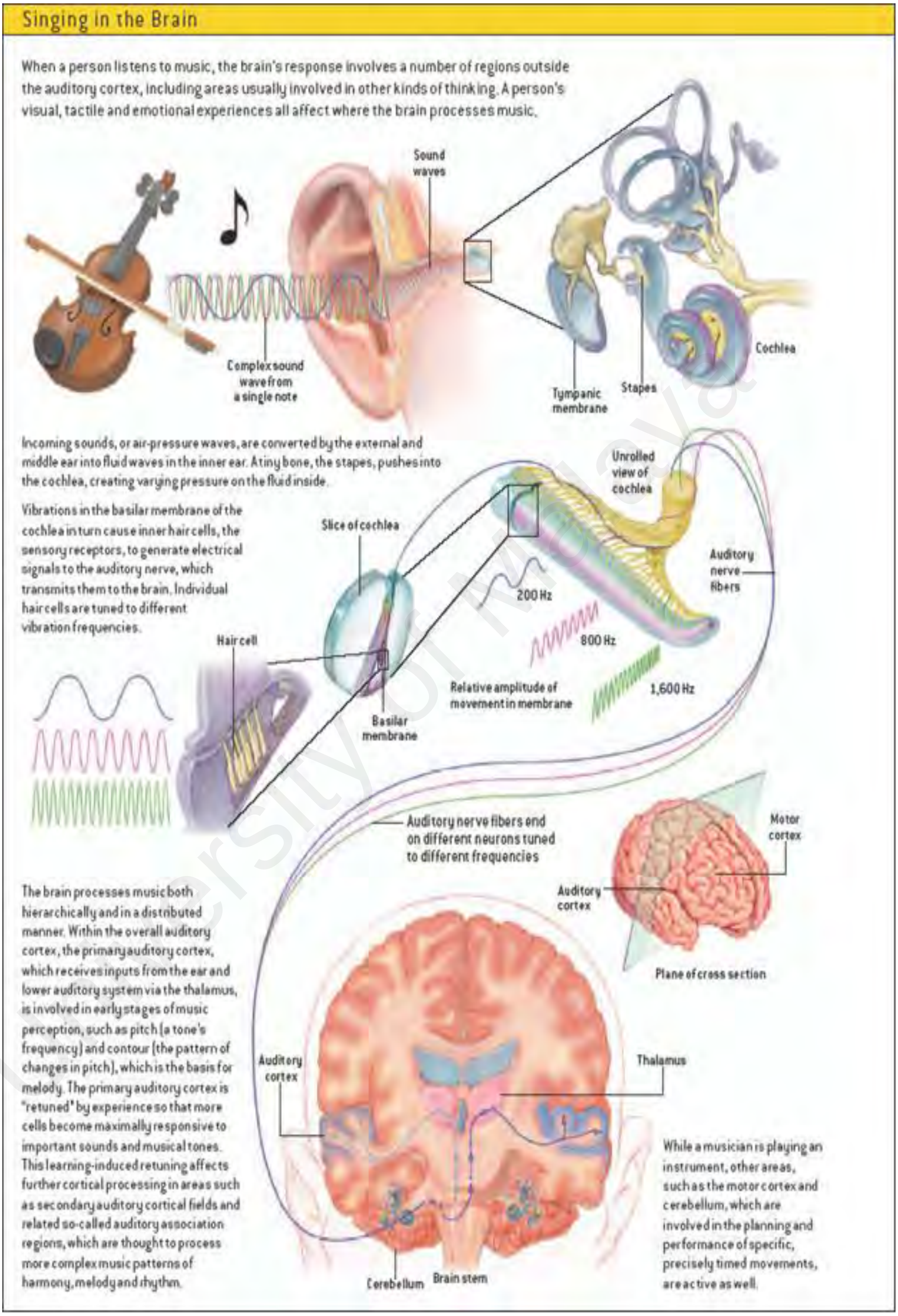


Figure 1.1: How music travels to the brain (Weinberger, 2006).

When music is being played, different parts of the brain react in a hierarchical progression. The process starts with the brain's primary auditory cortex receiving sound waves through the eardrum or inner ear which immediately activates the cerebellum. The cerebellum is the oldest part of the brain in evolutionarily terms which plays an important part in motor control. This is the area where precision, coordination, and accurate timing of movements is controlled. Both the ear and the cerebellum are known as low-level processing units because they perform the main feature extraction, allowing the brain to analyse sounds. The brain breaks down the sensory stimulus into timbre, pitch, amplitude, spatial location, tone durations, reverberant environment, and onset times of different notes. The breakdown is conducted through the brain neurons. These cells are specialized in transmitting information and the basic building blocks of the nervous system. After doing the breakdown, the neurons then connect the output to the high-level processing units located in the frontal lobe of the brain.

After breaking down the initial sensory stimulus, the cerebellum passes the signal to the thalamus. Similar to analyzing other sounds, the thalamus scans the signals through communication with the hippocampus, the brain's memory center, for stored historical sounds. At the same time, the thalamus links to the amygdala to initiate an emotional response (e.g. happiness, sadness and surprise) similar to the way the amygdala perceives how one feels when in danger without truly feeling them. This interaction is the same for the low-level and high-level processing units, letting the brain categorize music and evoke the appropriate emotional response.

The brain process of music shows that the brain nerves are stimulated to bring the pulses of brain waves created through the ear. At the same time, the nerves involving body motor control is exercised with the cerebellum being involved in breaking analyzing and breaking down the music to sensory stimulus. This complex procedure brings in many possibilities in better understanding the way our brains works and pave the way for medical applications, and at the same time, extend the benefits of music beyond just for enjoyment. Such applications are already moving up in the field of music therapy, using music to treat neurological issues that range from Parkinson's disease to Alzheimer's disease. As research continues, we can look forward to greater knowledge on how music can help build better therapeutic advancements in medicine. Figure 1.1 is an example that shows how music travels to the brain which studied and research by Weinberger (2006).

In the last three decades, there has been a significant increase in number of prospective, randomised studies that evaluates the clinical benefits of music where it is used as an alternative tool in the medical field. This spread of scientific research in the field of clinical music rehabilitation has generated significant levels of evidence which suggests that music has the ability to provide significant benefits to a wide variety of clinical settings as an adjuvant therapeutic tool (Mattei & Rodriguez, 2013). In the setting of a stroke, there are significant long-term effects to the brain functions where the brain cells were damaged during the event. Hence, post-stroke rehabilitation programs are to minimize the after-stroke effects, boost recovery, enhance the neuroplasticity effects, strengthen their independence, optimize psychosocial outcomes, help improve the quality of life and improving the patients' health physically and psychologically. Among the activities promoted, music is often recommended to help stimulate the brain and work on motor recovery. Therefore, this study aims to investigate the effect of music in the brain to stroke survivors.

1.2 Research Question

The research questions of this research are listed below:

(a) What local music is suited/appropriate to every Malaysian taste?

(b) How much effect can music do to the brain?

(c) Is there any difference in the TMS measurement of neuroplasticity between lesion and non-lesion hemispheres on stroke survivors after listening to music?

(d) Is there a difference to brain neuroplasticity in healthy individuals and stroke patients after listening to music?

1.3 Research Objectives

The research objectives of this research are listed below:

(a) To determine the preferred local songs that can be used

(b) To evaluate the effect of music to the brain through measurement of Motor Evoke Potential (MEP).

(c) To measure the neuroplasticity difference between lesion vs non-lesion sites in stroke survivors.

(d) To compare the difference of brain neuroplasticity after listening to music between healthy individuals and stroke survivors.

1.4 Problem Statement

Music has played an important part in every culture, even in ancient times until this present age. All over the world, each person has their own experience in response to music (Andrews, 1997). We are all familiar with how certain music can influence and change the mood, motivate and push you, or help you concentrate. Advances in technology has improved the neuroscience field, helping researchers measure the effect music has to the brain (Zatorre, Chen, & Penhune, 2007). Through these measurements, research showed that musicians tend to have a noticeably symmetrical brain as compared to normal people (Musacchia, Sams, Skoe, & Kraus, 2007). The audiovisual processing of speech and music, and subcortical auditory were enhanced. The corpus callosum, a band of nerve fibers that transmit neural messages between the two hemispheres of the brain, is also larger than a non-musician. Not only that, the parts of the brain that are responsible for auditory processing, motor control, and spatial coordination are found to be larger (Firszt, Ulmer, & Gaggl, 2006). However, for post-stroke survivors, learning new instruments for their rehabilitation process might be difficult due to their disabilities. In addition, the patient would need to have motivation, interest and discipline as it will slow the process to master an instrument. Daniel Abrams, a postdoctoral researcher at Stanford University School of Medicine, stated that when listening to music, the brain regions involving with attention, movement, planning and memory are always active; even though these structures are not related with auditory processing itself (Landau, 2016; Brewer, 2015). This means that the brain functions are not reduced to only the auditory areas of the brain when listening to music, but a large-scale network of neurons that includes prefrontal cortex, auditory cortex, motor cortex, visual cortex, sensory cortex, corpus callosum, amygdala, cerebellum, hippocampus, nucleus accumbens, autonomic nervous system, vestibular system, and the enteric nervous system (Landau, 2016). In a short, the complexity of the stimulus elicited with music to the brain along with the extent of outcome to their exposure to this stimulus shows that music listening is as complex as learning its instrument at brain activity. However, listening to music can improve and enhance the neuroplasticity of the brain. In order to explore this possibility, this study will thus examine the effects of music they familiar with on stroke survivors during the rehabilitation process.

1.5 Limitations of the Study

There are a few limitations to this study. First of all, the neuroplasticity effects of the subjects in this research vary from patient to patient due to their previous neuroplasticity effects after their responses to the TMS procedure. For example, a person who undergoes this procedure for the first time may have a different response as compared to a patient who has gone through the procedure several times. Therefore, the researcher tries to avoid choosing patients who have undergone regular TMS treatment. Secondly, every participant would have a different medical history and demographic background, and this may cause MEP reading to be a variable in the experiment. To minimize discrepancies, the research will select the potential patient based on the inclusion and exclusion criteria set. Finally, the environmental setting of this study is also considered a limitation as the presence of nurses and doctors during the procedure may affect the participant. Thus, the number of people was limited to only three people (the doctor-medical supervisor, the researcher and a nurse). Likewise, background noises and the condition of the treatment room were beyond the control of the researcher although all efforts were taken to ensure that noises were kept to a minimal.

1.6 Significance of Research

Many studies have encouraged the use of music as part of traditional post-stroke medical treatment. However even with evidence of the influence of music to the brain, there has not been sufficient scientific research to support the genre of music applied in rehabilitation for patients following a stroke in Malaysia. My research on using local music (i.e. P.Ramlee music) combines the use of non-invasive technique, TMS, on post-stroke rehabilitation that would bring in knowledge in this field to aid in establishing the benefits of music for patients' post-stroke situation and assists in treatment with music as a form of alternative therapy for individuals. Furthermore, TMS is currently gradually entering the arena of clinical rehabilitation with several years as a research tool in assisting therapy. In the following review, we will examine the current knowledge concerning post-stroke recovery, including contributions regarding the lesion and non-lesion hemispheres. Therefore, it is anticipated that this project would generate a great deal of interest and provide new perspectives on clinical approach, not only among stroke survivors, but also among the public and medical staff.

1.7 Project Timeline

Calendar Months:	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	22-24
Conceptual Phase												
1. Problem Statement												
2. Literature Review												
3.Clinical Fieldwork												
4.Theoritical Framework												
5. Formulating Hypotheses												
Design Planning Phase												
6. Research Design												
7. Research Protocol												
8. Population Specifications												
9. Sampling Plan												
10. Data Collection Plan												
11. Ethics Procedures												
Empirical Phase												
12. Collecting of Data												
13. Data Preparation												
Analysis Phase												
14. Data Analysis												
15. Interpretation of Results												
Dissemination Phase												
16. Presentation Reports												
17. Utilization of Findings												

This project was divided into five main phases, starting from the conceptual phase, design planning phase, empirical phase, and all the way to analysis phase and dissemination. The first conceptual phase consisted of problem statement, literature review, clinical fieldwork, theoretical framework and formulation hypotheses. Firstly, researcher worked closely with the music supervisor and medical supervisor to develop the conceptual framework for this research. Next, researcher conducted a thorough, continuous literature review to identify gaps in knowledge and experts in the field. *Project time: 4 months*

During the design-planning phase, researcher further developed research design in music and medical procedure, research protocol, population specifications, sampling plan, data collection plan and ethics procedure. After completion of draft proposal, researcher submitted an online application for human ethics to UMMC Medical Research Ethics Committee (MREC) for review. *Project time: 4 months*

After obtained the human ethics approval from MERC, the third phase of the research, which is the empirical phase, began, and data preparation and collection commenced. Researcher spent a total six months on the Department of Rehabilitation, University Malaya Medical Centre (UMMC) in order to obtain information about music preferences and selection of music, recruit potential sample subjects, perform the TMS procedure, collecting and organizing data. *Project time: 6 months*

After the completion of field work, the analysis phase is carried out. Data collected is analysed and the results interpreted. Researcher transcribed, coded, and analysed the data collected from the field work. The project supervisor is consulted in regard to the data interpretation and discussion. In between, the research literature regarding the role of music within music therapy, stroke, rehabilitation, neuroplasticity and P.Ramlee music continued being reviewed to ensure the content covers the relevant details. *Project time: 4 months*

The final phase (dissemination phase) consisted of presentation of reports and utilization of findings. The researcher submitted the Final draft of the thesis and await for the candidature defense. In order to utilize and share the findings of this research, the researcher will be presenting this study in the 10th WORLD CONGRESS FOR NEUROREHABILITATION Researcher will continue to work on researching the effect of music as a form of therapy to advance knowledge in order to contribute to better alternative treatments. *Project time: 6 months*

1.8 Research Methodology

This study uses mixed methods where the approach mainly adapts quantitative research and a minor in the qualitative approach with the aim to provide a better understanding of this research purposes and problems. The research first evaluated the comprehensive literature review regarding the effect of music in post-stroke rehabilitation to identify gaps in knowledge in order to categorise theories, issues, and problems in clinical practice into guiding questions. After that, experimental research designs are applied to collecting data according to medical research ethics (informed consent, assessment of risk and benefit, and participant selection) to ensure that there is due regard to existing laws, regulations and community attitudes. Data was analysed using the non-parametric test to avoid and minimize potential confounding factors. In the final part, the results and analysis were interpreted and disseminated in conferences and journals in order to fully utilise the findings. A detailed research methodology is further explained in Chapter 3.

1.9 Structure of Thesis

This section describes the effect of music in post-stroke rehabilitation which will be analysed and interpreted in terms of content and analysis. It will take the following five chapters. The five chapters include:

Chapter One is an overview of the main points of the thesis, consists of 'Introduction', 'Research Objectives', 'Research Questions', 'Problem Statement', 'Limitations of the Study', 'Significance of Research', 'Project Timeline', Research Methodology', 'Structure of the Thesis' and 'Chapter Summary'.

Chapter Two is a literature review on the current knowledge of stroke and the music intervention being used in order to effectively understand this thesis. Which was consists of 'Introduction', 'The development of Music Therapy in Malaysia', 'Defining Music Therapy', 'Clinical Consequences of Stroke', 'Localization of the Stroke', 'The Neuroanatomy of Music', 'Music in the Brain', 'Music and Neuroplasticity', 'Music effect on neurons of post-stroke patients', 'Research on Music in Stroke Rehabilitation', 'Introduction to Music in Malaysia', 'P.Ramlee Music', and 'Chapter Summary'.

Chapter Three is the research methodology which discusses the design of the research from the data collection to the analysis of data. Chapter Three discuss how the study was conducted. The chapter includes 'Introduction', 'Data collection', 'Flow Chart of the music and medical procedure involved in the experiment', 'Phase I : Songs Selection Process', 'Phase II : Medical procedure in Department of Rehabilitation University Malaya Medical Centre (UMMC)', 'Setting of the Experiment', 'Research Equipment', 'Subjects (Stroke Survivors & Healthy Individuals)', 'Research Measurement Instrument', 'Data analysis' and 'Chapter Summary'.

Chapter Four report the findings and present them in a systematic manner. This chapter will consist of 'Introduction', 'Statistical Raw Data', 'Descriptive Table', 'Comparison between Pre-test and Post-test' and 'Chapter Summary'.

Chapter Five is the final chapter of the thesis which consists of discussion and conclusion. The discussion will consist of argumentation and the conclusion will answer the research question. The chapter includes 'Introduction', 'Discussion', 'Conclusion', 'Significance and Clinical Applications', 'Recommendation for Future Research' and 'Chapter Summary'.

1.10 Chapter Summary

The use of music for stroke rehabilitation is not a new knowledge. Sadly, in Malaysia, this idea has yet to be implemented in therapy programs to aid stroke survivors in their recuperation. In the light of this issue, this research seeks to prove the effect of music to stroke survivors, using a specific type of music that could boost their rehabilitation. In addition to that, this study also investigated the difference of neuroplasticity for lesion and non-lesion sites in the brain for stroke survivors, comparing the quality found with those of healthy individuals. The researcher has presented the research questions, the problem statement and its limitations, as well as the significance of this investigation. Lastly, the project timeline is presented followed by a brief explanation of the research methodology.

In the next chapter, the review of literature begins with the definition of music therapy and the development of music therapy in Malaysia. Following that, a brief explanation of what stroke is and the parts of brain that would be affected. In addition to that, notes on how the brain processes music along with the brain's neuroplasticity are presented. Finally, previous studies that have been done in the area of music therapy in stroke rehabilitation, focusing on the effect of music, and the introduction to music in Malaysia and literature on P.Ramlee's music are discussed. The foundation for the review of the related literature on the topic of music therapy, neuroplasticity and post-stroke rehabilitation and their relationships were accessed from academic dissertations from both local and international context, reports, academic journals and books.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses the current knowledge of stroke and the effect of music in order to effectively understand this thesis. The purpose of chapter two is to facilitate understanding of a basic review of music therapy in post-stroke rehabilitation, where the use of music as part of a combination of therapies or polytherapy is more effective when compared to using a pharmaceutical approach alone. Besides that, this chapter also elaborates the development of music therapy in Malaysia and an overview on the music used for this research and its singer, P.Ramlee.

The chapter starts off with a definition and the development of music therapy in Malaysia. It moves on to explain what stroke is, and the two main types of stroke, as well as how it affects the brain. Next, it presents on how different parts of the brain react and connect to music. This chapter also talks on the differences in the brains and behaviour of musicians compared with non-musicians, emphasizing on variables that may moderate the relationship between music training and neuroplastic change. The chapter moves on to showing how music can influence the brain and its effect on patients undergoing rehabilitation, which is then followed by explanation about the relationship between music and neuroplasticity, linking it to how music therapy can benefit stroke survivors and the outcome of various researches. The final part of this chapter is the introduction to music in Malaysia and literature on P.Ramlee's music.

2.2 Defining Music Therapy

There are many ways music therapy is defined. It is a therapy based on engagement in musical activities that involves singing, listening, playing instruments or composing music (Merriam Webster, n.d.); it is a complementary therapy that uses music to help improve a person's overall health and well-being, relieving stress, pain, anxiety, and depression caused by a disease (National Cancer Institute, n.d.). There are various perspectives and definition found in therapy associations.

According to the World Federation of Music Therapy (WFMT), music therapy "is the professional use of music and its elements as an intervention… for individuals, groups, families, or communities seeking to optimize their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and wellbeing". The American Music Therapy Association (n.d.) defines music therapy as "clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program". Often, the program is used to "address physical, emotional, cognitive, and social needs of individuals" (American Music Therapy Association, n.d.).

British Association for Music Therapy (BAMT) views using music as therapy as a way to "provide a means of relating within a therapeutic relationship" (British Association for Music Therapy, n.d.). They understand that music plays an important role, stirring feelings and memories that helps people communicate with others. BAMT promotes the use and development of music therapy for children and adults with a wide range of needs. The Australian Music Therapy Association (n.d.) advocates for the value and accessibility of music therapy. They defined music therapy as an active support for people to improve their health, functioning and wellbeing with the assistance from professional therapists. As for the Canadian Association for Music Therapy (CAMT), it is a discipline in where music is used "purposefully within therapeutic relationships to support development, health, and well-being". It is important that this kind of therapy addresses the human needs within cognitive, communicative, emotional, musical, physical, social, and spiritual domains.

In the Malaysian field, the Malaysian Music Therapy Association (MMTA) share the same definition with WFMT, looking at music as an intervention for people who seek to "optimize their quality of life and improve their physical, social, communicative, emotional, intellectual, and spiritual health and wellbeing."

In summary, this section discussed on the meaning of music therapy as explained by six music therapy organization. Generally, it can be defined with using music as a tool to accomplish therapeutic purposes. It is with the support of musical involvement that may increase a person's overall physical rehabilitation and facilitating movement, motivate him or her to participate in the treatment, provide emotional support for clients and their families, and offer an outlet for expressing themselves.

2.3 Development of Music Therapy in Malaysia

Music therapy in Malaysia began in the 1990s with only five music therapists bringing in a form of therapy which uses music as tools to assist people with their recovery from physical ailments, mental health problems, cognitive impairments or depression. They started off being in special education, serving children with special needs – particularly those with cerebral palsy, autism, Down Syndrome and Attention Deficit Hyperactivity Disorder (ADHD). This kind of treatment started in private practice and has yet to be recognised for its benefits in public medical centres and hospitals (Lin, 2012; Fong & Mohd Jelas, 2010).

Through concerted efforts, two major music therapy committees were established, the Malaysian Music Therapy Association (MMTA) which started in the 2016s, and Malaysian Society for Music in Medicine (MSMM) which was established in 2013. Both committees have similar goals, which are (1) raising awareness of music therapy in Malaysia; (2) interpreting and advocating for services of the profession to other professional disciplines; (3) promoting the use of music as therapy in various clinical settings and interdisciplinary research collaborations, education, and (4) serving as a regulatory body for music therapists in Malaysia. They have conducted studies where they integrated music as a healing tool for different medical fields like pain management, immunity, and motor and cognitive functions (Chong, Foo, Yeow, Law, & Stanslas, 2014).

Even though music therapy has been improving in leaps and bounds in other countries, there are many challenges faced to establish it as a formal modality in public schools or even an alternative therapy in hospitals in Malaysia. Lack of subsidies from the government made it difficult for this kind of treatment to be promoted as it is placed as traditional complementary medicine (TCM) amongst other established complementary rehabilitation such as Malay postnatal massage, Chinese acupuncture and herbal therapy. In fact, it should be considered under allied health as it assists in part of rehabilitation and patient care. Many people often confused music therapy with music education; they assumed patients would need to learn to play an instrument as part of the treatment (Lin, 2012). Thus, many of the music therapists are self-employed or engaged with non-government organizations (NGOs). They would travel to their patients' homes or run their appointments in private centres, instead of having them in government or private hospitals.

Currently, there are only around 10 registered music therapists practicing in Malaysia, and majority of them are concentrated in the Klang Valley (Malaysian Music Therapy Association, n.d.). These therapists were all trained overseas from countries like United States of America, United Kingdom and Australia. They used a wide range of methods and frameworks in their treatment programs like lyric analysis and substitution, improvisation, toning, guided imagery and music (GIM), music psychotherapy, resource-oriented music therapy, and cognitive behavioural methods (Chong, Foo, Yeow, Law, & Stanslas, 2014).

Each therapist specialises in different spectrum of patients. Amongst them, Shoba Ramanathan focuses on the autistic spectrum disorders, looking to improve his patients' well-being (Ramanathan, n.d.), while Professor James Yeow, as the vice president of MSMM and senior lecturer from the department of psychology of HELP University would often give talks in music schools and various other organizations including the Malaysian Philharmonic Orchestra, JobStreet.com Malaysia and the Malaysian Institute of Management. Sherrene Teh works with children and adolescents with various disabilities and learning difficulties, Cheryl Mow covers the spectrum of children or teenagers with special needs and conducting seminars or workshops for various organizations, and Lim Kar Gee focuses on the domains of psychological, physical, and communication; she helps patients suffering from traumatic brain injury or adults with psychological and emotional trauma. She uses a variety of approaches such as Rhythmic Auditory Stimulation, Melodic Intonation Therapy, and lyrics discussion, song composing, and music imagery to aid her patients to support their coping mechanism, restore speech ability and physical functioning, and promote their psychological wellbeing. (Malaysian Music Therapy Association, n.d.). A recent breakthrough in the development in post-stroke rehabilitation by Dr Indra Selvarajah from University Putra Malaysia (UPM) has open doors in developing a music therapy programme for cardiac and stroke rehabilitation (Maganathan, 2016).

Through their efforts, music therapy has slowly been noticed by the public community. Voluntary visits to provide therapeutic music services, and publicity of the work done by local music therapists in newspaper articles, individual websites and promotional posts on social media (Facebook) are among the many efforts to build the reputation of using music as a treatment tool in rehabilitation not only for children but also adults. Several medical centres and hospitals like UMMC, Hospital Kuala Lumpur and Hospital Rehabilitasi Cheras (HRC) Kuala Lumpur have set up music therapy programs for patients suffering from cancer and mental health (Maganathan, 2016). However, advocacy is still needed to raise awareness, especially among healthcare practitioners outside major cities in Malaysia in order to give more Malaysians more options in therapy and rehabilitation, and a chance to improve their health and well-being.

2.4 Clinical Consequences of Stroke

Stroke occurs when the flow of oxygen-rich blood to a portion of the brain is impeded or severely reduced, which deprives your brain tissues of oxygen and nutrients. Without oxygen, brain cells start to die after a few minutes. When this happens, symptoms occur in the parts of the body that these brain cells control. However, the effects vary greatly from one individual to another because of differences in the severity and location of the brain cell damage. Some would suffer from temporary or permanent disabilities, while others experience changes psychologically or mentally (Tidy, 2017).

2.4.1 The Types of Stroke

There are two main types of stroke – ischemic (caused by blockage of an artery) and haemorrhagic (caused by bursting or leaking of a blood vessel).

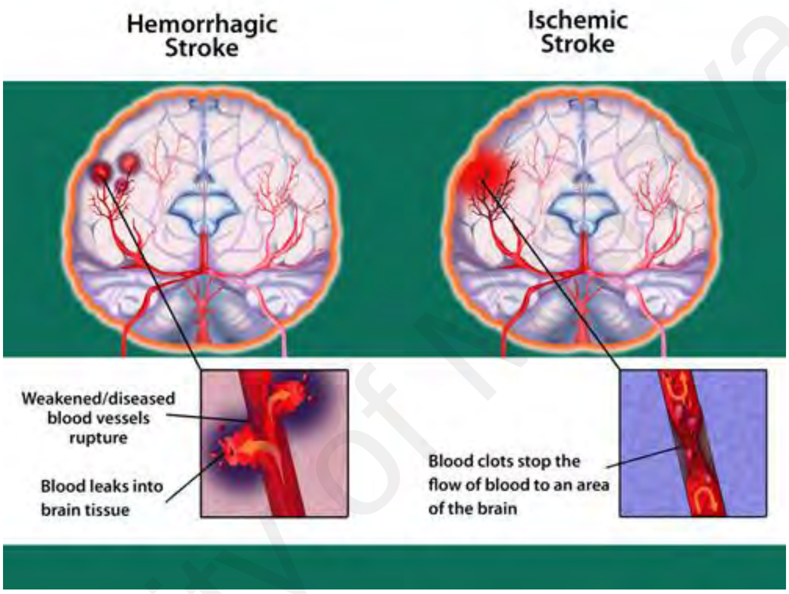


Figure 2.1: The contrast between haemorrhagic and ischemic stroke (Centre for Neuro Skills, n.d.).

The ischemic stroke is the more common type of stroke as about 80 percent were caused by arteries being blocked and the brain is affected. On the other hand, a haemorrhagic stroke occurs if a blood vessel in the brain leaks blood or ruptures. The pressure from the ruptured blood vessel damages the brain cells. High blood pressure and aneurysms (balloon-like bulges in an artery that can stretch and burst) are some of the causes to haemorrhagic strokes.

Another condition that's similar to a stroke is transient ischemic attack. It is also known as Transient Ischemic Attack (TIA) or 'mini-stroke'. TIA occurs when blood flow to a part of the brain is temporarily disrupted as shown in Figure 2.2. The symptoms experienced is similar to having stroke but not permanent as the damage to the brain cells is not permanent. Although the effect may be temporary, having TIA greatly increases the risk of having a stroke as this means that there is a partially blocked artery leading to or from the brain that can cause permanent damage later.

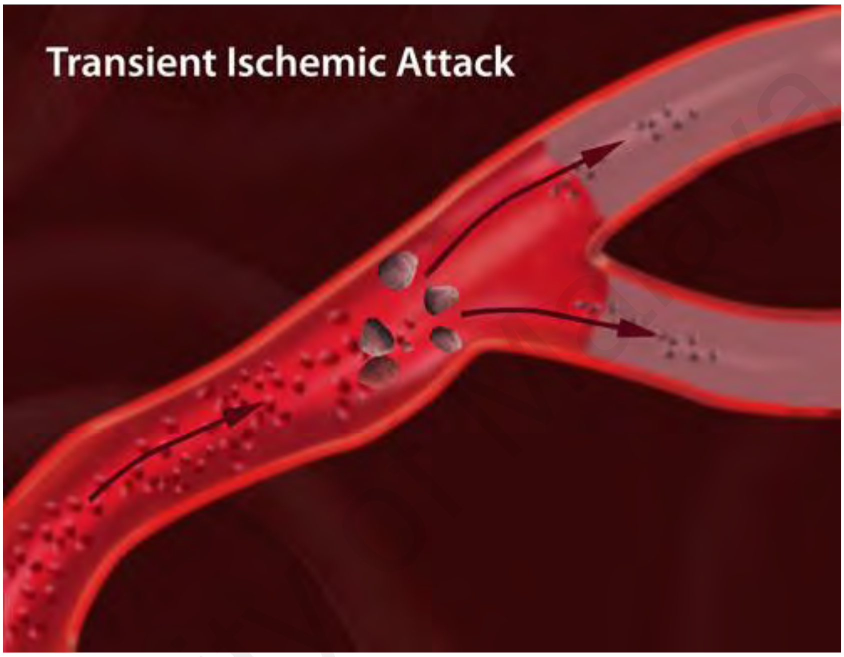


Figure 2.2: An image of how TIA happens with the blood clotting (Centre for Neuro Skills, n.d.).

2.5 Localization of the Stroke

The human brain is an extremely complex organ that controls various body functions. It is divided into two hemispheres, the left and right, which are joined by the corpus callosum, a bundle of nerve fibers that delivers messages from one side to the other. Each hemisphere controls different functions as well as the opposite side of the body. The effects of a stroke depend mainly where the obstruction occurs and the extent of brain tissues affected by it. If a stroke occurs and blood flow could not reach the region that controls a particular body function, that part of the body will not be able to work as it should. For example, if a stroke occurs toward the back of the brain (occipital lobe), the vision function will be impacted and may result in some disability (Lewis, 2016).

2.5.1 Right Hemisphere Disorders

The effects of a stroke depend on factors like the location of the obstruction and how much the brain tissue is affected. As mentioned, the hemisphere which the stroke affects will result in neurological complications on the side of the body it controls. For example, if the stroke occurs in the brain's right side, the left side of the body (and the left side of the face) will be affected. According to the American Heart Association (2012), clinical signs and symptoms include the following:

- Paralysis on the left side of the body – As the right side of the brain controls the left side of the body, the patient will have problems moving his or her limbs, more on the left side.
- Memory loss – The patient may have difficulty retaining information learned earlier. Furthermore, they also would have trouble processing new information.
- Visual-spatial perceptual deficits – The patient has left-side neglect – unable to see objects or people on his or her left side. For example, they may have trouble reading words on the left side of a page or may ignore anything on the left side.
- Organization – The patient will have trouble putting information together logically. This can cause problems when telling stories or giving directions. They may also have trouble when it comes to planning.

- Attention – The patient loses the ability to focus either to a task or concentrate on what he or she sees or hears.
- Subtle communication problems – Stroke patients, often those with aphasia from right hemisphere stroke, would have problems understanding jokes or non-verbal cues. They would misinterpret a shrug for another meaning, unnecessarily interrupting people, or say the wrong thing at the wrong time.

2.5.2 Left Hemisphere Disorders

If the stroke occurs in the left side of the brain, the right side of the body will be affected. The clinical signs and symptoms as mentioned in the American Heart Association (2012) include of the following:

- Paralysis on the right side of the body – The patient's movement would be restricted, more so on the right side of the body.
- Memory loss – Similarly, the patient has difficulty in remembering past information or processing new ones.
- Aphasia – Language impairment for stroke patients with aphasia include loss of ability to read or write, and inability to produce or understand comprehensible speech.
- Apraxia of speech (AOS) – Patients with AOS often appear to have trouble speaking, often struggling to position their mouth, tongue and lips (articulators) correctly when producing words and sounds.
- Agnosia – The patient could not identify objects (such as an apple or a key) and sensory information even though his/her senses are functioning normally.

- Organization – Problems with arranging information and planning in a proper order, is often reflected in communication difficulties for stroke patients.
- Social communication – The patient has an inability to understand and interpreting abstract language such as metaphors, making inferences, understanding jokes, and nonverbal cues.

2.5.3 Left vs. Right Brain

Figure 2.3 reflects the functions carried out by both the left and right side of the brain, and what happens if either side is injured.

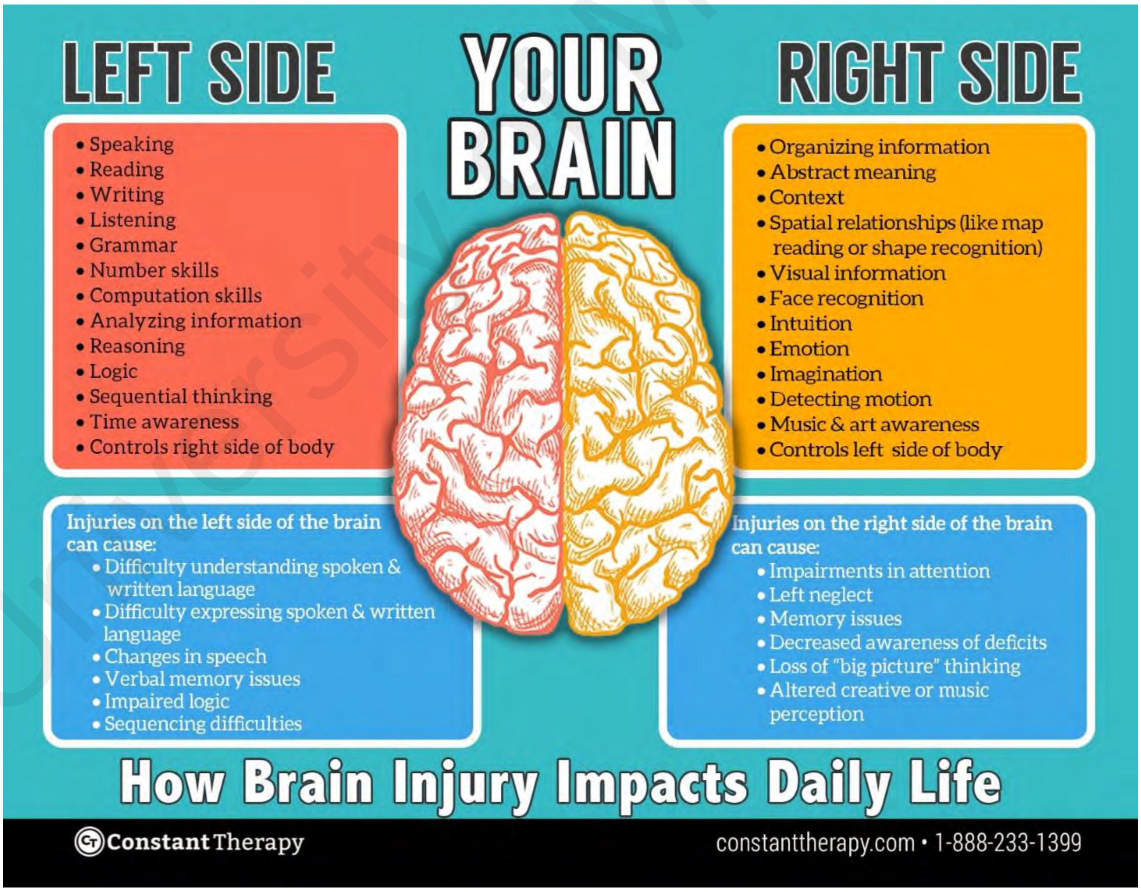


Figure 2.3: An infographic of the brain and the effect of brain injury (Constant Therapy, n.d.).

The brain is divided into two hemispheres. The left hemisphere controls movement and sensation in the right side of the body, while the right hemisphere controls movement and sensation in the left side. Thus, any damage to one of the hemispheres would affect the opposite side of the body. Aside from physical disabilities, injuries on the right hemisphere may cause a lack of awareness and perception, memory problems and inability to focus, and recognizing oral and visual patterns and designs such as music, and expressing and understanding emotions (Sandson, Manoach, Price, Rentz, & Weintraub, 1994). For most people, the left half of the brain is responsible for verbal and logical functions including language, listening, reading, speaking, and writing, thought and memory involving words (Allina Health Patient Education, 2011).

2.5.4 Brain Stem (Vertebral Basilar/Posterior Circulation) Stroke

The brain stem controls all basic activities of the central nervous system. This includes blood pressure, breathing, and body motor control. If a stroke occurs in the brain stem, depending on the severity of the injury, it can affect both sides of the body and may leave someone in a 'locked-in' state – a condition where the person is aware but could not communicate verbally or achieve any movement below the neck. Many patients with locked-in syndrome can only move their eyes. Clinical signs and symptoms include of the following:

(a) Decreased vital capacity in breathing, important for speech – The brain stem may not be able to properly send signals to allow patient to breathe. Breathing is a process that we do unconsciously, but during a brain stem stroke, breaths may be skipped or too shallow.

(b) Swallowing food and water (Dysphagia) – The patient has difficulty swallowing or could not swallow at all. This is because swallowing closes off the windpipe, and food or fluids from the mouth travelling down the esophagus would get stuck or end up through the wrong tube. This could cause them to choke or suffocate.

(c) Speech problem – The patient has difficulty pronouncing sentences or words, even if they know what to say and how. This problem stems from his or her brain signal for speech that is not relayed properly to the speech organs.

(d) Problems with balance and movement – Movement becomes uncoordinated and clumsy due to the disruption of communication between the brain and the rest of the body. This may also affect eyesight, where the eyes become stuck in one position.

(e) Dizziness and nausea (Vertigo) – Any damage to the brain stem would cause a disruption of signal between the brain and ears, upsetting how the body is perceived to be oriented. This results in dizziness and nausea which also cause difficulties with standing or walking.

(f) Insomnia – The patient has trouble falling asleep and would sometimes have sleep apnea, a condition where long pauses in breath or shallow breathing occurs during sleep, which often will wake the patient.

The severity of the effect depends on the extent of the injury and how quickly the stroke is given treatment (Lehr, 2016). Figure 2.4 shows how a brainstem stroke can happen when the highlighted area is being deprived of blood.

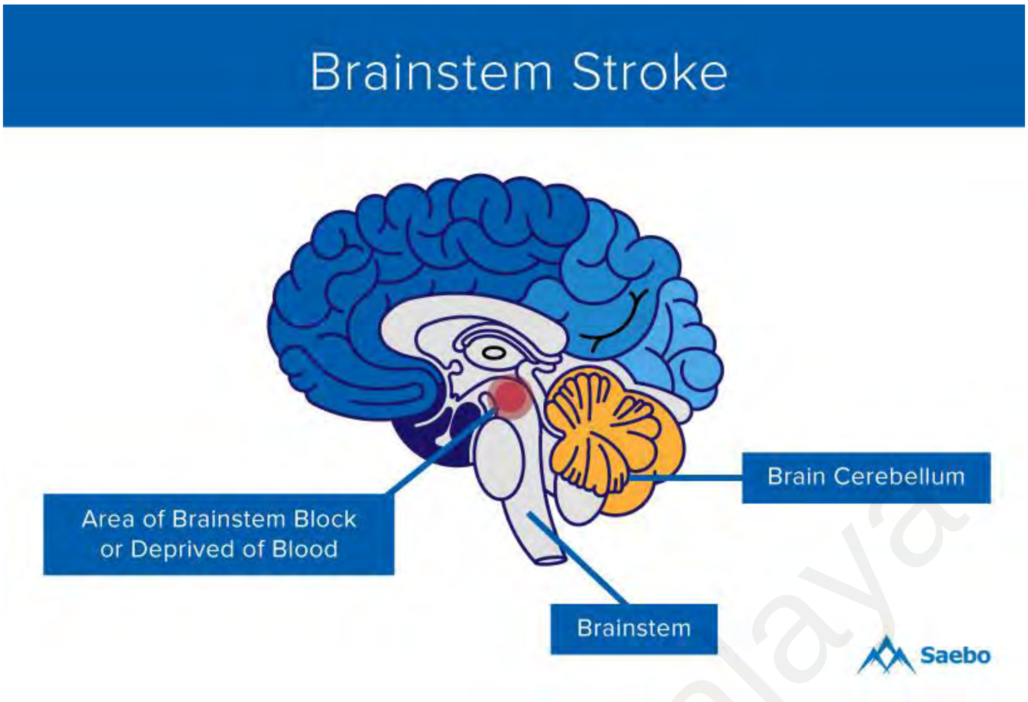


Figure 2.4: A diagram of brainstem stroke

(Saebo, 2017).

The above information provides the basic knowledge how stroke impact our daily life. It is important to know which part of the brain the stroke occurs and the symptoms to ensure a better rehabilitation treatment for the stroke survivors. In this research a comparison between lesion and non-lesion hemisphere for stroke patients would help in ascertaining the role of music as part of stoke rehabilitation. However, brainstem stroke could not be studied on due to the difficulty of recruiting the patients.

2.6 The Neuroanatomy of Music

Music has always been able to influence people; linking emotional, spiritual, and physical elements in the order how people perceive and respond to music. Research has shown how the body responds to music. Music unwinds the body - relaxing the heart beat and decreases blood pressure (Trappe, 2012). Scientists has discovered how different parts of the brain processes music. The brainwaves were monitored through electrical activity recorded in both the left and right hemispheres and revealed that the act of just listening to music used many different cortices of the brain.

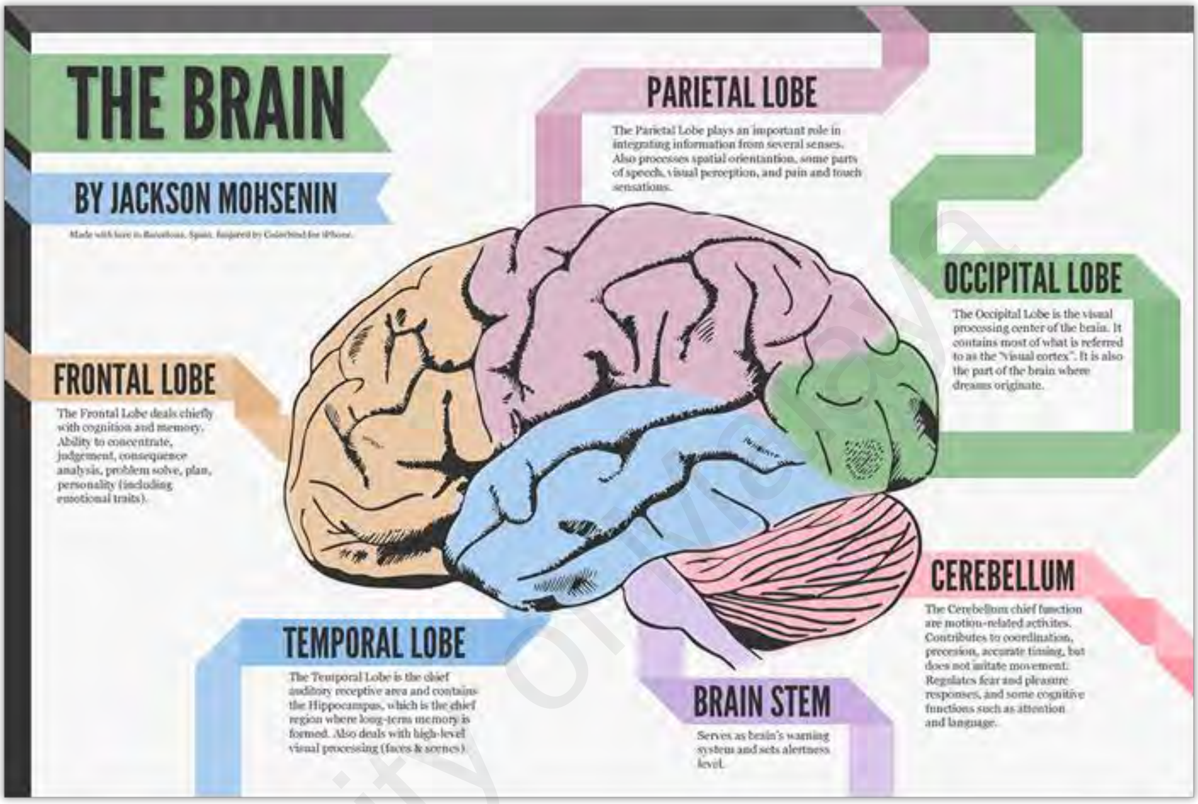


Figure 2.5: An infographic of the parts of the brain by Jackson Mohsenin (Holly, 2013).

As shown in Figure 2.5 above, there are four lobes to the brain where the cortices (the outer layer where most activity occurs) lay. All four lobes are involved when it comes to processing music:

(a) Frontal lobe

The frontal lobe is linked to reasoning, motor skills and higher-level thinking. Cortices on the frontal lobe associated with music are the prefrontal cortex, Broca's area and the motor cortex.

(b) Parietal lobe

The parietal lobe is associated with senses. However, the left parietal cortex is used when analyzing rhythms. It works with the left frontal cortex and the right cerebellum.

(c) Temporal lobe

The temporal lobe contains the auditory cortex. Information from music is taken in through the ear and is processed in the auditory cortex. Cortices associated with memories, speech production and language are also found on the temporal lobe.

(d) Occipital lobe

The occipital lobe is associated with interpreting the information that is transmitted from the retinas of the eyes. Music can trigger activity in the visual cortex.

(e) Cerebellum

The cerebellum translated to mean “little brain”. It carries out basic human functions, such as balance and basic facets of memory and learning.

The first three lobes directly respond to music while the last one has a secondary response.

The processing of music engages many areas distributed throughout the brain. Even with injuries to the brain, the human response to music is remarkably adaptable; even exposure to it can retune the way the brain handles musical inputs. By gaining the knowledge of where and how music is processed in the brain, it lays a foundation for this research. However, studies of the relationship between music and the brain among stroke survivors in Malaysia are small. There is a need to ensure more efforts on researching this field to create a specialized music therapy that will help stroke patients in Malaysia.

2.7 Music in the Brain

As previously discussed the brain has a complex ability to absorb music and process it. In this section, the researcher will explain further in detail the relationship between music and its impact on the human brain. Every lobe of the brain is involved some way or another, to make sense of music. The responses to music involve regions of the brain are shown in Figure 2.6 below.

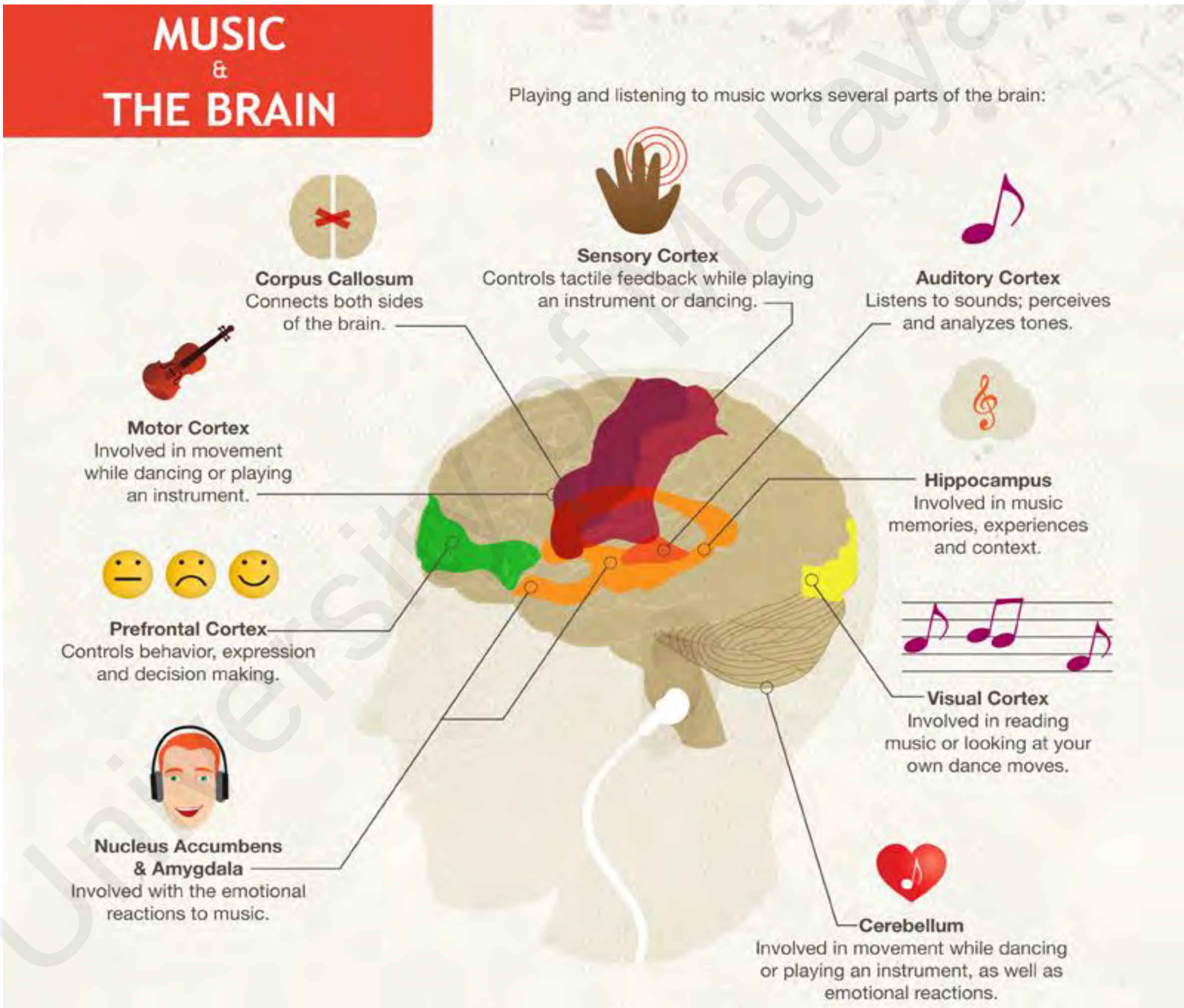


Figure 2.6: How parts of the brain process music

(Inside the Brain, 2013).

(a) Prefrontal cortex

The prefrontal cortex is active when the brain analyzes rhythms. It is involved with complex behavioral and social decisions.

(b) Broca's Area

Lyrics are the aspect of music that trigger a response in the Broca's area, which is associated with language production. Broca and Wernicke's areas work together with aspects of language.

(c) Motor Cortex

Good music can have secondary responses, which seem involuntary. The stimulation of neurons in the motor cortex is what causes one's feet to tap along with the music.

(d) Auditory Cortex

The auditory cortex plays a major role in assessing the pitch and volume of the sound that enters the ear. The ear translates the sound it hears to responses that the auditory cortex can analyze.

(e) Wernicke's Area

Wernicke's area is crucial to language comprehension. It works together with Broca's area in aspects of language.

(f) Visual Cortex

The visual cortex can respond to music by conjuring up images associated with a piece of music. Memories from a piece of music are triggered to produce these images.

(g) Right cerebellum

The right cerebellum is involved with analyzing rhythms and more mechanical aspects of music. The more complex the rhythms, the more areas of the cerebellum are involved.

(h) Hypothalamus

The hypothalamus is located above the brain stem and produces chemicals for the rest of the body. Dopamine is a chemical that controls the feelings associated with pleasure and reward. Listening to music triggers happy memories releases dopamine to the rest of the body.

Overall, studies have shown that music has a biological basis and that the brain has a functional organization for music (Weinberger, 2006). It's clear that almost every part of the brain participates in specific aspects of music processing, whether it is supporting perception like apprehending a melody or giving an emotional reaction. Research has proven that musicians appear to have additional specializations, particularly hyper development of some brain structures (as further explained in subchapter 2.6). These effects demonstrate that learning music retunes the brain, increasing both the responses of individual cells and the number of cells that react strongly to sounds that become important to an individual. As research on music and the brain continues, we can anticipate a greater understanding not only about music and its reasons for existence but also about how wonderful it really is.

2.8 Music and Neuroplasticity

The term 'neuroplasticity', also referred to as brain plasticity, is the ability of the brain to adapt and change in the central nervous system as a result of experience or adaptation to environmental demands. When neuroplasticity occurs, the brain reorganizes itself by creating new neural pathways. When this happened, the synapses are repeatedly stimulated, continuously having the neurons pass electrical signals from one to another due to repeated exposure to sensory (e.g. temporal, visual, physical, or 'somatosensory') stimuli in a process known as 'Hebbian learning' (Hebb, 1949). This well-established model stems from early animal studies (e.g. Hebb, 1949; Lashley, 1929) that led to an explanation of the adaptation of neurons in the brain during learning processes. It is with this idea that led to the convergence of neuroscience with music therapy and music medicine literature. Musical activity can provide an ideal stimulus in this context, constantly stimulating the neurons in the brain. It could potentially reshape the brain structures and its connectivity, and so could be harnessed to be an alternative to medical improvements for patients with neurological disability or disorders. The use of music for neurorehabilitation therapy has been researched and found to be effective most notably in motor rehabilitation, as well in speech, cognition, mood disorders, and disorders of consciousness.

With the development of neuro-imaging technology in the 1980s, musically induced neuroplasticity could be proven by neuroscientists, which paved the way to better understand neuroplasticity. One study done by Münte, Altenmüller, & Jäncke (2002), Pantev et al. (1998) found the brain functional reorganization extended across the sensory cortices in pianists and violinists. The repeated activity of practice and performance of music, activated so many neuronal systems had reshaped the pathways of neurons.

In another research on music learning, Putkinen, Tervaniemi, Saarikivi, and Huotilainen (2015) found that exposure to music activities from preschool through to adolescence can improve executive functions and control over auditory processing, after taking into account the differences between students who have been trained in music outside the school and those who did not receive such lessons. Similarly, musicians have also been found to have a highly specialized cortical reactivity in different genres. When given a tune, their brain could automatically track anything anomalous (i.e. oddball sounds, pitches, or rhythms embedded in musical recordings). This is proven in a research where Maxillomandibular Relationship (MMR) recordings of the responses of the brain were selectively enhanced for tuning in classical musicians, timing in classical and jazz musicians, transposition in jazz musicians, and melody contour in jazz and rock musicians (Tervaniemi, Janhunen, Kruck, Putkinen, & Huotilainen, 2015). The MMR record is important to bring attention to the diverse effects of music on neuroplasticity.

Patel (2011) introduced the Opera Hypothesis to better explain how musical activities could influence neuroplasticity in terms of speech processing. This model is used in explaining observed superior subcortical encoding of speech found in musically-trained individuals. There are five (5) conditions whereby musical experiences could affect plasticity in “speech-processing networks”:

1) *Overlap*: An overlap occurred in the brain network that processes acoustic features that is shared between music and speech;
2) *Precision*: when music placed more demand in the precision of processing within these shared networks compared to speech;
3) *Emotion*: the musical activities causes strong positive emotion within these networks;
4) Repetition: the musical activities that engage the speech-processing networks are frequeantly repeated; and
5) *Attention*: the musical activities are related to focused attention.

When all these conditions are met, according to the Opera Hypothesis, neural plasticity will occur with a higher precision for ordinary speech communication. With a better precision to the brain networks, speech processing would benefit as it shares the same network with music. Trost et al. (2014) further observed that the more we like music, the more areas of the brain that will be involved in attention and emotion processing, and this trainedithe mind to the rhythm of the music.

The natural effect of music to the brain plasticity has led to a creation of a new field to music therapy called the Neurologic Music Therapy (NMT). It consists of many techniques that were developed or incorporated to assist in rehabilitation for brain injuries and disorders (Thaut & Hoemberg, 2014).

In conclusion, the above literature supports the musical activity affected the change of neuroplasticity and beneficial on rehabilitation. It provides an overview of a growing concept related to recovery known as neuroplasticity, and how specific training models in music therapy utilize this relatively recently identified phenomenon (Bella, 2016). The growth in the medical field helped guide practicing clinician when attempting to build a lineage of systematic thought relevant to the use of music in rehabilitation. In this research, researcher review findings demonstrating functional and structural plasticity across different lobes scales that mediate motor skill learning through the effect of music with the purpose of identifying converging areas of interest and possible avenues for future research.

2.8.1 Brain Structure in Musicians and Non-musicians

The brain's adaptability to change from training and experience has proven its malleability. With active engagement, the neuroplasticity of the brain could not only be enhanced but also built a stable foundation to learning. From the principles concerning neuroplasticity, one can reason that the changes in brain structure for musicians is due to the long-term training and intense, specialised exposure to music. This hypothesis is supported in many research and often, studies concerning significant differences in brain morphology, connectivity and size often point out the unique brain structures of musicians. (Miendlarzewska, & Trost, 2013). As shown in Figure 2.7 below, the areas of the brain that displayed differences between musicians and non-musicians particularly involved frontal, motor, and auditory regions.

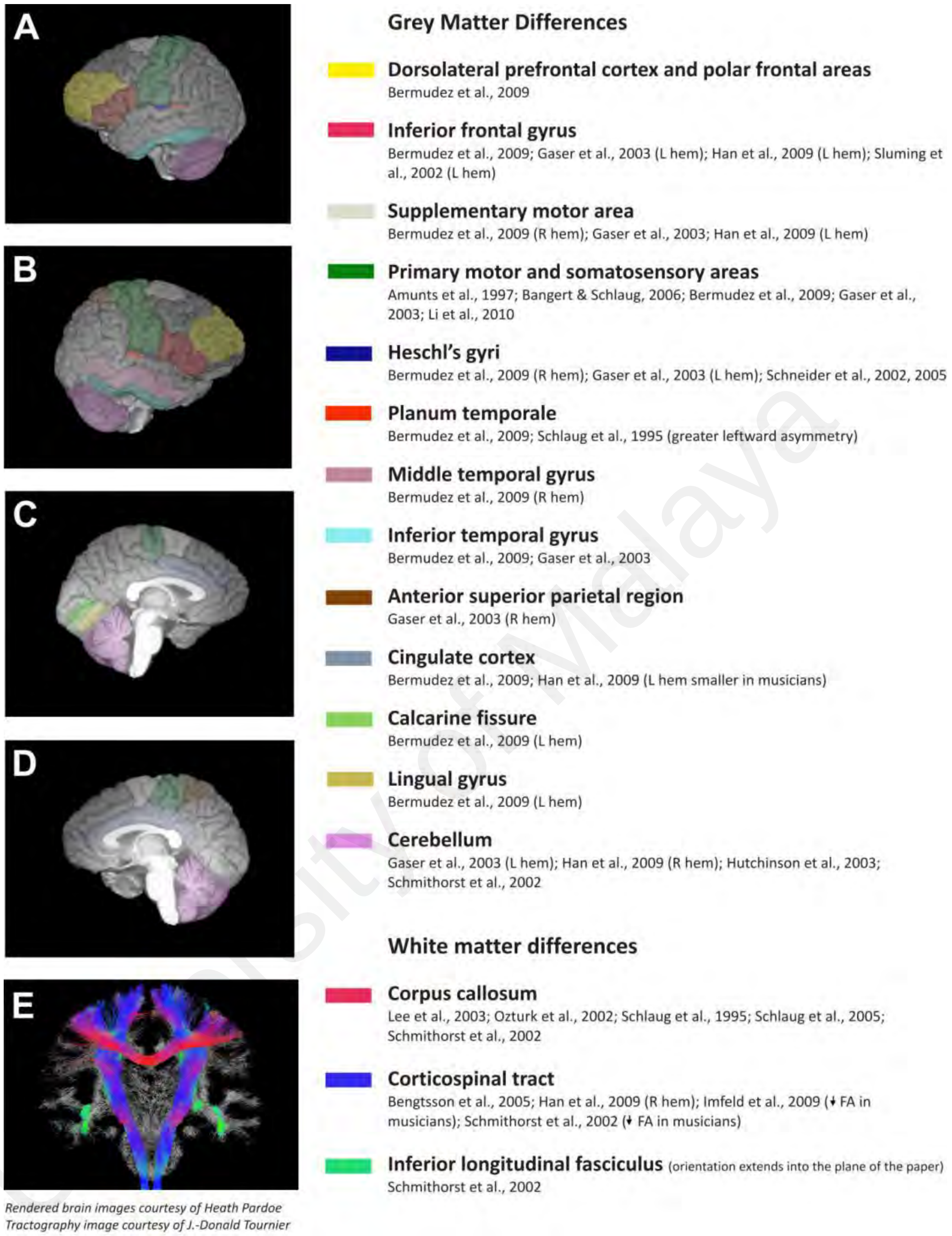


Figure 2.7: The approximate locations of structural brain differences found in studies of musicians compared to non-musicians (Merrett & Wilson, 2012).

In Figure 2.7 above, it is shown that all findings are bilateral and greater in musicians unless otherwise noted. There is a difference in brain structure for both the left lateral brain surface in (A) and (B) right lateral brain surface. This is the same for (C) left medial brain surface, (D) right medial brain surface and white matter tracts in (E). Demonstrations of brain structures between musicians and non-musicians were also studied on, first by Schlaug, Jäncke, Huang, & Steinmetz (1995) and Schlaug, Jäncke, Huang, Staiger, & Steinmetz (1995), who proved that musicians have "a larger anterior half of the corpus callosum and greater leftward asymmetry of the planum temporale" as compared to non-musicians. These studies were done in vivo and has encouraged more investigations concerning structural brain differences between musician—non-musician in other parts of the brain. These included the cerebellum (Hutchinson, Lee, Gaab, & Schlaug, 2003), the sensorimotor cortex (Amunts et al., 1997; Bangert & Schlaug, 2006; Li et al., 2010), the auditory cortex (Schneider et al., 2002; Schneider et al., 2005), the inferior frontal gyrus (Sluming et al., 2002), and white matter tracts (Bengtsson et al., 2005; Imfeld, Oechslin, Meyer, Loenneker, & Jäncke, 2009; Oechslin, Imfeld, Loenneker, Meyer, & Jäncke, 2010; Schmithorst & Wilke, 2002).

In conclusion, this above review professional musician represents an ideal model in which to investigate plastic changes in the human brain. The above literature supports the changes in brain structure of musicians by the use of music specialized, intense, and long-term training. If stroke survivors can re-organize their brains and learn to use their visual cortex to help remember words, then perhaps they can reorganize their brains as well. The structure of this thesis is based on this assumption. However, it requires doctors, therapists, and stroke survivors to develop new method that step-by-step require and teach stroke survivors to regain lost abilities and skills.

2.9 Music Effect on Neurons of Post-stroke Patients

The advancement of our understanding of the neuroplastic changes associated with post-stroke motor impairment and the innate mechanisms of repair is crucial. Music therapies that augment neuroplasticity are being explored to further extend the boundaries of post-stroke rehabilitation. The use of temporal cues in music and rhythm are important not only for the motor system but also involving arousal, orientation, and sustenance of attention. Rhythmic patterns synchronize with the internal oscillators in accordance with its temporal regularity, thereby having its effect on attentional processes. Similarly, music provides a temporal–metrical structure that facilitates perceptual grouping and chunking of the information being processed or learnt as well as can be used as a mnemonic device in memory formation. This means that music listening engage brain areas that are more towards general functions like neural circuits connecting to working memory, motor imagery, semantic processing, and target detection. Not only that, the limbic and para limbic brain areas are being engaged as well, which is important as it involves in inducing, maintaining, and modifying emotions. With such effect, it is not surprising that music can also possibly be used to modify or regulate the cognitive processing as the brain stimulation affects the non-musical domains of functioning as well. Figure 2.8 below demonstrated how the brain suffering from traumatic brain injury reacts to the effect of music in therapy.

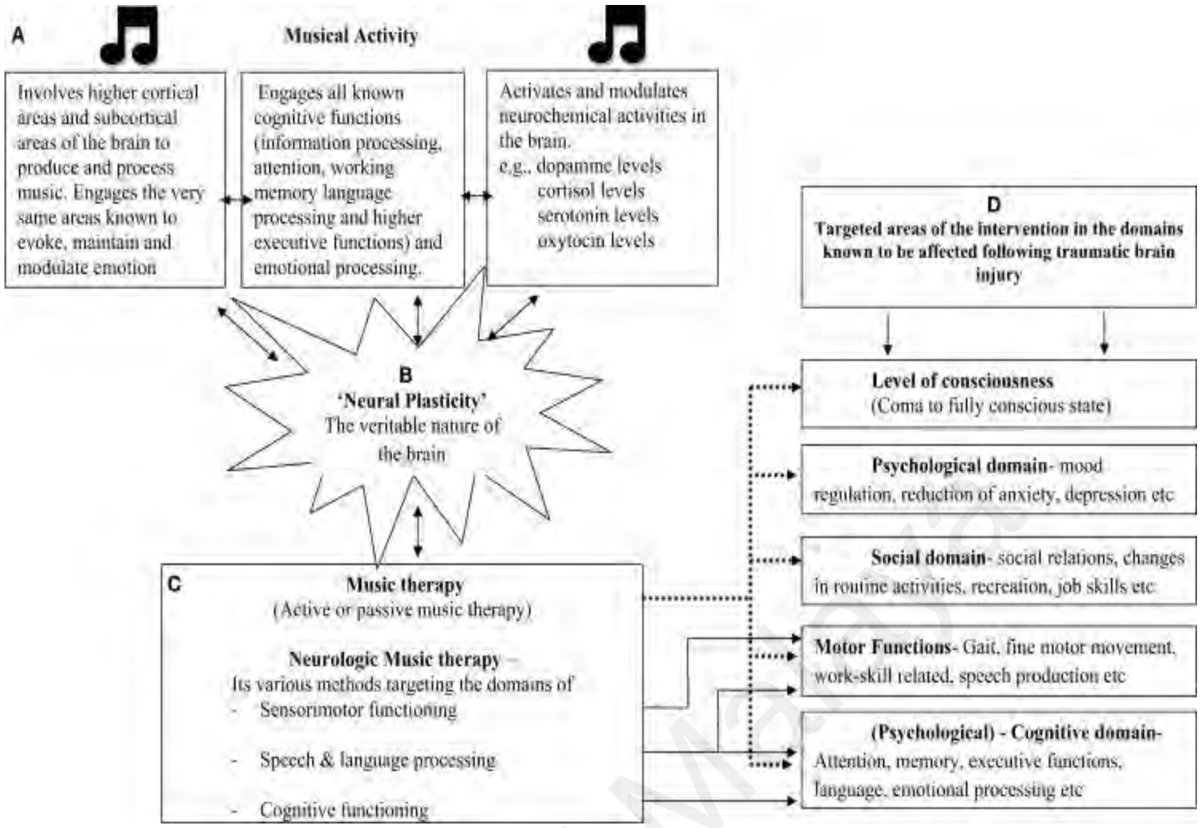


Figure 2.8: Schematic representation of how musical-based activities (active and passive) affects neural, cognitive, neurochemical functions, and the other various domains of functions known to be affected following traumatic brain injury (Hegde, 2014).

In conclusion, it can be seen music is a powerful tool to understand the functions of the brain and its behavioural interactions. Music has effect the domains of function such as level of consciousness, psychological domain, social domain, motor functions and cognitive domain. However, the main focus on this study is motor functions recovery through the music intervention rehabilitation in post-stroke patient by means of its enhancing the brain neuroplasticity ability. The above literature indicated that music can stimulate complex cognitive, affective, and sensorimotor processes in the brain that can be generalized and transferred to therapeutic applications.

2.10 Research on Music in Stroke Rehabilitation

This section describes the information on related studies in the aspects of how music helps in stroke rehabilitation.

According to neurologist Oliver Sacks, M.D, neurological disabilities are particularly common in older age groups; this is especially so for stroke, Parkinson's disease, and Alzheimer's disease and often necessitate their admission to nursing homes and chronic hospitals. There is also the fact that medicine cannot offer them any significant cure, their physical and mental states, their functioning can often be enormously improved by remedial and therapeutic measures of a non-medical method, for example, using art therapy and music therapy. (Forever young: Music and aging, 1992)

The power of music and its nonverbal nature make it an effective medium of communication. Music easily elicits movement, stimulating interactions between perception and action systems (Zatorre, Chen, & Penhune, 2007). Thus, music-making may be an effective way to induce plastic changes in the motor system. Music intervention is a prospective new series of therapy programs, and comprehensive research suggests that it could be useful because of its promotion of relaxation and of cognitive and motor improvement in post-stroke rehabilitation (Thaut, Peterson, & McIntosh, 2005). Therefore, music intervention has been developed with the aim of improving motor recovery and usually used in conjunction with traditional medical treatment after a stroke. There have been various studies that have supported the use of music intervention post-stroke, with finding to show that the combination therapy is more effective than a pharmaceutical approach alone.

In the study reported in the journal of the American Medical Association, researchers found that stroke patients who were given rhythmic auditory stimulation a half hour a day for three weeks had improved cadence, stride, and food placement compared with a control group. The researcher further found that the effect of the music therapy was lasting. They found that the patients retained the walking pattern they acquired during the training and could accurately reproduce their new stride thereafter. Dr. Michael Thaut, a prominent music therapist and the chief researcher, attributed the improvement to an entrainment effect that enhances the normal mechanism in the brain damaged by the stroke. The research further reported that in a case-controlled study in Scotland of long term institutionalized stroke patients, participants were chosen randomly and given music therapy had less depression and anxiety and more emotional stability and motivation to communicate than patients receiving standard care (Campbell, 2001). It is important to be able to develop a technique that can enhance the neuroplasticity of the brain whilst improve the motor function.

Pennisi et al. (1999) demonstrated that complete hand paralysis in association with the absence of early MEP –within 48 hours of ictus, predicted poor neurological recovery in one year for the 15 after-stroke patients (middle cerebral artery infarct) chosen as the subjects for his study. Conversely, the preservation of motor potentials evoked by TMS in the early period after stroke may portend good functional recovery. It means that the preservation of motor potentials evoked by TMS in the early period after stroke may portend good functional recovery.

Plastic changes also occur in musicians' brains compared to non-musicians. Gaser and Schlaug (2003) compared professional musicians (who practice at least 1 hour per day) to amateur musicians and non-musicians. They found that gray matter (cortex) volume was highest in professional musicians, intermediate in amateur musicians, and lowest in non-musicians in several brain areas involved in playing music: motor regions, anterior superior parietal areas and inferior temporal areas.

In MST, where the use of musical instruments in motor rehabilitation therapy has shown to be effective in post-stroke rehabilitation of motor function in some clinical trials. In terms of gait therapy, Schauer & Mauritz (2003) proved that music has better effect in improving a stroke patient’s walk compared to the conventional gait therapy. They speculated that a fixed memory in the patient's mind about the song and its timing may stimulate the improvement of gait even without the presence of an external pacemaker. Similarly, 20 patients with chronic hemiparetic stroke participated in a study conducted by Cha, Kim, Hwang, & Chung (2014). They were divided into two groups where one underwent intensive gait training with rhythmic auditory stimulation for a period of 6 weeks (30 minutes a day, five days a week), while the other underwent intensive gait training for the same duration. The result shows significant improvement in scores for the group with the intensive gait training with rhythmic auditory stimulation, on the Berg balance scale, gait velocity, cadence, stride length and double support period in affected side, and stroke specific quality of life scale compared with the control group after training.

Altenmüller, Marco-Pallares, Münte, and Schneider (2009) looked into improving impaired motor skills through music therapy. In the end, the study group of 32 stroke patients showed a significant improvement in fine as well as gross motor skills with respect to speed, precision, and smoothness of movements. There were also electrophysiological changes indicative of a better cortical connectivity and improved activation of the motor cortex.

In Friedman et al.’s (2014) study, an instrumented glove called MusicGlove was developed to help motor recovery through practice of gripping movements and thumb-finger opposition using video games. The participants sustained improvements in hand function at a one-month followup, and found the MusicGlove more motivating than the normal therapies, as measured by the Intrinsic Motivation Inventory (IMI), a multidimensional measurement device intended to assess the subjects involved based on their subjective experience related to a target activity in laboratory experiments. They benefited less from isometric therapy than MusicGlove training, but the difference was not significant (P>0.09) although MusicGlove games scores correlated strongly with the Box and Blocks (B & B) score. The Box and Block Test (BBT) measures unilateral gross manual dexterity. It is a quick, simple and inexpensive test. It can be used with a wide range of populations, including clients with stroke.

In the study, ‘MST in improving post-stroke patients' upper-limb motor function: A randomised controlled pilot study’ (Tong et al., 2015) showed significant improvements in the stroke patients’ motor functions of upper limbs after 4weeks' treatment. This study supports that MST, when combined with conventional treatment, is effective for the recovery of motor skills in post-stroke patients. The design for the study was thirty-three post-stroke patients with no substantial previous musical training was assigned to either audible music group (MG) or mute music group (CG), permitting observation of music's independent effect. All the patients received the conventional rehabilitation treatments with an extra 20 sessions of audible musical instrument training (MG) or ‘mute’ musical instrument training (CG). There are significant improvements for the subjects sorted into in the MG group, more than CG. It suggests that apart from the repetitive practices of MST, music may play a unique role in improving upper-limb motor function for post-stroke patients. (Tong et al., 2015)

In another single-blind, randomized, and controlled trial study designed by Särkämö et al. (2008), patients were tested to determine whether everyday music listening can facilitate the recovery of cognitive functions and mood after stroke. Besides receiving the standard medical care and rehabilitation, a sample size of 60 patients with a left or right hemisphere middle cerebral artery (MCA) were sorted into three groups - music, language and control. They were given daily tasks for two months to either listen audio books or music that they select on their own, depending on the group they were sorted into respectively. The control group did not receive any listening materials. After undergoing an extensive neuropsychological assessment, results revealed that recovery in the domains of verbal memory and focused attention improved significantly more in the music group than in the language and control groups. There were also fewer cases of depression and mood swings reported in the music group as compared to the control group. These findings showed that music listening is feasible for patients in the early post-stroke stage to enhance cognitive recovery and prevent negative mood (Särkämö et al., 2008).

The idea of music therapy is further supported by Schneider, Schönle, Altenmüller, & Münte (2007), who found that music-supported training program designed to induce an auditory–sensorimotor co-representation of movements is an effective approach for the motor skill neurorehabilitation of stroke patients. In their research, they tested 20 stroke patients without any previous musical experience participated in an intensive step by step training, first of the paretic extremity, followed by training of both extremities for three weeks. As a control, 20 stroke patients undergoing exclusively conventional therapies were also recruited. The assessments for pre- and post-treatment motor functions were monitored using a computerized movement analysis system (Zebris) and an established array of motor tests (e. g., Action Research Arm Test, BBT).

As a result, there was a significant improvement after treatment with respect to speed, precision and smoothness of movements (Schneider, Schönle, Altenmüller, & Münte, 2007)

It is theorized that MST can also induce changes to the brain, or plasticity, and result in the activation of the auditory-motor circuits that improve motor skills after acute or chronic stroke. Rodriguez-Fornells et al. (2012) analysed the structural magnetic resonance imaging data of post-stroke patients who listened to music for 6 months and revealed an increase in the gray matter volume and reorganization in the frontal areas of the brain (left and right superior frontal gyrus and the middle frontal gyrus) that enhanced the recovery of verbal memory, focused attention, and language skills.

A single-case study using multimodal imaging (fMRI-TMS) successfully demonstrated the MST can be a useful neuro-rehabilitation tool for patients with chronic stroke which leads to neural reorganization in the sensorimotor cortex (Rojo et al., 2011). The result showed that there is a marked improvement of movement quality in the participants, post-therapy. Moreover, functional magnetic resonance imaging (fMRI) of a sequential hand movement revealed distinct therapy-related changes in the form of a reduction of excess contralateral and ipsilateral activations. This was accompanied by changes in cortical excitability evidenced by TMS. Functional MRI in a music listening task suggests that one of the effects of MST is the task-dependent coupling of auditory and motor cortical areas.

Music has shown promise as an adjunct to treatment as well, and specific elements of music have been linked to significantly higher rates of positive emotion. In the research done by Camara, Rodriguez-Fornells, & Munte, (2008) and Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, (2011), emotional effects caused from listening, learning, and performing music engages networks and neurotransmitter systems that help merge new information and movements.

Aside from emotion, music listening influences cognitive functions as well. The executive functioning improves with therapeutic music which helps ease patients with traumatic brain injury into rehabilitation without aggravating their problems. Särkämö et al., (2008) reported that music listening significantly enhanced cognitive functioning in verbal memory and focused attention ($P < .01$ and $P < .05$, respectively, mixed-model analysis of variance), and decreased depression and confusion (both $P < .10$, 1-way analysis of variance), or positive emotion, in patients after middle cerebral artery stroke compared with those who are part of the control group. Thaut et al. (2009) gave post-stroke patients 30 minutes of NMT that focused on one aspect of rehabilitation (attention, memory, executive function, or emotional adjustment). The treatment showed improvement in executive function and overall emotional adjustment, and lessening of depression, sensation seeking, and anxiety. As for Hegde (2014), cognitive impairments can be alleviated through innovative methods such as music as a form of therapy.

Each method used for music therapy in the research above and on newer findings emerging from the fields of neuromusicology and music cognition has shown the evolution of music's role in cognitive rehabilitation is evolving. Research findings from these fields have contributed significantly to our understanding of music perception and cognition, and its neural underpinnings. From a neuroscientific perspective, indulging in music is considered as one of the best cognitive exercises. With "plasticity" as its veritable nature, brain engages in producing music indulging an array of cognitive functions and the product, the music, in turn permits restoration and corrects brain functions.

With scientific findings as its basis, NMT has been developed as a systematic treatment method to improve sensorimotor, language, and cognitive domains of functioning via music. Särkämö (2008) posits that stroke survivors who listened to music daily for a 6-month period has a lesser risk suffering from depression and confusion, and retained more verbal memory, and better focused attention than those who didn't listen to music. The process of listening to music helps boost stroke recovery as it activates the part of our brain that is associated with memory, motor function, and emotional processing. The real benefits of music therapy emerge during music-based rehab exercises. When movement is linked to a rhythmic beat, it creates an engaging environment that stimulates your brain and boosts motor recovery. In fact, the simple addition of music can turn almost any boring rehab exercise into a fun and effective experience (Flint Rehabilitation Devices, 2015).

This review of related literature indicated that no studies were present that researched the effects of music (using songs of a single language) on a multiracial society (Chinese, Malay and India) such as Malaysia. The above literature also shows that the motor skills are an important factor in stroke survivors' daily life. Relevant literature also indicated that there is a need for establishing readily costless-effective with non-pharmacological procedures that can be easily implemented by medical staff. However, based on these various developments, it appears that such therapy would be a good addition to benefit Malaysian medical therapy particularly for those in hospitals as a form of music rehabilitation. Thus, the present study hopes to fill the gap in the literature the effect of music in stroke rehabilitation.

2.11 Introduction to Music in Malaysia

The music of Malaysia can be divided into five main categories; classic music, folk music, syncretic music, popular music and contemporary art music. Each group has their own tune and genres.

The classic music is often associated with royalty as it is played for the royal family and elite members of society. The main genres of Malaysian classical music include the *nobat*, *gamelan*, *wayang Melayu*, and Hindustani traditions (Tan & Matusky, 2017). The composition consists of defined repertory which is steeped with theoretical historical base that requires extensive formal training. On the other hand, folk music is not systematic as it is learned through apprenticeship system where the master teaches the songs through rote method. It is performed in villages and farming regions during celebrations like rites of passage and festivals, reflecting the basic values and norms of that community (Tan & Matusky, 2017).

The syncretic music (or sometimes known as acculturated music) started in the 16th century, during the British colonisation where Malaya was then exposed to foreign musical and theatrical entertainment from Arab, Persian, Indian, Chinese, Western. As a result, syncretic music was produced with the combination of folk and classical elements of both the local and foreign music. It exists in the form of vocal, dance and theatrical music such as *dondang sayang, lagu melayu asli, zapin,* and *kerongcong* (Tan & Matusky, 2017).

Both the popular and contemporary art music uses a blend of Western music and Malaysian culture. The contemporary art music uses Western theory as its base but there is much of the Malaysian culture to create its own identity. The audience involved in this category is not big as it usually consists of a select people educated in the tradition.

On the other hand, popular music forms the largest audience, bringing in the most profit for the music industry. The form of popular music changes quickly, often according to the trend that is hyped at that time. It is disseminated through social and mass media, and live performances (Tan & Matusky, 2017). In fact, syncretic music was then considered popular music during the late 19th century going into the early 20th century as it is played in the halls of *bangsawan* (popular urban commercial theatre) and *joget* halls. The *bangsawan* was the first native theatre to be modelled along the western lines; it brings the development of the first Malay orchestra and the first popular music in the country (Tan, 1997). The theatre's popularity faded after World War II with the introduction of the film making and entertainment industry in Malaya. The rising star responsible for conquering this industry in the early 1950s was none other than Teuku Zakaria bin Teuku Nyak Puteh, or better known as P.Ramlee.

P.Ramlee's musical style developed from *bangsawan* music. He added Western instruments and European inflection to traditional music like the *dondang sayang*. However, *bangsawan* performances after World War Two started to decline when film-making and entertainment industry was introduced into Malaya. The expansion of the film industry swept through the country and it was then, that his songs and movies rose to fame. P.Ramlee's films were a hit in the cinemas while the gramophones and radios played his songs amidst popular Malay, Chinese, Indian, and Western music (Tan, 1997). The mass media played an important part in boosting P.Ramlee's image and his songs. The next section will discuss a summary of his music.

2.11.1 P.Ramlee's Music

P.Ramlee is looked upon as the Father of Malay films and the man who gave new life to Malay music. He marked the early success and popularity of the film and music industry in Malaysia, elevating the entertainment field to the heights of success during the fifties and sixties. His efforts and special talents infused the Malay music and film industry with an identity that has never been duplicated (Chopyak, 1985).

Figure 2.9: A portrait of P.Ramlee (Yeoh & Begum, 2014).

P.Ramlee composed many different songs about love, humour, criticism, satire, patriotism and culture. The lyrics of these songs were shaped by film themes, involving romantic or tragic love, family affairs, and folk tales from multi-cultural origins. His music is often unique as they were incorporated with rhythm and melodies ranging from local and foreign cultures. He explored Western and Latin American dance rhythms like the samba, rumba, rock and roll, and waltz. At the same time, the nationalistic sentiments of the mid-twentieth century encouraged his utilisation of Malay *asli* rhythmic pattern like the *joget, asli, zapin,* and *inang* into his music (Ahmad Sarji &

Harding, 2002). Besides infusing foreign and local rhythms, P.Ramlee also wrote melodic lines influenced from Middle East (Arabic) and Hindustani modes. He also combined Chinese pentatonic scales, fragments of familiar and popular Western tunes into some of his compositions.

Many of P.Ramlee's songs were composed to accompany scenes in the films he acted in and many became popular hits with his audience. The themes in his films ranged from stories about village to urban life, Arabian or Malay legends, comedies, family feuds to scenes in nightclub entertainments. The origins of the composed music largely depended on the film itself. For example, the song "*Ya Habibi Ali Baba*" was composed for the Arabian folk story, *Ali Baba Bujang Lapok* (1961). The song made used of Arabian modes to form its melodic line. In other films such as *Hujan Panas* (1953), *Labu-Labi* (1962), and *Masam Masam Manis* (1965) featured nightclub entertainments and the songs were infused with western popular dance rhythms like cha-cha-cha, rumba, samba, and beguine. The song, "*Bunyi Guitar*" from the film *Tiga Abdul* featured Pop Yeh Yeh element with swinging rhythm and prominently featured electric guitar play. In the film *Antara Dua Darjat* (1960), it features one of P.Ramlee's most famous songs "*Getaran Jiwa*". He uses the beguine rhythm to accompany this song; it was arranged in a Western homophonic style based on the diatonic scale. According to Chan (2014), the analysis of P.Ramlee's music revealed that he utilised excerpts from scales and melodies from three different cultures namely Chinese, Arabian and Indian. In addition to that, excerpts of Western popular tunes were also adapted into some of his songs. P.Ramlee's utilised melodic modes related to these cultures in some of his films which were based on legendary stories from Malay, Arabian, Chinese, Indian, and Western epics or folk tales. P.Ramlee incorporated the scales and modes to create culture-related character stereotypes, and to evoke the ambience and flavour of these various cultures. With so many unique combinations, it is no doubt that his music has garnered the nation's pride and recognition. All of there elements add on to the great of his music.

His style and music appeal to the public and he became the pioneer toward the development of popular music in Malaysia. He blended a variety of styles from Malaysia's different cultures like the Malay songs using harmonic minor and melodic minor scales, the Chinese narrow to slendro pentatonic scales and Indian keeping to 'Tala' rhythmic system and 'Raga' into scales (Sa'Re'Ga'Ma'Pa' Dha' and Ni). P.Ramlee's music until now is appreciated by many Malaysians who could share in connecting with the music. He set a musical approach that is symbolic to the many sides of Malaysia's multi-culture and innovated other artists in different ways to come in the future (Mahyuddin Ahmad & Lee, 2014). It is a representation of an era where social-cultural interaction merged to form the features of music that rose to great heights due to the dissemination of the mass media. To date, his songs still remain a hit among Malaysians listeners, from the old to the young. In fact, recently, his music has inspired a cross-cultural 2018 Chinese New Year music video to spread festive cheer and celebrate Malaysia's diversity on social media (Chu, 2018).

In the multicultural context of Malaysian society, the diversity of music is both an asset and a challenge to the music therapy community. Even though the therapy involved music process where a person is only required to listen, the choice of songs is important. When selecting music to be used in therapy, the therapist has to take into account the age, cultural, religion, difference, musical background, personal experience, and music preference of the patient. Despite the importance of the patients' music preferences in a therapy process, there are also other imperative justifications that should be considered. For this research, P.Ramlee's music chosen by the Department of

Rehabilitation UMMC laboratory staff, stroke survivors and their family members suitable for most Malaysian as well as the one that they are familiar with. With the popularity of P.Ramlee's music that has been played on radio and television since the 1950s, his music would be familiar with Malaysians that grew up learning about his contributions in music, film and also in painting.

2.12 Chapter Summary

This chapter has discussed in detail the different ways music therapy was used to help in improving the lives of post-stroke patients. The general review of the studies involved has shown the effectiveness of music in improving body motor functions, specifically music as a form of therapy. It is a multidimensional approach to stroke recovery as it provides both cognitive and emotional benefits. It gives a multimodal stimulus that activates many brain structures related to sensory processing, attention, and memory, and can stimulate complex cognition and multisensory integration.

A brief introduction to Music in Malaysia was being discussed with the purpose of understanding music in historical context and values of the cultures on shaping P.Ramlee's music. It continues on to explain his musical style, film and music. This information is crucial to understanding the musical style that he created and composed.

Stroke represents one of the most costly and long-term disabling conditions in adulthood worldwide and there are a need to determine the effectiveness of rehabilitation programs. As discussed in this chapter, playing or listening to music activates an interconnected network of subcortical and cortical brain regions which makes it possible to help minimize the after-stroke effects, boost recovery and enhance the neuroplasticity effects.

This chapter has provided a review of the literature that is pertinent to this study. It provides useful information for the researcher to plan the design of the study, sample selection, research measurement instrument, and data analysis. The following chapter outlines the methods, procedures, and data analyses that were used to examine effect of music on stroke survivors during rehabilitation.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This research is conducted by using mixed method that focuses on collecting both quantitative and qualitative data and analyzing them together. One main advantage of using mixed method is by combining both quantitative and qualitative approaches in combination would provide a more complete picture and better understanding of the research's problems than using only either approach (Creswell & Clark, 2007).

This chapter presents a description of the methodology of the study. It will first explain the research design used for this study. The design covered the different methods used for collecting data by using primary and secondary method; flow chart of the music and the medical procedures involved in the treatment. After that, the songs selection process is detailed. The data collection for the medical procedure is divided into three different stages to test and access the study's feasibility and potential. The stages are:

1) Songs selection process,

2) Process of TMS, and

3) Measurement of neuroplasticity between lesion and non-lesion hemispheres.

The purpose of the first stage is to pre-screen and select potential participants before the experiment. The second stage is to determine whether the effect of music will play a significant contribution in enhancing neuroplasticity in stroke survivors. Lastly, for the final stage is to study the difference in brain neuroplasticity effects of lesion vs non-lesions hemispheres in stroke survivors.

This chapter elaborates the setting of the experiment and research equipment used in the experiment. It continues with the detailed sample selection (stroke survivors and healthy individuals) based on inclusion and exclusion criteria followed by the research measurement instrument. The chapter concludes with explanation about the statistics approach used in data analysis.

3.2 Data collection

This research was carried out using both the primary and secondary methods. These methods were used to obtain information and to cover every aspect of this research. Data collection includes the following methods:

3.2.1 Primary Method

Primary method refers to first-hand information that is collected by the researcher through various methods like interviews, focus group discussion, questionnaires, observations, videography, and photography. Primary data is more authentic, reliable and objective because it has yet to be published. As primary data is current, it has a realistic view of the research which is not outdated. Not only that, the data is collected specifically for the purpose of this research which the researcher will not need to worry that the data is not connected to the topic being studied. The details of method for collecting primary data are as follows:

3.2.1.1 Interview

There were a few interviews conducted in this study. For the music choice in this study, interviews with laboratory staff, stroke survivors and their family members were done in order to obtain information about music preferences. The information gathered was the type of music the participants (stroke survivors and healthy individuals with 55 years old and above) like the most. During the medical safety screening procedures, the stroke survivors and their family were interviewed to obtain information about patient medical history (the type of stroke the patient has, the time duration from the last stroke, and which part of the brain did the stroke affect).

3.2.1.2 Focus Group Discussion

A focus group discussion was held between the researcher and a certified music therapist Miss Lim Kar Gee to gain understanding on music therapy and its development in Malaysia. Besides that, the researcher also consulted with well-known arrangers, Dr. Mohd Nasir Hashim and Dato' Johari Salleh to establish the type of music suitable to be used in this experiment. A discussion with Dato' Hj. Mokhzani Ismail from RTM was done while researcher doing a review in RTM to determine which P.Ramlee's songs are played the most in the station.

3.2.1.3 Questionnaire

Before the medical safety screening procedures, the medical team developed a set of questionnaires and the TMS safety screen (Refer to subchapter 3.4.1.1) according to medical protocol to obtain the demographic information and medical history from the stroke survivors and healthy individuals who participated in this research. The demographic information gathered include name, age, gender and right or left cerebrovascular accident (R/L CVA) stroke diagnosis. The TMS safety screen questionnaire was given to every subject selected as part of the sample group before confirming their participation to rule out any other contraindications if they are involved in the study. This is to further ensure that the risks are minimized.

3.2.1.4 Observation

Observations were carried out during and after the experiment to obtain data. During the experimental procedure, researcher conducts behavioural observation toward subjects' (stroke survivors and healthy individuals) overt responses (facial expressions and emotion) on P.Ramlee's music to understand to if the music is associated with pleasure or discomfort. From these overt responses, we can conclude whether the music would be effective in the experiment. Moreover, the patients' Electromyography (EMG) signals (refer to figure 3.8) were also observed and monitored in order to measure the MEP by using TMS.

3.2.1.5 Photography

Photographs were taken during the interview session with the stroke survivors and family member to document the research procedure. During the experiment, the photo of rehabilitation physician doing a TMS scan on the subject (refer to figure 3.7) and the placement of electrodes on the hand muscles (refer to figure 3.5) were taken to show the procedure of the experiment. Pictures of the research location and the location of the experiment were taken to document the location of the research. The equipment used in the experiment such as TMS and TMS waveform graph (Refer to figure 3.8) was also photographed for data analysis.

3.2.2 Secondary Method

The secondary method involves data that has already been assembled and summarized from other sources. Secondary method uses existing data obtained from readily available sources such as newsletters, magazines, pamphlets, newspapers, journals, reports and online database that were already published before. The review of literature in this research is based on secondary data and collected through content analysis, documentation and random sampling. The details of method for collecting secondary data are as follows:

3.2.2.1 Content analysis

Information regarding music therapy, the effect of music, stroke, post-stroke rehabilitation, neuroplasticity, music in the brain and P.Ramlee's music was gathered from various up-to-date resources such as printed publications and online database. The information included the definition of "music", "music therapy", and "post-stroke rehabilitation process", the relation between music and stroke and successful case studies from the past researches. The literature focusing on P.Ramlee's musical style, film and music was also collected to understanding the music that he created and composed. The researcher quantifies and analyses the meanings and relationships of the key words and concepts, organize and elicit meaning from the data collected and to draw realistic summary and conclusions from it.

3.2.2.2 Documentation

Documentation is essential as the data that emerged during the research process is needed for analysis. Demographic information for individuals that are part of the target population in this research is collected; this is important for subject selection. Behavioural observation toward subjects (stroke survivors and healthy individuals) overt music responses during the experiment is also documented, and neurophysiological monitoring via MEP reading is collected for analysis to answer the research questions of this research.

3.2.2.3 Random Sampling

Random sampling was carried out to sort the subjects into groups for this experiment. By using JavaScript random number generator, subjects were chosen at random for each group. Throughout the random sampling procedure, subjects (N=20) were divided into two main groups; healthy individuals and stroke survivors, and in each group, will be randomly selected into two sub-groups without music (control group) and with music (experimental Group). (Refer to appendix C)

3.3 Flow Chart of the music and medical procedure involved in the experiment

The flow chart in Figure 3.1 shows both the music and medical procedure involved in the experiment.

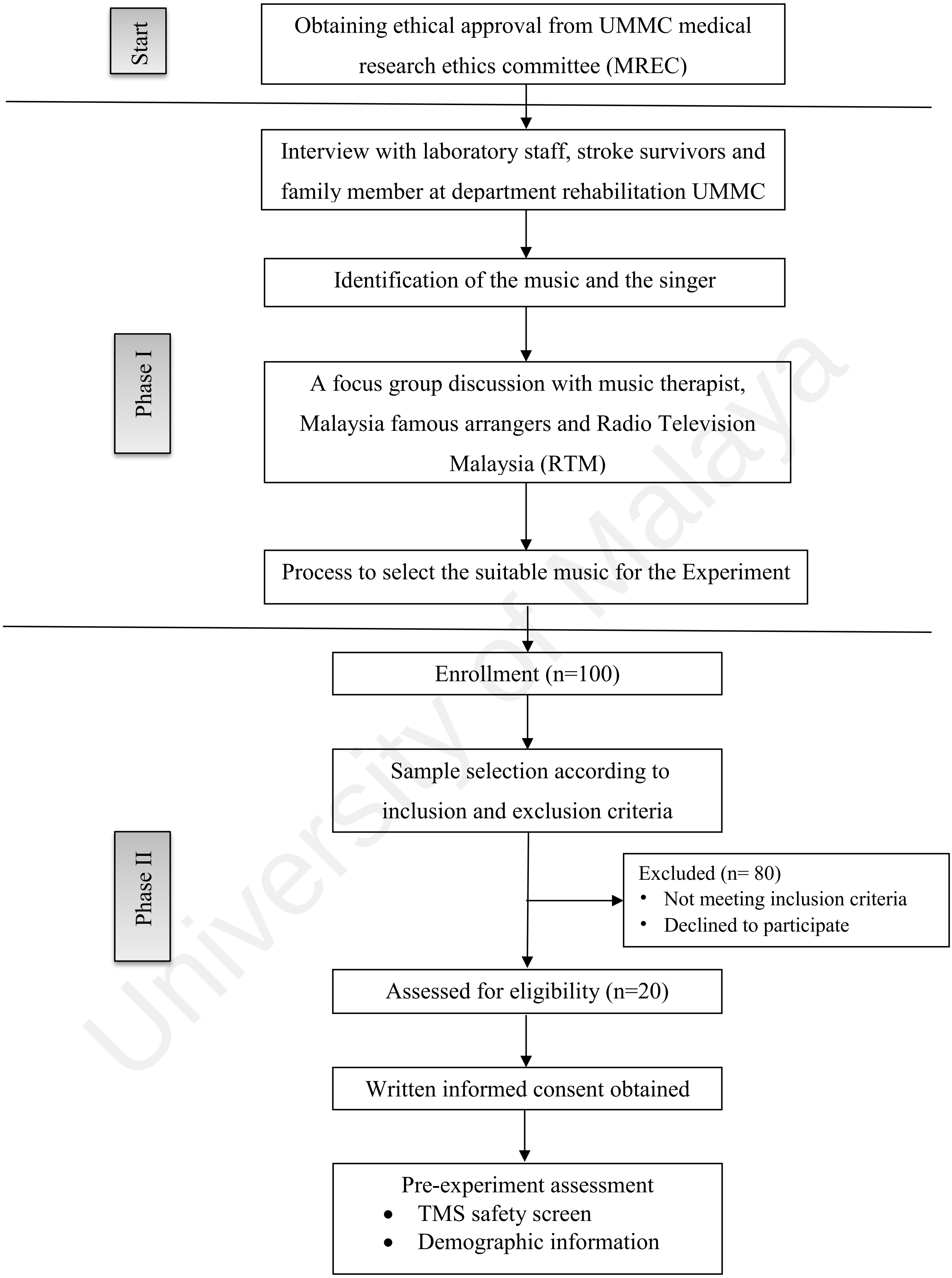


Figure 3.1: Flow chart of the music and medical procedure involved in the experiment.

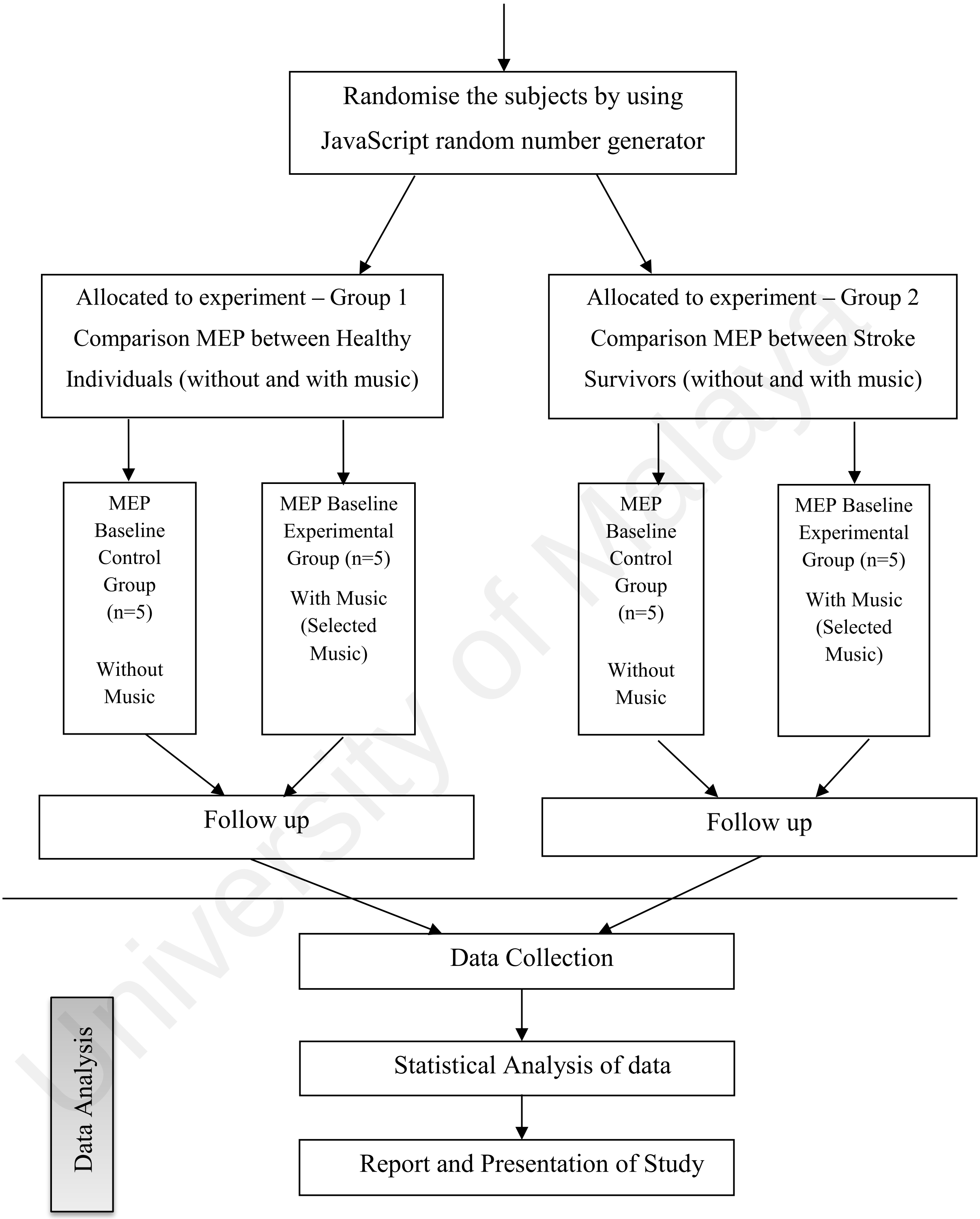


Figure 3.1, continued

Figure 3.1 shows the different phases of the research flow start from the beginning with the ethical approval from MREC to conduct this study, to Phase I (songs selection process) and Phase II (music listening experiment), and concluded with data analysis.

The ethical approval is important to ensure that the research is done successfully with minimal risk of harm to any individual involved. There are ten principles of ethical considerations compiled through Bryman and Bell (2007), after analysing the ethical guidelines set in professional social sciences research organisations:

1. Research participants should not be subjected to harm in any ways whatsoever.
2. Respect for the dignity of research participants should be prioritised.
3. Full consent should be obtained from the participants prior to the study.
4. The protection of the privacy of research participants has to be ensured.
5. Adequate level of confidentiality of the research data should be ensured.
6. Anonymity of individuals and organisations participating in the research has to be ensured.
7. Any deception or exaggeration about the aims and objectives of the research must be avoided.
8. Affiliations in any forms, sources of funding, as well as any possible conflicts of interests have to be declared.
9. Any type of communication in relation to the research should be done with honesty and transparency.
10. Any type of misleading information, as well as representation of primary data findings in a biased way must be avoided.

(Dudovskiy, 2016)

As research is a health-related experiment that involves human participants, the researcher would have to obtain ethical approval (Refer to Appendix E) from the UMMC Medical Research Ethics Committee (MREC). After the ethical approval has been given, the researcher starts on Phase 1: the songs selection process.

The first phase looks at the music that is to be used for the study. It is important that the chosen songs are suitable for the subjects chosen to ensure that the music intervention is effective. During the songs selection process, the researcher first collected data from the Department of Rehabilitation in UMMC to determine the music preferences among the potential subjects who are aged 55-years-old and above. The researcher approached the laboratory staff, stroke survivors and their family members gather the required information. They were interviewed and were given a questionnaire to complete. Each of the subjects was asked about their top ten favourite Malaysian songs and singers. During the songs selection process, a majority of the subjects began to singing or humming the P.Ramlee's songs when they answering the questionnaire. When the researcher asked the subjects to list the songs they would like to listen to and which songs are the familiar to other people, a majority of them select for P.Ramlee's songs as compared to the other songs. From the information gathered, P.Ramlee was listed as one of their favourite. Throughout the interview process, most of the interviewees commented the reason they select P.Ramlee's songs was because they grew up watching his movies and listening to his music. His melodies were simple and familiar to their ears.

Aside from the interview, a focus group discussion was held between the researcher, a certified music therapist and a few well-known arrangers in Malaysia to understand better about the effect of music, the music industry in Malaysia and the type of P.Ramlee music that are suitable for the subjects in this experiment. Besides that, the researcher also conducted a review with the Radio Television Malaysia (RTM) on P.Ramlee's songs to determine which are his most popular songs that been played in the station. Upon the conclusion of the interviews and completion of music list, the researcher conducted a second interview with the laboratory staff, stroke survivors and their family members to identify their favorite songs. Based on the information gathered from the survey among the subjects, several songs were identified and selected.

Phase 2 of this study involves measuring the effect of music to the brain, which would open a way to using music as a tool in medical treatment. The team conducting the experiment included the researchers, a group of nurses and a team of rehabilitation doctor of UMMC. The post-stroke survivors from Department of Rehabilitation, UMMC were recruited to participate in investigating the effect music listening has for post-stroke rehabilitation. Their family members and the staff from UMMC's Department of Rehabilitation were recruited as well to make up the healthy individual Group that will also undergo the same procedure in this investigation. The potential subjects (n=100) were previously checked by the researcher to ensure the subject criteria set (Refer to table 3.3 And 3.4) in the experiment. This is because if any potential participant fits with one of the exclusion criteria (e.g. having neurological disorder or psychiatric illness), he or she would not be selected as the data would not be accurate; which would invalidate the results. Therefore, a total of 80 subjects were excluded after screening and diagnosis of 100 patients and healthy individuals.

From the criteria set, a total of 20 subjects were selected from both the stroke survivors and healthy individuals to study their motor functions and neuroplasticity toward the music listening. After obtaining the written informed consent (Refer to Appendix B), the study procedure was explained in detail and the participant information sheet (Refer to Appendix A) is given to the patient by the researcher and medical team. During pre-experiment assessment, they had to do the TMS Safety Screen test (Refer to topic 3.4.1.1) and fill up the demographic information to ensure the safety of their well-being before undergoing the TMS scanning.

The selected subjects were then randomised by using a JavaScript random number generator to produce customized sets of random numbers in to either the healthy individuals group and stroke survivors group, and in each group, will be randomised into two sub-groups without music (control group) and with music (experimental Group). According to their sub-groups, each subject would be put in a TMS laboratory which will either be playing music or without music for 20 minutes, and then TMS procedures were carried out as per ward protocol.

Therefore, the data collected was conducted from before the start of TMS procedure and follow up after the procedure. The data collected was statistical analysed by using SPSS software. The details of the research will be further elaborated in the following subchapter.

3.4 Phase I: Songs Selection Process

Music is something that every individual will encounter in their daily lives, be it directly or indirectly. As the music is heard more frequently by individuals in their daily lives, it subconsciously become familiar to them, and integrated indirectly into their daily lives (Gibbons, 1977). Therefore, this study aims in finding the best choice of music that will help stroke rehabilitation and its effectiveness in improving stroke survivor's neuroplasticity.

The music used for this study plays an important role in ensuring the subjects can beneficial from it. To ensure the music picked would suite the subjects undergoing the experiment, interviews were conducted and surveys were done to determine the music preferences for the Malaysian population of people aged above 55 years old as that would be minimum age required for the participants of this study. The researcher gathered the data of musical taste during the Department of Rehabilitation of UMMC's laboratory staff, stroke survivors and their family members were interviewed and given a questionnaire regarding their music preference. Those interviewed are all aged 55 years old and above and were chosen to fulfil the similar criteria for selecting this study's subjects. For stroke patients who have difficulty responding (e.g. speech impairment, vision problems), their family members assisted them during their interviews and help complete the necessary consent forms and questionnaire. This ensures the patients do not experience distress. An alternative way where the interview is conducted with the patient's family members without the patient's presence would also be an effective way of initiating non-threatening contact.

A total of 100 subjects who are 55 years old and above were recruited from the Department of Rehabilitation UMMC laboratory staff, stroke survivors and their family members. Each of them was asked to fill up a questionnaire with simple demographic data (name, age and gender) and their top 10 favourite songs and singers (Refer to Appendix D). The researcher tabulated the data according to the top 10 most mentioned singers' names. The data from these interviews is tabulated into Table 3.1 and illustrated in the form of a bar chart in Figure 3.2 below.

Table 3.1: Laboratory staff, stroke survivors and their family members' top ten favourite singers

Singers	Vote
P.Ramlee	498
M.Nasir	70
R. Azmi	39
Jasni	26
Momo Latif	26
Saloma	25
S. M. Salim	21
Uji Rashid	21
Hail Amir	19
Ahmad C. B.	12
Total	757

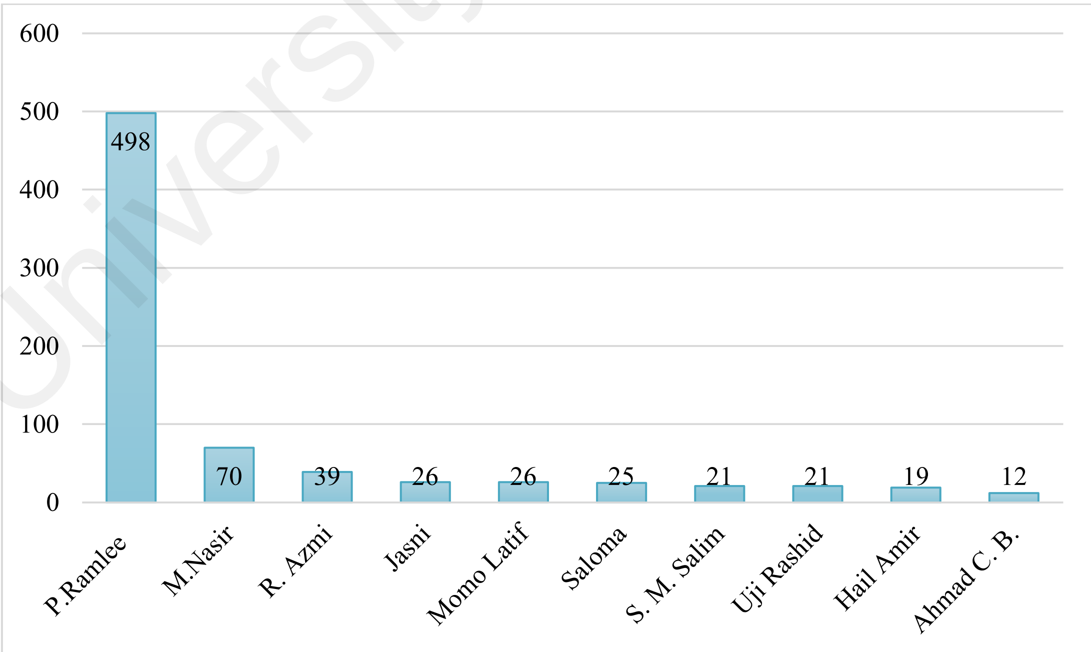


Figure 3.2: Laboratory staff, stroke survivors and their family members' top ten favourite singers

100 subjects aged 55 years old and above and are part of the Department of Rehabilitation UMMC laboratory staff, stroke survivors and their family members participated in this survey. Each of them was asked to list down their 10 favorite singers. From the list, there were frequent mention of singers like P.Ramlee, M.Nasir, and R. Azmi. From the lists by one hundred subjects, there were a total of 30 names for favourite singers. The researcher compiled and tabulated the top 10 singers as shown in Table 3.1 and Figure 3.2. Hence, from the 1000 names mentioned, 757 were for the top 10 favorite singers in mentioned table above, another 243 were for another 20 singers. The top 10 most mentioned favourite singers chosen by the subjects are: P.Ramlee, M. Nasir, R. Azmi, Jasni, Momo Latif, Saloma, S. M. Salim, Uji Rashid, Hail Amir and Ahmad C. B. From the top 10 favourite songs selected by the subjects, P.Ramlee's name was mentioned 498 times, second highest was M. Nasir who was selected by 70 people as one of their favourites and followed by R. Azmi (39 times), Jasni and Momo Latif tied at fourth place with 26 times respectively, Saloma (25 times) was one of the favourites at number 6, S.M Salim and Uji Rashid were both at number 7 with their names stated 21 times each respectively in the list, Hail Amir at eight place with his name mentioned 19 times, and Ahmad C. B. (12 times) is at tenth place. P.Ramlee emerged the most mentioned in every subject list as seen in the Table 3.1 and Figure 3.2, and it can be concluded that most of the subjects' favourite artist is P.Ramlee.

After completing the survey, researcher conducted the literature searches throughout the Malaysia music history using available materials such as publications, newspapers, magazines, and on-line data bases. Through literature searches done, P.Ramlee's name has emerged as the most famous composer in Malaysia's music industry. A prominent icon in Malaysia's entertainment industry, P.Ramlee was a composer, songwriter, singer, producer, film director and actor who is on par with other international composer such as Gilbert and Sullivan from England and Rodgers and Hammerstein from USA. The name P.Ramlee catapulted the growth of Malaysian music and film industry during the 1950's (FelixEntertainmentDocCom Production, 2001), which is famous during subjects' (55 years old and above) youth. His fame has even reached as far as Singapore, Brunei Sumatra and Indonesia, as well as in Hong Kong and Japan (Tam, 2012). To date, his films and songs are still popular by Malaysians of every generation whether they are young or old. His strong influence on Malaysia's popular culture back then is reflected in modern productions and songs. P.Ramlee's classic movies continue to be a hit amongst today's viewers, as television stations air reruns of his famous titles, and production houses churn DVD copies of his award-winning work. His top five films were made during the golden Age of Malay cinema in the 1950s and 1960s, and four of the movies were produced and directed by P.Ramlee.

(a) *Penarek Becha* (1955)

(b) *Pendekar Bujang Lapok* (1959)

(c) *Ibu Mertua Ku* (1962)

(d) *Tiga Andul* (1964)

P.Ramlee's songs are often composed to be used in his movies. As listed in the top fifteen P.Ramlee songs by RTM Radio and Televisions Channels in their top hits charts, all the songs were featured in his movies:

(a) *Azizah* – Film: *Penarek Becha*

(b) *Bunyi Gitar* – Film: *'Tiga Abdul'* / 'Three Abduls' (1964)

(c) *Tiga Abdul* – Film: *'Tiga Abdul'* / 'Three Abduls' (1964)

(d) *Jeritan Batin Ku* – Film: *'Ibu Mertua Ku'* / 'My Mother In-Law' (1962)

(e) *Di Mana Kan Ku Chari Ganti* – Film: *'Ibu Mertua Ku'* / 'My Mother In-Law' (1962)

(f) *Engkau Laksana Bulan* – Film: *'Penarek Becha'* / 'Trishaw Man' (1955)

(g) *Getaran Jiwa* – Film: *'Antara Dua Darjat*' (1960)

(h) *Inang Baru* – Film: *'Penarek Becha'* / 'Trishaw Man' (1955)

(i) *Dendang Perantau*

(j) *Uda Dan Dara*

(k) *Malam Bulan di Pagar Bintang* – Film: *Pendekar Bujang Lapok* (1959)

(l) *Tunggu Sekejap* – Film: *Sergeant Hassan* (1958)

(m) *Jangan Adek Angan Angan* – Film: *Musang Berjanggut* (1959)

(n) *Merak Kayangan* – Filem: *'Hujan Panas'* (1953)

(o) *Jangan Tinggal Daku* – Film: *'Ibu Mertua Ku*' / 'My Mother In-Law' (1962)

As we can see, the greatest hits mostly derived from the top five Malay films, its means a great film could create good music. Also, his life achievement included the title "The Most Versatile Talent" obtained from the 10th for the Asian Film Festival award in Tokyo 1963, for the "*Ibu Mertuaku*" film (Abdul Hamid, 1999). This award was presented in recognition of his greatness in three areas, namely acting, directing, and the music composing (Wan The, 2003). This film has contributed three attractive songs "*Jangan Tinggal Daku*," "*Di Manakan Kucari Ganti*," and "*Jeritan Batinku*." Which became the icon of the film. Some songs have remained a favorite with the local majority because of the simplicity of his melodies. Undeniably, his songs are also familiar to most Malaysian and have also been aired on radio and television often (Tam, 2012). Besides that, P.Ramlee's songs have often been a companion to the subjects participating in this research. According to Dato' Hj. Mokhzani Ismail, these songs are easy to comprehend and have playable arrangements and are often played on the radio or television along with some traditional songs that are more familiar to their generation.

Even after P.Ramlee passed away in 1973, his movies and songs continue to bring an impact, not only to the nation but also to people around the world. Malaysia's favourite jazz singer, Sheila Majid has an album dedicated to the legend P.Ramlee, and it became her bestselling one yet. In her first concert in Los Angeles, California, USA, at the Commerce Hotel & Casino, she sang a medley of P.Ramlee songs like '*Bunyi Gitar', 'Tiru Macam Saya*' and '*Bila Larut Malam'*. Australian native, Raymond Crooke who loves singing folk songs from all around the globe has done several cover versions of his songs. His songs were also a popular choice by many singers when they performed on stage or on the screen.

There were also many things done as a dedication to him: a gallery museum in Penang has been constructed in the memory of the Malaysian legend, in line with the Penang State Government's initiative to revive the great figures of art who are from the state. In Kuching, *Bintang P Ramlee*, synonymous with Radio Televisyen Malaysia (RTM) Sarawak, has become one of the most popular reality programme in the country. Besides that, an annual P.Ramlee festival is hosted to commemorate the legend and to promote the arts to the community.

Every Hari Raya Aidilfitri, movies and songs by P.Ramlee will be broadcasted on air, with current singers also re-creating versions of his classics on TV shows, P.Ramlee and Hari Raya are synonymous that it has become a tradition (Afdeza Monir, 2015). Even for Chinese society, his music has inspired a cross-cultural Chinese New Year music video to spread festive cheer and celebrate Malaysia's diversity on social media (Chu, 2018). His musical style has a strong influence of Western tonality but it still reflects Malaysia's multi-cultural atmosphere (Chan, 2012).

After completed the literature search, researcher scheduled a focus group discussion with the music therapist and arrangers in Malaysia. The discussion with the arrangers revealed that P.Ramlee's legacy is still being remembered, and has inspired many musicians, arranger and composers. One of the arrangers, Dr. Mohd Nasir Hashim, commented that P.Ramlee was the most iconic name in the Malaysian entertainment industry. He commented that he himself has referred to P.Ramlee's original works and name in western classical form or popular music style to do his orchestra arrangements. Fellow arranger, Dato' Johari Salleh also commented he himself is an arranger and conductor who likes to interpret the works of other musicians like P.Ramlee in his showcase (Saiful Bahri Kamaruddin, 2014).

According to Lim Kar Gee, music listening enhances cognitive, emotional, and neural recovery extensively activate the human brain. This increased the blood flow which assists the brain in restoring the blood vessels and synaptic connections that were damaged by stroke. Besides that, music that the subjects are most familiar with would often connect to memories and experiences, and with it, personal emotions. This connection provides comfort and support when undergoing highly stressful and life-changing events.

Based on the information gathered from the above, the experimental songs will be selected from P.Ramlee's greatest hits. The duration for music listening experiment was 20 minutes, therefore approximately 6 songs will fulfil the time length. Subjects were asked to vote on their favorite songs respectively by fill up the questionnaire. The researcher then collected the votes for every song and shortlist them to the top six songs with the highest number of votes. Below are the results of the songs:

Table 3.2: List of favorite songs as voted by laboratory staff, stroke survivors and their family members

	Title	Vote
1*	*Azizah*	70
2*	*Bunyi Gitar*	68
3	*Tiga Abdul*	30
4*	*Jeritan Batin Ku*	45
5	*Di Mana Kan Ku Chari Ganti*	39
6*	*Engkau Laksana Bulan*	59
7*	*Getaran Jiwa*	57
8	*Inang Baru*	41
9	*Dendang Perantau*	20
10	*Uda Dan Dara*	29
11	*Malam Bulan di Pagar Bintang*	9
12	*Tunggu Sekejap*	36
13	*Jangan Adek Angan Angan*	21
14	*Merak Kayangan*	14
15*	*Jangan Tinggal Daku*	62
	Total	600**

*Top voted six songs

**Each subject is given 6 votes to choose their favourite songs. There are a total of 100 subjects.

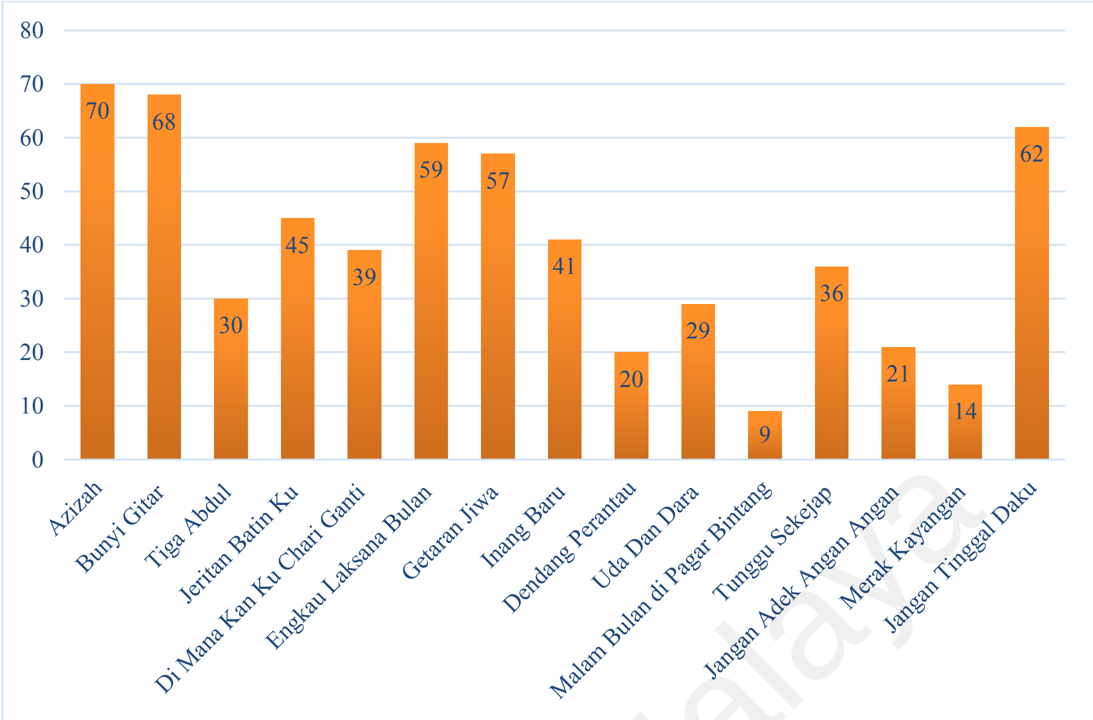


Figure 3.3: Graph of favorite songs as voted by laboratory staff, stroke survivors and their family members

The table and figure above displayed the results for the procedure process, P.Ramlee favorite songs between the shortlisted six songs. One hundred subjects with 55 years old and above from laboratory staff, stroke survivors and their family members participated in this survey. Each person will have to choose 6 out of 15 songs from the P.Ramlee greatest hits obtain from RTM. The total vote for one hundred people with six votes for each person is 600. Based on the results tabulated above, it can be seen that the six songs with the highest number of votes were *Azizah, Bunyi Gitar, Jeritan Batin Ku, Engkau Laksana Bulan, Getaran Jiwa,* and *Jangan Tinggal Daku* and with the number of votes were 70, 68, 45, 59, 57 and 62 respectively. It can be concluded that the selected song will be the experimental song in this research. Next, the following subchapter will be discussing the medical procedure in UMMC

3.5 Phase II : Medical Procedure in Department of Rehabilitation University Malaya Medical Centre (UMMC)

For this pilot controlled test study, a sample size of 20 subjects (55 years old and above) has been determined through clinical discussion between the researcher and medical team in order to test for management, feasibility and effects, before planning a larger trial determined through power analysis. An experimental design with music listening procedure is used whereby the subjects in both the stroke survivor and healthy individual groups were randomized into two groups: Control group (without music) and Experimental group (with music). The music listening procedure (Refer to subchapter 3.4.2) was done once for every individual where their baseline for brain activity was measured right after. The TMS procedure was used to identify and measure MEP signal. This medical procedure was conducted in three subsequent stages, each stage with definite and precise objectives and methodology as following:

3.5.1 Stage One: Songs Selection Procedure

The idea of this stage is to explore the type of music that is able to enhance brain neuroplasticity and pre-screen the subjects before the experiment, and therefore, could benefit the most for stroke rehabilitation. As some stroke survivors are unable to respond, the guardian or family member for the subjects for stroke survivors will filled out the questionnaire, demographic data forms and TMS Safety Screen questions for the study indicating patient history of musical interest used for experiment purposes. The researcher has also interviewed family members of the stroke survivors participating in the research to further delve into the music favorite and interests of the subjects in order to reduce any distress that may occur.

3.5.1.1 TMS Safety Screen

Before undergoing the TMS analysis, the subjects were asked a set of questions as part of the safety screening for their well-being. Below are the questions that have been approved by the UMMC's MREC:

Below is a standard set of question that covers the essential absolute and relative contraindications:

1. Do you have an adverse reaction to TMS? (The most common adverse events reported were application site pain and headache.)
2. Do you have seizure or have you ever had a convulsion or a seizure? (Epilepsy is an absolute contraindication)
3. Do you have an Electroencephalogram (EEG)? (Recording of EEG activity immediately before, during, and after TMS is possible provided that certain technical challenges are addressed and few precautions taken)
4. Do you have head injury or neurosurgery? (Conditions that will increase the risk to patient's health in the event of a seizure)
5. Do you have any metal in your head (outside of the mouth,) such as shrapnel, surgical clips, or fragments from welding or metalwork? (Metal can be moved or heated by TMS. Therefore, the presence of metal anywhere in the head, excluding the mouth, is generally a contraindication to TMS.)
6. Do you have any implanted devices such as cardiac pacemakers, medical pumps, or intracardiac lines? (TMS may interfere with electronics and those with heart conditions are at greater risk in event of seizure)

7. Do you suffer from frequent or severe headaches? (Recurrent headaches of no known cause that do not respond to over the counter medications are a relative contraindication)
8. Have you ever had any other brain-related condition? (Presence of other neurological disease that may be associated with an altered seizure threshold)
9. Have you ever had any illness that caused brain injury? (Conditions that will or may increase the risk of seizure)
10. Are you taking any medications? (e.g. Tricyclic anti-depressants, neuroleptic agents, and other drugs that lower the seizure threshold)
11. Does anyone in your family have epilepsy? (Epilepsy amongst first degree relatives is a relative contraindication)
12. Do you need further explanation of TMS and its associated risks?

The TMS Safety Screen is the standard procedure for medical (Rossi, Hallett, Rossini, Pascual-Leone, & Safety of TMS Consensus Group, 2009). The questions were given verbally where the subjects would answer them. Their answers were then written down by the researcher. Any clarification or questions were also addressed during this safety screening session.

3.5.2 Stage Two: Process of TMS

In accordance to the objectives of this research, this stage aims to discover answer to the following issues:

(a) To determine the effects of music in stroke rehabilitation through augmenting stroke survivors brain neuroplasticity by measuring the MEP using TMS (Refer to subchapter 4.4.2)

(b) To determine the best placement for TMS in recording patient MEP thus reflecting patient's brain neuroplasticity. (Refer to Figure 3.6)

(c) To determine the anatomical factor as well neuronal circuit that involve in brain neuroplasticity in relation to music rehabilitation.

As explained in the sample selection in subchapter 3.7.1, the subjects involved are divided into two groups: stroke survival and healthy individuals. Each group was further split into two sub-groups – the control group (without music) and experimental group (with music). The experimental group for each group was exposed to music as part of their rehabilitation while the other group acted as the control group where no music will be involved in their therapy. Each subject was brought to a TMS laboratory alone where they were told to relax for 20 minutes. Music videos of the selected songs were played in room for subjects that are part of the experimental group, while the other group will not have any music. At the end of the 20 minutes session their MEP was measured using TMS. The results in this phase will help us determine whether music listening intervention play a significant contribution in enhancing neuroplasticity in stroke survivors.

3.5.3 Stage 3: Measuring Neuroplasticity between Lesion and Non-Lesion Hemispheres

This stage looked to study the difference brain neuroplasticity effects of lesion vs non- lesions hemispheres in stroke survivors. The measurement of their MEP took into account the effects of music rehabilitation of the same stroke survivors by measuring the difference in lesion vs. non- lesions hemispheres. This is because stroke alters the balance between excitation and inhibition between the hemispheres which could occur over time following a stroke. Depending on the time from the stroke, down-regulation of the activity in the lesion hemisphere and in the unaffected hemisphere, or up-regulation of activity in perilesional brain regions may minimize damage or promote functional recovery. Both groups had their MEP measured and compared, individually and as a collective in order to note the effect of music.

3.5.4 TMS Coil Localization

The measurement for stages 2 and 3 are conducted through this process. For accuracy in navigating TMS, determination of the hotspot location of hand muscles is crucial because it is the basis for the resting motor threshold (RMT) in recording a patient's MEP, thus reflecting the patient's brain neuroplasticity. Single-pulse magnetic stimuli were delivered using the Magstim Rapid^2 stimulator with a flat 70 mm figure-of-eight magnetic coil. At the beginning of a TMS motor mapping procedure, electrodes were placed on the hand muscles of the participant that are to be mapped. We routinely mapped the index finger (FDI), thenar space and wrist. These electrodes were connected to the TMS machine that controls the firing of the coil and analysed the muscle responses. Figure 3.4 show an example of the electrodes placement on the hand muscle mapping below.

Figure 3.4: An image of the placement of electrodes on the hand muscles.

Similarly, for the cortical mapping, single-pulse magnetic stimuli were delivered using a Magstim 2002 (Magstim, UK) stimulator with a Double 70mm Alpha Coil. The subjects wore elastane cap to map the potential stimulation sites. The international 10–20 marking system was used to optimize the best stimulation site as shown below in Figure 3.5.

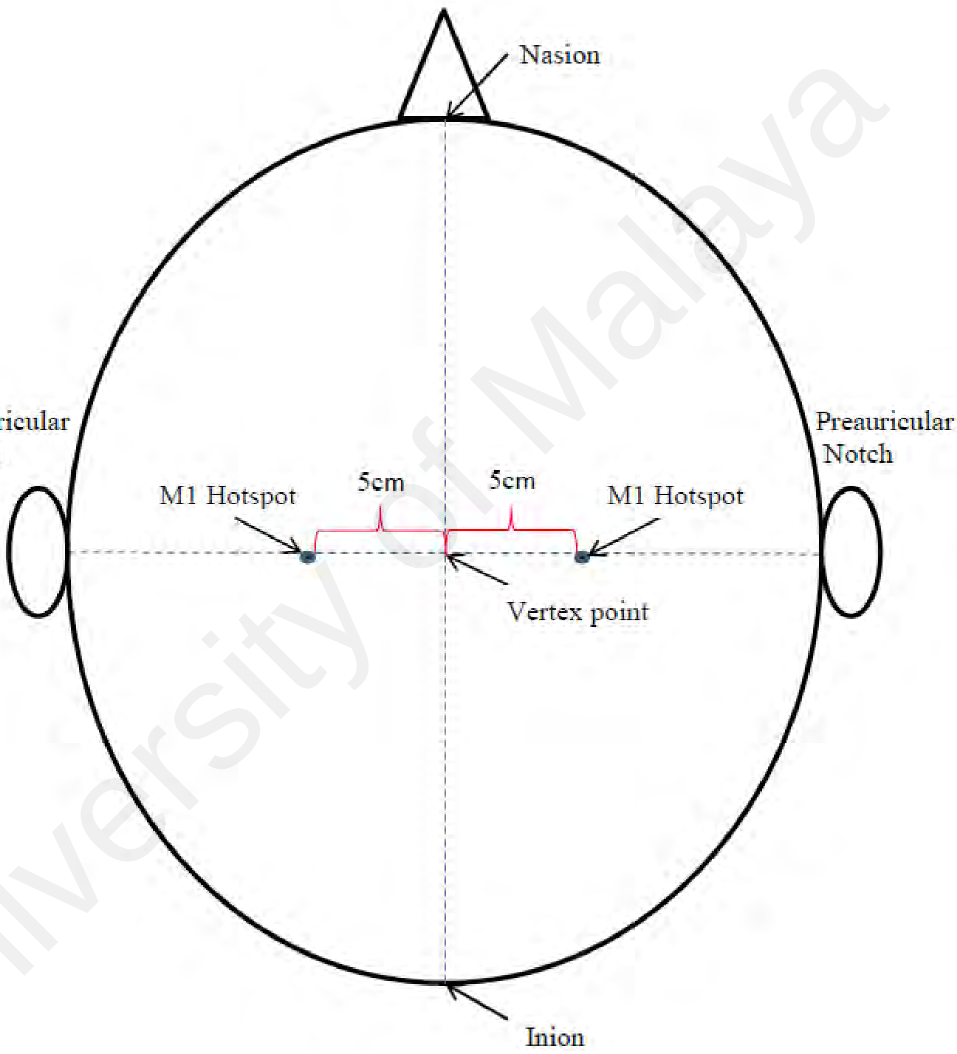


Figure 3.5: The 10-20 marking system used for cortical mapping.

Using the international 10–20 system, the vertex point (the middle of both Preauticular notch and the middle of Nasion and Inion) was measured and marked to be used as a reference. The M1 hotspots were located 5 cm lateral from the vertex point. The coil was set at an angle of 45 degrees to the midline and tangential to the scalp with the handle pointing backwards (in a lateral to medial and caudal to rostral position), such that the induced current flowed in a posterior-anterior direction. To determine the optimal site of stimulation (hotspot), the coil was moved around the M1 of the target muscles to trigger the M1 overlapped area for both the Extensor Carpi Radialis Brevis (ECRB) (one of the mapped muscle that control movements at the wrist) and FDI (one of the mapped muscle that control movements at the index finger) muscles that gave the largest MEP response. This overlapped M1 area is called the ‘‘combined hotspot’’. The optimal spot for stimulation of the FDI muscle is more anteriorly and laterally located relative to the vertex than that for the ECRB muscle.

The Rossini-Rothwell Method: RMT was defined as the minimal stimulus intensity that evoked 5 MEPs in a series of ten tests with amplitude of at least 50 mV from the combined hotspot of both ECRB and FDI muscles. Hence, the same RMT was used for both muscles. The RMT for each subject was determined by increasing and decreasing stimulus intensity in 5–10% intervals until MEPs of appropriate size were elicited. An example of TMS treatment done by UMMC’s doctor is shown below in Figure 3.6:

Figure 3.6: The rehabilitation physician doing a TMS scan on the subject.

Once the coil was positioned as per the mapping, the magnetic coil was fired and responses from the muscle electrodes were read. A graph of muscle response in microvolts (*uV*) versus time in milliseconds (*ms*) was generated for each muscle being mapped. Figure 3.7 shows an example graph in waveform of the TMS.

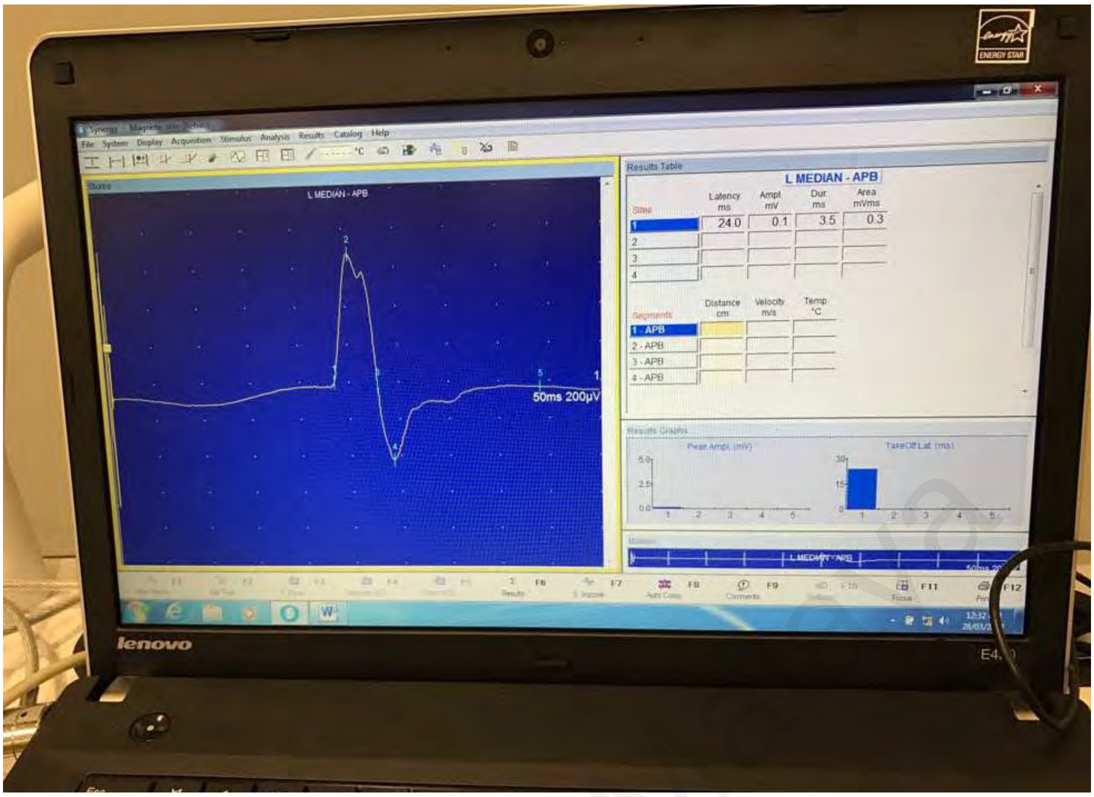


Figure 3.7: An image of the TMS waveform graph.

Each waveform was coded semi-automatically to extract the times corresponding to the takeoff, peak, trough, and recovery of the response. The two measures most often used in the analysis of motor mapping data are latency and amplitude. The latency of the response is defined as time of the takeoff in *ms* and the amplitude is the absolute difference between the peak and trough in *uV*. When the magnet is placed directly over the ‘hotspot’ of a muscle (or region of cortex that controls that muscle), the amplitude of the response should be large and the latency of the response should be small, as compared to the responses when the coil is place away from the hotspot.

3.6 Setting of the Experiment

The testing and assessment of the stroke survivors and healthy individuals were done in the Rehabilitation department where the process of music listening is incorporated into the medical routine of the subjects. The experiment of the process of music listening was conducted in a quiet room for both control and experimental group, while the analysis and assessment of their progress were measured at the TMS procedure room.

3.7 Research Equipment

There are three types of equipment used in this research. The first involved electronic devices used for playing the music selected in this research. The researcher used a laptop, speakers and music software to ensure the music runs its course as the experiment is in process. The second type is the equipment for assessing the plasticity of the brain, the TMS is used for MEP recording and tabulating. Lastly, the final equipment was used for analysing the data; the researcher applied the SPSS software for statistical calculation of the data collected from the medical assessment.

3.8 Subjects Selection (Stroke Survivors & Healthy Individuals)

The subjects for this study were chosen by the medical team and researcher. There will be two groups involved for this research with a total of 20 subjects. The first group consists of stroke survivors and the second comprises of healthy individuals. The researcher is primarily interested in precise estimates of feasibility and acceptability, as well as outcome variability that will aid in the planning of a larger, sufficiently powered efficacy trial. According to different neuro researches which pilot studies are conducted with TMS, a minimum number sample size of 5 per group is ample to allow relative precision in making conclusions regarding feasibility outcomes (Julkunen et al., 2008; Kolbinger, Höflich, Hufnagel, Müller, & Kasper, 1995; Tretriluxana, Kantak, Tretriluxana, Wu, & Fisher, 2015).

A list of all the stroke survivors from the Rehabilitation department UMMC was examined. With the advice of medical team, the researcher shortlisted the stroke survivors to be selected according to the criteria as shown in Table 3.3 below.

Table 3.3: Criteria for selection of stroke survivors.

Inclusion criteria	Exclusion criteria
1. 55 years old above (The risk of having a stroke more than doubles each decade after the age of 55.) 2. Has experienced stroke 3. Patients of Rehabilitation unit. 4. Able to hear. 5. Healthy enough to participate in the study. 6. Able to attend the experiment sessions without schedule conflicts. 7. No contraindications to undergoing a TMS. 8. No history of epilepsy/seizures.	1. Neurological disorder or psychiatric illness. 2. Has an implanted metallic hardware near coil: • pacemakers • implantable medical pumps • ventriculoperitoneal shunt 3. After brain surgery. 4. Severe spasticity/pain. 5. With uncontrollable issues due to natural aging.

The subjects involved in this group (N=10) were stroke patients aged 55 years and above, who were admitted to the department of rehabilitation UMMC. Potential subjects were scrutinized in order to ensure that none fulfill the exclusion criteria as mentioned in Table 3.4. It is important they fulfill the inclusion criteria to minimize the risk of any danger to themselves – they have to be healthy enough in order to participate in the study; no history of seizures or epilepsy; they should be able to hear well; they have to be able to attend the experiment sessions without schedule conflicts; and have no contraindications to undergoing TMS.

In the second group, healthy individuals are selected from members of the laboratory staff of UMMC, and family members of the stroke survivors involved as post-stroke survivors in the Rehabilitation department. The criteria for participating are show in Table 3.4 below.

Table 3.4: Criteria for selection of healthy individuals.

Inclusion criteria	Exclusion criteria
1. 55 years old above (The risk of having a stroke more than doubles each decade after the age of 55).	1. Neurological disorder or psychiatric illness.
2. Healthy.	2. Has an implanted metallic hardware near coil: a) pacemakers b) implantable medical pumps c) ventriculoperitoneal shunt
3. No contraindications to undergoing a TMS.	3. After brain surgery.
4. No history of epilepsy/seizures.	4. Severe spasticity/pain.
	5. With uncontrollable issues due to natural aging.

The subjects involved in this group (N=10) are healthy individuals aged 55 years and above. Potential subjects were analyzed in order to ensure that none fulfill the exclusion criteria as mentioned in Table 3.4. For the inclusion criteria, they must not have any illness such as stroke and have no contraindications to undergoing TMS. One important criteria that the researcher stresses on is that they don't have history of epilepsy or seizures in order to summarize any risk that might endanger the subjects themselves.

The people chosen to undergo the experiment in both groups (stroke survivors & healthy individuals) were then approached and the procedure of the research was explained to them. After obtaining consent from (Refer to Appendix B) the parties of both groups, the researcher and medical team selected 10 people from each group using random sampling generated with JavaScript random number generator to form Group 1 Comparison MEP between Healthy Individuals (Without music, With music) and a Group 2 Comparison MEP between Stroke Survivors (Without music, With music). (Refer to Appendix C).

3.9 Research Measurement Instrument – Transcranial Magnetic Stimulation (TMS)

A NIBS technique that consists of a magnetic field emanating from a wire coil held outside the head. The magnetic field from the wire coil attached to the TMS measuring machine induces an electrical current in nearby regions of the brain. TMS was originally developed as a diagnostic tool for mapping brain function. It appears promising as a treatment for some neuropsychiatric conditions, particularly major depression, as well as predominantly utilized in the study of brain physiology and function, neuroplasticity and its behaviour relevance, and the functional networks between various brain regions. TMS are shown to induce long-term effects on cortical excitability that last for months after the intervention, (Dimyan & Cohen, 2011) which may, in turn, lead to long-lasting behavioural modifications. These effects are believed to engage mechanisms of neuroplasticity, rendering NIBS well-suited to promote recovery of cognition and motor functions, especially in combination with other types of rehabilitative methods. Results from several studies show that active stimulation of either the affected or the unaffected motor cortex in combination with physical and occupational therapy improves motor outcome after stroke. For example, a meta-analysis of 50 randomized clinical trials and 1282 patients with stroke found that TMS were effective in improving motor outcomes after stroke (Adeyemo, Simis, Macea, & Fregni, 2012).

Even though results have shown that TMS has an effect in improving motor mobility for post-stroke survivors, they would need multiple treatments to see the results. As mentioned, TMS was built to map the brain functions (Liepert, Graef, Uhde, Leidner, & Weiller, 2000) and this would be a good measurement instrument for this research.

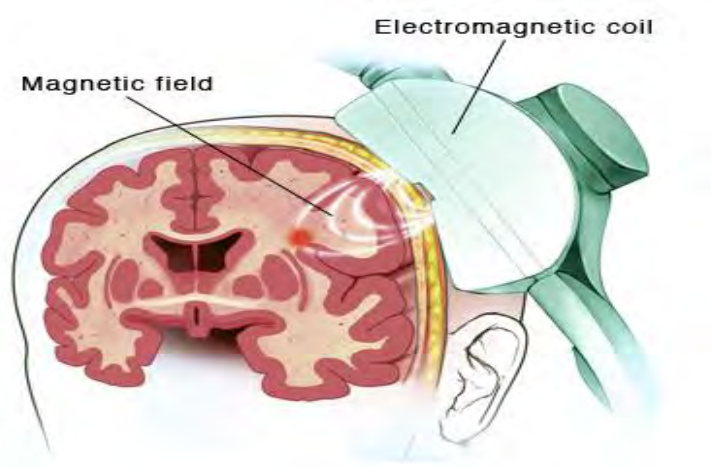


Figure 3.8: An image of how TMS works (Mayo Clinic, 2017).

3.9.1 Medical Assessment Equipment in UMMC Rehabilitation Department

(a) Magstim Rapid²

The Magstim Rapid² is ideal for a wide variety of research fields, as well as therapeutic applications. It can also deliver single pulse stimulation protocols using 230V or 110V supply. This equipment is considered ideal for researchers studying rTMS effects in the following applications:

(a) Cognitive neuroscience – Cognitive neuroscience is an interdisciplinary area of research that combines measurement of brain activity (mostly by means of neuroimaging) with a simultaneous performance of cognitive tasks by human subjects (Pereira, 2007).

(b) Psychiatry – Psychiatry is the branch of medicine focused on the diagnosis, treatment and prevention of mental, emotional and behavioural disorders (American Psychiatric Association, n.d.).

(c) Neurophysiology – Neurophysiology is a discipline within the health sciences which deals with the measurement and assessment of nervous system function rather than the anatomy of the nervous system (Thomas, 2016).

(d) Rehabilitation – The process of helping a person who has suffered an illness or injury restore lost skills and so regain maximum self-sufficiency. For instance, rehabilitation work after a stroke may help the patient walk and speak clearly again (MedicineNet.com, n.d.).

With all the usual benefits of a Magstim product, including reliability, simplicity and speed of set up, the Rapid² also features a unique temperature prediction algorithm that gives users a high degree of confidence that a protocol can be achieved.

Figure 3.9: A model of the Magstim Rapid^2 used to measure the subjects' MEP (Magstim Rapid^2, n.d.a).

(b) Double 70mm Alpha Coil

The D70mm Alpha coil is a direct replacement for the most widely used coil in research literature, the 9925-00 coil. The excellent stimulating performance and focality of this coil has made it the coil of choice for many key opinion leaders in the field of neuroscience for the past two decades. The coil has been designed for use with the latest Magstim stimulators and requires no separate adaptor. Its coil head has dual interlock switches on the handle to prevent inadvertent or accidental triggering of the coil.

Figure 3.10: An image of the Double 70mm Alpha Coil (Double 70mm Alpha Coil, n.d.b).

3.10 Data Analysis

The data is measured using non-parametric tests – Wilcoxon signed-rank test and Mann Whitney test. For these tests, the discontinuous numeric variables and demographic characteristics will be summarized using descriptive statistics.

3.10.1 Non-parametric Test: Wilcoxon Signed-rank Test.

The Wilcoxon signed-rank test is a rank-based non-parametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. Below are the assumptions for the Wilcoxon signed-rank test:

(a) Dependent variable should be measured at the ordinal or continuous level. Ordinal scale, ratio scale or interval scale are dependent variables.

(b) Independent variable should consist of two or more categorical, independent groups.

(c) There should be an independence of observations where there is no relationship between the observations in each group or between the groups themselves.

(d) All groups should have the same shape distributions.

One of these research objectives is to do the comparison between pre- and post-test for the two groups (stroke survivors and healthy individuals) based on two different variables (control and experimental) separately. Another objective for this research is to compare the MEP between lesion and non-lesion sites on stroke survivors. Based on the assumption for the Wilcoxon signed-rank test above, the dependent (MEP) and independent (healthy individuals and stroke survivors), lesion hemispheres (left and right) variable have fulfilled the requirement, as well as the independence of observations – there is no relationship between stroke survivors & healthy individuals.

3.10.2 Non-parametric Test: Mann Whitney Test.

The Mann-Whitney test is used to compare differences between two independent groups when the dependent variable is either ordinal or continuous, but not normally distributed. Below are the assumptions for the Mann Whitney test:

(a) random samples from populations

(b) independence within samples and mutual independence between samples

(c) measurement scale is at least ordinal

Another objective for this research is to compare the MEP between healthy individuals and stroke survivors. Based on the assumption above, the independent variables that meet this criterion include group (stroke survivors and healthy individuals), variables (control and experimental). As the data is not normally distributed, Mann Whitney test is suitable for the statistical calculation.

Although both Wilcoxon signed-rank test and Mann Whitney test are not as powerful as the ANOVA, but for pilot study, that is enough to see if there is a possibility continue and further this research into bigger sample size.

3.11 Chapter Summary

This study aims to investigate the effect of music intervention on stroke survivors during rehabilitation. The subjects for this study were 20 subjects (55 years old and above), consisting of stroke survivors and healthy individuals. The instruments used to collect data included laptop, speakers, music software, TMS machine, demographic questionnaire and music preferences questionnaire.

Data was collected in two phases, 1) songs selection process, and 2) music experiment. The first phase was to determine the type of music applied in the second phase. In the second phase, the music listening was conducted on the subjects that are part of the experimental group to measure the MEP signal for future data analysis.

The data was analysed quantitatively using the SPSS software. Descriptive statistic such as mean and median were employed. The Wilcoxon signed-rank test was employed to investigate the relationships between the dependent (MEP) and independent (healthy individuals and stroke survivors), lesion hemispheres (left and right) variable. The Mann-Whitney test were used to investigate relationships between group (stroke survivors and healthy individuals) and variables (control and experimental).

The next chapter discusses the results of the analysis. The results are presented according to the research objectives and questions.

CHAPTER FOUR

DATA & ANALYSIS

4.1 Introduction

This chapter presents the data collection and the data analysis. The statistical primary data is in the form of MEP and tabulated at pre- and post-test during the procedure. The primary data was then analysed using SPSS software for the non-parametric test: Wilcoxon signed-rank test and Mann Whitney test. SPSS is the statistical software used to solve research problems by means of ad-hoc analysis, hypothesis testing, geospatial analysis and predictive analytics (IBM Analytics, n.d.). Statistical data analysis began with Wilcoxon signed-rank test to evaluate the MEP on the healthy individuals group and stroke survivors group on two types of variables (control and experimental) separately.

The Wilcoxon signed-rank test is a non-parametric analysis that statistically compared of the average of two dependent samples and assess for significant differences (Surhone, Timpledon, & Marseken, 2010). This test was applied to compare the comparison between lesion and non-lesion hemispheres of stroke survivors. The stroke survivors with different CVA were compared according to their corresponding lesion hemisphere (left or right) against their own non-lesion hemisphere (left or right). Another non-parametric test, the Mann Whitney test was applied to the comparison between healthy individuals and stroke survivors.

The Mann Whitney test is a non-parametric test used to assess for significant differences in a scale or ordinal dependent variable by a single dichotomous independent variable (Macfarland & Yates, 2016). After completing the statistical data analysis, the chapter moves on to the discussion section in Chapter five in order to answer the research question posed in this study.

4.2 Statistical Primary Data

Primary data is data that that is gathered for a research study before that information has been transformed or analysed in any way. It is represented exactly as it was gathered at its source without transformation or calculation (Lavrakas, 2008). The primary data is tabulated into four different tables (Table 4.1 until Table 4.4 below) and figures (Figure 4.1 until Figure 4.4) for 20 subjects with the age of 55 years old and above according to the groups that they were sorted into. Each table consists of the details for five subjects: age, gender (F for female and M for male), right or left cerebrovascular accident (R/L CVA), result of MEP left/right hemispheres for pre and post-test:

Table 4.1: Control group (Stroke Survivors)

Subject	Age	Gender	R/L CVA	MEP Left (mV)		MEP Right(mV)	
				Pre	Post	Pre	Post
1	56	M	L	0.2	0.2	0.1	0.1
2	67	F	L	0.1	0.1	0.5	0.5
3	55	F	R	0	0	0	0
4	55	M	L	0	0.5	2.5	2.5
5	60	M	L	0	0	0.8	0.8

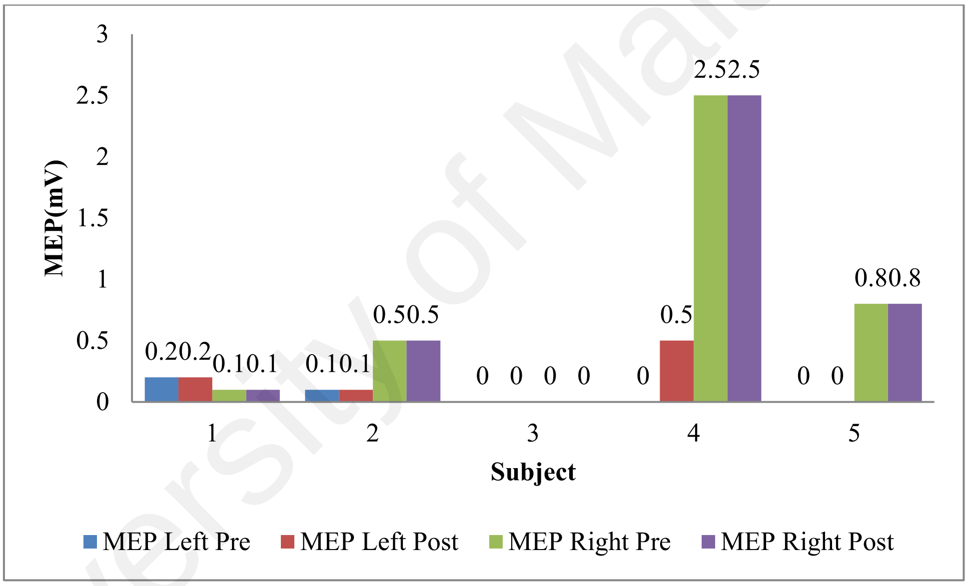


Figure 4.1: Control group (Stroke Survivors)

Table 4.1 above represents the data for the control group of stroke survivors and figure 4.1 above illustrates the data in the form of bar chart. In this control group, there are a total of two females and three male subjects. Of the five, there are four who are diagnosed with L CVA and one with R CVA. Subjects 1, 2 and 5 showed no changes for MEP in left and right hemispheres for pre and post-test. However, Subject 4 reported an improvement of MEP in left hemisphere increased from 0 (pre-test) to 0.5 (post-test). Subject 3 has no MEP response in the both hemispheres; this is because when the stimulation of the primary motor cortex (M1) of the hemisphere did not elicit discernible, reproducible, MEP amplitude in at least five out of ten stimulations at any location, this was considered “no response”. From the preliminary result, we can conclude that there were no changes for the MEP level for most of the subjects in the control group. The reason for this could be that there is no cortical excitability happening in the brain. It requires a specific event or activity to trigger cortical excitability, and one of the most powerful sources of auditory stimulation can be triggered by music (Sacks, 2006). In this case, the subjects in this group were in the TMS laboratory without the music intervention for 20 minutes. The results show that the MEP remained the same. It means without the music intervention, there was no cortical excitability in both hemispheres as shown in table and graph above.

Table 4.2: Experimental group with P.Ramlee’s music (Stroke Survivors)

Subject	Age	Gender	R/L CVA	MEP Left (mV)		MEP Right (mV)	
				Pre	Post	Pre	Post
1	76	M	L	0.5	1	4	2
2	55	F	R	0.8	1.6	0	0
3	55	M	R	1.4	1.8	0	0
4	60	M	L	0.5	1.2	0.5	0.8
5	64	M	L	0	0.1	1	2

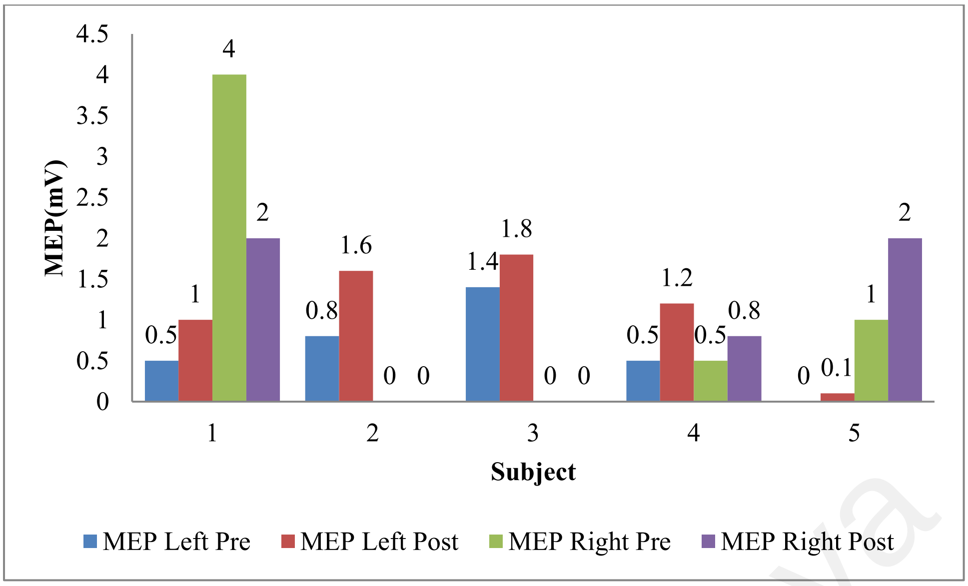


Figure 4.2: Experimental group with P.Ramlee's music (Stroke Survivors)

Table 4.2 above represents the data for the experimental group of stroke survivors that listened to P.Ramlee's music. The data is also demonstrated in the form of bar chart in figure 4.2 above. In this group, there are one female and four male subjects, with three who are diagnosed with L CVA and two with R CVA. Scans on Subjects 1 to 5 revealed that their MEP in the left hemispheres has increased drastically from 0.5 to 1, 0.8 to 1.6, 1.4 to 1.8, 0.5 to 1.2 and 0 to 0.1 respectively. Listening to music can increase the cortical excitability; and, we can see the MEP increased after the music listening sessions. Aside from activating cortical excitability, music could evoke emotional response to the individual. Many of P.Ramlee's music often relate to the messages and social commentaries made in his films; most of the people remember the stories when listening to his music. It may be possible that when the subject was listening to P.Ramlee would have it trigger their emotions caused by the increase in their MEP. It was also proven when one of the subjects cried during the music listening sessions. Aside from activating cortical excitability, music could evoke emotional response to the individual. Many of P.Ramlee's music often relate to the messages and social commentaries made in his films; most of the people remember the stories when listening to his music. The researcher suggests that listening music be part of the stroke survivors' everyday activities, developing a rhythm that helps them throughout the rehabilitation.

Table 4.3: Control group (Healthy Individuals)

Subject	Age	Gender	R/L CVA	MEP Left (mV)		MEP Right (mV)	
				Pre	Post	Pre	Post
1	60	M	-	0.4	0.4	0.4	0.4
2	60	F	-	0.5	0.5	0	0
3	55	F	-	0. 1	0. 1	0. 1	0. 1
4	56	M	-	1	1	1	1
5	59	F	-	1	1	2	2

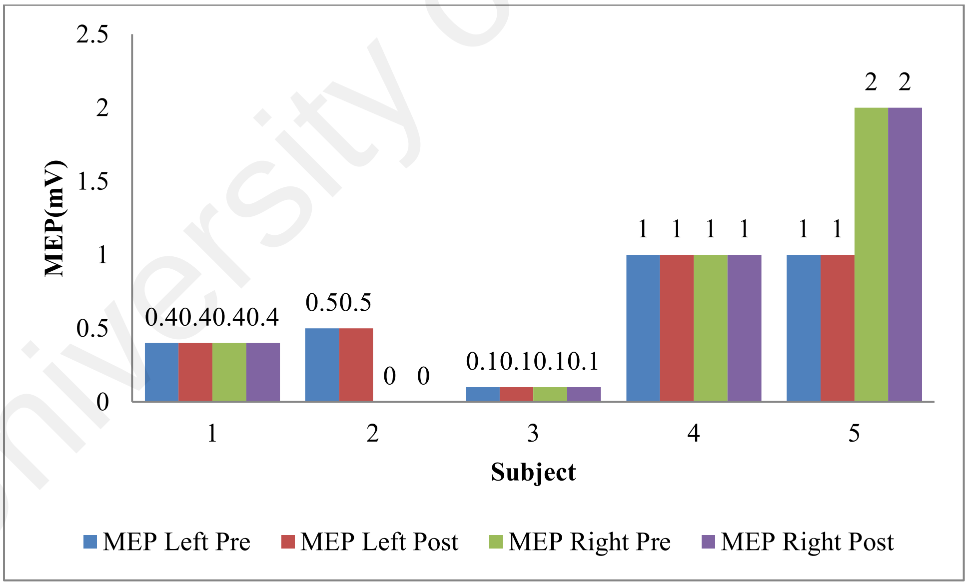


Figure 4.3: Control group (Healthy Individuals)

In Table 4.3 above, the information represents the data from the control group consisting of healthy individuals with three female and two male subjects and further illustrated in form of bar chart in figure 4.3 above. As the subjects in this group are from the healthy individuals group, the R/L CVA is not applicable to them. The scans shown in the table indicated that there was no difference between pre- and post-test for left and right hemispheres MEP level. As mentioned earlier (Table 4.1 and Figure 4.1 above), without cortical excitability to the brain, there will be no difference to the MEP. The same situation is found in this group too. As there was no music during the experiment, their cortical excitability was not increased, which resulted in no changes to their MEP reading.

Table 4.4: Experimental group with P.Ramlee's music (Healthy Individuals)

Subject	Age	Gender	R/L CVA	MEP Left (mV)		MEP Right (mV)	
				Pre	Post	Pre	Post
1	57	F	-	0	1	0.8	1.8
2	63	F	-	1	1.2	1	1.4
3	60	F	-	0.8	1.2	1	1.2
4	57	F	-	1.7	2	1.4	1.8
5	79	F	-	2	2	4	4

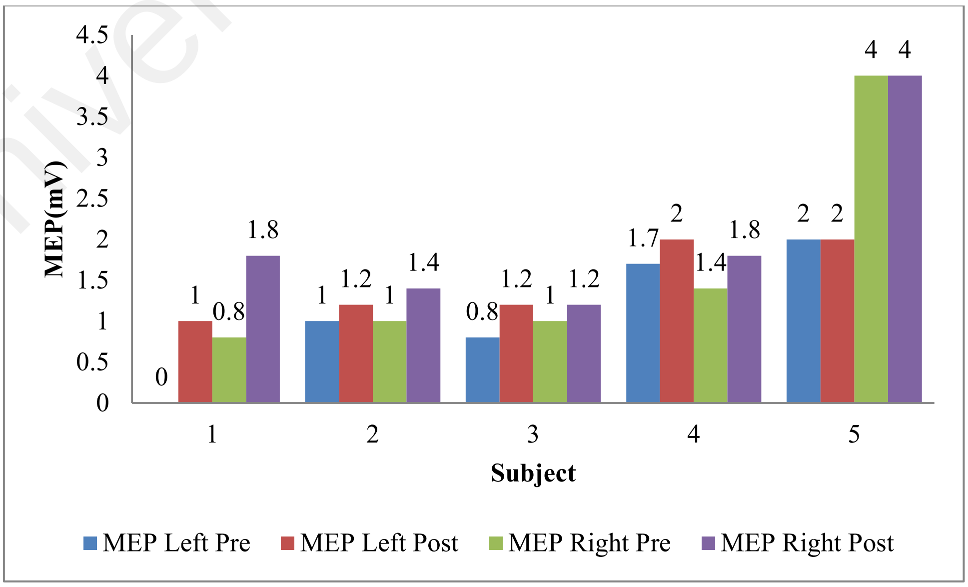


Figure 4.4: Experimental group with P.Ramlee's music (Healthy Individuals)

Table 4.4 above illustrates the data for the healthy individuals that are part of the experimental group. The group is exposed to P.Ramlee's music in this experiment, and their MEP readings are reflected in the form of a bar graph in figure 4.4 above. Like the previous group, the R/L CVA also does not apply to these subjects as they are also part of the Healthy Individuals group. Results for Subjects 1 to 4 indicated that there is an obvious improvement for MEP level for both hemispheres. Their MEP reading for the left hemisphere shows an increase from 0 to 1, 1 to 1.2, 0.8 to 1.2 and 1.7 to 2 respectively. The results of MEP in right hemisphere proven an increased as well with 0.8 to 1.8, 1 to 1.4, 1 to 1.2 and 1.4 to 1.8 for subjects 1 to 4. Nonetheless, subject 5 showed no improvement on the MEP level for either hemisphere even after the music listening sessions. Generally, the majority of the results indicated that there is a positive impact with P.Ramlee music towards the hemispheres of the brain. According to the research done by Stanford University School of Medicine, music engages the brain over a period of time, the process of listening to music could be a way that the brain sharpens its ability to anticipate events and sustain attention (Mitzi, 2007). As we can see, the cortical excitability of the subjects for this experimental group was increased after the music listening sessions. Even as they are healthy individuals, listening to music has shown to affect their brains. Besides that, relating music to what they have experienced is also another reason for boosting cortical excitability; in this case, the songs brought them back to the movies made by P.Ramlee which stimulated the brain.

The data from tables 4.1 to 4.4 has shown almost no changes to the MEP reading for subjects involved in the control group for both the stroke survivors group and healthy individuals group (Tables 4.1 and 4.3). However, there is an obvious increase for the experimental group in the stroke survivors group and healthy individuals group (Tables 4.2 and 4.4). The results have reflected the effect of P.Ramlee music has towards the neuroplasticity of the brain.

During the data collection process, the subjects from experimental group (stroke survivors) were excited and curious about the music listening as well as process of TMS, because they get to know something can help with their health condition and boost recovery with no side effect. Furthermore, the subject from control group also commented they wish they were in the experimental group while the researcher explained the detail of the study. When the entire subject knows P.Ramlee music was the test object in this study, they were eager to know the result of the study as they familiar with his songs. Overall, the combination music with rehabilitation was bringing a new insight into stroke recovery toward subjects. Its offers a valuable addition support to the stroke survivors by providing a method or tool with an inexpensive, easy access and conduct on the path way of their rehabilitation.

4.3 Descriptive Table

The descriptive statistics table is where SPSS Statistics has generated description for the variables. The table below is the the data according to age (mean), gender and R/L CVA.

Table 4.5: Ages (mean), gender, R/L CVA by for the Healthy Individuals and Stroke Survivors

	Healthy Individuals (N=10)	Stroke Survivors (N=10)
Age (Mean)	60.6	60.3
Gender	F = 8 M = 2	F = 3 M = 7
R/L CVA	L = 0 R = 0	L = 7 R = 3

According to the American Stroke Association (n.d.), women have significantly higher chance to experience stroke than male, but gender is not the variable in this study due to the small sample size. A total of 20 subjects were recruited based on the aforementioned inclusion criteria. There are eight female and two male subjects with the mean age of 60.6 years for healthy individuals. For the stroke survivors group, there are three female and seven male subjects with the mean age of 60.3 years. The Right/Left (R/L) Cerebrovascular Accident (CVA) criterion is not applicable on healthy individuals, only for stroke survivors; there are seven who are diagnosed with L CVA and three with R CVA. Further discussion on the result will be elaborated in the next section.

4.4 Comparison between Pre-test and Post-test

In this section the comparison between pre- and post-test was conducted for two groups (healthy individuals and stroke survivors) who are divided further based on two different experiment (control and experimental). This analysis was done for both left and right data in the form of MEP. Tables 4.6 and 4.7 below demonstrates the data on the comparison of subjects before (Pre) and after (Post) MEP results for healthy individuals and stroke survivors group. In addition, the data also illustrated in the form of bar chart in figures 4.5 and 4.6 below.

4.4.1 Healthy Individuals Group

Table 4.6: Wilcoxon signed-ranks test for the comparison of pre- and post-experiment for the Healthy Individuals group

MEP	Group	Median		Mean		Z	P value
		Pre	Post	Pre	Post		
Left (mV)	Control	0.5	0.5	0.6	0.6	.000	1.000
	Experimental	1.0	1.2	1.1	1.48	-1.826	.068
Right (mV)	Control	0.4	0.4	0.7	0.7	.000	1.000
	Experimental	1.0	1.8	1.64	2.04	-1.841	.066

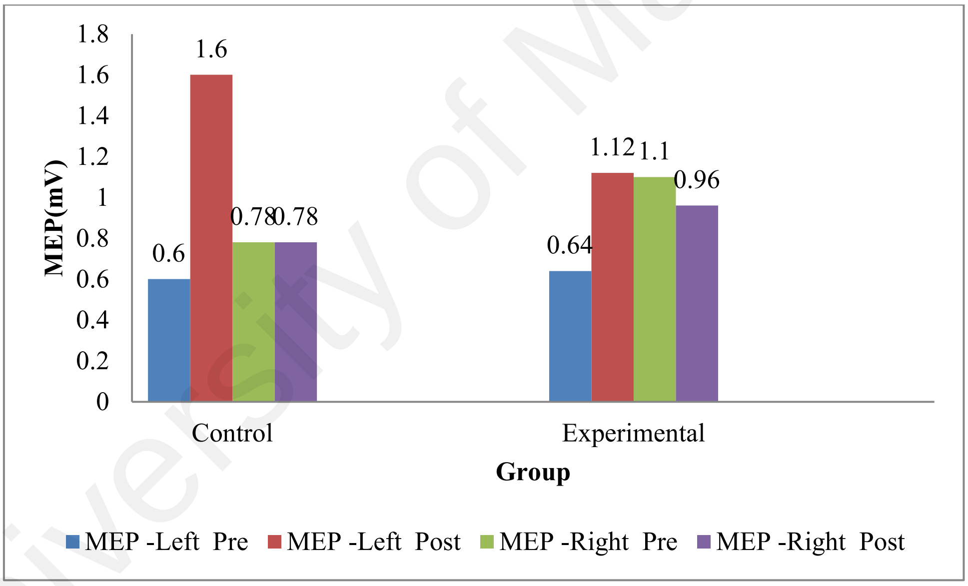


Figure 4.5: Wilcoxon signed-ranks test for the comparison of pre- and post-experiment for the Healthy Individuals group

The Wilcoxon test was used to compare the pre and post for two different methods of experiment (with music and without music). The significance level in this study was P value < 0.05 level. Based on the above results, although the result for experimental group is statistically not significant, we can see that the P value for left and right MEP is 0.068 and 0.066, which bordered on a statistically significant value P < 0.05. This can be concluded that music listening is thus said to have an effect on the brain. For the mean of the control group (left and right), there were no changes. On the other hand, the mean for the experimental group increased after the music listening. Further study with a bigger sample size is needed to produce a significant and noticeable result.

Overall, this study has shown that music listening may have a possible positive effect and beneficial influence toward improved the MEP thus neuroplasticity in healthy individuals. Aside from the therapeutic purposes, listening to music not only shapes the organization of the developing brain but also produces long-lasting changes even after brain maturation is complete (Lahav, Saltzman, & Schlaug, 2007). Not only that, listening to music is known to provoke emotions as well as increase interpersonal communications and interactions.

4.4.2 Stroke Survivors Group

Table 4.7: Wilcoxon signed-ranks test for the comparison of pre- and post-experiment for the Stroke Survivors group in Left CVA

MEP	Group	Median		Mean		Z	P value
		Pre	Post	Pre	Post		
Left - Lesion (mV)	Control	0.05	0.15	0.08	0.2	1.000	0. 317
	Experimental	0.50	1.0	0.33	0.77	1.604	0.109
Right – Non-lesion (mV)	Control	0.65	0.65	0.97	0.97	0.000	1.000
	Experimental	1.0	2.0	1.83	1.60	0.000	1.000

***Significant at 0.05 level**

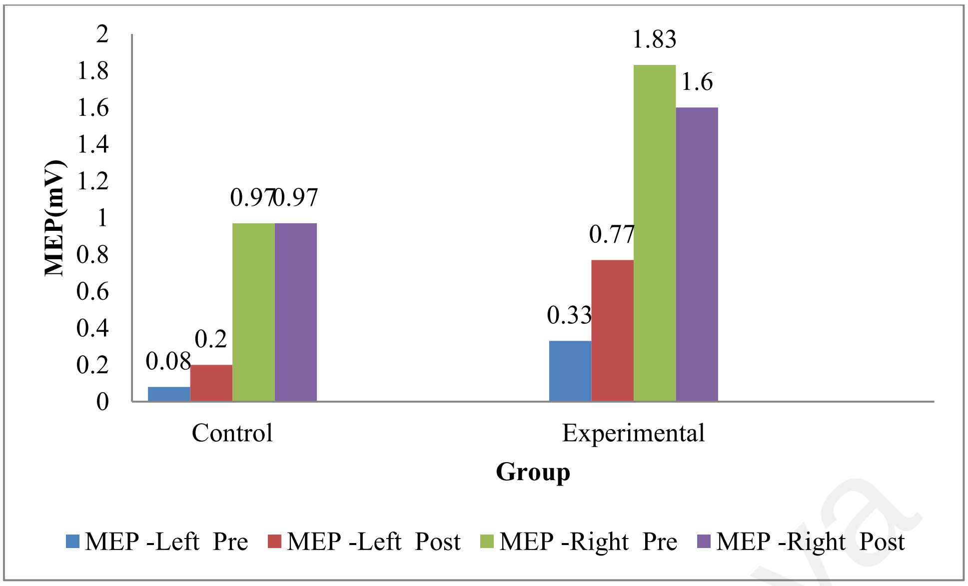


Figure 4.6: Wilcoxon Signed Ranks Test for the comparison of pre- and post- experiment for the Stroke Survivors group

The Wilcoxon signed-rank test was used to compare between the pre- and post-condition for both groups. Both the control and experiment groups recorded no MEP responds in the Right CVA. Therefore, the statiscal test only focuses on the Left CVA. The significance level in this study was P value < 0.05 level. The results indicated that difference between pre and post-test was not significant for both control and experimental groups. Although the result for right MEP is statistically not significant, but as we can see, there is an obvious improvement for post-test (mean and median). The mean results for the left hemisphere in the control and experimental groups have a significant increase more than the right hemisphere. This can be concluded that music listening has an effect on the brain. The outcome specifically for the control group was interesting where the mean increased from 0.08 (pre-test) to 0.2 (post-test). It is possible that this is due to the fact that the patients in this group are L CVA.

Overall, there is a positive improvement for post-test (mean & median) in all the groups, especially for the median and mean on the left hemisphere in both control and experimental groups. The functions of the left brain include listening, even though the right side of the brain makes us aware of music, could this may influence the results as well. We can say that if with a sufficiently large sample size, a statistical test will demonstrate a significant difference. The result shows that music listening may have a significant impact towards the hemispheres of the brain. The fact that the adult brain can undergo continual modifications highlights the potential of rehabilitation treatments that are designed to induce plastic changes to overcome impairments due to brain injury. For this purpose, music may be a suitable medium because it transmits visual, auditory, and motor information to a specialized brain network consisting of frontal, temporal and parietal regions (Wan, Demain, Zipse, Norton, & Schlaug, (2010).

4.4.3 Lesion vs. Non-lesion Hemispheres

This section compares the lesion and non-lesion hemispheres on stroke survivors. This analysis was done for both left and right lesion hemispheres data in the form of MEP. Table 4.8 below provides the data on the comparison of subject before (Pre) and after (Post) MEP results for stroke survivor group and bar chart in figure 4.7 and figure 4.8 below demonstrated the data from the table.

Table 4.8: Wilcoxon signed-ranks test for the comparison between lesion and non-lesion hemispheres on Stroke Survivors group

R CVA	Group	LS R	NLS L	MD	Z	P Value
Pre	Control	0(0)	0(0)	0	-	-
	Experimental	0(0)	1.1(1.1)	-1.1(-1.1)	-1.342	.180
Post	Control	0(0)	0(0)	0	-	-
	Experimental	0(0)	1.7(1.7)	-1.7(-1.7)	-1.342	.180
L CVA	**Group**	**LS L**	**NLS R**	**MD**	**Z**	**P Value**
Pre	Control	0.075 (0.05)	0.975 (0.65)	-0.9(-0.6)	-1.461	0.144
	Experimental	0.333 (0.5)	1.833 (1)	-1.5(-0.5)	-1.342	0.180
Post	Control	0.2 (0.15)	0.975 (0.65)	-0.775(-0.5)	-1.461	0.144
	Experimental	0.733 (1)	1.6 (2)	-0.867 (-1)	-1.069	0.285

L - Left

R – Right

LS – Lesion

NLS – Non-Lesion

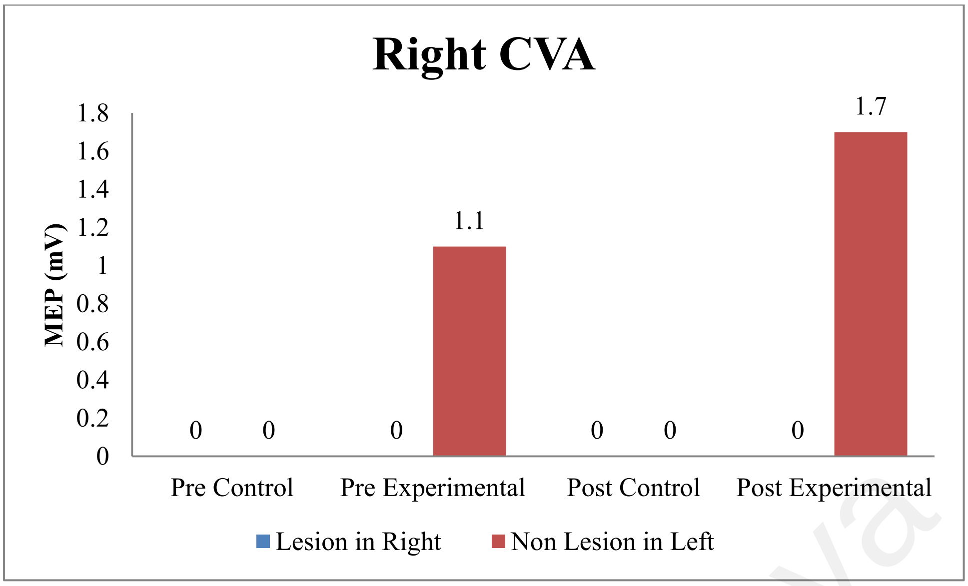


Figure 4.7: Wilcoxon signed-ranks test for the comparison between lesion and non-lesion hemispheres on Stroke Survivors (Right CVA)

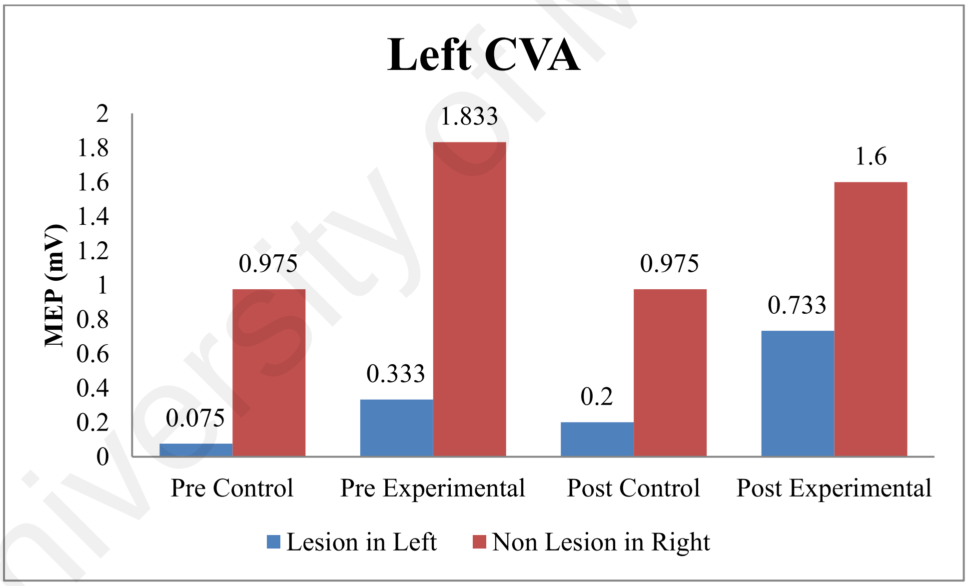


Figure 4.8: Wilcoxon signed-ranks test for the comparison between lesion and non-lesion hemispheres on Stroke Survivors (Left CVA)

The Wilcoxon signed-rank test was applied to compare lesion and non-lesion hemispheres on stroke survivors. The significance level in this study was P value < 0.05 level. As there is only a limited size for the control group right lesion hemisphere, therefore no statistical test was done. As for experimental group, no MEP responds in right hemisphere, as a result no mean data for right lesion hemisphere, however there was no statistically significant difference for non-lesion left hemisphere compare to lesion right hemisphere.

The L CVA revealed there were no significant differences (P = 0.144, 0.180, 0.144, and 0.285) for the dependent variables (pre- and post-test) on the both lesion and non-lesion hemispheres for control and experimental group. The table also showed a similar effect from the music played towards lesion and non-lesion hemisphere, with a higher increase in the mean on the lesion hemisphere. This shows that there is a possible substantial impact with music listening towards the lesion hemisphere. According to Warren (2008), listening to music involves both hemispheres, although a majority of activity does occur in the right hemisphere of the brain. Despite which hemisphere the brain's neuroplasticity shown a capacity to change and adapt accordingly to substitute for the brain injury that occurred. Hence, listening to music affects the brain's learning capacities, increasing the size of the auditory and motor cortex to boost up the recovery of stroke.

4.4.4 Healthy individuals vs. stroke survivors

Another objective for this research was to compare the neuroplasticity difference between healthy individuals' vs stroke patients using TMS. This study compares the effect of music listening to the hemispheres of the brain for two groups – healthy individuals and stroke survivors – who were divided in groups based on two different variables (control and experimental). This analysis was done for both left and right brain hemispheres in the form of MEP. Table 4.9 below provides the calculation of data on the comparison between healthy individuals and stroke survivor group for before (Pre) and after (Post) MEP results. Figure 4.9 below demonstrated the data comparison between healthy individuals and stroke survivors for control group in bar chart form as well as figure 4.10 below demonstrated the data comparison between healthy individuals and stroke survivors for experimental group.

Table 4.9: Comparison between Healthy Individuals and Stroke Survivors

Group	Variable (mV)	Healthy Individuals Mean (Median)	Stroke Survivors Mean (Median)	Mean Difference (MD)	Z	P value
Control	Pre.MEP.Left	0.6(0.5)	0.06(0)	0.54	-2.341	0.019*
	Post.MEP.Left	0.6(0.5)	0.16(0.1)	0.44	-1.798	0.072
	Pre.MEP.Right	0.7(0.4)	0.78(0.5)	-0.08	-0.105	0.916
	Post.MEP.Right	0.7(0.4)	0.78(0.5)	-0.08	-0.105	0.916
Experimental	Pre.MEP.Left	1.1(1)	0.64(0.5)	0.46	-1.16	0.246
	Post.MEP.Left	1.48(1.2)	1.12(1.2)	0.36	-0.851	0.395
	Pre.MEP.Right	1.64(1)	1.1(0.5)	0.54	-1.277	0.202
	Post.MEP.Right	2.04(1.8)	0.96(0.8)	1.08	-0.949	0.343

***Significant at 0.05 level**

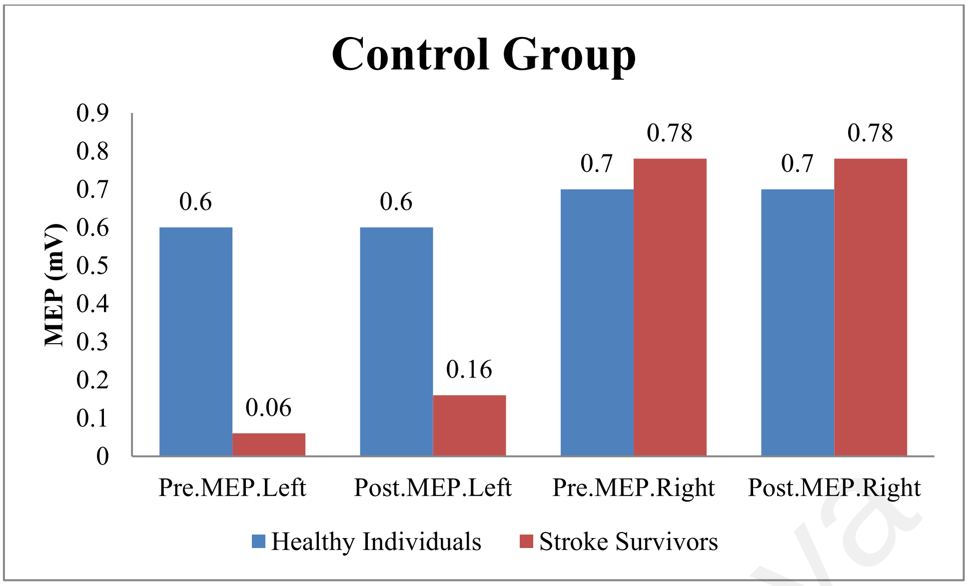


Figure 4.9: Comparison between Healthy Individuals and Stroke Survivors for Control group

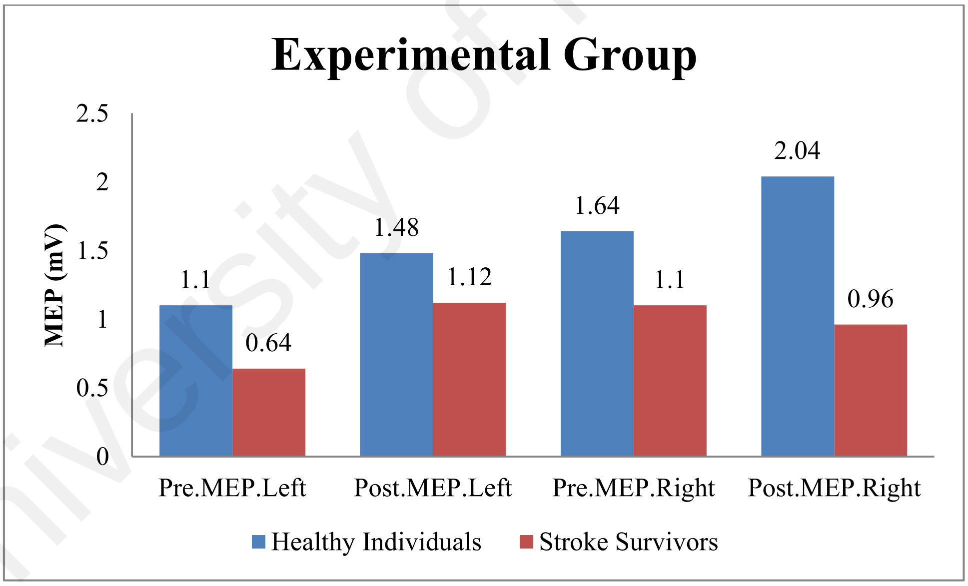


Figure 4.10: Comparison between Healthy Individuals and Stroke Survivors for Experimental group

The Mann Whitney test was used to compare the pre- and post-test for two experiment groups (control and experimental). The significance level in this study was P value < 0.05 level. According to the results of comparing between the healthy individuals and stroke survivors for all the research variables in control and experimental group, it was found that the highest difference in MEP occurred in the control group where their pre-experiment MEP in the left hemisphere was MD= 0.54 which was significant (Z= -2.341, P= 0.019). This was followed by the post-experiment MEP reading for the left hemisphere (MD= 0.44) which was not statistically significant (Z= -1.798, P= 0.072). This difference between healthy individuals and stroke survivors for the MEP result in right hemisphere for both pre and post MEP was (MD= -0.08) which was not statistically significant (Z= -0.105, P= 0.916). Overall, there is a significant difference of MEP result between the healthy individuals and stroke survivors for the P value; for control pre MEP in left hemisphere is 0.019. This means that there is a difference between the healthy and stroke group's MEP levels on the control pre MEP in left hemisphere.

As for experimental group, the mean difference between healthy individuals and stroke survivors for the pre- and post - MEP values in left hemisphere was 0.46 and 0.36. The P value for comparison between group for pre- left hemisphere (Z=- -1.16, P= 0.246) and post- left hemisphere (Z= -0.851, P= 0.395) was statistically not significant. On the other hand, the result for pre- MEP in right hemisphere (MD= 0.54) which was not statistically significant (Z= -1.277, P= 0.202) followed by post- MEP in right hemisphere (MD= 1.08) which was also not statistically significant (Z= -0.949, P= 0.343). In conclusion, there is no significant difference in MEP level between healthy individuals and stroke survivors.

Aside from the control group with pre- MEP in left hemispheres, the result is statistically not significant for the rest of group. Therefore, it is proven that there is no difference between healthy individuals and stroke survivors' experimental group with P.Ramlee's music, along with control group post MEP in left hemisphere as well as pre and post MEP in right hemispheres. Thus, P.Ramlee music can be said to have the same effect toward both group. According to Janata (2009), there is a part of the brain that "associates music with memories when we experience emotionally salient episodic memories that are triggered by familiar favorite songs from our personal past." In other words, familiarity with music can reconnect people with deep, meaningful memories from their past experiences.

In this study, P.Ramlee's music is a popular during 60s and 70s in many Malaysian youths and it is still being played up to this day. The experiment group who are to listen to the music which they are familiar with, would experience the activation of several parts of their brain such as motor cortex, frontal lobe, and the Hypothalamus, primarily in the right hemisphere (Janata & Graffon, 2003). This proves that music listening can boost cortical excitability to obtain responses that are very similar to those obtained from healthy individuals. Based on the result above, listening to P.Ramlee music might increase the neuroplasticity of the brain, improve stroke outcomes, and enhance motor functions among stroke survivors'.

4.5 Chapter Summary

This chapter has discussed in detail the sorted data collected and data analysis into descriptive data, measuring the MEP readings for pre- and post-test for healthy individuals and stroke survivors, and comparing the lesion vs. non-lesion hemispheres for stroke survivors. From the data above, there is an overall improvement of MEP after the music listening for the experimental group. This meant that P.Ramlee music does stimulated the cortical excitability. The ability to induce cortical excitability with NIBS techniques (TMS) has provided novel and exciting opportunities for examining the role of the human cortex when listening to music. Additionally, the induction of lasting changes in cortical excitability can modify the changes in neural pathways (neuroplasticity) and interact with motor function. Such findings would bring new insights in rehabilitation with using such approaches, making it possible to induce functionally significant changes in stroke survivors.

The analysis of the data has shown the answers to the research questions stated in Chapter One. The first research question asks what local music would be appropriate to every Malaysian taste? Throughout the first phase of the experiment – the songs selection process, P.Ramlee emerged the most mentioned in every participant's list (as reflected in Table 3.1 and Figure 3.2), and it can be concluded that P.Ramlee's songs is the most suited to every Malaysia taste. His music has also shown positive effects towards neuroplasticity when the brain is being measured with TMS. These results proved that music has a potential for post-stroke rehabilitation.

For the second research question on how much effect can music do to the brain, analysis from the data collected from the experiment revealed obvious changes in neuroplasticity due to a positive increase of reading for post-test (mean & median) for the experiment group which was given music to listen to. Although the evaluations were limited to data taken after one session of listening to music, the slight increase of reading shows that music has already affected the brain even within a small time-frame.

The third research question looks at the the neuroplasticity difference between lesions vs. non-lesion hemispheres in stroke survivors. One of the purposes for this research is to increase the neuroplasticity in lesion hemisphere in order to improve the motor function of stroke survivors. Any part of the body's motor function requires both hemispheres of the brain to control and create the movement of the muscles of the body (Mutha, Haaland, & Sainburg, 2012). In order to accomplish it, this research look at how much music has influence to the brain by measuring the MEP. The MEP was measured before and after music intervention and the results show that there is no difference between lesion and non-lesion hemispheres.

The last question was to determine the difference in neuroplasticity between healthy individuals and stroke survivors. In comparing the brain neuroplasticity between healthy individuals and stroke survivors, this research looks to see if that music can boost cortical excitability to obtain responses from stroke survivors that are very similar to those obtained from healthy individuals. Analysis of the data shows that there was no difference between healthy individuals' and stroke survivors in terms of neuroplasticity.

Overall, there is a positive response toward using P.Ramlee's music in post-stroke rehabilitation, but no changes were seen in the control group of both the healthy individuals and stroke survivors. All the subjects have voiced their enjoyment throughout the TMS procedure. The researcher suggests that music intervention could be introduced into the stroke rehabilitation program in hospital as an alternative method that can help stroke survivors heal physically and mentally.

In the subsequent chapter would be the discussion and conclusion of this study followed by the suggestions for the future research that could be conducted in this area.

CHAPTER FIVE

DISCUSSION & CONCLUSION

5.1 Introduction

This chapter discusses the overall achievement obtained from all chapters. The discussion section will focus on the results of the effect of music to the brain, especially for patients in post-stroke rehabilitation, what properties of music that result the changes and future plans for a more sizeable number of subjects for a full-scale research. Then the chapter moves on to the conclusion of the study which looks at the significance and clinical applications of music to post-stroke rehabilitation, and potential future research.

5.2 Discussion

A pilot study is defined as a preliminary small study that is used to test the feasibility of the project proposal, data collection instruments, subject recruitment strategies, and other research techniques in preparation for a larger study (Stewart, 2008). This pilot study represents a first step in a series of investigations as a dialogue between music and rehabilitation. It shows that these research methods may open the way to getting more definite results on the effect of music to the brain to stroke patients. Examining 20 patients was the first attempt to evaluate whether the study's hypothesis can be tested with the chosen methods and to pinpoint any potential flaws as well as troubleshoot any equipment problems.

This study is a pilot test that is an experimental design with the effect of music with a small sample of 20 participants made up of stroke survivors and healthy individuals, who were aged 55 years old and above. The research compares the neuroplasticity of their brains after undergoing music listening. The results suggest that music listening helps produce positive changes in neuroplasticity leading to the improvement of the subjects' motor performance. This is also reflected in previous studies that showed music has a beneficial effect in the field of stroke rehabilitation as it enhances neurological functions, speeds up the recovery of cognitive functions, and improves mood and the quality of life experienced (So-Young & Grocke (2008). Apart from that, a study conducted by scientists from the Houston Methodist Hospital suggests that familiar, positive music may have the advantage to increase activation and functional connectivity in the brain and may provide targeted therapeutic benefits to those recovering from a stroke (Karmonik et al., 2016). With this, it is possible that using the unique of P.Ramlee's music can accelerate the rehabilitation for post-stroke survivors which proves that music listening has equally significant benefits as an adjuvant therapeutic tool in a wide variety of clinical settings.

The late musical composer P.Ramlee was a multi-talented artist; he was also active in the Malaysian film industry where he was not only an actor but also a singer, a songwriter, a screenwriter, a film director and also a painter. During his career, he was involved in the writing, filming, and production of about 66 films and 390 songs. Although he passed away more than four decades ago, he still occupies a significant place in Malaysian life. The film and music industry in Malaysia then largely depend on the public's flavour and appeal and his success is proven when his films still appear regularly on television and his songs are widely known in Malaysia. He is the subject of countless newspaper articles and even has a popular stage musical devoted to him, *P.Ramlee: The Musical*, which often boasted of a sold-out performance.

P.Ramlee adapted several styles to innovate his music according to the needs of the public in general. He tried with some limited success to utilise Western rock and pop ideas into his music; he was one of the few Malay musicians to use rock and roll beats (Lockard, 1991, p. 24). One element that he used in his songs is repetition. Figure 5.1 below shows the repetition of phrase technique in the melodic verse for the song, "*Azizah*". The 'A' phrase is repeated between two stanza lines, '*Rupa kamu yang cantik*' to '*Mata kamu yang bulat*'. This simple repetition makes the song catchy and easy to sing along.

Figure 5.1 Musical excerpt from "*Azizah*"

This repetition technique is also used in "*Engkau Laksana Bulan*". Below is an excerpt of the lyrics and melody from the piece. The sequence of the melody line is repeated for two different lines of lyrics. This idea of repetition in line also is an influence from the Western style of music.

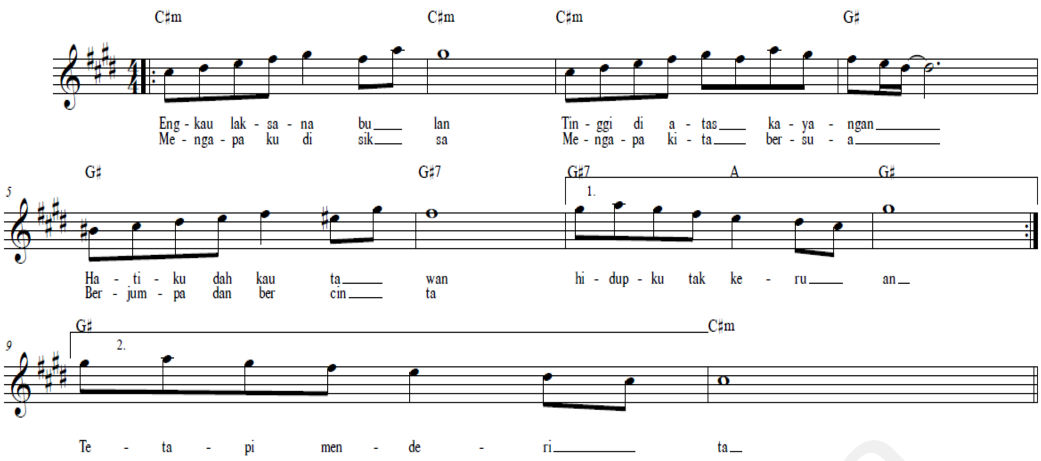


Figure 5.2 Musical Excerpt from "*Engkau Laksana Bulan*"

Besides that, his music compositions also show various influences by music from different cultures such as from China, Japan, Indonesia, and Middle East (Abdul Hamid Adnan, 2015). One example is the "*Bunyi Gitar*", which is uses the twist rhythm style. P.Ramlee used a variety of chords in his composition like major 7^{th} and minor 7^{th}, to the diminished, augmented, suspended minor b5 and also 6^{th} chords. The variation of his chords creates a rich and colourful harmony in his composition. There were also complicated chords such as major 2^{nd}, major 9^{th}, -9, #9, 11^{th}, and 13^{th} inserts to his melodies. This provides clarity for harmonic motion and harmonic tension. The chord progression facilitates a particular melody line. In "*Bunyi Gitar*", there were many changes from major to minor chords. The song uses a dominant 7^{th} but the next melody "*Irama twist*" ends on minor 7th chords. This creates a harmonic that is similar to the Eastern culture style of music which would suit many Malaysians.

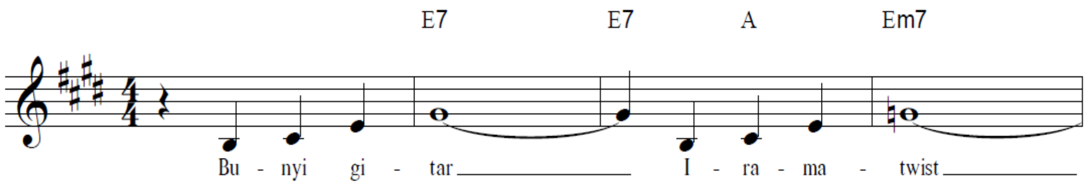


Figure 5.3 Musical Excerpt from "*Bunyi Gitar*"

One of P.Ramlee's most famous songs, *'Getaran Jiwa'* is applied new experiment on this research; P.Ramlee uses the beguine style to accompany this song based on the diatonic scale. Beguine is the national dance from Martinique in the West Indies, which is sung in slow polka with a dotted rhythm (Gammond, 1991, p. 49). In Figure 5.4 below, the Beguine is created from the rhythm created by the combination of various Western instruments. *'Getaran Jiwa'* is sung in the Malay language. The combination of non-Western rhythms and the Malay language embodies the eclectic nature of the local communities in Malaysia (Chan, 2003).

Figure 5.4 The beguine rhythm (transcribed by Clare Chan Suet Ching, 2011)

Another distinct characteristic of P.Ramlee songs is his singing style. He sings in a rubato and laid back style despite the regular background rhythm, an example of this is from the song "*Jeritan Batinku*", which can be heard on the attached CD.

The lyrics of P.Ramlee songs were shaped by film themes, which featured romantic or tragic love, family affairs, and folk tales from multi-cultural origins. The lyrics of P.Ramlee songs captured the hearts of many as it is relatable to different life experiences. "*Jangan Tinggal Daku*" for example, translates as 'Don't Leave Me'. Its lyrics depicts a person calling out desperately to their loved one to not leave them behind. As mentioned in chapter four, one of the participants cried while listening to this song as the lyrics seem to strongly stir his or her feelings and most of his songs, the lyrics are based on the story line of his film.

P.Ramlee's music is a full package of songs that never fail to touch people's hearts. The impact from the combination of song (melody, harmony and lyrics) and film (comedy and slice of life) gives a a meaningful value to those who listens or watches his works. That is why P.Ramlee's contribution to the performing arts is very significant as his songs are still being enjoyed by many till this day. In this study, we can see that the subjects involved prefer P.Ramlee music as they are familiar with this songs and films. His music is not only aesthetically beautiful; but also evergreen that often conjures nostalgic sentiments. His music appealed to multi-cultural communities because it embodied qualities that reflected a harmonious state of living much desired and imagined. One of the subjects commented that: 30 years ago, when he was watching the famous *Masam Masam Manis* and *Ali Baba and 40 thieves*, his daughter who was just 6 and his son who was 3 was so excited to see the movies, were thriving with laughter and enjoying every move this effervescent hero makes. He was so surprised by the power of P.Ramlee's movies. He said, "The movie has a natural attraction for any age; whether you are 3 to 80 you will always enjoy P.Ramlee's movies." His children always watched P.Ramlee's movies and he was totally awed by the way P.Ramlee presents and acts. Also, this is one of many similar comments from other patients.

This shows that P.Ramlee's filmography and music do have huge impact toward the local people of this country. Malaysia may have many famous composers, but P.Ramlee is one of the few that still touches every person's heart with his songs, be it humour, soul or romance. P.Ramlee's music carries a good message in the movie; the themes in P.Ramlee's movie played a major role in determining the types of music he would write to accompany the various scenes in his movies. He composed music to suit the theme, dramatic actions, melodrama and scenes in the movie he acted in. When listening to his music alone, we surely can relate the music with the movie, which triggers our emotion and leading our feelings along with the story. Besides that, his songs were often broadcasted through different media and many singers have performed them with their own twists. As such, many would have had heard P.Ramlee's songs. Thus, most of the patients would know and respond positively his music.

The music selection for this research was taken from P.Ramlee's collection of movie soundtracks for the original songs played. The music played was also accompanied with the music video. This is because music videos are visually attractive as compared to music alone. According to (Hanser & Mark (2013), most studies have reported concurrent background music to enhance the emotional valence when music and pictures are emotionally congruent. The opinion was proven when one of the subjects cried during the experiment; the subject stated that the music playing triggered their emotions, like they can relate with the song.

Many people have some piece of music that they could relate and connect to their feelings. For instance, music that gives a positive, emotional connection to it would bring up memories and emotions when we hear it. From the results on lesion vs. non-lesion hemispheres, the effect of music toward neuroplasticity shows a remarkable similarity. This shows that it is the music which drives the brain processes regardless of age, gender, or background. That familiarity with P.Ramlee's music seems to have an effect for every subject who listens to it; it may also encourage the restoration of connectivity within the brain nerves that will promote a more functional recovery as well.

For stroke survivors, their brains will have a side that is unaffected by stroke (non-lesion hemisphere), and another which is affected (lesion hemisphere). Hence, when viewing their MEP, it is logical to say that the non-lesion side will have a good amplitude of response while the affected side will have a lesser, smaller or flat amplitude. MEP is a neurophysiological measurement that describes activity of the brain to define the integrity of the motor function which will assist in movement or responses of the body (Walsh, Kane, & Butler, 2005; Simis et al., 2015). So, this means that for the networking of the neurons, signals from the lesion hemisphere of the brain cannot reach the extremity due to the pathway being affected which resulted in difficulty in getting the MEP reading. If the MEP signal is good, this means that the integrity of the pathway is intact and, therefore the signal can be sent to a part of the body to respond. If there is no MEP response, it means that somewhere along the way, the neuron signal is stuck or could not pass through to reach its destination. This normally occurs within the brain. If music is beneficial in helping increase the MEP, it can also mean that it can help in recovery of the brain. There is a need to look at it as a therapeutic tool to enhance recovery as it does not show any detrimental effect towards the patient as well.

MEP has shown to be a diagnostic tool to analyse the hemispheres of the brain. This is why this research uses it to evaluate the effect of music towards the brain. The TMS equipment is able to measure the MEP as neurophysiological markers, ensuring that it can be measured visually. This meant that the brain muscles are shown and its electromyogram is measured to look at the circuit of the brain. For example, if we want to move our hand, we can view and measure the MEP as the brain sends the signal – moving from the part that controls movement – towards the hand, telling it to move. Using music as stimulation towards the neurons, this research looks at how much influence music has to the brain by measuring the MEP on motor function. This also shows how much it influence the motor function, which often a problem for stroke survivors.

Usually in stroke, the time frame between getting a stroke and recovery place a very important aspect. A shorter time frame will increase the chances of recovery. Researches done suggested the first six months being the golden period. This means that if stroke survivors start physiotherapy the first six months, their chances of recovering will be so much better (Lee et al, 2015; Caswell, 2015). This is why many doctors would advise the patient to go for rehabilitation as soon as they can, the sooner they begin stroke rehabilitation, the more likely they can regain lost abilities and skills. For this research, the patients recruited as subjects, had an average experience stroke two years ago, which is more than the six months of the golden period. Most of them showed an increase of MEP with exposure to music. Although the result may not be statically significant, this meant that music still has a potential for further improvement if we were use it as a therapeutic tool for a longer period of time.

Aside from the positive influence of music, the research also aims to see the effect of brain activity (cortical excitability) to ascertain if the activity can be modulated. Zhao et al.'s (2017) research on study brain stimulation showed sufficient evidence that brain activity can be modulated. It is with this concept of modulation that the researcher wants to know if music has that ability to modulate the brain. The experiment conducted increases the cortical excitability on both control and experimental groups consists of the healthy individuals and stroke survivors, and measuring the lesion vs. non-lesion hemispheres of the brain. The results suggest that there is a positive excitability; therefore there is a possibility of music being able to modulate the brain. This effect can aid facilitate or disrupt the brain electric activity; it can help with creating temporary or somewhat permanent desirable brain changes. The possibilities on enhancing brain activity, making it more receptive suggest an array of potential therapies of combining music with rehabilitation for the brain. For example, music support therapy helps patients on their gait cycle (walking) would suggests that through increase in the cortical excitability of the brain increases brain activity and, improving their gait as well as postural stability.

With the brain's large capacity for automatic simultaneous processing and integration of sensory information, musical training would have an extensive effect on the brain. Thus, this one aspect is relevant for stroke rehabilitation as proven in Musacchia, Sams, Skoe, & Kraus' (2007) study where musicians were found to have enhanced subcortical auditory and audio-visual processing of speech and music (Musacchia, Sams, Skoe, & Kraus, 2007). The results indicated that listening to music have a facilitating effect on neuroplasticity, which is associated with functional coupling between emotional and auditory brain regions (Strzemecka, 2013). Secondly, music listening after stroke not only enhances behavioural recovery, but also induces fine-grained neuroanatomical changes in the recovering brain (Särkämö et al, 2014). Thus, music is effective and suitable for stroke survivors and can be used during their rehabilitation procedure in order to enhance brain neuroplasticity ability.

5.2.1 Lesion vs. Non-lesion Hemispheres

Cortical mapping of the hand motor area was conducted using a TMS-dedicated navigation system and recording MEP in the contralateral FDI muscle. TMS offer non-invasive approaches of stimulating the cortical surface of the brain, while epidural electrodes can be surgically implanted to stimulate the motor cortex directly. One of the objectives of this study was to determine the best placement for TMS in recording patient MEP thus reflecting patient's brain neuroplasticity. M1 hotspot stimulation has demonstrated a good performance on TMS treatment. For each subject, the researcher applied an average of 70-90 pulses at 70 to 90% of the resting motor threshold (RMT). Majority of the subjects get their reading during the first or second time stimulation, and providing the highest MEP. Therefore, we can conclude that M1 hotspot is the best placement for this research. The TMS results in this research showed a therapy-related increase in the amplitude of the MEP. These changes reflected similar results from previous studies on post-stroke rehabilitation (Särkämö et al., 2010; Johansson, 2010).

Recovering from a stroke is a long and difficult process, almost one-third of patients with stroke exhibit persistent disability after their initial cerebrovascular episode. Many of them suffer from motor impairments as a result of stroke. Traditional rehabilitation therapy uses exercise and training to restore motor functions, however, better training strategies and therapies to further enhance the effects of these rehabilitative protocols are currently being researched and pursued for post-stroke disabilities (Johansson, 2010; Strzemecka, 2013). For many stroke survivors, music as a form of therapy could be a solution (Forsblom, 2012). In this study, the music has increased the stroke survivors' mean MEP scores, lesion and non-lesion hemisphere. Although it is not statistically significant, it still indicates that music may have a positive neuroplasticity effect to the brain. It could help inspire patients to strengthen motor, speech, and cognitive skills—the abilities they cherish most. The right tunes move people physically and emotionally, and they are also a way to keep strenuous rehabilitation sessions fun. When combined with traditional therapies, music therapy can have amazing and lasting effects on stroke survivors' lives.

5.3 Conclusion

Music is often a daily melody or rhythm which surrounds the human activity, accessed easily through the radio, television, audio records or videos. This daily exposure gets us used to being surrounded by different kinds of music, and we would build a preference for the music we like. As such, our preferences have given us different reaction to the music we listened to – the preferable music would reflect a positive feeling in us while the ones we don't like would give a negative reaction. In conclusion, the purpose of this study was to compare and analysis the therapeutic effects of music for effective rehabilitation through studying the effects of music during rehabilitation on post-stroke patients.

This study is innovative in many respects. Firstly, the first research objective of this study is to to determine the preferred local songs that can be used. It is crucial to take into account the subjects' interest in music based on their culture, background and age. Throughout the first phase of the experiment – the songs selection process, P.Ramlee tops the list, being mentioned by every particiapant when asked for their favourite local music (as reflected in Table 3.1 and Figure 3.2), and it can be concluded that P.Ramlee's songs is the most suited to every Malaysia taste. Overall the statistic mean results provide noticeable and positive effect on stroke survivors and healthy individuals. It can be concluded that P.Ramlee's music is suitable and effective on post-stroke rehabilitation. The results of this experiment show that P.Ramlee music provides a positive, emotional connection that stimulates the mind and bring up memories and emotions they have experienced when they hear it.

The second objective of this study is to evaluate the effect of music to the brain through measurement of MEP. There is an obvious improvement for post-test (mean & median). This proves that P.Ramlee's music may produce positive changes in neuroplasticity leading to the improvement of the subjects' motor performance. In this case, P.Ramlee's music showed the positive improvement for post-test regardless of stroke survivors or healthy individuals; it gives a possibility that P.Ramlee's music is suitable to be played as therapeutic music in a multi-racial society like Malaysia.

The third objective of this study is to measure the neuroplasticity difference between lesion vs. non- lesion hemisphere in stroke patients. The results (see Table 4.8) report there were no significant differences (P = 0.144, 0.180, 0.144, and 0.285) for the dependent variables (pre- and post-test) on both lesion and non-lesion hemispheres for control and experimental group. Besides that, the result also shows similar effects towards both the lesion and non-lesion hemispheres; the effect leans more on the lesion hemisphere higher with the higher increase in the mean. This shows that music may have an influence on the hemispheres of the brain, and might bring some impact for people with lesioned hemisphere.

The fourth objective of this study is to compare the neuroplasticity difference between healthy individuals' vs. stroke patients using TMS. There is a significant difference of MEP result between the healthy individuals and stroke survivors for the P value; for control experiment pre-test left MEP is 0.019. This means that there is a difference between the healthy and stroke group's MEP levels on the control experiment pre-test left hemisphere. Although the result is statistically not significant for the rest of treatment, but we can see the control experiment P value for post-test left MEP is at 0.072 which approaches the conventional levels of significance. Perhaps almost all the left hemisphere could be significant because the TMS on left lesion hemisphere had a bigger increase in mean. It can be concluded that there is no difference between healthy individuals and stroke survivors' experimental group with P.Ramlee's Music, along with control group post MEP in left hemisphere as well as pre and post MEP in right hemispheres. This data show that music listening can possibly boost cortical excitability to obtain responses that are very similar to those obtained from healthy individuals.

Although not every result is statically significant, overall it shows the positive improvement on the mean and median. The data suggest that the music listening may produce positive changes in neuroplasticity leading to the improvement of the subjects' motor performance. Brain stimulation using music as medium show positive changes in MEP which shows a possibility of mending damaged brain cells and improve the recovery of stroke survivors. These results are coherent with previous studies, demonstrating the effects on the modulation of the strength of neuroplasticity within the motor cortex during music listening on post-stroke rehabilitation (Särkämö et al., 2014; Thaut., McIntosh, & Hoemberg, 2015; Schlaug, 2015). Further research is currently in progress and the following steps are planned.

This study seeks to identify unforeseen problems, such as inclusion or exclusion criteria for sample selection, time required to examine each patient, the quality of a proposed questionnaire, and estimation of the variability of key variables (for sample size calculation in future actual research). Nonetheless, this study may be limited in that the number of subjects was small as this is only a pilot test. The results discover that in the R/L CVA of the subjects being uneven and may have been skewed with the recruitment of more female than male subjects. There should be an equal and adequate number of R/L CVA subjects to ensure a reliable finding. More subjects and statistical analysis of the MEP results may help provide a better result. Further studies to compensate for such problems may be needed.

In terms of applying music as a therapy to healthy individuals, a bigger sample group would be able to reflect the normative value of this research (for example, how much can P,Ramlee music affect the MEP level). To get the normative data, we can look at it from the aspect of races, age and culture. This research did not apply this idea, setting the stroke population as a homogenous population as the aim is to know if music has an effect to the neuroplasticity of the brain. This is similarly applied to the normal (healthy individuals) population.

The selection of stroke for this study is because it is the most homogenous neurological problem. Many of the stroke population suffered lesions to one half of their brain, as oppose to other types of neurological disease (which can occur in different parts of the brain). Aside from that, stroke has been researched by many as it is homogenous, predictable and has no bias. With this, the study is able to rule out biasness of the symptoms of brain injury – which is often found for other kinds of neurological diseases or brain injuries. This study is able to choose to focus on a particular post-stroke disability – motor function – without bias reasoning as many stroke patients suffer from this effect after stroke.

According to music therapist Lim Kar Gee, music therapy is still considered to be very new in our country Malaysia. As such, the activities that are part of this form of therapy is also still developing. Music listening is one such process that is still considered new. Compared to other therapy or medical treatments, music listening is a natural way for aiding rehabilitation as it does not use any form of medication. Music is low in cost, readily available and has no untoward side effects. Hence, the Malaysian Association of Rehabilitation Physicians Association (MARP) should support, encourage and promote the benefits of music therapy. In addition, the government, universities and hospitals should play their part in the development and advancement of music intervention in Malaysia as it is a method that can help people physically and mentally through natural ways.

As this pilot study has demonstrated its feasibility towards the brain in regard to motor functions, the researcher will use different arrangement of P.Ramlee music from multiple set up of ensemble, instrument and singer to test the possibility of different result in future research.

5.4 Significance and Clinical Applications

The novelty of this study lies on highlighting the significance the effect of music to the brain, enhancing the brain neuroplasticity ability which reflects a positive look for rehabilitation to post-stroke patients, as well as, finding the best music for effective rehabilitation. This project's strong distinguishing feature is that music is effective, non-invasive technique and yet a fun method for in working the neuroplasticity of the brain. It is a window of opportunity for us to better understand the complexity of human brain and its comprehension of aesthetic, creativity and its complex neuronal circuit in interpreting music in its different forms. This could also lead to having a music program as an adjunct to stroke rehabilitation.

This study's findings also add to the knowledge of implementing music listening in therapeutic activities. This research has shown the ease of availability of sources for music listening as a therapeutic activity (YouTube, iTunes, radio and music players) where it could also be very practical even in hospital wards where staffs have few resources and little time. With the help of multiple sources and family members, suitable music can be found for anyone undergoing therapy. From this research, P.Ramlee's music is used to investigate if a playlist made up of local music that everyone is familiar could provide a positive impact toward stroke survivors. This could be paired with rehabilitation as an adjuvant therapeutic tool if there shows any success. In the end, the results of this study may provide information to help researchers design better rehabilitation treatments after stroke.

5.4.1 Recommendation for Future Research

The preliminary evidence revealed in this research has shown a possibility of a clearer analysis of the data if larger randomized controlled study can be performed to get a more substantial result. With positive findings of MEP that involves physiological recovery, we hope to continue our observation to further include behavioural changes for people undergoing stroke rehabilitation, focusing on lesion vs. non-lesion hemispheres between groups. Potential future research could include an equal number for the sample size between R/L CVA as their objective for reliability of statistical testing.

The possibilities for future research focusing on various aspects of music and neuroplasticity are vast and challenging. Investigating in the related areas would be a big contribution to the development in using music to aid the brain. Further research may be able to identify other ways that can improve motor function through music listening, and pair it with rehabilitation for stroke survivors. The uniqueness of P.Ramlee’s music should also be continued in future. We can look into the effect of his music towards emotions, marking down parts of his songs which evokes non-verbal reaction (i.e subject cries, smiles, laugh, frowns, wrinkle eyebrows, foot tapping, moves body and so on) or influence the moods of the listeners. Not only that, we could also test the songs could enhance memories of patients. There is also the option of expanding the target population to include doctors or nurses in the ward. Furthermore, the music can be used by the new young generation through making new arrangement like the orchestra, big band, and piano solo repertoire. With that, there are so many possibilities for P.Ramlee’s music to reach out to everyone regardless of age, location and health.

Further research for this study is currently in progress that will continue investigating the effect of music on neuroplasticity. This research is to be proposed to be further used in the hospital at a higher level, because music listening has possible produce positive changes in neuroplasticity in terms of rehabilitation to the improvement of the subjects’ motor performance. In addition, more collaboration between music and medicine should be introduced to the medical staff to have a clear understanding about the effect of music in therapy. Advice and recommendations from the medical staff towards such a research will welcomed and appreciated in order to improve the research.

Stroke poses a major economic burden to the country and family. The Malaysian government officials should emphasize health care development and services in view of the high number of cases annually, in order to provide effective, efficient primary and secondary prevention for stroke patients. Due to lack of advancement in pharmaceutical treatments for acute stroke, there should be an emphasis on prevention and improving health approaches such as public stroke awareness campaign to increase the public's awareness of signs and symptoms of stroke, national health day to promote the important of healthy diet and regular exercise, specialised stroke units provide an extra adjuvant treatment such as music therapy. More clinical trials and research that focus on the stroke are also needed as this approach would positively impact Malaysian economic development.

5.5 Chapter Summary

In this conclusion of the study, a brief summary of what has been done by providing a closing statement of the validity and contribution of this study. The limitations faced when conducting the study been discussed as well as the direction for other researches can focus in future research and recommendations for conducting further studies in this field.

It is hoped that this study will add to the pool of documented literature on the effect of music and rehabilitation to encourage more research in this area so as to enable further understanding of the complex concept of neuroplasticity. This study has contributed to the body of knowledge by filling the gaps of findings by using music in post-stroke rehabilitation. A study to approach the uniqueness of P.Ramlee's music should be investigated in other fields as well.

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LIST OF PUBLICATIONS AND PAPERS PRESENTED

JOURNAL PUBLICATION

1. Beh, W.F., Mohd Nasir Hashim, Wan Ju Tan, Zarina Adbul Latif. (2018). Music listening intervention vs local anaesthetic cream for pain management in infants undergoing venepuncture: a collaborative trans-disciplinary research. *Journal of pediatric research,5*(1);1-10.

PAPERS PRESENTED

1. Beh, W.F., Lydia Abdul Latif, Nasir Bin Hashim, & Chung, T.Y. (2018, February 7-10). The brain symphony for post-stroke rehabilitation - A pilot randomized controlled study. Paper presented at the *10th World Congress for Neurorehabilitation*, Renaissance Mumbai Convention Centre Hotel, Powai, Mumbai, India (Oral presentation).